IIS (deemed to be UNIVERSITY), Jaipur
Department- Physics
Programme- B.Sc. Physics
OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	EmPSOy critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find emPSOyment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.
PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Acquire a systematic and coherent understanding of the academic field of Physics, its different learning areas and applications to applied problems of Physics and its linkages with related disciplinary subjects like Chemistry, Mathematics, Statistics , Life sciences, Environmental sciences, Computer science, Information Technology .
PSO 2	Attain procedural knowledge that leads to different types of professional and industrial applications also useful in research and development, teaching and public service.
PSO 3	Acquire specialization in a specific field related to current and emerging developments in Physics such as LASER and optical fibers,digital electronics, nuclear physics etc.
PSO 4	Recognize the importance of mathematical modeling simulation and computing, and the role of approximations in simplification of problems and mathematical approaches to describe the physical world.
PSO 5	Plan and execute Physics-related experiments or investigations, analyze and interpret data collected using appropriate methods, including the use of appropriate software, error analysis and use of statistical tools.
PSO 6	Demonstrate problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions and develop numerical solving ability.
PSO 7	Identify and apply appropriate physical principles and methodologies to solve a wide range of problems associated with fields.

PSO 8	Develop communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner.
PSO 9	Demonstrate professional behavior such as being objective, unbiased and truthful in all aspects of work
PSO 10	Develop ability to identify the potential ethical issues in work-related situations.
PSO 11	Gain hands-on experience in a number of the practical methods and techniques used in basic science research and by conceptualizing and handling independently the projects sanctioned to them.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSOS)

Course	COs	PSOs										
		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11
PHY 101	CO1:	X		x			x			x		
	CO2	X								x		
	CO3	X					x			x		
	CO4	X		x						x		
	CO5	X		x			x			x		
	CO6	X		x			x			x		
PHY 102	CO7	X		x			x			x		
	CO8	X		x			x			x		
	CO9	X		x			x			x		
	CO10	X		X						x		
	CO11	X		X						x		
	CO12	X		X						x		
	CO13	X								x		
	CO14	X								x		
	CO15	X								x		
PHY 103	CO16	X	x	X		x	x	x		x		x
	CO17	X	x			x	x	x		x		x
	CO18	X	x			x		x	x	x	x	x
PHY 201	CO19	X					x			x		
	CO20	x		X			x			x		
	CO21	x		X			x			x		
	CO22	x		X			x			x		
	CO23	x		X			x			x		
	CO24	x					x			x		
PHY 202	CO25	x								x		
	CO26	x		X			x			x		
	CO27	x		X			x			x		
	CO28	x								x		
	CO29	x		X						x		
PHY203	CO30:	x	x			x		x		x		x
	CO31	x	x			x		x		x		x
	CO32	x	x			x		x		x		x
	CO33	x	x			x		x		x		x

PHY 301	**CO34**	x		X			x			x		
	CO35	x					x			x		
	CO36	x								x		
	CO37	x		X						x		
	CO38	x								x		
PHY 302	**CO39**	x					x			x		
	CO40	x					x			x		
	CO41	x		X			x			x		
PHY303	**CO42**	x	x			x		x		x		x
	CO43	x	x			x	x	x		x	x	x
	CO44	x	x			x		x		x		x
	CO45	x	x			x		x		x		x
PHY 401	**CO46**	x		X	x					x		
	CO47	x		X	x		x			x		
	CO48	x		X	x		x			x		
	CO49	x		X	x		x			x		
	CO50	x			x					x		
	CO51	x		X	x		x			x		
PHY 402	**CO52**	x		X						x		
	CO53	x								x		
	CO54	x								x		
	CO55	x		x			x			x		
	CO56	x								x		
	CO57	x								x		
	CO58	x								x		
	CO59	x		x			x			x		
PHY 403	**CO60:**	x	x			x		x	x	x		x
	CO61	x	x			x		x	x	x		x
	CO62	x	x			x		x	x	x		x
	CO63	x	x			x		x	x	x		x
	CO64	x	x			x		x	x	x	x	x
PHY501	**CO65**	x		x						x		
	CO66	x		x			x			x		
	CO67	x		x			x			x		
	CO68	x								x		
	CO69	x					x			x		
PHY 502	**CO70**	x		x			x			x		
	CO71	x		x			x			x		
	CO72	x		x						x		
	CO73	x		x						x		
	CO74	x		x			x			x		
PHY 503	**CO75**	x	x			x		x		x		x
	CO76	x	x	x		x		x		x		x
	CO77	x	x	x		x		x		x		x
	CO78	x	x			x		x		x		x
	CO79	x	x	x		x		x		x	x	x
PHY 601	**CO80**	x								x		
	CO81	x								x		
	CO82	x								x		
	CO83	x					x			x		
	CO84	x								x		

	CO85	x								x		
	CO86	x								x		
PHY 602	**CO87:**	x		x						x		
	CO88	x		x						x		
	CO89	x		x						x		
	CO90	x		x						x		
	CO91	x		x		x	x			x		
PHY 603	**CO92**	x	x			x		x		x		x
	CO93	x	x			x		x		x		x
	CO94	x	x			x		x		x		x
	CO95	x	x			x		x		x		x
	CO96	x	x			x		x		x	x	x

B.Sc. Physics with Physics as an elective (2020-2021)
COURSE OUTCOMES - Semester I

PAPER CODE-PHY 101
Mechanics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

To acquaint the students with the fundamental laws and principles involved in motion and to introduce some properties of matter like elasticity so that they develop abilities and skill that are relevant to the study and practice of Physics related to general properties of physical bodies. After completing a course on Mechanics, the students will acquire abilities to apply its knowledge to basic problems of the physical world.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 101	**Mechanics (Theory)**	**The students will be able to –** **CO1.** Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. **CO2.** Learn the concept of fictitious forces arising in a non-inertial frame and study its effects.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Demonstration, problem solving in tutorials	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO3. Understand the phenomena of collisions and their description in center of mass and laboratory frames and correlation between them. **CO4.** Apply Kepler's laws to describe the motion of planets and satellite in circular &elliptical orbits. **CO5.** Understand special theory of relativity and apply it to length , time mass and energy of a moving object. **CO6.** Understand the principles of elasticity through the study of Young Modulus, modulus of rigidity, torsion of a cylinder & Bending of beam.	**Learning activities for the students:** Self learning assignments, Effective questions, numerical solving ,Seminar presentation.	

CONTENTS

Unit I: Physical Laws and Frames of Reference **10 Hrs.**

Inertial and non inertial frames, examples, Transformation of displacement, velocity and acceleration between different frames of reference involving translation in uniform motion, Galilean transformation and invariance of Newton's laws, Transformation equations of displacement velocity and acceleration for rotating frames, Fictitious forces (Coriolis force and centrifugal force), effects of Centrifugal and Coriolis forces due to earth's rotation, Focault's pendulum.

Unit II: Centre of mass: **9 Hrs.**

Centre of mass of a two particle system, motion of centre of mass and reduced mass conservation of linear momentum, elastic and inelastic collision of two particles in laboratory and center of mass frames, motion of a system with varying mass, Angular momentum conservation with examples, charged particle scattering by nucleus.

Unit III: Motion under central forces: **8 Hrs.**

Motion under central forces, gravitational interaction, general solution under gravitational interaction, discussion of trajectories, cases of elliptical and circular orbits, Keplers laws.

Unit IV: Special theory of relativity: **9 Hrs**

Postulates of special theory of relativity, Lorentz transformations, length contraction, Time dilation, transformation and addition of velocities, Relativistic Doppler's effect, space- like space time interval, time-like space time interval.

Unit V: Elastic Properties of Matter: **9 Hrs.**

Elastic constants: Young's Modulus, Bulk Modulus, Modulus of Rigidity, Poisson's ratio. Relations between the elastic constants, torsion of a cylinder.

Bending of beams: Bending moment, Cantilever, Potential energy and oscillation of a loaded cantilever, cantilever loaded at one end (i) when weight of beam is negligible

(ii) When weight is considered, Beam supported at both ends and loaded in the middle, Experimental determination of elastic constants (Y, η ,σ).

BOOKS RECOMMENDED:

- "Elements of Mechanics", Gupta, Prakash and Agrawal, Pragati Prakashan, Meerut.
- "Elements of Mechanics", J.C.Upadhyaya ,Himalaya Publishing House,2006.
- "Fundamental University Physics", Vol. I and II, Addison Wesley, Reading Mars, LISA.
- "Berkley Physics Course", Vol. I, Mc. Graw Hill, New York.
- "The Feynmann Lectures in Physics", Vol. 1, R. P. Feynman, R.B. Leighton and M. Sands , B.I. Publications, Bombay, Delhi, Calcutta, Madras.
- "Physics",Part 1, David Halliday and Resnick , John Wiley and Sons, Inc. Newyork.
- "Properties of Matter", D.S.Mathur, S.Chand & Company.

PAPER CODE-PHY 102
Electromagnetism
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
This course will acquaint the students with the scalar and vector fields, gradient, divergence, curl and their physical significance. Students will also learn about the fields produced by moving charges and magnetic fields in matter, electromagnetic induction, Maxwell's equations and electromagnetic waves. This course will provide the student the ability to apply its knowledge to problems related to electromagnetic fields and waves.
Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 102	**Electromagnetism (Theory)**	**The students will be able to –** **CO7.** Explain and evaluate the Gradient of a scalar quantity, Divergence and Curl of a vector quantity. **CO8.** Apply Poisson's and laplace's equation to solve a variety of problems. **CO9.** Articulate knowledge of magnetic forces to calculate various forces between different types of static and moving charges. **CO10.** Derive Biot Savart's law and apply it to find the magnetic field due to various types of current carrying elements.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation,Problem Solving in tutorials, guest lectures **Learning activities for the students:** Self learning assignments, Effective questions, Seminar	Class test, Semester end examinations, Quiz, Solving problems ,Assignments,Presentations

		CO11. Describe the moments of charge distribution and the effect of dielectrics on different system of charges. **CO12.** Explain the relation between atomic polarizability and electric susceptibility. **CO13.** Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media. **CO14.** Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density. **CO15.** Course will equip the students with required prerequisites to understand electrodynamics phenomena.	presentation, Solving numericals	

CONTENTS

Unit I: Scalar and vector fields **9 Hrs.**

Partial derivatives, Gradient of a scalar function. Line integral of a vector field, Divergence and Curl of a vector field, Physical significance of divergence & curl and their expressions in Cartesian coordinates, Gauss divergence theorem, Stokes curl theorem, Laplacian operator, Poisson's and Laplace's equation.

Unit II: Dynamics of a charged particle **9 Hrs.**

Magnetic forces, Invariance of charge, Electric field measured in different frames of reference, Field of a point charge moving with constant velocity, Interaction between a moving charge and other moving charges.

Unit III: Magnetostatics **10 Hrs.**

Ampere's law in differential form, Magnetic Vector Potential, Poisson's equation for vector potential, magnetic field due to a current carrying wire and deduction of Biot-Savart's law.

Electric current due to an orbiting electron, Bohr Magneton, Orbital gyro magnetic ratio, Electron spin and spin magnetic moment, magnetic susceptibility, magnetic field caused by magnetized matter, Magnetization current, Free current its H field.

Unit IV: Electrostatics and dielectrics **9 Hrs.**

Moments of a charge distribution, Atomic and molecular dipoles, Atomic Polarizability, Permanent dipole moment, Dielectrics, capacitor filled with dielectric, the potential and field due to a polarized sphere, dielectric sphere in a uniform electric field, The electric field of charge in dielectric medium and Gauss law, Relation between electric susceptibility and atomic polarizability, Polarization due to changing electric field. The bound charge current.

Unit V: Maxwell's equations and electromagnetic waves **9 Hrs.**
Faraday's laws of electromagnetic induction, its integral and differential form, Maxwell's displacement current, Maxwell's equations in differential and integral form. Poynting's theorem ,Wave equation , EM waves in a non-conducting dielectric medium, Plane monochromatic waves in a non-conducting medium, Energy flux in a plane electromagnetic wave, Radiation pressure.

BOOKS RECOMMENDED

- "Electricity and Magnetism with Electronics", K.K.Tewari, S.Chand & Co. Ltd. (2001)
- "Electricity and Magnetism", D.Chattopadhyay, P.C.Rakshit, New Central Book Agency (P) Ltd.
- "Elements of Electromagnetics", Mathew, N.D. Sadika, New Delhi, Oxford University Press.
- "Electricity and Magnetism", W.J.Duffin , Mc Graw Hill Book Co., Fourth edition.
- "Electromagnetics", B.B.Laud ,New Age International Publishers, Second edition.
- "Electromagnetic theory and electrodynamics", Satya Prakash, Kedar Nath Ram Nath & Co. Publishers, Meerut, Ninth edition.
- "Physics Part 2",D.Halliday and R.Resnick, John Wiley and Sons, Inc. Newyork.
- "Principles of Electricity and Magnetism",S.Palit, Narosa Publishing House.

PAPER CODE-PHY 103
Practicals
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to
This course introduces students to the methods of experimental physics. Emphasis isgiven onlaboratory techniques such as accuracy of measurements and data analysis. The concepts that arelearnt in the lecture sessions aretranslated to the laboratory sessions thus providing a hands-onlearning experience.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 103	**Practicals (Practical)**	**The students will be able to –** **CO16.** Understand the concept of conversion of galvanometer to ammeter and voltmeter ,R-C circuit, LR circuit, specific resistance ,electromagnetic induction ,charging and discharging of a	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments,asking viva voce questions	Class test, Semester end examinations, Viva voce, Practical record file

		condenser, Carey Foster's bridge and Faraday's Law by performing experiments. **CO17.** develop the skills to determine elastic constants like Young's modulus , modulus of rigidity etc of metallic bar/plate by different methods . **CO18.** Develop oral and written scientific communication skills, and to think critically and work independently.	**Learning activities for the students:** Performing Experiments, taking observations, Analysis and interpretation of results, preparation of record file	

CONTENTS

List of Experiments

1. To study the variation of charge and current with time in a R-C circuit for different time constants using a DC source (charging and discharging characteristics of a condenser).
2. To determine the specific resistance of the material of a resistance wire and to determine the difference between two small resistances using Carey Foster's bridge.
3. To study the behavior of voltage and current in a LR circuit with AC power source. Also to determine power factor, impedance and phase relations.
4. To study the behaviour of RC circuit with varying resistance and capacitance using AC mains as a power source and also to determine the impedance and phase relationship between voltage and current in the circuit.
5. To study the electromagnetic induction and to verify Faraday's Law.
6. To study the characteristics of a junction diode .
7. To determine Y,η and σ by Searl's method.
8. To determine Young's modulus by bending of beam.
9. To determine modulus of rigidity of a wire using Maxwell's needle.
10. To determine the surface tension of given liquid at room temperature using Jaeger's method.
11. To convert Galvanometer into an ammeter of given range.
12. To convert Galvanometer into a Voltmeter of given range.

NOTE - Students are expected to perform any eight experiments from the given list. Two experiments out of the eight will be set in the examination paper.

COURSE OUTCOMES - Semester II

PAPER CODE-PHY 201
Oscillations and waves
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
To familiarize the students with motion of different types of oscillators and also with wave motion in different medium. This will enable the students to develop abilities and skill to solve problems related to waves and oscillations.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 201	Oscillations and waves (Theory)	**The students will be able to –** **CO19.** Understand physical characteristics of SHM, and obtaining solution of the oscillator using differential equations **CO20.** Solve for the solutions and describe the behavior of a damped, driven and coupled harmonic oscillator in both time and frequency domains. **CO21.** Understand and implement Fourier series. **CO22.** Calculate logarithmic decrement relaxation factor and quality factor of a harmonic oscillator. **CO23.** Solve wave equation and understand significance of electromagnetic waves **CO24.** Gain knowledge on applications of transverse and longitudinal waves.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Demonstration, problem solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: Simple harmonic and damped Oscillator **10 Hrs.**
Simple harmonic motion, Differential equation of simple harmonic motion, examples:-mass on a spring, Torsional oscillator. LC Circuit, Potential energy curve and small oscillations in one dimensional potential well, Energy of oscillations, mass and two spring system. Damped harmonic oscillator, Mathematical formulation

of damped harmonic oscillator, Energy of damped oscillator, Power dissipation, Relaxation time, Quality factor of damped harmonic oscillator

Unit II: Driven harmonic oscillator **8 Hrs.**

Driven harmonic oscillator , Mathematical formulation of driven harmonic oscillator , Frequency response on amplitude and phase, Quality factor of driven oscillator, Resonance, Sharpness of resonance, Power absorption by forced oscillator, Series and parallel LCR circuit.

Unit III: Coupled oscillators **9 Hrs.**

Equation of motion of two coupled simple harmonic oscillators, Normal modes, motion in mixed modes ,dynamics of a linear chain of coupled oscillators with nearest neighbor interaction, Energy transfer between modes, Electrically coupled circuits (capacitive and inductive), Reflected impedance, effect of coupling and resistive load.

Unit IV: Lattice vibrations and Fourier analysis: **9 Hrs.**

Equation of motion for one dimensional monatomic and diatomic lattice, acoustic and optical modes, dispersion relation, concept of group and phase velocities, Fourier Analysis of square, saw tooth and triangular wave forms.

Unit V: Wave motion **9 Hrs.**

Wave equation, Transverse waves in a string, Elastic waves in a solid rod, Pressure waves in a gas column, Plane electromagnetic waves, Energy and Momentum of EM waves, Radiation pressure,Radiation resistance of free space.

BOOKS RECOMMENDED:

- "The Physics of Waves and Oscillations", N.K.Bajaj, Tata Mc Graw Hill Publishing Co., 2003.
- "Oscillations, waves and electromagnetism", Satya Prakash, Pragati Prakashan, Meerut.
- "Fundamental University Physics", Vol I and II , M.Alonso & J.Finn, Addisson Wiesley.
- "Vibrations and Waves", A.P. French, CBS Publication and Distributors.
- "Berkeley Physics Course", Vol. I , New York, Mc Graw Hill.
- "Vibrations and waves", I.G. Main ,Cambridge University Press.
- "The Physics of Vibrations and Waves", H.J.Pani, John Wiley & Sons.
- "Fundamentals of vibrations and Waves", S.P.Puri, Tata Mc. Graw Hill Pub. Co.,NewDelhi.
- "Oscillations and Waves",K.S.Sharma, M.K.Saxena and G.R.Chhabra ,Rajasthan Hindi Granth Academy, Jaipur.
- "Waves and Oscillations",N.Subramanyam,Vikas Publishing house.

PAPER CODE-PHY 202
Optics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

This course familiarizes the students with the phenomenon of interference, diffraction, polarization, LASER and holography to enable them to acquire sufficient understanding and knowledge to recognize the usefulness of these phenomena in everyday life and also stimulate their interest in Physics. Further, the students also acquire knowledge of working principles and applications of LASER in Industry, Science and Technology.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 202	**Optics (Theory)**	**The students will be able to –** **CO25.** Understand the concept of Fermat's principle and apply it to prove laws of reflection and refraction, Refraction at a spherical surfaces and cardinal points. **CO26.** Acquire Knowledge of interference and learn about Young's double slit experiment, Newton's rings, Michelson interferometer and its Applications. **CO27.** A brief idea about Fresnel and Fraunhoffer diffraction, zone plate and a convex lens and their relations to solve the problems. **CO28.** Knowledge of electromagnetic waves, Polarization and Optical activity . **CO29.** Differentiate ordinary ray from LASER ray, knowledge about lasers and Holography .	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation,Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems in tutorials, Assignments, Presentations

CONTENTS

Unit I: Geometrical Optics **10 Hrs.**

Fermat's principle extremum path, Laws of reflection and refraction from Fermat's principle, Refraction at a spherical surfaces (convex surface and concave surface) cardinal points ,construction of a image using cardinal points, Newton's formula; Relationship between f_1 and f_2 ;Relationship between f_1 , f_2 , μ_1 and μ_2, Cardinal points of a coaxial system of two thin lens.

Unit II: Interference **8 Hrs.**

Young's double slit experiment, types of interference: division of amplitude, division of wave front, Coherence: temporal and spatial coherence, Interference in thin films, colour in thin films, Newton's rings, Determination of wavelength and refractive index of liquid by Newton's rings, Michelson interferometer, Applications of Michelson interferometer: determination of wavelength, difference of wavelength and thickness of thin films.

Unit III: Diffraction **9 Hrs.**
Fresnel diffraction: Fresnel's assumptions, Half period zones, Distinction between interference and diffraction, Difference between Fresnel and Fraunhoffer diffraction, , diffraction at a circular aperture, straight edge and thin slit, zone plate, difference between zone plate and a convex lens.
Franunhoffer diffraction: Diffraction at single slit, Diffraction at double slit, Diffraction at N slits(simple derivation), plane diffraction grating, dispersion by a grating, resolving power of a grating.

Unit IV: Polarization **9 Hrs.**
Plane electromagnetic waves. E and B of linearly, circularly, elliptically polarized electromagnetic waves.
Polarization by reflection, Huygens theory of double refraction, production and Analysis of plane, circularly and elliptically polarized light, Quarter and half wave plate. Optical activity, specific rotation, Biquartz and half shade polarimeters.

Unit V: LASER and holography **9 Hrs.**
Difference between ordinary and LASER source, stimulated and spontaneous emission, Einstein A and B coefficients, Population inversion, Principle of laser action, Metastable states, Pumping, types of LASER, construction, working and energy levels schemes of He-Ne and Ruby laser, Applications of LASER.
Basic concepts of holography, construction of hologram and reconstruction of image, important features of hologram and uses of holography.

Books Recommended:

- "A textbook of Optics", Brijlal and Subramaniam, S.Chand & Company Ltd.,23rd edition.
- "Essentials of Lasers and non-linear Optics",G.D.Baruah, Pragati Prakashan, Meerut.
- "Text books of Optics and Atomic Physics", D.P. Khandelwal, Himalaya Publishing House.
- "Optics", Ajoy Ghatak ,Tata Mc Graw Hill Pub.Co. Ltd, 2007.
- "Physics Part II", D.Halliday and R.Resnick, John Wiley & Sons, Inc., Newyork.
- "LASERS: Theory and Applications", K.Thyagrajan, A.K.Ghatak, Macmillan India Ltd.

PAPER CODE-PHY 203
Practical
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to
This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions pertaining to Optics and Oscillations are translated to the laboratory sessions thus providing a hands-on learning experience.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 203	**Practicals (Practical)**	**The students will be able to –** **CO30.** Develop knowledge and skill to determine wavelength of Sodium light by grating, Newton's rings and Fresnel's Biprism experiment and dispersive power of prism. **CO31.** Demonstrate basic concept of resonance in series LCR circuit and damping of a compound pendulum. **CO32.** Understand Brewsters law by verifying it. **CO33.** Learn about variation of magnetic field along the axis of a current carrying circular coil .	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, taking observations , Analysis and interpretation of results, Error analysis, preparation of viva voce questions and maintain practical record,	Class test, Semester end examinations, Viva voce, Practical record file

CONTENTS

List of Experiments

1. To determine wavelength of Sodium light by grating.
2. To determine wavelength of Sodium light by Fresnel's Biprism.
3. To determine dispersive power of a prism using Mercury light.
4. Using Newton's rings find out the wavelength of the given monochromatic source.
5. Using Michelsons's interferometer, find out λ and $\Delta\lambda$ for Sodium Light.
6. To determine Brewster's angle and refractive index of glass by using spectrometer and Polaroids.
7. To study damping of a compound pendulum and to determine the quality factor.
8. To study the charging of a condenser by unidirectional varying voltage pulses/alternating voltage pulses and then to integrate them.
9. Study of dependence of velocity of wave propagation on line parameter using torsional wave apparatus
10. To study the variation of magnetic field along the axis of a current carrying circular coil. Plot the necessary graph and hence determine the radius of circular coil.
11. To study resonance in a series L C R circuit and determine Q factor of the circuit.
12. To study the variation of reflection coefficient of nature of termination using torsional wave apparatus.

NOTE - Students are expected to perform any eight experiments from the given list. Two experiments out of the eight will be set in the examination paper.

COURSE OUTCOMES - Semester III

PAPER CODE-PHY 301
Thermodynamics and Statistical Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
To acquaint the students with basic laws of thermodynamics and statistical physics, methods of producing low temperatures, Carnots engine so that they develop the scientific attitude to relate this knowledge to their daily life experiences. They learn about the efficiency and develop an aptitude to design more efficient systems.

Course Outcomes (COs):

Course		Learning outcome	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title	(at course level)		

PHY 301	**Thermodynamics and Statistical Physics** **(Theory)**	**The students will be able to –** **CO34.** acquire working knowledge of the zeroth and first law of thermodynamics, identify the relationship and correct usage of infinitesimal work, work -energy, heatcapacity, specific heat, latent heat, and enthalpy of a system **CO35.** Identify which procedure to be used to produce low temperature and to analyze the difference between Liquid He I and He II. **CO36.** .Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function. **CO37.** Learn advanced topics related to Quantum Statistical Mechanics and use the partition function for calculations about the canonical ensemble. **CO38.** Get acquainted with advanced topics such as the Fermi energy of a system of Non-interacting Fermions and its relation to the chemical potential.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation,Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: Basic Thermodynamics **10 Hrs.**

The Zeroth law, Various indicator diagrams(P-V diagram), First law of thermodynamics, Reversible and irreversible processes, Carnot's engine, Carnot's cycle and efficiency of Carnot's engine, reversibility of Carnot's engine, Carnot's theorem. Second law of thermodynamics, (different statements and their equivalence) Entropy, Principle of increase of entropy, Thermodynamic scale of temperature, Thermodynamic scale as an absolute scale, Third law of thermodynamics.

Unit II: Thermodynamic Relations **8 Hrs.**

Maxwell's thermodynamic relations, Triple point, Clausius Clapyron latent heat equation,Effect of pressure on boiling point of liquids, Helmholtz free energy, Enthalpy, Gibbs function,Internal energy,Thermodynamic potentials, Deduction of Maxwell's relations from thermodynamic potentials.

Unit III: Production of low temperatures **8 Hrs.**

Joule Thomson expansion and JT coefficient for ideal as well as Vander Waals gas, Porous plug experiment, Temperature of inversion, Regenerative cooling, cooling by adiabatic expansion and demagnetization, liquid He, He I and He II, Peculiar properties of He II, Nernst heat theorem.

Unit IV: Distribution of molecular velocities **9 Hrs.**

Distribution law of molecular velocities, Most probable, Average and RMS velocities, energy distribution function, Experimental verification of Maxwell velocity distribution, Principle of equipartition of energy.
Mean free path and collision cross section, distribution of mean free path, Transport of mass, momentum and energy and their interrelationship, (coefficient of viscosity, thermal conductivity & diffusion)

Unit V **10 Hrs.**

Classical Statistics :

Phase space, micro and macro states, Thermodynamic probability, relation between entropy and thermodynamic probability, Monatomic ideal gas, specific heat capacity of diatomic gas and specific heat of solids.

Quantum Statistics :

Failure of classical statistics (Blackbody radiation and various laws of distribution of radiation, qualitative discussion of Weins and Rayleigh Jeans Law) Postulates of quantum statistics, Indistinguishability of wave function and exchange degeneracy, Bose Einstein statistics and its distribution function,. Planck's distribution function and radiation formula, Fermi Dirac statistics and its distribution function.

BOOKS RECOMMENDED:

- "Heat and Thermodynamics", Singhal, Agarwal and Prakash , Pragati Prakashan.
- "Heat and Thermodynamics", Brijlal and Subramaniam, S. Chand & Sons.
- "Thermodynamics and Statistical Mechanics", S.L.Kakani, Sultan Chand & Sons.
- "Statistical and Thermal Physics", S. Loknathan and R.S. Gambhir, Prentice Hall, New Delhi 1991.
- "Thermodynamics, kinetic theory of gases and Statistical Mechanics", F.W.Sears, G.L.Salinger, Narosa Pub. House.
- "Introduction to Statistical Mechanics", B.B. Laud, Mc Milan India Ltd.
- "Fundamentals of Statistical and Thermal Physics", Federick Reif, Tata Mc Graw Hill, 1992.
- "Heat and Thermodynamics", M.S.Yadav, Anmol Publications.
- "Fundamentals of Statistical Physics", A.K. Das Gupta, New Central Book Company, Calcutta, 2003.

PAPER CODE-PHY 302
Electronics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

This course aims to develop the fundamental knowledge of electronics by learning various topics viz. circuit analysis**,** network theorems, P-N diode equation, rectifiers, filters, transistors and transistor amplifiers and their analysis. Students will also learn feedback amplifiers, logic gates and fabrication of IC's. The course helps them to develop skills to design electronic circuits for various applications.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 302	**Electronics (Theory)**	**The students will be able to –** **CO39.** A systematic and coherent understanding of basic Electronics including the concepts and theories. **CO40.** A broad and fundamental understanding of electronic circuit elements, dc power sources, diodes, rectifiers, filters, transistors, amplifiers, logic gates and basics of electrical wiring. **CO41.** knowledge with reference to working of various tools like inductors, capacitors, multimeter, voltmeter, ammeter etc.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation,Problem Solving in tutorials, demonstration **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I

Basic Circuit Analysis **10 Hrs.**

Open and short circuits, Impedance, Admittance and Hybrid parameters of any four terminal network, Kirchoff's laws, Mesh and Node analysis.

Various Circuit theorems

Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transformer theorem and Reciprocity theorem.

Unit II

Semi conductor diode and rectification **9 Hrs.**

p-n junction diodes, I-V characteristics, diode as a rectifier, half-wave and full-wave rectifiers : calculations of ripple factor, efficiency and regulation , bridge rectifiers.

Filters: Series inductor, shunt capacitor, L-section and π section filters.

Voltage regulation : Zener diode, breakdown voltage (avalanche and zener effect), voltage regulation, voltage multipliers.

Unit III

BJT and amplifiers: **9 Hrs.**

Basic construction of pnp and npn transistors and their operation, Input and output characteristics of CB, CC and CE configurations, active, saturation and cut-off regions, Load line and Q-point, Two-port analysis of a transistor using h-parameters, Analysis of CB, CE and CC amplifier for current gain, voltage gain, input and output impedances using h-parameters,Gain-frequency response of an amplifier.

Unit IV

Feed-back amplifier: **8 Hrs.**

Concept of feed-back, positive and negative feedback, voltage and current feedback circuits (series and parallel circuits).

Advantages of negative feedback: Stabilization of gain, effect on input and output impedances, reduction of non-linear distortion, effect on gain-frequency response.
Oscillators: Barkhausen criterion, RC oscillators, Colpitt's oscillator, Hartley oscillator, crystal oscillators and its advantages.

Unit V
Digital Electronics: **9 Hrs.**
Transistors as a switch, Logic fundamentals: AND, OR, NOT, NAND, NOR, XOR gates. Boolean algebra, De Morgan's theorem, positive and negative logic, Logic gates circuit realization using DTL and TTL logic, Simplification of Boolean expressions.
Integrated Circuit Technology:
Integrated circuit vs. discrete components, Integrated circuit processing, Oxidation, diffusion, photolithography, epitaxy, chemical vapour deposition, Bipolar transistor fabrication.

BOOKS RECOMMENDED:

- "Electronic Devices and Circuits", Jacob Millman and Christos Halkias, TMH , 9th edition.
- "Electronic Fundamentals and Applications", John D. Ryder, Prentice Hall of India Pvt. Ltd.,(1983) New Delhi.
- "Digital Computer Electronics", Albert Paul Malvino, Tata Mc Graw Hill Pub. Co. Ltd., New Delhi.
- "Hand book of Electronics", Kumar and Gupta, Pragati Prakashan, Meerut.
- "Basic Electronics and Solid State", B.L. Theraja, S.Chand, 2002.
- "Integrated Electronics, Analog and Digital circuits and systems", Millman & Halkias, Mc Graw Hill Ltd. (1972).
- "Electronic devices and circuits" , Soni and Gupta, Dhanpat Rai and Sons.
- "Basic Electronics and Linear circuits", Bhargava and Kulshreshtha, TMH ,1984.
- "Principle of Electronics" (for numerical problems) V.K. Mehta, S.Chand ,2002.
- "Basic Electronics", Kal, Prentice Hall of India, 2002.
- "Electronic Devices and Circuit Theory", Robert Boylestad and Nashelsky, Prentice Hall of India, Fifth edition.
- "Engineering Electronics", John D Ryder, Mc Graw Hill Book Co.

PAPER CODE-PHY 303
Practicals
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to

This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions are translated to the laboratory sessions thus providing a hands-on learning experience.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 303	**Practicals (Practical)**	**The students will be able to –** **CO42.** Assess the validity of physical theories through the design and performance of an experiment. **CO43.** Analyse the uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). **CO44.** Be able to demonstrate lee's method and platinum resistance thermometer. **CO45.** Be able to handle useful equipment's related to electronics like transistor,amplifier, logic gates.	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, taking observations , Analysis and interpretation of results, Error analysis, preparation of viva voce questions and maintain practical record,	Class test, Semester end examinations, Viva voce, Practical record file

CONTENTS

List of Experiments

1. Using platinum resistance thermometer, find the melting pint of a given substance.

2. To determine thermal conductivity of a bad conductor by Lee's method.

3. To determine 'J' by Calender and Barne's method.

4. Determine the thermodynamic constant = C_p/C_v using Clement's and Desorm's method.

5. Study of variation of total thermal radiation with temperature.

6. To plot thermo emf versus temperature graph for Cu-Fe thermo couple and to determine temperature of a hot source (use sand bath).

7. To study the variation of power transfer to different loads by a D. C. source and to verify maximum power transfer theorem.

8. Study of half wave rectification using single diode and application of L & π section filters.

9. To study characteristics of a given transition PNP/NPN (CE, CB & CC configuration).

10. Study of single stage transistor audio amplifier (variation of Gain with Frequency).

11. To verify laws and network theorems in D C circuits.

12. Using discrete components, study OR, NOT, AND logic gates.

NOTE - Students are expected to perform any eight experiments from the given list. Two experiments out of the eight will be set in the examination paper.

COURSE OUTCOMES - Semester IV

PAPER CODE-PHY 401
Mathematical Physics And Numerical Methods
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
The objectives of this paper are to acquaint the students with different types of coordinate systems, tensors, four vectors etc. The students will also learn to make Fourier analysis of complex functions and use various numerical methods for solving different types of Physical Science problems.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

PHY 401	**Mathematical Physics and Numerical Methods** **(Theory)**	**The students will be able to –** **CO46.** Find the divergence, gradient or curl of a vector or scalar field expressed in terms of orthogonal curvilinear coordinates. **CO47.** Analyze the application of Doppler's and Compton Effect in day to day life. **CO48.** Apply a range of techniques to solve first & second order partial differential equations and Model physical phenomena using partial differential equations such as the heat and wave equations. **CO49.** Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc. **CO50.** Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics. **CO51.** Solve initial and boundary value problems in differential equations using numerical methods and apply various numerical methods in real life problems.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation,Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

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CONTENTS

UNIT I

Orthogonal curvilinear coordinate system : 12 Hrs.

Orthogonal curvilinear coordinate system, scale factors, Expressions for gradient, divergence and curl and their application to Cartesian, Circular Cylindrical and Spherical polar coordinate systems.

Tensors:

Coordinate transformations, Transformation of covariant, contra variant and mixed tensors. Addition, subtraction, outer product , contraction and inner product of tensors, Quotient law, Symmetric and antisymmetric tensors, Metric tensor.

Dirac delta function and its properties.

UNIT II

Four vectors: 8 Hrs.

Four vector formulation, four velocity vector, energy-momentum four vector, relativistic equation of motion; invariance of rest mass, orthogonality of four force and four velocity, Lorentz force as an example of four force, transformation of four frequency vector, longitudinal and transverse Doppler's effect, Compton effect.

UNIT III

Boundary value problems: 10 Hrs.

Techniques of separation of variables and its application to the following boundary value problems (i) Laplace's equation in three dimensional Cartesian coordinate system – line charge between two earthed parallel plates, (ii) Helmholtz equation in circular cylindrical coordinates-Cylindrical resonant cavity, (iii) Wave equation in spherical polar coordinates-the vibrations of a circular membrane, (iv) Diffusion equation in two dimensional Cartesian coordinate system-heat conduction in a thin rectangular plate.

UNIT IV

Fourier Series and Integrals: 8 Hrs.

Introduction, Fourier series and coefficients, functions with point of discontinuity, arbitrary period, even and odd functions, half range expansion, Parseval's theorem.

UNIT V

Numerical Methods: 7 Hrs.

Introduction, Finite-Difference Operators, Differential Operator related to the Difference Operator, Truncation error, Numerical interpolation, Roots of equations, Initial-value problems –Ordinary Differential equations: Taylor's method, Euler's method and direct method. Trapezoidal and Simpson's rule for numerical integration.

BOOKS RECOMMENDED:

- "Mathematical Methods" , Potter and Goldberg, Prentice Hall of India (1998).
- "Mathematical methods in Physics", D.Biswas, New Central Book Agency (P) Ltd.
- "Mathematical Physics", M.P.Saxena, P.R.Singh, S.S.Rawat, P.K.Sharma, CBH, Jaipur.
- "Applied Maths for Engineers and Physicists",Pipes and Harvill, McGraw Hill.
- "Advanced Engineering Mathematics", Ervin Kreyzig 5^{th} Edition, Wiley Eastern Ltd.
- "Numerical Methods", S. Balachandra Rao, C.K. Shantha, University Press, 1992.
- "Mathematical Physics",Ellgnine Butkon, Addisson Wiesley.
- "Mathematical Physics",Gupta, Vikas Publishing House.

PAPER CODE-PHY 402
Condensed Matter Physics and Devices
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

To familiarize the students with the basics of condensed matter physics which form the basic for further studies in condensed matter physics. The students get acquainted with the crystal structure, properties of solids, superconductivity and magnetism which strengthens the theoretical base for research in contemporary fields of condensed matter physics like imperfect solids and nano particle physics. The students acquire abilities to undergo research or involve in business related to material science.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 402	**Condensed Matter Physics and Devices (Theory)**	**The students will be able to –** **CO52.** Have a brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, Crystal structure, diffraction of X-rays by crystalline materials. **CO53.** Have knowledge of lattice vibrations, phonons and in depth knowledge of Einstein and Debye theory of specific heat of solids. **CO54.** Develop an understanding of the band theory of solids and ability to differentiate between insulators, conductors and semiconductors. **CO55.** Learn about methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor. **CO56.** Comprehend the basic theory of superconductors, Type I and II superconductors, their properties and physical concept of BCS theory. **CO57.** Acquire knowledge of different types of magnetism from diamagnetism to ferromagnetism, hysteresis loops and energy loss. **CO58.** Understanding of working of LEDs, photodiode and solar cells. **CO59.** Knowledge of Operational amplifiers , its characteristics and various applications.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**

Crystal structure: Symmetry elements in crystal, Unit cell, Wigner Seitz cell, fundamental lattice system and types, Miller indices, crystal structures of simple cubic, FCC, BCC, HCP, diamond.

Crystal Diffraction: Bragg's law, X-ray and neutron diffraction, Rotating crystal method, laue Method and Powder method.

Unit II **9 Hrs.**
Thermal Properties of solids: Concepts of thermal energy and Phonons, Einstein theory of specific heat, Debye model of lattice specific heat.
Band theory of solids: Formation of bands, distinction between metals, insulators and semiconductors, periodic potential of a solid, wave function in a periodic lattice and Bloch theorem, Physical origin of effective mass,negative effective mass and holes.

Unit II **9 Hrs.**
Electrical conductivity: Drude Lorentz theory of electrical conductivity. Sommerfield theory of conduction in metals, Mathiessen's Rule, Thermal conductivity and Wiedemann – Franz law, The Hall effect.

Superconductivity: Zero resistivity, Critical temperature, critical magnetic field, Meissner effect, Type I and type II superconductors, BCS theory (Basic idea),High Tc superconductors.

Unit IV **9 Hrs.**
Magnetic Properties: Classification of magnetic material, Diamagnetism, Paramagnetism due to free ions and conduction electrons, Curie's law, ferromagnetism
Nature and Origin of Weiss molecular field. Domains, hysterisis loop, outline of antiferromagnetism and ferrimagnetisms, ferrites.

Unit V **9 Hrs.**
Solid State Devices: Light emitting diode (LED) and its application, Solar cell, SCR.
Operational amplifier: Differential amplifiers, differential gain and CMRR, inverting and non-inverting configurations Applications of op-amp: adder, subtractor, differentiator and integrator.
Field affect Transistor (FET): Classification of various types of FET, constructional details of FET, drain characteristics and baising of FET, operating regions, pinch-off voltage, idea of metal oxide semiconductor field effect transistor (MOSFET).

BOOKS RECOMMENDED:

- "Introduction to Solid State Physics", C. Kittel, Wiley Eastern, New Delhi, Seventh Edition.
- "Solid State Physics", S.O. Pillai, 3rd edition 1999, New Age International, New Delhi.
- "ElectronicDevices &Circuit Theory",Boylestad & Nashelsky , Prentice Hall of India.
- "Solid state physics", A.J Dekker ,Macmilan India Ltd.
- "Solid state Physics", R.L. Singhal, Kedar Nath Ram Nath Publishers, 2001.
- "Theory of solids", L. Azaraf, Tata Mc.Graw Hill Publishing Co.
- "Solid State Physics", S.L. Gupta and V.Kumar, Kedar Nath RamNath & Co., Meerut
- "Electronic Devices and Circuits" , Soni,Gupta , Dhanpat Rai and Sons.
- "Elements of Solid State Physics", J.P.Srivastava, Prentice Hall of India, New Delhi.

PAPER CODE-PHY 403
Practical and Project

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to
This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions are translated to the laboratory sessions thus providing a hands-on learning experience. Project component will help to create research aptitude in the students and help them to develop a Scientific approach in solving problems related to physics.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 403	**Practical and Project**	**The students will be able to –** **CO60.** Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). **CO61.** Be able to handle circuits like voltage regulator ,FET,voltage multiplier. **CO62.** Understand the importance of experimental and theoretical analysis. **CO63.** Develop a Scientific approach in solving problems related to physics. **CO64.** Develop scientific writing skills.	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, taking observations , Analysis and interpretation of results, Error analysis, preparation of viva voce questions and maintain practical record,	Class test, continuous assessment ,Semester end examinations, Individual and Group project, Presentation, Viva voce, Practical record file

CONTENTS

List of Experiments

<u>Section – A</u>

1. To determine band gap using a junction diode.

2. To study the Zener regulated power supply with different loads.

3. To study the characteristics of F E T.

4. Study of the temperature dependence of resistance of a semiconductor (four probe method) and to determine its band gap.

5. To study FET as an amplifier.

6. To study a voltage multiplier circuit to generate high voltage DC from AC.

Section – B

1. Project

Details of Project

Students of semester IV are required to choose a topic for the project from a list approved by the department. They are required to perform a new experiment or carry out studies for writing a review article on a subject. At the end of the semester, a project report shall be submitted by each student. This project will be assigned to them in the beginning of the IV semester.

Evaluation of Project:

A mid term evaluation of the project will be made along with the CA test. This will carry 30 % of the total marks assigned for the project. At the end of the semester, the student shall be examined on the basis of project report submitted by her by a panel of external and internal examiners. The external appointed for the practical exam shall also evaluate the project along with the internal project supervisors. The evaluation of project will be based on presentation / viva-voce.

Total duration of practical exam and project evaluation shall be 5 hours.

Students are expected to perform four experiments in all from which they will have to perform one experiment in the semester end exam.

COURSE OUTCOMES - Semester V

PAPER CODE-PHY 501
Quantum Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
This paper aims to develop the basic knowledge of quantum mechanics and its application to various problems. It also deals with the techniques of wave mechanics like Schrödinger equation and its solution, angular momentum and spin. The student develops the understanding of quantum nature of e.m. radiations or light and wave nature associated with microscopic particles, the notion of quantum states, operators etc.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 501	**Quantum Physics** **(Theory)**	**The students will be able to –** **CO65.** Understand the concept of Wave mechanics and Schrodinger equation to solve problems. **CO66.** Acquire knowledge of Quantum mechanical operators and Ehrenfest's theorem to solve problems. **CO67.** Apply Schrödinger equation to solve problems using Boundary condition and continuity condition . **CO68.** Apply Schrodinger equation to determine the solution of Simple harmonic oscillator and Rigid rotator. **CO69.** Know the basics of Angular momentum, momentum operators and and commutation relations .	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

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Unit I **9 Hrs.**

Introduction to Wave mechanics :

Duality of radiation and matter, De broglie's hypothesis, justification for the relation, Experimental confirmation of $\lambda = h/p$ (Davission and Germer experiment).

Uncertainty principle relating to position and momentum, relating to energy and time, its applications to various quantum mechanical problems such as:

(i) Non-existence of electrons in nucleus
(ii) Ground state energy of H-atom
(iii) Ground state energy of Harmonic oscillator
(iv) Natural width of spectral line

Schrodinger equation:

Wave function and its interpretation, Schrödinger time dependent and time independent one-dimensional equation, three-dimensional Schrödinger wave equation, probability current density, physical meaning of ψ, conditions to be satisfied by ψ.

Unit II **9 Hrs.**

Operator formulation in Quantum mechanics:

Operators, algebra of operators, commutative property, linear operators, Commutator operator, eigen values and eigen functions, operators for momentum, K.E., Hamiltonian, total energy and angular momentum, Fundamental postulates of Q.M.

Hermitian operators, orthonormality, degeneracy, Commutation relations, Ehrenfest's theorem, Bohr's principle of complementarity, principle of superposition.

Unit III

Simple solutions of Schrödinger equation: **8 Hrs.**

Boundary and continuity conditions on the wave function. Particle in one dimensional box, eigen function and eigen values, discrete energy levels, generalization to 3-D and degeneracy of levels

Boundary value problems:
Step potential, Penetration through rectangular barrier, calculation of reflection and transmission coefficients. Quantum mechanical tunneling. Square well potential problem, reflection and transmission coefficient and resonant scattering.

Unit IV **8 Hrs.**
Simple harmonic oscillator (1-D Case): Schrödinger equation and its solutions, eigen function, energy eigen values. Zero point energy, parity, symmetric and anti-symmetric wave functions with graphical representation.
Rigid rotator: Schrodinger equation and its solution.

Unit V **10Hrs.**
Angular Momentum
Introduction: orbital angular momentum,Operators for its Cartesian components, commutation relations, mutual as well as with L^2 ,L^+ and L^- operators , their interpretation as step operators, eigen values of L_z, Total angular momentum operators, commutation relations obeyed by the components of generalized momentum operator. Commutation relation of J_z with J_+ and J_- , J_+ and J_- ,commutation relation of J^2 with J_+ and J_-.

BOOKS RECOMMENDED:

- "Quantum mechanics" L.L. Schiff, Tata Mc Graw Hill.
- "Quantum mechanics", Chatwal and Anand, Himalaya Publishing House.
- "Elementary Quantum Mechanics and Spectroscopy" Kakani, Hemrajani and Bansal, College Book House Jaipur.
- "Introduction to Modern Physics",H.S. Mani and G.K. Mehta, East West Press Pvt. Ltd., New Delhi.
- "Quantum Mechanics", S.P. Singh, M.K. Bagde and Kamal Singh,S. Chand & Co.
- "Quantum Mechanics", A Listair, I M Rac, ELBS (low price edition).
- "Quantum Mechanics", S.N.Biswas, Books & Allied,Calcutta (P) Ltd.
- "Perspectives of Modern physics", A.Beiser, Mc Graw Hill.
- "Problems on Quantum Mechanics", Dr. S.L.Kakani, Arihant Publishing House.

PAPER CODE-PHY 502
Nuclear and Particle Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
To give the students insight into the fundamentals of nuclear and particle physics.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 502	**Nuclear and Particle Physics** **(Theory)**	**The students will be able to –** **CO70.** Have a basic knowledge of nuclear size ,shape , binding energy.etc and also the characteristics of nuclear force in detail. Gain knowledge about liquid drop model and semi empirical mass formula. **CO71.** Grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics. **CO72.** Understand the basic forces in nature and classification of particles and study in detail conservations laws . **CO73.** . Understand the structure and working of different accelerators and compare them. **CO74.** Describe the construction and working of nuclear detectors and analyze them.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solvingin tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**

Nuclear Properties: Rutherford's theory of α particle scattering, Basic properties: charge, mass, size, spin, magnetic moment, electric quadrupole moment, Parity, Binding energy per nucleon and its observed variation with mass number of the nucleus. Semi empirical mass formula –coulomb energy, volume energy, surface energy, other corrections, explanation of binding energy curve, Liquid drop model ,Nuclear forces and their properties, Theory of nuclear forces.

Unit II **9 Hrs.**

Nuclear Fission: Energy release in fission, Theory of nuclear fission and liquid drop model, Barrier penetration – Theory of spontaneous fission, Nuclear chain reaction, condition of controlled chain reaction, Principle of nuclear reactors, classification of reactors.

Nuclear Fusion: Energy release in fusion, fusion reactions in stars : carbon and pp cycle.

Unit III **10 Hrs.**

Particle Physics: Classification of elementary particles, properties of particles. Fundamental interactions, Conservation laws : Energy ,momentum, angular momentum, charge, lepton number, Baryon number, isospin, strangeness, Invariance under charge,parity,C.P.,time and C.P.T.,(Qualitative discussion).

Cosmic rays: Properties of cosmic rays ,properties of secondary radiation, electronic showers ,geomagnetic effects, cosmic ray stars, the origin of cosmic rays.

Unit IV **9 Hrs.**

Accelerators: Need for accelerators, Ion sources, Van De graff generator, Drift tube, linear accelerator, Wave guide accelerator, cyclotron ,synchrocyclotron, electron synchrotron, proton synchrotron.

Unit V **8 Hrs.**

Detectors: Ionization chamber , Proportional Counter, Geiger Muller Counter, Scintillation counter, Cloud chamber, Bubble chamber, Spark chamber , Solid state detectors.

Nuclear mass spectroscopy: Basic components of mass spectroscope.

BOOKS RECOMMENDED:

- "Nuclear Physics", D.C. Tayal, 4th rev. edition. 1992,, Himalaya Publishing, House, Bombay.
- "Nuclear physics", Irving Kaplan, 2nd edition, Addition Wiesley Publishing Company.
- "Atomic Nucleus", R.D. Evans ,Mc Graw Hill, New York.
- "Introduction to Elementary Particles", D. Griffiths, Harper and Row, New York, 1987.
- "Elements of Nuclear Physics", Pandey and Yadav, Kedar Nath Ram Nath, Meerut, Seventh Edition .
- "Nuclear Physics : Theory and experiments", R.R. Roy and B.P. Nigam, New Age International (P) Limited.
- "Radiation Detectors and Measurement", F.Knoll, John Wiley & Sons, Second Edition.

PAPER CODE-PHY 503
Practicals
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to

This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions are translated to the laboratory sessions thus providing a hands-on learning experience.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 503	**Practicals (Practical)**	**The students will be able to – CO75.** Apply the theory to design the basic electrical circuits	**Approach in teaching:** Demonstration, Group activity,	Class test, Semester end examinations, Viva voce,

		CO76. Understand circuits involving diodes, transistors, solar cells, etc., **CO77.** Analyze the response of the circuits **CO78.** Use basic circuits to create amplifier circuits, oscillator,regulated power supplies etc.. **CO79.** Develop oral and written scientific communication skills, and to think critically and work independently.	Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, taking observations , Analysis and interpretation of results, Error analysis, preparation of viva voce questions and maintain practical record,	Practical record file

CONTENTS

List of Experiments

1. Determination of Stefan's constant.

2. Determination of Planck's constant using a Photocell.

3. Determination of Planck's constant using a solar cell.

4. Study of power supply using two diodes/bridge rectifier with various filter circuits.

5. To perform various logic functions using NOR and NAND gates, i.e., OR, NOT, AND, NOR, NAND, X-OR gates.

6. To measure CMRR and input bias current and offset current using OP-AMP.

7. Study of characteristics of GM counter and verification of inverse square law for same strength of a radioactive source.

8. Study of absorption of β-rays in Aluminum foil using GM counter and to determine its absorption coefficient.

9. Determine ballistic constant of a ballistic galvanometer.

10. To determine self-inductance of a given coil by Anderson's bridge using AC.

11. To study Hall Effect and to determine Hall coefficient.

12. Application of operational amplifier as (a) inverting amplifier and (b) non inverting amplifier

NOTE - Students are expected to perform any eight experiments from the given list. Two experiments out of the eight will be set in the examination paper.

COURSE OUTCOMES - Semester VI

PAPER CODE-PHY 601
Atomic and Molecular Spectroscopy
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
This course aims to introduce various types of spectra for hydrogen, alkali and alkaline earth atoms. It also gives an introduction to X-ray spectra. Techniques of Molecular spectroscopy are also discussed in this paper, which include IR and Raman spectra. After learning this course student develops capabilities of making spectroscopic analysis of materials and draw conclusions from the same regarding nature of material.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning andteaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 601	Atomic and Molecular Spectroscopy (Theory)	**The students will be able to –** **CO80.** Explain the different types of spectra. **CO81.** Discuss Hydrogen ,Alkali metals and alkali metal atom spectra **CO82.** Describe Stern-Gerlachexperiment, spectral terms and their notations **CO83.** Understand X-Ray spectra and Applications of Moseley's law. **CO84.** Learn the salient features of IR spectra and its experimental arrangements. **CO85.** Understand the Raman spectra along with its classical and quantum theories. **CO86.** Apply the results of Raman spectra to determine the structure of molecules.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I

Introduction to Atomic Spectra: **8 Hrs.**

Types of spectra, spectrum of Hydrogen atom, spectral lines, the spinning electron, space quantization, quantum numbers and their physical interpretation, quantum numbers for complete atom, magnetic moments of an atom and Landes 'g' factor, Larmor's theorem, Stern and Gerlach experiment, fine structure of the Hydrogen lines, spectral terms and their notation.

Unit II

Spectra of alkali and alkaline atoms: **9 Hrs.**

Different series in alkali spectra, Ritz combination formula, spin orbit interaction, explanation of salient features of alkali spectra, doublet structure in alkali spectra (fine structure), Transition rules, intensity rules, spectra of alkaline earth metals, coupling schemes: L.S and j-j coupling, selection rules in atoms of two valence electrons, singlet and triplet series, spectrum of Helium atom.

Unit III

X-ray spectra: **9 Hrs.**

Continuous x-ray spectrum, characteristic emission and absorption spectrum and their explanation, energy levels, Moseley's law, combination principle, fine structure of x-ray lines, fluorescence yield and Auger effect, soft x-ray emission and structure of absorption edges.

Unit IV

Infra red spectroscopy (vibrational and rotational spectra): **9 Hrs.**

Salient features of vibrational rotational spectra, vibrating diatomic molecules as a harmonic oscillator, fine structure of vibrational rotational bands, interaction of vibrational and rotational energies, experimental arrangements for studying IR spectra.

Unit V

Raman Spectra: **10 Hrs.**

Raman effect and its salient features, Observation of Raman spectra, classical theory of Raman effect, quantum theory of Raman effect, probability of energy transition in Raman effect, vibrational Raman spectra, Pure rotational Raman spectra, structure determination from Raman and infra red spectroscopy.

BOOKS RECOMMENDED

- "Elements of Spectroscopy", Gupta, Kumar, Sharma, Pragati Prakashan, 2006.
- "Fundamentals of molecular spectroscopy", Collin N. Banwell and Elaine M. McCash, Tata McGraw Hill Publishing Company Ltd. New Delhi, 2005.
- "Atomic Spectra and Atomic structure", Gerhard Herzberg , Kreiger Pub.Co.,Second Edition.
- "Molecular Spectra and Molecular structure: Spectra of diatomic Molecules", Gerhard Herzberg, Dover Publications.
- "Introduction to Atomic Physics", Enge, Wehr and Richards, Addison Wiesley, London.
- "Atomic and Nuclear Physics", A.B. Gupta, New Central book agency Pvt. Ltd.

PAPER CODE-PHY 602
Information Communication Theory
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
Information Communications Technology - or technologies (ICT) is an umbrella term that includes all technologies for the communication of information. This course gives a brief idea of the technology of wireless communication and networks. The objective of this course is to provide a comprehensive technical survey of wireless communication, fundamentals, of mobile communications, wireless networks and protocols wireless applications, 3G and higher communication systems.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 602	**Information Communication Theory** **(Theory)**	**The students will be able to –** **CO87.** Understand the fundamentals of transmission and wireless systems **CO88.** Explain the working of cellularwieless networks and compare different generations. **CO89.** Have knowledge of different parameters of satellite communication. **CO90.** Know about the antenna, its types and wave propagation. **CO91.** Learn about optical fibers and analyse intermodal dispersion.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I
Introduction and Transmission Fundamentals: 9 Hrs.
Introduction: Wireless comes of age, The Cellular revolution, The global Cellular network, Broadband, Future trends.
Transmission Fundamentals: Signals for conveying information: Time domain concepts, Frequency domain concepts, Relationship between data rate and bandwidth.
Analog and Digital data transmission: Analog and digital data, analog and digital signaling, Analog and digital transmission.
Channel Capacity: Nyquist bandwidth, Shannon capacity formula.
Transmission Media: Terrestrial microwaves, Satellite microwaves, Broadcast radio, Infrared.

Unit II
Cellular Wireless Networks: 9 Hrs.
Principles of Cellular networks: Cellular network organization, operation of cellular systems, mobile radio propagation effects, power control; First generation analog : spectral allocation, operation, AMPS control channels.
Second generation TDMA: Time division multiple access, Mobile wireless TDMA design considerations, Global system for mobile communications, GSM network architecture.
Second generation CDMA: CDMA, Mobile wireless CDMA design considerations.

Third generation mobile technology ,fourth generation mobile technology , Introduction to fifth generation systems.

Unit III
Satellite Communication: 9 Hrs.
Satellite parameters and configurations: Satellite Orbits, GEO, LEO, MEO satellites, frequency bands, transmission impairments, satellite network configurations, Capacity allocation – Frequency division : Frequency division multiplexing, Frequency division multiple access(FAMA,DAMA); Capacity Allocation-Time division

Unit IV
Antennas and Propagation: 9 Hrs.
Antennas: Radiation patterns, Antenna types, Antenna Gain.
Propagation Modes: Ground Wave propagation, Sky Wave propagation, Line of Sight propagation.
Line of Sight Transmission: Attenuation, Free Space loss, Noise, The expression E_b / N_0, Atmospheric absorption, Multipath, Refraction.
Fading in the Mobile Environment: Multipath propagation, Error compensation Mechanisms.

Unit V
Optical Fibres: 9 Hrs.
Total internal reflection, Optical fibre, Coherent bundle, Classification of optical fibres, Advantages of optical fibres, Types of rays, Modes of propagation of optical fibres, Dispersion-inter model dispersion: for multimode step index fibre and for graded index multimode fibre, Losses in optical fibre, Fibre cable, Optical fibre communication system, Optical fibre cable construction, Applications of optical fibre.

BOOKS RECOMMENDED:

- "Wireless Communication and Networks", William Stallings, Prentice Hall of India,2005.
- "Modern Physics", S.L. Kakani, Shubhra Kakani , Viva Books private Ltd.,2007
- "Electronic communication systems", George Kennedy, Mc Graw Hill, 3rd edition 1985.
- "Principles of communications – Systems, Modulation and Noise", R.E. Ziemer and W.H. Tranter, Jaico Publishing House 1996.
- "Wireless Communication", Reppaport, Pearson Education
- "Digital Satellite Communications", Tri, Tata Mc Graw Hill International
- "Mobile Cellular Telecommunications", William C.Y. Lee, Mc Graw Hill International Edition.
- "Satellite Communication System", M. Richharia, Mac Millan.
- "Introduction to Optical Fiber", Allen H Cherin, Mc Graw Hill.
- Principles of communication systems", Taub. Schilling ,Mc. Graw Hill 2nd edition 1986.

PAPER CODE-PHY 603
Practicals
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to

This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions are translated to the laboratory sessions thus providing a hands-on learning experience

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 603	**Practicals (Practical)**	**The students will be able to –** **CO92.** Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions . **CO93.** Understand and demonstrate functions of CRO. **CO94.** Handle useful transmission line circuitsand calculate its parameters **CO95.** Develop the skill to determine melting point of wax. **CO96.** Develop oral and written scientific communication skills, and to think critically and work independently	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, taking observations , Analysis and interpretation of results, Error analysis, preparation of viva voce questions and maintain practical record,	Class test, Semester end examinations, Viva voce, Practical record file

CONTENTS

List of Experiments

1. Study of Iodine Spectrum with the help of a grating, spectrometer and ordinary bulb.
2. To determine the specific rotation of sugar by polarimeter.
3. To verify Malus cosine law with the help of a photo-voltaic cell.
4. To determine curie temperature of monel alloy.
5. Measurement of capacitance by De-Sauty bridge.
6. Measurement of electronic charge by Millikans's oil drop method.
7. Study of R-C Transmission Line.
8. Study of L-C Transmission Line.
   a. At definite frequency
   b. At variable frequency

9. To study amplitude modulation and demodulation and measure modulation index.

10. To study single side band AM using balanced modulator.

11. Study the frequency response of a transistor wide band amplifier with and without feedback. Also obtain input and output impedance of the amplifier.

12. To determine the recovery time of a diode.

NOTE - Students are expected to perform any eight experiments from the given list. Two experiments out of the eight will be set in the examination paper.

Programme- B.Sc. Mathematics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	Employ critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology
PO5	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.

PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Communicate mathematics effectively by written, computational and graphic means.
PSO 2	Create mathematical ideas from basic axioms.
PSO 3	Formulate the hypothesis, theories, techniques and proofs provisionally.
PSO 4	Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.

PSO 5	Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.
PSO 6	Formulate and develop mathematical arguments in a logical manner.
PSO 7	Acquire good knowledge and understanding in advanced areas of mathematics.
PSO 8	Formulate and use quantitative models arising in social science, business and other contexts.
PSO 9	Develop problem modeling and problem solving skills.
PSO 10	Impart comprehensive knowledge and understanding of theoretical fundamentals in operational research.
PSO 11	Develop mathematical problem-solving skills for certain types of real-world problems and their variants in a variety of mathematical contexts.
PSO 12	Provide hands-on training to the students in the form of practical work to address some significant issues faced by industries.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSOs)

Course	COs	PSOs											
		PSO 1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO 10	PSO 11	PSO 12
MAT101	**CO1**	x										x	
	CO2			x			x						
	CO3			x	x								
	CO4	x	x										
	CO5				x			x					
MAT102	**CO6**	x			x								
	CO7	x						x		x			
	CO8				x			x				x	
	CO9							x				x	
	CO10				x	x		x					
	CO11	x	x										
MAT103	**CO12**	x	x										x
	CO13	x							x				x
MAT201	**CO14**	x			x			x					
	CO15							x					x
	CO16			x	x				x				
	CO17								x			x	
	CO18										x		x
MAT202	**CO19**	x			x	x		x					
	CO20	x			x			x					
	CO21	x			x			x					
	CO22	x				x		x				x	

	CO23	x				x		x				x	
MAT203	**CO24**					x	x	x		x		x	x
	CO25					x	x	x		x		x	x
MAT301	**CO26**		x	x	x		x			x		x	
	CO27		x	x				x				x	
	CO28		x	x				x					
	CO29		x	x			x						
	CO30		x	x			x					x	
MAT302	**CO31**				x	x				x	x		
	CO32				x	x		x					
	CO33				x	x				x		x	
	CO34					x				x		x	
	CO35					x				x		x	
MAT303	**CO36**	x				x	x			x			x
	CO37	x						x					x
	CO38	x					x			x			x
	CO39	x										x	x
MAT401	**CO40**				x			x	x			x	
	CO41				x			x					
	CO42				x			x					
	CO43				x			x		x			
	CO44				x			x				x	
	CO45				x			x					
MAT402	**CO46**						x	x	x	x			
	CO47				x		x	x	x			x	
	CO48				x			x			x		
	CO49				x	x		x			x	x	
	CO50				x	x		x			x		
MAT403	**CO51**	x				x	x						x

	CO52	x				x	x						x
	CO53	x				x	x			x		x	x
	CO54	x				x	x					x	
MAT501	**CO55**		x	x	x								
	CO56		x		x			x				x	
	CO57		x		x			x					
	CO58		x		x			x					
	CO59		x		x			x					
MAT502	**CO60**	x	x								x	x	
	CO61			x	x		x				x		
	CO62							x	x		x		
	CO63							x		x	x		
	CO64					x			x		x	x	
MAT503	**CO65**					x							x
	CO66					x							x
	CO67					x			x				x
	CO68					x			x				x
	CO69					x							x
	CO70					x			x				x
	CO71					x			x				x
	CO72					x	x		x				x
	CO73					x			x				x
MAT601	**CO74**		x		x			x					
	CO75			x		x		x					
	CO76			x		x		x					
	CO77							x		x		x	
	CO78		x		x		x						
	CO79		x				x						
	CO80			x			x						

MAT602	**CO81**		x	x		x		x					
	CO82		x			x		x					
	CO83		x			x		x					
	CO84					x		x		x			
	CO85					x		x		x			
	CO86					x		x		x			
MAT603	**CO87**	x					x		x				x
	CO88	x					x		x				x
	CO89	x					x		x				x
	CO90	x					x		x				x
	CO91	x					x		x				x
	CO92	x					x		x				x

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE - MAT 101
Discrete Mathematics and Number Theory
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Acquaint the students with the fundamentals of discrete mathematics and number theory and its applications.
2. Make the students aware about graph theory, theorems related to prime numbers, relations and digraph etc.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 101	**Discrete Mathematics and Number Theory (Theory)**	**The students will be able to –** **CO1:** Learn about partially ordered sets, lattices and their types. **CO2:** Understand Boolean algebra and Boolean functions. **CO3**: Familiarise with modular arithmetic and find primitive roots of prime and composite numbers. **CO4:** Assimilate various graph theoretic concepts and familiarize with their applications. **CO5:** Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, and their consequences.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Graphs Theory: Basic Terminology, Types of graph, paths and cycles, Euler graph and cycle, Hamiltonian graph and cycle, Shortest path algorithm (Djikstras algorithm), Graph isomorphism, Planar graph, Graph colorings and chromatic number.

Unit II **9 Hrs.**

Relation and Diagraphs: Product sets and partitions, Paths in relation and diagraphs, Properties of relations, Equivalence relations. Trees: Introduction, m-ary trees, Properties of trees, Spanning trees, Minimal spanning trees, Binary search trees.

Unit III **9 Hrs.**

Pigeonhole principle, Recurrence relation, Generating functions. Ordered relations and Structures: Partially ordered sets, Extremal elements of partially ordered sets.

Unit IV **9 Hrs.**

Elementary divisibility properties, Division algorithm, Greatest common divisor, Least common multiplier, Euclid's lemma.

Unit V **9 Hrs.**

Bezout's lemma, Prime number, Eucledian Algorithm, Fundamental theorem of arithmetic, Congruence, Chinese remainder theorem.

BOOKS RECOMMENDED

- Bernard Kolmann, Robert C. Busby and Sharon Ross, Discrete Mathematical Structures, PHI Delhi, 1997.
- R.C. Choudhary, M.C. Goyal and D.C. Sharma, Discrete Mathematics, Ramesh Book Depot, 2018.
- C. L. Liu, Elements of Discrete Mathematics, McGraw Hill,2009.
- Thomas Koshy, Elementary Number Theory with applications, Elsevier Academic Press, 2014.
- S.K. Pundir and R. Pundir, Theory of Numbers, Pragati Prakashan, Meerut, 2012.
- Norman Biggs, Discrete Mathematics, Oxford University Press UK, 2003.
- V. K. Bala krishnan, Introductory Discrete Mathematics, Prentice Hall, 1996.
- Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill Pub. Co. Ltd., New Delhi, 2003.
- Richard Johnson Baugh, Discrete Mathematics, Pearson Education Asia, New Delhi, 2008.
- David M. Burton, Elementary Number Theory, McGraw Hill, 2007.
- J.P.Trembly, and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Pub. Co. Ltd, New Delhi, 2003.
- Ralph. P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, Pearson Education Asia, Delhi, 2002.

PAPER CODE - MAT 102
Differential Calculus
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Acquaint the students with fundamental concepts of single variable calculus.
2. Explore the solution of problems from a mathematical perspective and help to prepare students to succeed in upper level math, science, engineering and other courses that require calculus.
3. Determine if an infinite sequence is convergent or divergent.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
	Differential Calculus (Theory)	**The students will be able to –** **CO6:** Compute the expression for the derivative of a function using the rules of differentiation,	**Approach in teaching:**	Quiz, Poster Presentations,

MAT 102		Including the power rule, product rule, and quotient rule. **CO7:** Compute the expression for the derivative of a composite function using the chain rule of differentiation, differentiate a relation implicitly and compute the line tangent to its graph at a point, differentiate exponential, logarithmic, and trigonometric and inverse trigonometric functions. **CO8**: Interpret the value of the first and second derivative as measures of increase and concavity, convexity of functions, compute the critical points of a function on an interval. **CO9:** Identify the extremas of a function on an interval and classify them as minima, maxima or saddles using the first derivative test, use the differential to determine the error of approximations. **CO10:** Understand the consequences of Rolle's theorem and the Mean Value theorem for differentiable functions. **CO11:** Able to trace cartesian and polar curves.	Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Taylor's and Maclaurins theorems with different remainders, Expansion of sin(x), cos(x), e^x, log(1+x), $(1+x)^m$, Derivative of an arc, Pedal equation (Cartesian and Polar Curves).

Unit II **9 Hrs.**

Infinite series of non-negative terms, Convergences (definition), Test for Convergence (Without Proof): Comparison test, Cauchy's nth root test, D'Alembert's ratio test, Raabe's test,D'Morgan's test, Cauchy's condensation test, Logarithm ratio test, Gauss test. Alternating Series – Leibnitz Test, Absolute and conditional convergence.

Unit III **9 Hrs.**

Partial differentiation, Total derivative, Euler's theorem for homogeneous functions, Maxima and minima of functions of two independent variables: necessary and sufficient conditions (without proof), Lagrange's undetermined multipliers (without proof) and related problems.

Unit IV **9 Hrs.**

Radius, center and chord of curvature, Envelopes (Cartesian curves), Asymptotes (Cartesian and Polar curves).

Unit V **9 Hrs.**

Multiple points, Classification of double points: Node, cusp, point of inflexion, Tracing of Cartesian and polar curves.

BOOKS RECOMMENDED

- Shanti Narayan, Differential Calculus, S. Chand & Co. Pvt. Ltd. New Delhi, 1996.
- M. Ray and G.C. Sharma, Differential Calculus, Shivlal Agarwal & Co. Agra, 1998.
- Gorakh Prasad, Text Book on Differential Calculus, Pothishala Pvt. Ltd, Allahabad, 1992.
- H.S. Dhami, Differential Calculus, New Age International (P) Ltd., New Delhi, 2012.
- Schaum's, Theory and Problems of Advanced Calculus, Schaum's outline series New York, 2011.
- Ahsan Akhtar and Sabiha Ahsan, A Text Book of Differential Calculus, PHI Ltd. New Delhi, 2002.
- G.N. Berman, A Problem Book in Mathematical Analysis, Mir Publishers, Moscow, 2004.
- G.C. Sharma and Madhu Jain, Calculus, Galgotia Publication, Dariyaganj, New Delhi, 1996.
- Chaurasia, Goyal, Agarwal, Jain , Differential Calculus, RBD, Jaipur,2006.
- Ulrich L. Rohde, G.C. Jain, Ajay K. Poddar and A.K.Ghosh Introduction to Differential Calculus, Wiley Publications USA, 2012.

PAPER CODE - MAT 103
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Familiarize with software MATHEMATICA, for numerical computation of the fundamental arithmetic operations using Mathematica.
2. Computate the fundamental concepts of single variable and multivariable calculus.
3. Demonstrate algebraic facility with algebraic topics including linear, quadratic, exponential, logarithmic, and trigonometric functions.
4. Produce and interpret graphs of basic functions of these types.
5. Solve equations and inequalities, both algebraically and graphically.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT 103</td><td>Practical (Practical)</td><td>The students will be able to –

CO12: Wolfram Mathematica is software used to perform both simple and complicated mathematical calculations which requires no previous knowledge of or training in computer programming
CO13: This course is about programming in Mathematica oriented into advanced data analysis and will cover such areas as econometrics in addition to the language of the software itself. Because it can be used for a variety of computational techniques it can be useful for students in mathematics, the sciences, management, economics, finance, accounting and information sciences.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Power Point Presentations, Informative videos

Learning activities for the students:
Self learning assignments, Effective questions, presentations,
Giving tasks</td><td>Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination</td></tr>
</table>

CONTENTS

Students are required to familiarize themselves with software MATHEMATICA, for numerical computation on the following topics:

1. Introduction and simple arithmetic operations using Mathematica.
2. Limit of a function y = f(x).
3. Sum of the n-term of series.
4. Finding limit of a series, convergence of the series.
5. Differentiation of single variable functions y= f(x) and product of two and more than two single variable functions h(x) = f(x)g(x).
6. Partial differentiation of order one of functions z= f (x, y) and their representation in Jacobian Matrix.
7. Partial differentiation of order two for functions z= f (x, y) and their representation in Hessian Matrix.
8. Partial differentiation of order three for functions z= f (x, y).
9. Third order partial derivatives and their representation in Hessian matrix.
10. Hessian and Jacobian Matrix at a fixed point.
11. Solution of first order differential equation.
12. Solution of first order simultaneous differential equation.
13. Extreme point and value of a function of single variable.
14. Extreme point and value of a function of two variables.
15. Tracing of single variable curves.

BOOKS RECOMMENDED

REFERENCES

MATHEMATICA- Stephen Wolfram, Cambridge

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester II

PAPER CODE - MAT 201
Integral and Vector Calculus
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Understand the basic concepts like indefinite and definite integrals, improper integrals real-valued functions of one variable (including algebraic, trigonometric, inverse trigonometric, exponential, and logarithmic functions).
2. Demonstrate the integral ideas of the functions defined including line, surface and volume integrals - both derivation and calculation in rectangular, cylindrical and spherical coordinate systems and understand the proofs of each instance of the fundamental theorem of calculus.
3. Use the techniques of integration in several contexts, and to interpret the integral both as an anti-derivative and as a limit of a sum of products.
4. The basic concepts are illustrated by applying them to various problems where their application helps arrive at a solution.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
	Integral and Vector Calculus (Theory)	**The students will be able to –** **CO14:** The integral ideas of the functions defined including line, surface and volume integrals - both derivation and calculation in rectangular, cylindrical and spherical coordinate systems and understand the proofs of each instance of the fundamental theorem of calculus.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations,	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects,

MAT 201		**CO15**: Evaluate double and triple integrals for area and volume. **CO16:** Differentiate vector fields, Determine gradient vector fields and find potential functions. **CO17:** Evaluate line integrals directly and by the fundamental theorem. Use Green's theorem and the Divergence theorem to compute integrals. **CO18:** The differential ideas of divergence, curl, and the Laplacian along with their physical interpretations, using differential forms o to represent derivative operations.	Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Reduction formulae: $sin^n x,\ cos^n x,\ tan^n x\ and\ sin^m x\ cos^n x$, where m, n are positive integers. Definition and properties of Gamma and Beta functions, Relation between Gamma and Beta functions, Duplication formula and problems related to these functions.

Unit II **9 Hrs.**

Rectification: Length of cartesian and polar curves. Quadrature: Area of cartesian and polar curves, Volumes and surfaces of solids of revolution (cartesian and polar forms).

Unit III **9 Hrs.**

Double integrals, Change of order of integration, Triple integrals, Dirichlet's integral.

Unit IV **9 Hrs.**

Scalar and vector point function, Differentiation and integration of vector point function, Gradient, Directional derivatives, Divergence and curl of a vector point function.

Unit V **9 Hrs.**

Identities involving differential vector operators, Gauss' divergence, Stokes' and Green's theorems (without proof) their applications and related problems.

BOOKS RECOMMENDED

- Gorakh Prasad, A Text Book on Integral Calculus, Pothishala Pvt. Ltd, Allahabad, 1992
- Shanti Narayan, Integral Calculus, S. Chand & Co. Pvt. Ltd., New Delhi, 1996.
- Shanti Narayan, A Text Book of Vector Calculus, S. Chand & Co. Pvt. Ltd. New Delhi, 1996.
- M. Ray and H. S. Sharma, Vector Algebra and Calculus, Students and Friends Co. Agra, 1998.
- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2005.
- G. C. Sharma and Madhu Jain , Integral Calculus, Galgotia Publication, Dariyaganj, New Delhi,1996.
- P. K. Mittal and Shanti Narayan, Integral Calculus, S.Chand & Co. Pvt. Ltd. New Delhi, 2005.
- Muray R. Spiegel, Vector Analysis, Schaum Publishing Company, New York, 2007.
- Saran and Nigam, Introduction to Vector Analysis, Pothisala Pvt. Ltd, Allahabad, 2001.

- Paul C. Matthews, Vector Calculus, Springer London, 2005.
- G.C. Sharma and Madhu Jain, Vector Analysis and Geometry**,** Galgotia Publication, Dariyaganj, New Delhi, 1996.

PAPER CODE - MAT 202
Three Dimensional Geometry
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Demonstrate basic knowledge about three dimensional shapes like sphere, cone , cylinder and central conicoid.
2. Understand the concepts & advance topics related to two & three dimensional geometry.
3. Study the applications of conics.
4. Study the application of Sphere, cone and cylinder.
5. Study how to trace the curve.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 202	**Three Dimensional Geometry (Theory)**	**The students will be able to –** **CO19:** Understand the concept and shapes of three dimensional surfaces like sphere, cone, cylinder and central conicoid. **CO20:** Determine the equation of a plane section of these surfaces. **CO21:** Determine the equation of tangent planes and condition of tangency. **CO22:** Differentiate between the cases of intersection of 3D shapes with line and plane (whether they cut, touch or doesn't intersect the shape). **CO23:** Understand the concept of ruled and skew surfaces, generating lines on ruled surfaces.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Definition, General equation of a sphere, Centre and radius of a sphere, Great circle, Equation of circle, Diameter form of the equation of a sphere, Tangent line and tangent plane of a sphere, Condition of tangency for a line and tangent plane, Angle of intersection of two spheres, Condition of orthogonality of two spheres.

Unit II **9 Hrs.**

Condition for general equation of second degree to represent various form of surfaces, Cone, Quadratic cone, Enveloping cone, Condition for general equation of second degree to represent a cone, Intersection with a line and a plane, Angle between the intersecting lines of cone, Tangent plane.

Unit III **9 Hrs.**

Reciprocal cone, Right circular cone, Definition and equation of a cylinder, Enveloping cylinder, Right circular cylinder.

Unit IV **9 Hrs.**

Conicoid, Central conicoid, Standard equation of ellipsoid, hyperboloid of one sheet and hyperboloid of two sheets, Nature and shape of central conicoid, Intersection of a line and a central conicoid, Tangent line and tangent plane, Condition of tangency, Director sphere.

Unit V **9 Hrs.**

Developable surface, Skew surface, Generating lines of central conicoid, System of generating lines, Equation of generator through one point and two points on the principle elliptic section of a hyperboloid of one sheet.

BOOKS RECOMMENDED

- N. Saran and R.S. Gupta, Analytical Geometry of Three Dimensions**,** Pothisala Pvt. Ltd, Allahabad, 1992.
- G.C.Sharma and Madhu Jain, Co-ordinate Geometry (2-D&3-D)**,** Galgotia Publication, Dariyaganj, New Delhi, 1996.
- Shanti Narayan and P.K. Mittal, Analytical Solid Geometry, S. Chand & Co. Pvt. Ltd. New Delhi, 2007.
- T. A. Chishti and S. Pirzada, Analytical Solid Geometry, Orient Black Swan India, 2007.
- S.L. Loney, The Elements of Coordinate Geometry**,** Macmillan and Co., London, 1989.
- R.J.T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan India Ltd, 1994.
- P. R. Vittal, Analytical Geometry: 2D and 3D, Pearson Education India, 2013.
- Brahma Nand, B.S. Tyagi and Bhudev Sharma, Coordinate Solid Geometry, Kedar Nath Ram Nath, Meerut, 2003.

PAPER CODE - MAT 203
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Demonstrate plotting of cartesian, polar and parametric curves.
2. Produce and draw graphs of basic functions of these types.
3. Demonstrate Graphical plotting of 2D and 3 D figures.
4. Compute the fundamental concepts of integral calculus.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 203	**Practical (Practical)**	**The students will be able to –** **CO24:** Wolfram Mathematica is software used to perform both simple and complicated mathematical calculations which requires no previous knowledge of or training in computer programming **CO25:** This course is about programming in Mathematica oriented into advanced data analysis and will cover such areas as econometrics in addition to the language of the software itself. Because it can be used for a variety of computational techniques it can be useful for students in mathematics, the sciences, management, economics, finance, accounting and information sciences.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Students are required to familiarize themselves with software MATHEMATICA, for numerical computation on the following topics:

1. Tracing of a polar curves. Tracing of multiple polar curves.

2. Tracing of polar curve with angle variation.
3. Plot styling of polar curves.
4. Tracing of parametric curves. Tracing of multiple Parametric curves.
5. Tracing of Parametric curve with angle variation.
6. Plot styling of parametric curves.
7. Tracing of cartesian line curves of functions of two variables.
8. Tracing of a region of a functions of two variables.
9. Plotting of 2 D figures using graphics (points, line, circle, ellipse, disc).
10. Graphical plotting of 3 D figures using graphics (points, line, sphere, cone, cylinder).
11. Indefinite and definite integration of algebraic, trigonometric, exponential and logarithmic functions, their composition & product.
12. Double integration with change the order of integration.
13. Triple integration.
14. Finding length, area using integration.
15. Finding volume using integration.

BOOKS RECOMMENDED

REFERENCES

MATHEMATICA- Stephen Wolfram , Cambridge.

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester III

PAPER CODE - MAT 301
Analysis-I
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Develop an understanding of real numbers, limit point, open and closed sets.
2. An introduction to limit and convergence of a sequence, continuous functions on closed intervals.
3. Riemannian integration and proper integrals.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 301	**Analysis-I (Theory)**	**The students will be able to –** **CO26:** Describe fundamental properties of the real numbers that lead to the formal development of real analysis. **CO27:** Demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration. **CO28:** Understand the concept of continuous functions on closed interval and Riemannian integration. **CO29:** Construct rigorous mathematical proofs of basic results in real Analysis. **CO30:** Appreciate how abstract ideas and rigorous methods in mathematical analysis can be applied to important practical problems.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Real number system as a complete ordered field, Open and closed sets, Limit point of sets, Bolzano Weirstrass theorem, Concept of compactness, Heine Borel theorem.

Unit II **9 Hrs.**

Real sequences, Limit and convergence of a sequence, Monotonic sequences, Cauchy's sequences, Sub sequences and Cauchy's general principle of convergence.

Unit III **9 Hrs.**

Properties of continuous functions on a closed interval, Derivable functions: Derivative of composite function, Inverse function theorem, Limit and continuity of a function of two variables, Rolle's and Darboux theorem.

Unit IV **9 Hrs.**

Riemann Integration, Lower and upper Riemann integral, Properties of Riemann integration, Mean value theorem of integral calculus, Fundamental theorem of integral calculus.

Unit V **9 Hrs.**

Improper integrals: Kinds of improper integral, Tests of convergence of improper integrals and related problems.

BOOKS RECOMMENDED

- Shanti Narayan, A Course of Mathematical Analysis, S. Chand and Co., New Delhi, 1995.
- T.M. Apostol, Mathematical Analysis, Norosa Publishing House, New Delhi, 2000.
- K.C. Sarangi, Real Analysis and Metric Spaces, Ramesh Book Depot, Jaipur, 2006.
- Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, John Wiley & Sons Canada, 2011.
- P.K. Jain and S.K. Kaushik, An Introduction to Real Analysis, S.Chand and Co., New
- Delhi, 2000.
  2. S. Lang, Undergraduate Analysis, Springer-Verlag, 1997.
  3. R.R. Goldberg, Real Analysis, Oxford and IBH Publishing Company, New Delhi, 1999.
- Charles Chapman Pugh, Real Mathematical Analysis, Springer, 2004.
- Stephen Abbott, Understanding Analysis, Springer, 2010.

PAPER CODE - MAT 302
Differential and Difference Equations
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Differentiate the different types of Differential Equations and apply the appropriate analytical technique for finding the solution of first order and selected higher order ordinary differential equations.
2. Evaluate first order differential equations including separable, homogeneous, exact, and linear.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 302	**Differential and Difference Equations (Theory)**	**The students will be able to –** **CO31:** Students will be able to solve first order differential equations utilizing the standard techniques for separable, exact, linear, homogeneous, or Bernoulli cases. **CO32**: Students will be able to find the complete solution of a non-homogeneous differential equation as a linear combination of the complementary function and a particular solution. **CO33:** Students will be introduced to the complete solution of a homogeneous differential and difference equations with constant coefficients by the method of undetermined coefficients. **CO34:** Students will be able to find the complete solution of a differential equation with constant coefficients by variation of parameters. **CO35:** Students will have a working knowledge of basic application problems described by second order linear difference equations with constant coefficients.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Linear differential equation of first order first degree and irreducible forms, Exact differential equation and equation which can be made exact using I.F. First order higher degree differential equations solvable for x, y, p, Clairaut's form.

Unit II **9 Hrs.**

Linear differential equation with constant coefficients, Complimentary function and particular integral, Homogeneous linear differential equations with variable coefficients, Simultaneous differential equations.

Unit III **9 Hrs.**

Linear differential equation of second order: Linear independence of solutions, Solution by transformation of the equations by changing the dependent and independent variable, Factorization of operators, Method of variation of parameters, Method of undetermined coefficients.

Unit IV **9 Hrs.**

Partial differential equations of the first order, Lagrange's linear equation, Charpit's general method of solution, Homogeneous linear partial differential equations with constant coefficients, Equations reducible to equations with constant coefficients.

Unit V **9 Hrs.**

Difference equation: Definition and order of difference equation, first and higher order homogeneous linear difference equations, Difference equation reducible to homogenous form, Non-homogeneous linear difference equation, Complementary functions, Particular integrals.

BOOKS RECOMMENDED

- Zafar Ahsan, Differential Equations & Their Applications, PHI, New Delhi, 1998.
- J. L. Bansal and H.S. Dhami, Differential Equations, JPH, 2012.
- K.K. Gupta and D.C. Agarwal, Linear Difference Equation, Krishna Prakashan, 2004.
- A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd, London, 1997.
- Frank Ayres, Theory and Problems of Differential Equations, TMH, 2002.
- D. A. Murray, Introductory Course on Differential Equations, Orient Longman, 2004.
- I. N. Sneddon, Elements of Partial Differential Equations, TMH, 2001.
- Walter G. Kelley and Allan C. Peterson, Difference Equation: An Introduction with Applications, Academic Press London, 2001.
- Saber Elaydi, An Introduction to Difference Equation, Springer, 2005.

PAPER CODE - MAT 303
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Familiarize with software SCILAB, for numerical computation of the fundamental arithmetic operations.
2. Demonstrate plotting of 2D and 3 D curves.
3. To study construction of a vector/matrix and operations.
4. Computate the fundamental concepts of single variable and multivariable calculus.
5. Demonstrate algebraic facility with algebraic topics including linear, quadratic, exponential, logarithmic, and trigonometric functions.
6. Produce and interpret graphs of basic functions of these types.
7. Solve equations and inequalities, both algebraically and graphically.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 303	**Practical (Practical)**	**The students will be able to –** **CO36:** Develop programs in SCILAB. **CO37:** Evaluate, analyze and plot results. **CO38:** Perform mathematical Modelling in SCILAB. **CO39**: Good understanding of Linear algebra and Signal processing concepts.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Students are required to familiarize themselves with software SCILAB, for numerical computation on the following topics:

1. Introduction of SCILAB.
2. Commands for managing a session, Input and output commands.
3. Some primary mathematical function (Arithmetic function, trigonometric function, logarithm and exponent function).
4. Commonly used operators and special characters.
5. Vector, matrix and array commands.
6. Construction of a vector with operations on vectors.
7. Matrix representation and some operations on matrix.
8. Special matrices and element operations on matrix.
9. Eigen values and Eigen vectors.
10. Plotting commands.
11. Create 2D graph and customize line, Plot multiple graphs.
12. Scaling and coloring and Line styles in 2D graphs.
13. Add title axis labels and legend to graph.
14. 3D graph plotting, Scaling and coloring and line styles in 3D graphs.
15. Add title axis labels and legend to graph.

BOOKS RECOMMENDED

REFERENCES

Open source of SCILAB: http//:www.scilab.org.
Scilab-6.0.2(64-bit)/Scilab-6.0.2(32-bit)

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester IV

PAPER CODE - MAT 401
Mechanics
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Learn about the motion of particles in various cases and conditions.
2. Learn about how to Familiarize with subject matter, which has been the single centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT 401</td><td>Mechanics (Theory)</td><td>The students will be able to –

CO40: Develop an understanding of the principles of dynamics.
CO41: Ability to analyze the dynamics of rigid bodies. Discuss the motion on smooth and rough planes. Discuss general motion of rigid body, Kepler's laws.
CO42: Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
CO43: Students learn about the central force and its applications.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Power Point Presentations, Informative videos

Learning activities for the students:
Self learning assignments, Effective questions, presentations, Giving tasks</td><td>Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination</td></tr>
</table>

		CO44: Students learn about the moment of inertia of various bodies. **CO45:** Student gets idea about the constrained motion inside the smooth vertical circle.		

CONTENTS

Unit I **9 Hrs.**

Rectilinear motion: Radial and transverse components of velocity and acceleration, Tangential and normal components of velocity and acceleration, Simple Harmonic Motion: Hooke's Law, Horizontal and vertical elastic strings.

Unit II **9 Hrs.**

Rectilinear motion in a resisting medium, Central forces, Kepler's law of planetary motion.

Unit III **9 Hrs.**

Friction, Work, Energy, Impulsive forces.

Unit IV **9 Hrs.**

Motion of a particle on inside and outside of a smooth vertical circle and smooth vertical cycloid.

Unit V **9 Hrs.**

Moment of Inertia: Moment of inertia of a rod, Rectanglular lamina, Circular ring, Arc, Sector, Disc, Hollow and solid spheres, Cylinder, related problems based on theorems of perpendicular and parallel axis.

BOOKS RECOMMENDED

- Y.N. Gaur, M.C. Goyal and A.K. Mathur**,** Dynamics, Ramesh Book Depot, 2015
- M.D. Raisinghania, Dynamics, S. Chand & Co. New Delhi, 2006.
- D.C. Gokhroo, S. R. Saini and R. k. Arora, Elements of Dynamics**,** Jaipur Publishing House, 2014.
- K.C. Sharma, D.C. Gokhroo and S. R. Saini, Elements of Statics, Jaipur Publishing House, 2014.
- J. L. Synge and B. A. Griffith, Principles of Mechanics Mc Graw Hill, 1942.
- S.L .Loney, The Elements of Statics and Dynamics, Part I, Cambridge University Press, 1914.
- Ramsey A.S, Dynamics, CBS Publishers and distributors, 1913.

- M. Ray and G. C. Sharma, A Textbook on Dynamics, S. Chand & Co., 1951.
- G. Aruldas, Classical Mechanics**,** Prentice Hall of India, 2008.
- A. R. Vasishtha and Gupta, Dynamics of a Particle**,** Krishna Prakashan Mandir, 2014.
- David Morin, Introduction to Classical Mechanics with Problems and Solutions, Cambridge University Press, 2003.

PAPER CODE - MAT 402
Numerical Analysis
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. An understanding of numerical methods to obtain approximate solutions to mathematical problems.
2. An introduction to numerical methods to solve interpolation based problems, ordinary differential equations, various numerical root finding problems.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 402	**Numerical Analysis (Theory)**	**The students will be able to –** **CO46:** Explain the concept of finite differences and solves interpolation problems for equal intervals. **CO47:** Describe the concept of central difference, Numerical differentiation and be able to solve interpolation problems for unequal intervals. **CO48:** Understand the concept of Numerical Integration and able to solve related problems. **CO49:** Find the numerical solution of Algebraic and Transcendental equations. **CO50**: Solve the system of linear equations and ordinary differential equations.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

(Note: Non-Programmable scientific calculator up to 100 MS is permitted)

CONTENTS

Unit I **9 Hrs.**

Differences, Relation between differences and derivatives, Difference of polynomials, Factorial notation, Newton's forward and backward interpolation formula (with proof).

Unit II **9 Hrs.**

Divided differences : Newton's and Lagrange's divided differences formulae. Central differences: Gauss's, Stirling's and Bessel's interpolation formulae, Numerical differentiation.

Unit III **9 Hrs.**

Numerical integration: Newton-Cotes quadrature formula, Trapezoidal formula, Simpson's $1/3^{rd}$ and $3/8^{th}$ formulae, Gaussian integration.

Unit IV **9 Hrs.**

Inverse Interpolation, Numerical solution of algebraic and transcendental equations: Bisection method, Regula-falsi method, Method of iteration and Newton Raphson's Method, Newton's iterative formula for obtaining square and inverse square root.

Unit V **9 Hrs.**

Solution of a system of linear equations: Direct method (Gauss elimination method, LU-decomposition method), Iterative methods (Jacobi and Gauss Seidal method, SOR method), Theorems based on iterative methods, Solutions of first order ordinary differential equations: Picard's method, Euler's method, Runge-Kutta method.

BOOKS RECOMMENDED

- J.L. Bansal and J.P.N. Ojha, Numerical Analysis, Jaipur publishing house, 2015.
- M.C. Goyal, D.C. Sharma and Kavita Jain, Numerical Analysis, RBD, 2015.
- M.K. Jain and Iyengar, Numerical Methods Problems and Solutions**,** New Age International Ltd., 2007.
- James B. Scarborough, Numerical Mathematical Analysis, Oxford and IBH publishing 1966.
- J.P. Chauhan, Numerical Analysis, Krishna Prakashan Meerut, 2014.
- Curtis F. Gerald and Patrick O. Wheatley, Applied Numerical Analysis , *Pearson, 2003.*
- Gourdin and Boumahrat, Applied Numerical Methods, Prentice Hall of India,1996.
- Melvin J. Maron and Robert J. Lopez, Numerical Analysis a Practical Approach, Machmillon Publishing Company, New York, 3rd Edition ,1991.
- H.C. Saxena, Finite differences& Numerical analysis, S.Chand and Co. New Delhi, 2010.
- B.S. Goel and S.K. Mittal, Numerical Analysis, Pragati Prakashan, Meerut, 2007.
- Walter Gautschi, Numerical Analysis, Birkhauser Springer US, 2012.

PAPER CODE - MAT 403
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Familiarize with software SCILAB, for numerical computation of the fundamental arithmetic operations.
2. Demonstrate algebraic facility with algebraic topics including linear, quadratic, exponential, logarithmic, and trigonometric functions.
3. Produce and interpret graphs of solutions of some numerical problems.
4. Solve numerical differentiation and integrations with the help of software, and represents the solutions algebraically and graphically.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 403	**Practical (Practical)**	**The students will be able to –** **CO51:** Develop programs in SCILAB **CO52:** Evaluate, analyze and plot results. **CO53:** Perform mathematical Modelling in SCILAB. **CO54:** Good understanding of Linear algebra and Signal processing concepts	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Students are required to familiarize themselves with software SCILAB, for Numerical Computation on the following topics:

1. Scripts files and functions files.
2. Creating and running scripts file.

3. Creating function-file and use of in-build function files.
4. Programme for addition/Subtraction of numbers.
5. Programme for multiplication of numbers.
6. Programme for addition of squares of (even/odd) numbers.
7. Solution of Linear programming problems in SCILAB.
8. Ordinary differentiation and integration.
9. Programme for differentiation.
10. Programme for partial differentiation.
11. Programme for integration.
12. Programme for numerical integration.
13. Plotting in Programming.
14. Programme for numerical solution of ordinary differential equation.
15. Plotting of results of ODE.

BOOKS RECOMMENDED

REFERENCES

Open source of SCILAB: http//:www.scilab.org.
Scilab-6.0.2(64-bit)/Scilab-6.0.2(32-bit)

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester V

PAPER CODE - MAT 501
Algebra
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Develop the ideas about group, field, ring and their homomorphism.
2. Understand the introduction to vector space.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 501	**Algebra (Theory)**	**The students will be able to –** **CO55:** Describe group, subgroup, related properties and theorems. **CO56:** Differentiate between cyclic group, permutation group, quotiant group and normal subgroup. **CO57:** Identify homomorphism and isomorphism of groups. **CO58:** Describe rings, sub-rings, related properties and theorems, Ideal and characteristic of a ring. **CO59:** Describe field, sub-field, related properties and theorems.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Definition of a group with examples and related properties, Order of elements in a group and related theorems, Subgroup.

Unit II **9 Hrs.**

Cyclic group, Permutation group, Cosets, Lagrange's theorem, Normal subgroup, Quotient group.

Unit III **9 Hrs.**

Homomorphism and Isomorphism of group, Fundamental theorem of homomorphism of group. Ring: Definition, examples and elementary properties, Subring.

Unit IV **9 Hrs.**

Integral domain, Field, Subfield and their related properties, Ideal of a ring, Characteristic of a ring.

Unit V **9 Hrs.**

Vector space: Definition and examples, Subspace, Linear combination of vectors, Linear span, Linearly dependent and independent vectors and their properties, Bases and dimension(Definition and examples only).

BOOKS RECOMMENDED

- K. C. Sarangi, Elements of Abstract Algebra, RBD, Jaipur, 2009.
- I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 2008.
- G. C. Sharma and Shivlal Agarwal, Modern Algebra,& Co. Agra, 1998.
- Joseph Gallian, Contemporary Abstract Algebra, Cengage Learning USA, 2013.
- Deepak Chatterjee, Abstract Algebra, PHI. Ltd. New Delhi, 2001.
- P. B. Bhattacharya , S.K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 2001.
- Thomas W.Judson and Robert A. Beezer, Abstract Algebra: Theory and Applications, 2015.
- A.R.Vasishtha, J. N. Sharma and A.K. Vasishtha, Linear Algebra, Krishna Prakashan, 2010.
- Robert M. Thrall and Leonard Tornheim, Vector Spaces and Matrices, Dover Publications Inc. New York, 2011.

PAPER CODE - MAT 502
Operation Research
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Understand the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research.
2. Understand the concept of Linear programming problem with applications to transportation, assignment and game problems. Such problems arise in manufacturing resource planning and financial sectors.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT 502</td><td>Operation Research (Theory)</td><td>The students will be able to –

CO60: Understand the mathematical tools that are needed to solve optimization problems.
CO61: Identify and develop operational research models from the verbal description of the real system
CO62: Use advanced LPP in his or her application area.
CO63: Formulation and applications that are used in solving business decision problems.
CO64: Formulate and model a linear programming problem from a word problem and solve them graphically.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Power Point Presentations, Informative videos

Learning activities for the students:
Self learning assignments, Effective questions, presentations, Giving tasks</td><td>Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination</td></tr>
</table>

(Note: Non-Programmable scientific calculator up to 100 MS is permitted.)

CONTENTS

Unit I **9 Hrs.**

Introduction, Objective of Operation Research, Scope of Operation Research, General L.P.P.: Formulation of the problem, Graphical method, Simplex Method, Big M method, Two-phase method.

Unit II **9 Hrs.**

Duality in L.P.P., Transportation problem: Optimality test, Degeneracy in transportation problem, unbalanced transportation problem, Assignment problem.

Unit III **9 Hrs.**

Theory of Games: Introduction, Description and characteristics of game theory, Two-person zero sum game, Solution of mixed strategy problems, Principle of dominance, Solution of mix game by linear programming method.

Unit IV **9 Hrs.**

Inventory control: Introduction, EOQ models with and without shortages.

Unit V **9 Hrs.**

Queuing theory: Definition, Pure birth model, Pure death model, Single server model with finite and infinite capacity.

BOOKS RECOMMENDED

- Kanti Swaroop, P.K. Gupta and Manmohan, Operations Research, Sultan Chand and Sons, 2002.
- G. C. Sharma and Madhu Jain, Operations Research, Students Friends and Co. Agra, 2013.
- S.D. Sharma, Operations Research Theory, Methods and Applications, Kedarnath and Ramnath Co., Meerut, 2012.
- B. S. Goel and S. K. Mittal, Operations Research, Pragati Prakashan, 2014.
- Saul and Gauss, Linear Programming Methods and Applications, Mc-Graw Hills Book Company, 1984.
- P. K. Gupta and D. S. Hira, Problems in Operations Research, S. Chand and Co. New Delhi, 2010.
- Frederick S. Hillier and Gerald J. Lieberman, Introduction to Operations Research, Mc-Graw Hills, 2001.
- H. A. Taha, Operations Research an Introduction, Macmillan Publishing Company, New York, 2017.
- Wayne L. Winston, Operation Research Applications and Algorithm, Duxbury Press USA, 2004.

PAPER CODE - MAT 503
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Familiarize with software MATLAB, for numerical computation of the fundamental arithmetic operations.
2. Compute the fundamental concepts of single variable and multivariable calculus.
3. Demonstrate the operations on vectors and matrices.
4. Produce and interpret graphs of basic functions in 2D and 3D.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 503	**Practical (Practical)**	**The students will be able to –** **CO65:** Use programming operations to calculate solutions. **CO66:** Determine better and more accurate solutions. **CO67:** Perform and evaluate algebraic and trigonometric operations using built-in functions. **CO68:** Assign and manage variables. Manipulate vectors and matrices, use matrix indexing, and determine matrix dimensions. **CO69:** Generate linearly spaced vectors. **CO70:** Create and evaluate x-y plots and subplots suitable for technical presentation. **CO71:** Create, test, and execute user-defined functions and sub-functions. Create function input validation. **CO72:** Perform and evaluate relational and logical operations. Perform numeric and symbolic differentiation **CO73:** Solve linear systems of equations.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Students are required to familiarize themselves with software MATLAB, for numerical computation on the following topics:

1. Introduction of MATLAB.
2. Commands for managing a session, Input and output commands.
3. Some primary mathematical function (Arithmetic function, trigonometric function, logarithm and exponent function).
4. Commonly used operators and special characters.
5. Vector, matrix and array commands.
6. Construction of a vector with operations on vectors.
7. Matrix representation and some operations on matrix.
8. Special matrices and element operations on matrix.
9. Some statistical function.
10. Plotting commands.
11. Create 2D graph and customize line, Plot multiple graphs.
12. Scaling and coloring and line styles in 2D graphs.

13. Add title axis labels and legend to graph.
14. 3D graph plotting, Scaling and coloring and line styles in 3D graphs.
15. Add title axis labels and legend to graph.

BOOKS RECOMMENDED

REFERENCES

MATLAB- High performance numeric computation and visualization software

B.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester VI

PAPER CODE - MAT 601
Complex Analysis
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Introduce the fundamental ideas of the functions of complex variables, developing a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, complex integrals and a range of skills which will allow students to work effectively with the concepts.
2. Identify and construct complex-differentiable functions.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT601	**Complex Analysis (Theory)**	**The students will be able to –** **CO74:** Demonstrate the remarkable properties of complex variable functions, which are not the features of their real analogues **CO75:** Acquire knowledge about different types of functions viz. analytic, entire and meromorphic functions occur in complex analysis along with their properties **CO76:** Apply the knowledge of complex analysis in diverse fields related to mathematics.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:**	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

		CO77: Utilize the concepts of complex analysis to specific research problems in mathematics or other fields. **CO78:** Enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering. **CO79:** Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations. **CO80:** Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.	Self learning assignments, Effective questions, presentations, Giving tasks	

CONTENTS

Unit I **9 Hrs.**

Complex plane, Extended complex plane: Stereographic projection, Complex valued functions Limit, continuity and differentiability, Analytic functions, C-R equations, Harmonic function, Construction of an analytic function.

Unit II **9 Hrs.**

Complex integration, Complex line integrals, Cauchy's integral theorem, Cauchy's fundamental theorem, Indefinite integrals, Fundamental theorem of integral calculus for complex function.

Unit III **9 Hrs.**

Cauchy's integral formula, Analyticity of the derivative of an analytic function, Liouville's theorem, Poisson's integral formula, Morera's theorem, Maximum modulus principle. Taylor's and Laurent's series.

Unit IV **9 Hrs.**

Singularities, Branch points, Meromorphic functions and entire functions, Riemann's theorem, Casorati-Weirstrass theorem, Rouche's theorem, Fundamental theorem of algebra, Residue at a singularity, Cauchy's residue theorem.

Unit V **9 Hrs.**

Evaluation of real definite integral by contour integration (problems only).

BOOKS RECOMMENDED

- G. N. Purohit and S. P. Goyal, Complex Analysis, Jaipur Publishing House, 2015.
- H. S. Kasana, Complex Variables: Theory and Applications, Prentice Hall, Delhi, 2005.
- S. Ponnuswamy, Introduction to Complex Analysis, Narosa Publishers, 2011.
- P. K. Banerji, V. B. L. Chaurasia and S. P. Goyal, Functions of a Complex Variable, RBD Publishing House, 2017.
- R. Murray Spiegel, Theory and Problems of Complex Variables, Schaum Outline Series, 1974.
- K. K. Dubey, Fundamentals of Complex Analysis Theory and Application, International Publishing House, 2009.

- Rolf Nevalinna and Veikko Paatero, Introduction to Complex Analysis, AMS Chelsea Publishing, 2007.
- Joseph Bak and Donald J. Newman**,** Complex Analysis, Springer, 2010.
- James Ward *Brown* and Ruel V. *Churchill*, Complex Variables and Application**,** McGraw Hills Book Co., 2010.

PAPER CODE - MAT 602
Analysis-II
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

1. Introduce the basic ideas of analysis for Fourier Series, convergence of Sequences, Metric spaces etc.
2. Emphasis has been laid on Cauchy's sequences, continuous mappings, connected, compact sets and related theorems.

Course Outcomes (Cos):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 602	**Analysis-II (Theory)**	**The students will be able to –** **CO81:** Identify the difference between periodic and piecewise continuous function. **CO82:** Calculate Fourier series expansion of even and odd function. **CO83:** Identify point wise and uniform convergence of sequences and series of functions. **CO84:** Define Metric space and its properties. **CO85:** Understand the concept of continuous mapping, sequence and sub-sequence in metric space. **CO86:** Learn the separable, compact, connected and product space.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **9 Hrs.**

Fourier series: Periodic and piecewise continuous function, Dirichlet's conditions, Fourier series representation of function on intervals [$-\pi$, π], [0 , π] and on arbitrary intervals, Fourier series of odd and even function.

Unit II **9 Hrs.**

Sequence and series of function: Point wise and uniform convergence, Cauchy criterion and Weirstrass M-Test (including proof), Abel's and Dirichlet's Test (Without proof),Uniform convergence and continuity, Term by term differentiation and integration.

Unit III **9 Hrs.**

Metric Space: Definition with examples, Bounded set, Open set, Closed set, Neighborhood, Boundary points and limit points, Exterior point, Closure of a set, Metric subspace.

Unit IV **9 Hrs.**

Continuous mappings, Sequence in a metric space, Cauchy sequence, Subsequence, Completeness of metric space.

Unit V **9 Hrs.**

Separable spaces, Compact spaces and Compact sets, Connected spaces and Connected sets, Bolzano's theorem, Product spaces.

BOOKS RECOMMENDED

- Shanti Narayan, A course of Mathematical Analysis, S. Chand and Co New Delhi, 1995.
- T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 2000.
- K.C. Sarangi, Real Analysis and Metric spaces, Ramesh Book Depot Jaipur, 2006.
- G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill Education Pvt. Ltd., 2016.
- Michael O'Searcoid, Metric Spaces, Springer, 2007.
- Irving Kaplansky, Set Theory and Metric Space, AMS Chelsea Publishing, 2001.
- Heinonen, Juha, Lectures on Analysis on Metric Spaces, Springer, 2001.
- P.K. Jain and K. Ahmad, Metric Spaces, Narosa Publishing House, New Delhi, 1998.
- Savita Arora and S. C. Malik, Mathematical Analysis, New Age International, 1992.

PAPER CODE - MAT 603
Practical
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. Creating and running scripts M-file using the software MATLAB, for numerical computation of the fundamental arithmetic operations.
2. Demonstrate of simple programs including linear, quadratic, exponential, logarithmic, and trigonometric functions.
3. Produce and interpret graphs of solutions of some numerical problems.
4. Solve numerical differentiation and integrations with the help of software, and represents the solutions algebraically and graphically.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 603	**Practical (Practical)**	**The students will be able to –** **CO87:** Create and execute a script. **CO88:** Build programs to solve various mathematical problems **CO89:** Solve numeric ODE's. **CO90:** Perform numeric and symbolic integration. **CO91:** Demonstrate innovation and creativity in your approach to solve complex problems **CO92:** Demonstrate 3D graphing.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Giving tasks	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Students are required to familiarize themselves with software MATLAB, for numerical computation on the following topics:

1. Introduction of M-Files in MATLAB.
2. M-File scripts and M-File functions.
3. Creating and running scripts file.
4. Editing and existing M-File.
5. Programme for addition/Subtraction of numbers.
6. Programme for multiplication of numbers.
7. Programme for addition of squares of (even/odd) numbers.
8. Programme for numerical integration using Trapezoidal rule.
9. Programme for numerical integration using Simpson's 1/3 rule.
10. Programme for numerical integration using Simpson's 3/8 rule.
11. Programme for numerical solution of ordinary differential equation using Euler's method.
12. Programme for numerical solution of ordinary differential equation using Euler's Modified method.
13. Programme for numerical solution of ordinary differential equation using 2^{nd}order Runge-Kutta method.
14. Programme for numerical solution of ordinary differential equation using 3^{rd} order Runge-Kutta method.
15. Programme for numerical solution of ordinary differential equation using 4^{th} order Runge-Kutta method.

BOOKS RECOMMENDED

REFERENCES

MATLAB- High performance numeric computation and visualization software.

(deemed to be UNIVERSITY) JAIPUR

Programme- B.Sc. Geography

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	Employ critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.

PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Students will acquire an understanding of and appreciation for the relationship between geography and culture.
PSO 2	Students will acquire an understanding of and appreciation for the role that geography can play in community engagement.
PSO 3	Students will develop the ethical aptitudes and dispositions necessary to acquire and hold leadership positions in industry, government, and professional organizations.

PSO 4	Students will read, interpret, and generate maps and other geographic representations as well as extract, analyze, and present information from a spatial perspective.
PSO 5	Students will understand through lectures but also local, regional, and/or international travel the interconnection between people and places and have a general comprehension of how variations in culture and personal experiences may affect our perception and management of places and regions.
PSO 6	Students will have a general understanding of physical geographic processes, the global distribution of landforms and ecosystems, and the role of the physical environment on human populations.
PSO 7	Students will have a general understanding of cultural geographic processes, the global distribution of cultural mosaics, and the history and types of interaction between people within and among these mosaics.
PSO 8	Students will have a general understanding of global human population patterns, factors influencing the distribution and mobility of human populations including settlement and economic activities and networks, and human impacts on the physical environment.
PSO 9	Students will be able to think in spatial terms to explain what has occurred in the past as well as using geographic principles to understand the present and plan for the future.
PSO 10	Students will have a general understanding of how the physical environment, human societies, and local and global economic systems are integral to the principles of sustainable development.
PSO 11	Students will have a general understanding of the various theoretical and methodological approaches in both physical and human geography and be able to develop research questions and critically analyze both qualitative and quantitative data to answer those questions.
PSO 12	Students will be able to present a research report, including an explanation of methodology and scholarly discussion, both orally and in written form and, wherever possible, utilize cartographic tools and other visual formats

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

Course	COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
GEO-101	CO 01				x		x			x	x		
	CO 02				x		x			x	x		
GEO-102	CO 03	x	x			x	x	x	x				
	CO 04	x	x			x	x	x	x				
	CO 05	x	x			x	x	x	x				
	CO 06	x	x			x	x	x	x				
GEO-103	CO 07				x				x	x		x	
GEO-201	CO 08				x		x			x	x		
	CO 09				x		x			x	x		
GEO-202	CO 10	x	x			x	x	x	x		x		
	CO 11	x	x			x	x	x	x		x		
	CO 12	x	x			x	x	x	x		x		
GEO-203	CO 13				x				x	x		x	
	CO 14				x				x	x		x	
GEO-301	CO 15	x	x			x	x	x	x	x	x		
GEO-302	CO 16	x	x			x		x	x		x		
	CO 17	x	x			x		x	x		x		
	CO 18	x	x			x		x	x		x		
GEO-303	CO 19				x				x	x		x	
GEO-401	CO 20	x				x	x	x	x		x		
	CO 21	x				x	x	x	x		x		
	CO 22		x	x			x				x		

GEO-402	**CO 23**		x	X			x				x		
	CO 24		x	X			x				x		
GEO-403	**CO 25**				x				x			x	
GEO-501	**CO 26**	x				x		x		x		x	
GEO-502	**CO 27**		x			x			x		x		
	CO 28		x			x			x		x		
	CO 29		x			x			x		x		
GEO-503	**CO 30**				x		x				x	x	
GEO-601	**CO 31**			X								x	x
	CO 32			X								x	x
GEO-602	**CO 33**				x		x			x		x	
	CO 34				x		x			x		x	
GEO-603	**CO 35**		x		x	x	x				x		
	CO 36		x		x	x	x				x		x

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE- GEO 101
Lithosphere
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper will help the students to study the earth surface, tectonic occurrences, movements and resultant landforms.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 101	**LITHOSPHERE (Theory)**	**The students will be able to –** **CO01:**Constructivist theory forms the wide range of active learning approaches to engage students in enhancing the knowledge about lithosphere. **CO02:**They will be able to know the processes regarding the formation of the Universe as well as the different systems of earth like Plate tectonics etc.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

UnitI: **9 Hrs.**

Solar system.Origin of the Earth- Introduction to various theories: Gaseous, Planetesimal, Tidal and Big-Bang.Time Zone & International Date Line.Geological Time Scale.Interior of the Earth.

Unit II: **9 Hrs.**

Origin of continents and oceans-Theory of Continental Drift (Wegener's Drift theory); Introduction of Plate tectonics, Sea-floor spreading, Origin of Mountains, Mountain Building Theories (Joly, Kober, Homes).Theory of Isostasy

Unit III: **9 Hrs.**
Forces of the Earth: Endogenetic and Exogenetic.Rocks: Igneous, Sedimentary, and Metamorphic.Volcanoes - Types and related landforms.Earthquakes

UnitIV: **9 Hrs.**
Denudation: (i) Weathering- types and results,(ii) Erosion, Normal Cycle of Erosion by Davis and Penck,(iii) Mass wasting/ mass movements

Unit V: **9 Hrs.**

Agents of erosion- Works of Running water, Glaciers,Wind,Sea Waves,Groundwater

BOOKS RECOMMENDED

- Khullar D.R.: Physical GeographY, Kalyani Publishers, 2012
- Bunnett,R.B Physical Geography in Diagrams, Delhi : Pearson Education, 2006
- Strahler, A.N. and Strahler, A.H.: Elements of Physical Geography, Johan Wiley & Sons, 1984
- Ahamed, E. Geomorphology, Kalyani Publishers, New Delhi, 1985
- Singh, Savindra : Physical Geography, Pravalika Publications, Allahabad, 2019
- Strahler, A.M.: Modern Physical Geography. John Wiley and Sons. 1983

- Prajapati,R.V: EncyCOpedia of Outline Physical Geography, New Delhi : Cyber Tech Publications, 2010
- Taneja, Ravi Physical Geography Jaipur : Sublime Publications 2006

PAPER CODE- GEO 102
Physical and Human Geography of Rajasthan
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to

1. Study of Rajasthan will help the students in knowing the regional aspects of the state, its Physical conditions, demographic elements and population characteristics.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 102	**PHYSICAL AND HUMAN GEOGRAPHY OF RAJASTHAN (Theory)**	**The students will be able to –** **CO03:** The students will acquire an understanding of and appreciation for the relationship between geography and culture of Rajasthan. **CO04:** They will read, interpret, and generate maps and other geographic representations as well as extract, analyze, and present information from a spatial perspective. **CO05:** Students will have a general understanding of physical geographic processes, the spatial distribution of landforms and ecosystems, drainage pattern, climate, soils, etc. **CO06:**Students will have a general understanding of demographic structure, the distribution of various tribes and the history and interaction between people within and among these mosaics along with population dynamics and the various regional developmental programs implemented in the state.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**

Introduction :Location and Geopolitical Significance.

Physiography : Geological Structure and Relief Major Physiographic Divisions and their Importance -Western sandy plain,-Aravalli range,-Eastern plains,-Hadoti plateau.

Climate : Characteristics and Climatic conditions Agro-climatic classification.

Unit II: **9 Hrs.**

Drainage: Rivers: Arabian sea drainage system,Bay of Bengal drainage system,Inland Drainage ,Lakes : Sweet and Saline,

Soil: Types and Distribution,Desertification.

Desert Development Programme

Unit III: **9 Hrs.**

Vegetation: Types and Factors: Physical, Climatic and Biotic.

Forests: Types, Depletion , Conservation and Management

Forest Products: Major and Minor

Unit IV: **9 Hrs.**

Population Analysis:- Population Growth(post independence), Distribution and Density: Factors and Spatial Trends (2011)**,**Spatial patterns of population-Gender Ratio, Age composition, Rural-Urban ,Pattern And Occupational Pattern.

Unit V: **9 Hrs.**

Factors affecting the Site and Situation of settlements-Forms, Types and Patterns of Rural settlements.

Selected Tribes of Rajasthan: Meena,Bhils,Garasia

Area development Programs in Rajasthan: Aravalli Hill Development Program, Tribal Sub-Plan,Watershed Development Plan.

BOOKS RECOMMENDED:

- Sharma,H.S :Climate Change and Natural Resources : A Study of Indian Desert (New Delhi : Concept Publishing Company, 2018
- Sharma, H.: Geography of Rajasthan (Hindi) (Sheetal Printers, 2003)
- Chauhan: Geography of Rajasthan (Hindi); vol. 1 (Jodhpur : Vigyan Prakashan,1994)
- Chauhan: Geography of Rajasthan (Hindi); vol. 2 (Jodhpur : Vigyan Prakashan,1994)
- Saxena,Hari Mohan: Rajasthan KaBhugol (Rajasthan Hindi granth Academy, 2009)
- Bhalla,L.R. : Geography of Rajasthan (Kuldeep Publication ,2011)
- Nathuramka, L: Economy of Rajasthan (R.B.D. Publications, New Delhi,2014)

PAPER CODE- GEO 103
Introduction to Statistics in Geography
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to

1.To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 103	**INTRODUCTION TO STATISTICS IN GEOGRAPHY (Practical)**	**The students will be able to –** **CO07:** The students will be benefitted, as they will learn to depict and analyse the geographic data and use it in the other theory papers.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

Statistics (Introductory) : Variables: definition and types**,**Data and its arrangements (Tabulation**)**

Statistical Diagrams: their construction and properties

Mono dimensional diagrams: Line ,Bar ,Pyramid

Two dimensional diagrams: Square Block, Rectangular, Pie, Ring

Three dimensional diagrams:Spherical, Cube, Block Pile

BOOKS RECOMMENDED

- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, NewDelhi.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.

- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *PrayogicBhoogolRooprekha*, Kalyani Publications, New Delhi.
- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester II

PAPER CODE- GEO 201
Atmosphere and Hydrosphere
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1.This paper will acquaint the students with the global climatic conditions and the oceanography.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 201	**ATMOSPHERE AND HYDROSPHERE (Theory)**	**The students will be able to –** **CO08:** Students are enabled to know the air masses and weather conditions in the atmosphere and they are in position to know about the climatic change over the earth surface. **CO09:** Students can enhance their knowledge about life and configuration of oceans and their impact on the earth surface.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: 9 Hrs.

Composition and Structure of Atmosphere,Insolation ,Introduction to Heat budget of the earth,Factors affecting Temperature,Horizontal and Vertical distribution of atmospheric temperature ,Inversion of Temperature ,Temperatures: world patterns- July and January

Unit II: 9 Hrs.

Atmospheric pressure belts of the world,planetary and local winds,monsoons and jet streams,COuds,Humidity,Rainfall: Types and Distribution,Air masses.

Unit III: **9 Hrs.**

Temperate and tropical cyCOnes,Precipitation: types and distribution,Koppen's and Thornthwaite's classification of world climate,Global warming

Unit IV: **9 Hrs.**

Introduction to Oceanography: Temperature, Density and Salinity of ocean water,Oceanic relief : Atlantic Ocean,Indian Ocean,Pacific Ocean.Ocean Movements : Waves, Currents and Tides

Unit V: **9 Hrs.**

Ocean Deposits,Coral Reefs,Geo strategic significance of oceans and Antarctica.

BOOKS RECOMMENDED

- Critchfeild, H.- General Climatology, Prentice Hall, New York ,2002
- Mathur,J.R.: Climatology, McGraw Hill, New York(Latest Edition)
- Patterson.S.: Introduction to Meterorology, McGraw Hill Book Co. London (Latest Edition)
- Striger,E.T.: Foundation of Climatology, Surjeet Publications, Delhi, 1982
- Thurman,H.B.: Introductory Oceanography, Charles Webber E.Mem Publishing Co. 1984
- Gerald,S.: General Oceanography: An Introduction, John Wiley & Sons, New York, 1980
- Lal.D.S, Climatology, Allahbad Publications
- Singh, Savinder : Physical Geography, Pravalika Publications, Allahabad, 2019
- Trewartha, G.T. and Ikrata: Introduction to climate, International Studies.

PAPER CODE- GEO 202
Economic Geography of Rajasthan
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. The economic geography of Rajasthan helps the students know about the natural resources, means of irrigation, agriculture and industries of the state.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			

GEO 202	**ECONOMIC GEOGRAPHY OF RAJASTHAN (Theory)**	**The students will be able to –** **CO10:** The students will learn about the various economic resources like animal, water, agricultural, Industrial and mineral. **CO11:** They will learn about the various problems and prospects about agriculture, trade, tourism and transport which shall benefit the economic development in the state. **CO12:** They will also become aware about the need of conservation and protection of various natural resources to embark on a sustainable future.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**

Water Resources: Sources of irrigation.Irrigational Projects : Indira Gandhi Canal Project, Chambal Project ,Bhakra Nangal Project,Beas Project,Mahi Bajaj Sagar Project ,Eastern Rajasthan Canal Project.

Unit II: **9 Hrs.**

Agricultural Resources: Land use,Major crops: Bajra, Wheat, Jowar,Cash crops: Sugar cane, Cotton, Oil seeds,Agricultural Regions of the State**,**Problems of Agriculture development.

Unit III: **9 Hrs.**

Livestock: Distribution and density ,Breeds : Cattle, Sheep, Goats, Camels and Poultry**,**Dairy Development Program

Unit IV: **9 Hrs.**

Mineral and Power Resources: Spatial distribution ,Metallic: Zinc, Lead, Copper and Tungsten,Non-Metallic: Gypsum, Mica, Asbestos, Manganese and Marble,Conventional sources of energy: Coal, Petrol, Natural gas,Non-Conventional sources of energy: Wind and Solar

Unit V: **9 Hrs.**

Industrial Resources: Major Industries: Zinc ,Copper,Textile,Tourism,Railways and Roads.

BOOKS RECOMMENDED

- Sharma,H.S :Climate Change and Natural Resources : A Study of Indian Desert (New Delhi : Concept Publishing Company, 2018
- Sharma, H.: Geography of Rajasthan (Hindi) (Sheetal Printers, 2003)
- Chauhan: Geography of Rajasthan (Hindi); vol. 1 (Jodhpur : Vigyan Prakashan,1994)
- Chauhan: Geography of Rajasthan (Hindi); vol. 2 (Jodhpur : Vigyan Prakashan,1994)
- Saxena,Hari Mohan: Rajasthan KaBhugol (Rajasthan Hindi granth Academy, 2009)

- Bhalla,L.R. : Geography of Rajasthan (Kuldeep Publication ,2011)
- Nathuramka, L: Economy of Rajasthan (R.B.D. Publications, New Delhi,2014)

PAPER CODE- GEO 203
Scales and Statistical Methods in Geography
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1.To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 203	**SCALES AND STATISTICAL METHODS IN GEOGRAPHY (Practical)**	**The students will be able to:** **CO13:** The students will start learning the technique of cartography here onwards. As, scales form the basics. **CO14:** Also the Statistical methods will be supplemented to their learning of the last class.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations,Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

SCALES: Definition and Types ,Conversion of R.F into Statement and Visa-versa ,Construction of Plain, Comparative and Diagonal scale.,Construction of a physical/ political map of Rajasthan.

BOOKS RECOMMENDED

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, New Delhi.
- Monkhouse, F.J. and Wilkinson, H.R.(1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *PrayogicBhoogolRooprekha*, Kalyani Publications, New Delhi.

- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester III

PAPER CODE- GEO 301
Geography of India
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper helps the student to have a regional study of India- learning its Physiography, drainage, climate, agriculture scenario, industrial trends and transport.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
GEO 301	GEOGRAPHY OF INDIA (Theory)	**The students will be able to:** **CO15:** Students will get an introduction to the main regions of India with the knowledge of resources, drainage, climate and its impact and mainland and transport network analysis.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**
Physical Setting: Location of India in the world context,Physiography,Drainage.Climate: Seasons, Mechanism of Indian monsoons, Climatic regions.Soil types and their distribution,Natural vegetation

Unit II: **9 Hrs.**

Resources: Mineral and Power resources: Distribution and production of bauxite ore, copper, iron ore, lead and zinc, coal, petroleum and natural gas,Livestock resources, Water and Marine Resources, water conservation

Unit III: **9 Hrs.**

Agriculture: Infrastructure : Irrigation, institutional factors–land holdings and land reforms,land capability,green revolution,agro-climatic regions.

Unit IV: **9 Hrs.**

Industries: Evolution of industries and Factors affecting location of industries.major industries: iron and steel, agro based, petro chemical, cotton textile. major industrial regions ,Industrial development and their changing pattern.

Unit V: **9 Hrs.**

Transport: Roads, railways, waterways, airways and pipeline networks and their importance.

BOOKS RECOMMENDED:

- Deshpande C.D.: India-A Regional Interpretation, Northern book Centre, New Delhi. 1992.
- Mitra, A : Levels of Regional Development India Census of India, Vol. I, Part I-A (i) and (ii) New Delhi, 1967.
- Routray, J.K. : Geography of Regional Disparity, Asian Institute of Technology, Bangkok, 1993.
- Singh, R.L. (ed.): India A Regional Geography. National Geographical Society. India, Varanasi, 1971.

PAPER CODE- GEO 302
Human Geography
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. The study of human geography helps the students to know about the human components in geography.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 302	**HUMAN GEOGRAPHY (Theory)**	**The students will be able to –** **CO16:**The students will be able to describe what geography and human geography is and also appreciate the nature and scope of human geography. **CO17:** They will understand population dynamics and migration along with the concepts given by different thinkers. **CO18:** They will learn about the tribes and societies of the world They will learn	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

		about urban and rural structure and development in the country.		

CONTENTS

Unit I: 9 Hrs.

Definition, aim and scope ,Relation of Human Geography with other sciences,Essential facts of Human geography by Brunches and Huntington,Determinism, Possibilism and Neo- determinism.

Unit II: 9 Hrs.

Evolution of Man,Pleistocene age and humans,Races of Mankind.

Unit III: 9 Hrs.

Ecumene and Non Ecumene Regions.Population Growth: distribution and density.Concepts of Over,Under and Optimum population.Population resource regions according to Akermann**.**

Unit IV 9 Hrs.

Elements of the environment and their impact on the Habitat, Economy and Society of:Eskimos, Pygmies, Khirgiz.

Unit V 9 Hrs.

Bases of Classification of Settlements.House Types and Patterns of rural and urban settlements.

BOOKS RECOMMENDED:

- Haggett, P. (2001). *Geography: A Global Synthesis,* Prentice Hall, New York.
- Husain, M. (1994). *Human Geography,* Rawat Publications, Jaipur.
- Kaushik, S.D. (2011). *ManavBhugol*, Rastogi Publication, Meerut.
- Singh, K. N. and Singh, J. (2001). *ManavBhugol*, GyanodayaPrakashan, Gorakhpur.
- Singh, L.R. (2005). *Fundamentals of Human Geography,* ShardaPustakBhawan, Allahabad.

PAPER CODE- GEO 303
Techniques of Relief Representation in Geography
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 303	**TECHNIQUES OF RELIEF REPRESENTATION IN GEOGRAPHY (Practical)**	**The students will be able to –** **CO 19:** The syllabus focuses on basic skills required in Cartography and understanding Toposheets.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

Representation of Relief: Spot heights, Bench Marks, Hachures, Hill Shading.
Contours: Study and depiction of-Hill, Waterfall, Lake, Plateau, Gorge, U - Shaped Valley, V - Shaped Valley, Hanging Valley, Convex Slope, Concave Slope, Ridge, Cliff.
Profiles: - Serial, Superimposed**, Projected** Composite.

BOOKS RECOMMENDED:

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, New Delhi.
- Monk house, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *Prayogic Bhoogol Rooprekha*, Kalyani Publications, New Delhi.
- Sharma, J.P. (2010). *Prayogic Bhugol*, Rastogi Publishers, Delhi.

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester IV

PAPER CODE- GEO 401
Contemporary Geography of India
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper helps the student to study India in detail knowing its culture, settlements, political scenario and planning.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
GEO 401	**Contemporary Geography of India (Theory)**	**The students will be able to:** **CO20:** Students are enabled to know the social processes in Indian society as well as the tribal groups also **CO21:** They also get the knowledge of settlement study of the subcontinent and political behavior of Indian gait with special reference to geopolitical approach on contemporary issues and techniques of disaster management.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: 9 Hrs.
Major tribes and their problems.Population: Growth, distribution and density of population;Population problems and policies.

Unit II: 9 Hrs.

Settlements: Classification and types of rural settlements.Functional classification of urban settlements.Urbanization, Problems of Urban Slums in metropolitan cities

Unit III: 9 Hrs.

Regional Development and Planning.Objectives of five year plans.Multilevel planning.Planning for backward areas and region.Role of Planning Commission in development of India.

Unit IV: 9 Hrs.

India and Geopolitics : Geographical basis of Indian federalism; Role of India: SAARC, ASEAN, G20, BRICS.

Unit V: **9 Hrs.**

Contemporary Issues: North eastern tribes and their issues.Environmental hazards–landslides, earthquakes, floods and droughts, environmental pollution and environmental management strategies.

BOOKS RECOMMENDED:

- Deshpande C.D. : India-A Regional Interpretation, Northern book Centre, New Delhi. 1992.
- Mitra, A : Levels of Regional Development India Census of India, Vol. I, Part I-A (i) and (ii) New Delhi, 1967.
- Routray, J.K. : Geography of Regional Disparity, Asian Institute of Technology, Bangkok, 1993.
- Shafi, M : Geography of South Asia, McMillan & Co., Calcutta, 2000.
- Singh, R.L. (ed.) : India A Regional Geography. National Geographical Society. India, Varanasi, 1971.
- Spate, O.H.K. and Learmonth, A.T.A. India and Pakistan - Land, People and Economy Methuen & Co. London. 1967.

PAPER CODE- GEO 402
Environmental Geography
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper benefits the students in the field of Environment.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 402	**ENVIRONMENTAL GEOGRAPHY (Theory)**	**The students will be able to –** **CO22:** The students will understand about the Structure and Components of Environment, Ecology and Ecosystem. They will study about ecological succession and ecological energetics. **CO23:** They will acquire knowledge about biodiversity and the value of	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

		Resource. They will gain information regarding environmental pollutions and problems along with their Cause, Effect and Remedies. **CO24:** They will be Made aware about conservation of resources and Understand the various environmental protection methods like Environmental Impact Assessment.	questions, Seminar presentation	

CONTENTS

Unit I: **9 Hrs.**

Environment and its concepts, Scope and Concept of Ecology.Perspective on man environment Relationship,the effect of environment on man: biophysical and behavioral ideology,The effect of man on environment: direct and indirect.

Unit II: **9 Hrs.**
Population and community ecology, structure, general process of succession: Hydrosere, Xerosere, Mesosere.

Unit III: **9 Hrs.**

Ecosystem: biotic and abiotic, concepts of food chain, food web,trophic structure and ecological pyramids, production, consumption and decomposition in an ecosystem; Concept of Biomes of the world (Desert and Grassland)

Unit IV **9 Hrs.**
Environmental pollution with reference to India -Air, Water, Noise, Soil. Global environmental issues: Global Warming , Global Cooling,Climate change.

Unit V **9 Hrs.**

Environmental Management Conservation of :Renewable and Non Renewable Resources Concept of Environment impact assessment.

BOOKS RECOMMENDED:

- R.E, Dickinson, Makers of Modern Geography. Casper, J.K. (2010). *Changing Ecosystems: Effects of Global Warming*, Infobase Pub., New York.
- Saxena, H.M. (2013). *Environmental Geography*, Rawat Publications, New Delhi.
- Singh, S. (2001). *ParyavaranBhugol,* PrayagPustakBhawan, Allahabad. (in Hindi).
- Singh, S. (2017). *Environmental Geography,* PrayagPustakBhawan, Allahabad.
- Marsh, W.M. and John Grossa, Jr. (2002). *Environmental Geography: Science, Land Use and Earth Systems*, John Wiley & Sons, San Francisco.

PAPER CODE- GEO 403
Surveying and Statistics in Geography
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
GEO 403	SURVEYING AND STATISTICS IN GEOGRAPHY (Practical)	**The students will be able to –** **CO25:** This practical component will add ground application to the students' knowledge. And it will be supplemented with statistics.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations,Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

Socio-Economic Survey (field)**:** Conduction and report writing.
Instrumental Survey: Prismatic Compass Survey.
Statistical Methods: Correlation- Karl Pearson's Method and Spearman's Rank Difference Method**,**Co-efficient of Variation**,**Lorenz Curve.
Skewness

BOOKS RECOMMENDED:

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, New Delhi.
- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *PrayogicBhoogolRooprekha*, Kalyani Publications, New Delhi.

- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester V

PAPER CODE- GEO 501
Evolution of Geographical Thought
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. To introduce the students to the philosophical and methodological foundations of the subject and its place in the world of knowledge,
2. to familiarize them with the major landmarks in development of geographic thought at different periods of time during its foundation period.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
GEO 501	**EVOLUTION OF GEOGRAPHICAL THOUGHT (Theory)**	**The students will be able to:** **CO 26:** Students can enhance the knowledge about temporal succession of geographical views from ancient times to the 20th century so that they are able to know the development of thought in the field of geography in India as well as the world.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**
Geographical knowledge of the ancient period: Evolution of geographical knowledge ,Indian, Greeks and Roman scholars.

Unit II: **9 Hrs.**

Geography of medieval period: Contributions by Arab geographers,Dark Age**,** Renaissance and its impact on geographical knowledge.

Unit III: **9 Hrs.**

Development of scientific geography:Varenius and Immanuel Kant.

Unit IV: **9 Hrs.**

Geography in the nineteenth century: Founders of Modern Geography:Contributions by Humboldt, Ritter, Ritchofen, Ratzel .

Dualism in Geography: Human and Physical, Regional and Systematic.

Unit V: **9 Hrs.**

Geography in the twentieth century: Vidal de la Blache, Ellsworth Huntington, Carl O Sauer,Major Paradigm Shifts**-**Quantitative Revolution ,Behavioral Revolution, Humanism, Radicalism.

BOOKS RECOMMENDED:

- Husain,Majid: Evolution of Geographical Thought (Rawat Publications,2004,2010)
- Singh,Manoj: Evolution of Geographical Thought (New Delhi : Sonali Publications, 2016)
- Dikshit,R.D.: Geographical Thought : a contextual history of ideas (New Delhi:Prentice Hall,2004)
- Peet, Richard:Modern Geographical Thought (Oxford,UK : Blackwell Publishers, 2004)
- Rana,Lalita :Evolution of Geographical Thought (New Delhi : Concept Publishing Company ,2014)
- Rana,Lalita :Systematic Record of Evolution (New Delhi : Concept Publishing Company, 2014)
- Pandey,Akhilesh K: History of Geographic Thought (India : Ancient Publishing House, 2015)

PAPER CODE- GEO 502
Economic Geography
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper helps the student know about the various economic aspects of the world. It helps them study about the various natural resources, crops and minerals etc.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			

GEO 502	**ECONOMIC GEOGRAPHY (Theory)**	**The students will be able to –** **CO27:** Through this paper students are able to know the different economic processes in geography prevailed over the earth surface. **CO28:** They may be aware of the importance of the resources and their regional distribution in different parts of the world, specifically India also. **CO29:** They will know the different trade practices and their related organization.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: 9 Hrs.

Meaning and definition of economic geography.Sectors of economy: Primary, Secondary, Tertiary, Quaternary, Quinary activities.Natural Resources: Definition, Classification, Distribution, exploitation and conservation of Soil, Fisheries and Water (River).

Unit II: 9 Hrs.

Geography of Primary Production Agriculture: Wheat, Rice, tea and Coffee.Classification of World Agricultural types according to Whittelsey.World distribution, Production and uses of Minerals:Metallic: Iron, Aluminum, Copper, Mica and Lead.Non- Metallic: Bauxite, Graphite and Gypsum.

Unit III: 9 Hrs.

Energy Resources:Conventional energy resources: distribution and utilization of coal, petroleum and natural gas. Non-Conventional sources of energy: Distribution and Prospects of Hydro-electricity, Wind and Solar Energy.

Unit IV 9 Hrs.

Iron and Steel and Cotton Textile industries.Introduction to the industrial regions of U.S.A., Japan, Brazil and China.

Unit V 9 Hrs.

International Trade Agreements and Policies: Study of WTO, EU, NAFTA, SAFTA

BOOKS RECOMMENDED:

- Alexander, John W., Economic Geography, Prentice Hall; 2nd Revised edition edition (1 February 1979)
- Maurya.S.D, Human & Economic Geography, Pravalika Publications, Allahabad, 2018
- Janaki V.A, Economic Geography ,Concept Publishing Co, NewDelhi
- A Study Of Resources, The World Press Private Limited, Kolkata, 2002
- Khanna K.K and Gupta V.I, Economic Geography and Commercial Geography, Published by Sultan Chand & Sons, New Delhi, 2019

PAPER CODE- GEO 503
Toposheet and Weather Instruments in Geography
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 503	**TOPOSHEET AND WEATHER INSTRUMENTS IN GEOGRAPHY (Practical)**	**The students will be able to –** **CO30:** The students will add on to their basic knowledge of Toposheet interpretation and weather instruments. This will help them understand two basic components.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

Toposheet: Classification, Topographical Symbols, Interpretation of Indian topographical Sheets.

Meteorological Instruments: Maximum and Minimum Thermometer,Dry and Wet Bulb thermometer,Rain Gauge,Wind Vane,Anemometer,Aneroid Barometer,Interpretation of Indian topographical Sheets.

Mapping: Quantitative Map: Dot Map, Isopleth Map, Choropleth Map.
Qualitative Map: Chorochromatic, Chororschematic maps.
Weather Graphs: Climograph and Hythergraph.
Weather Symbols and Weather Maps: Study of Indian weather maps of January and July.

BOOKS RECOMMENDED:

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, New Delhi.
- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *PrayogicBhoogolRooprekha*, Kalyani Publications, New Delhi.
- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

B.Sc. Geography (2020-2021)

COURSE OUTCOMES - Semester VI

PAPER CODE- GEO 601
Research Methodology in Geography
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. This paper is an attempt towards making the student aware of the various aspects of Research Methodologies and their relevance in the field of Geography.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
GEO 601	RESEARCH METHODOLOGY IN GEOGRAPHY (Theory)	**The students will be able to:** **CO31:** This paper will make the students enabled towards the development of research aptitude so that they can prepare a project report, Hypothesis and all other steps involved in their organizing research. **CO32:** They become Computer Savvy also so that they can apply new techniques in their research methodology i.e. GIS, Remote Sensing etc.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**
Research: Concept and Types.

Research Methodology: Definition and concept.
Significance of research in Geography.

Unit II: **9 Hrs.**

Nature of Geographic Research: Fundamental Research and Applied Research,Methods and Sources of Geographic Information,Major steps in Geographic Research.
Hypotheses: Introduction,Formulation and Testing.

Unit III: **9 Hrs.**
Sampling: Definition,Types,Methods.

Experimental Method:Concept,Importance of Geography Laboratory.

Unit IV: **9 Hrs.**
Data Collection and Analysis: Methods of Data collection: Observation, Questionnaire, Case Study**,** Interview.

Techniques of Data Analysis: Introduction, Quantitative vs. Qualitative Methodologies, Role of Statistics in Geographical Research.

Unit V: **9 Hrs.**

Introduction to the Computer Software and Tabulation of Data: Role of SPSS, Role of GIS and Remote Sensing

Guidelines for Project Report Writing: An In-campus Case Study as a Class Activity.

BOOKS RECOMMENDED:

- Agarwal,Chetan : Research Methodology in Geography (Common Wealth Publishers, New Delhi ,2012)
- Sharma,Vijay: Research Methodology in Geography (Common Wealth Publishers ,New Delhi, 2014)
- Murthy,K.L.Narasimha :Research Methodology in Geography (Concept Publishing Company, New Delhi ,2014)
- Azad,Ismael: Research Methodology in Geography(Omsons Publications, New Delhi 2015)
- Misra, Singh: Research Methodology in Geography :Social,Spatial and Policy Dimensions (Rawat Publications, New Delhi,2002)
- Garg,SunilQuantitive Techniques and Research Methods in Geography (Random Publications, New Delhi, 2017)
- Mahmood,Aslam: Statistical Methods in Geographical Studies (Rajesh Publications, New Delhi, 1998)

PAPER CODE- GEO 602
Introduction to Remote Sensing
(Theory)

Credits: 3
Maximum marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to –

1. To provide exposure to students in gaining knowledge on concepts and applications of Remote Sensing in acquiring planning and development and resource mapping

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
GEO 602	**INTRODUCTION TO REMOTE SENSING (Theory)**	**The students will be able to –** **CO33:** To develop a basic understanding of the students of the subject from a geographical perspective. **CO34:** Then interrelate and pursue this science in their academic involvements.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **9 Hrs.**

Aerial Photography and Remote Sensing : Properties of Light, Introduction of the concept of Aerial photography, Introduction of the concept of Remote Sensing**,** Difference between Remote Sensing & Aerial Photography.

Unit II: **9 Hrs.**
Basic Principles of Remote Sensing: Processes involved in Remote Sensing, Electromagnetic radiation and EMR spectrum, Atmospheric windows, Interaction of EMR spectrum with ground objects.

Unit III: **9 Hrs.**

Remote Sensing Platforms and Sensors: Active & Passive Sensors, Resolution, Multiple imaging Sensor System, Landsat, SPOT, IRS

Unit IV **9 Hrs.**
Interpretation of Data Products: Photographic and digital data, False colour composite, Elements and interpretation of Satellite imagery.

Unit V **9 Hrs.**

Application of Remote Sensing: Preparation of Geomorphological maps, Preparation of land use/land cover maps, Forest classification and Watershed management

BOOKS RECOMMENDED:

- Joseph, G. 2005: Fundamentals of Remote Sensing, United Press India.
- Lillesand T. M., Kiefer R. W. and Chipman J. W., 2004: Remote Sensing and Image Interpretation, Wiley. (Wiley Student Edition).
- Singh R. B. and Murai S., 1998: Space-informatics for Sustainable Development, Oxford and IBH Pub.
- Wolf P. R. and Dewitt B. A., 2000: Elements of Photogrammetry: With Applications in GIS, McGraw-Hil
- Vyas P.R, Remote Sensing and Digital Image Analysis, Rawat Publications, 2014
- Vyas P.R, Remote Sensing and Systems: basics and Applications, Rawat Publications, 2014
- Mohan, Madan, Basic Notes on GeoinformaticsPrincipales and Concepts, New Delhi : R K book, 2014

PAPER CODE- GEO 603
Map Projection and Surveying
(Practical)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
GEO 603	**MAP PROJECTION AND SURVEYING (Practical)**	**The students will be able to –** **CO35:** The basic focus of this practical paper to understand the utility and construction of the various basic types of Projections. **CO36:** The syllabus also entails a survey for ground knowledge enhancement.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:**	Class test, Semester end examinations,Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work

			Field activities, Simulation, Presentation, Giving tasks	reports, seminar/ presentations and viva voce

CONTENTS

Projection: Utility and Graphical construction of: Conical Projection: Simple Conical Projection with one and two Standard Parallel, Bonne's Projection, Polyconic Projection. Cylindrical Projection: Equal Area Projection, Mercator's Projection, Gall's Projection.Polar Zenithal Projection:Equidistant Projection, Gnomonic Projection**,** Stereographic Projection.

Physical Survey (field): Conduction and Report preparation.

BOOKS RECOMMENDED:

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, NewDelhi.
- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Singh, G. (2004). *Map Work and Practical Geography*, Vikas Publication House, Delhi.
- Singh, R.L. (1998). *PrayogicBhoogolRooprekha*, Kalyani Publications, New Delhi.
- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

Programme- B.Sc. Statistics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	EmPSOy critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find emPSOyment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyze the data to decipher the degree to which their scientific work supports.

PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Gives a platform to students for pursuing higher studies.
PSO 2	Helps them to enhance their knowledge about programming language and statistical software like Excel, R, C.
PSO 3	Ability to use skills in Statistics and different practicing areas for formulating and tackling data related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics.
PSO 4	Improving problem solving skills that are required to solve different types of Statistics related problems with well-defined solutions, and tackle open-ended problems that belong to the other disciplinary-area boundaries.
PSO 5	Enhances theoretical rigor with technical skills which prepare students to become globally competitive to enter into a promising professional life even after graduation.

PSO 6	This program offers a range of opportunities in academics, Government Services, Indian Statistical Services, Banking and Insurance Sectors, CSO and NSSO as Investigator.
PSO 7	Analyse the behaviour of the population and sample data and fit the appropriate distribution on them.
PSO 8	Ability to deal with the problems related to process of product making, transportation cost of material, assignment of jobs in industry, market demand and supply, income and expenditure of individual and group, comparing the price, quantity and value indices.
PSO 9	Students are able to forecast the value of series depending on various factors like time, production, sales.
PSO 10	Ability to fit various curves and distribution on the data to examine the pattern and outliers.
PSO 11	Read, understand, calculate and compare the data related to the vital events.
PSO 12	Ability to understand and perform the scaling of scores and also check reliability and validity of data for group and individual.
PSO 13	Ability to understand the population behaviour and apply an appropriate method of probability sampling to selecting the sample for further analysis.
PSO 14	Analysing the data for known and unknown population using various sampling techniques and design of experiments.
PSO 15	Able to compare two or more population parameters using parametric and non-parametric test.
PSO 16	Develop an ability to make proper inference about confidence interval and to use sample statistic to estimate population parameters and check their reliability.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSOS)

Course	COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12	PSO13	PSO14	PSO15	PSO16
STT-101	CO1	x		x	x	x	x					x		x	x		
	CO2	x		x	x	x	x										
	CO3	x		x	x	x	x										
	CO4	x		x	x	x	x										
STT-102	CO5	x		x	x	x	x										
	CO6	x		x	x	x	x			x	x						
	CO7	x		x	x	x	x				x						
	CO8	x		x	x	x	x										
	CO9	x		x	x	x	x										
STT-103	CO10	x	x	x	x	x	x			x	x						
	CO11	x	x	x	x	x	x			x	x						
	CO12	x	x	x	x	x	x			x	x						
	CO13	x	x	x	x	x	x					x					
STT-201	CO14	x		x	x	x	x										x
	CO15	x		x	x	x	x	x									x
	CO16	x		x	x	x	x	x			x				x		x
	CO17	x		x	x	x	x	x			x						x
	CO18	x		x	x	x	x	x			x						x
STT-202	CO19	x		x	x	x	x					x		x			
	CO20	x		x	x	x	x			x	x						
	CO21	x		x	x	x	x			x							
	CO22	x		x	x	x	x			x	x						
	CO23	x		x	x	x	x										
	CO24	x		x	x	x	x			x					x		
STT-203	CO25	x	x	x	x	x	x	x			x	x					x
	CO26	x	x	x	x	x	x	x			x	x					x
	CO27	x	x	x	x	x	x	x		x	x				x		x
	CO28	x	x	x	x	x	x			x	x						
	CO29	x	x	x	x	x	x					x					
STT-301	CO30	x		x	x	x	x	x							x	x	x
	CO31	x		x	x	x	x	x							x	x	x
	CO32	x		x	x	x	x	x			x				x	x	x
	CO33	x		x	x	x	x	x			x				x	x	x
STT-302	CO34	x		x	x	x	x					x	x				
	CO35	x		x	x	x	x					x	x				
	CO36	x		x	x	x	x		x		x						
	CO37	x		x	x	x	x		x								
STT-303	CO38	x	x	x	x	x	x	x	x				x			x	x
	CO39	x	x	x	x	x	x	x	x				x			x	x
	CO40	x	x	x	x	x	x	x	x							x	x
	CO41	x	x	x	x	x	x		x		x						x
STT-401	CO42	x		x	x	x	x										x
	CO43	x		x	x	x	x										x
	CO44	x		x	x	x	x										x
	CO45	x		x	x	x	x										x
	CO46	x		x	x	x	x										x
STT-402	CO47	x		x	x	x	x		x			x					
	CO48	x		x	x	x	x		x			x					
	CO49	x		x	x	x	x		x								
	CO50	x		x	x	x	x		x	x							
	CO51	x		x	x	x	x		x	x							
	CO52	x	x	x	x	x	x		x	x		x					x

STT-403	**CO53**	x	x	x	x	x	x		x	x		x					x
	CO54	x	x	x	x	x	x		x	x							
	CO55	x	x	x	x	x	x		x			x					
STT-501	**CO56**	x		x	x	x	x							x	x		x
	CO57	x		x	x	x	x							x	x		x
	CO58	x		x	x	x	x							x	x		x
STT-502	**CO59**	x		x	x	x	x		x								
	CO60	x		x	x	x	x		x								
	CO61	x		x	x	x	x		x								
STT-503	**CO62**	x	x	x	x	x	x		x					x	x		x
	CO63	x	x	x	x	x	x							x	x		x
	CO64	x	x	x	x	x	x		x								
STT-601	**CO65**	x	x	x	x	x	x										
	CO66	x	x	x	x	x	x										
	CO67	x	x	x	x	x	x										
STT-602	**CO68**	x		x	x	x	x								x		x
	CO69	x		x	x	x	x								x		x
	CO70	x		x	x	x	x								x		x
STT-603	**CO71**	x	x	x	x	x	x								x		x
	CO72	x	x	x	x	x	x								x		
	CO73	x	x	x	x	x	x								x		
	CO74	x		x	x	x	x										x
	CO75	x		x	x	x	x										x

B.Sc. Statistics (2020-21)
COURSE OUTCOMES - Semester I

PAPER CODE- STT 101
Basic Mathematics and Official Statistics
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
Paper is designed to acquaint the students with elementary mathematics and official statistics so students understand the basic and the role of statistics in public and private sector.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-101	**Basic mathematics and Official Statistics (Theory)**	**The students will be able to –** **CO 1:** More familiar with institutional, legal and principles of functioning of official statistics.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions	Classroom Quiz Assignments Class Test Individual Presentation

		CO 2: Deeper knowledge about the mathematical functions and operations. **CO 3:** More knowledge about how to determine combination and permutations. **CO 4:** Deeper knowledge about how to integrate and differentiate the simple and complex function.	**Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	

CONTENTS

Unit I **9 Hrs.**

Polynomials, exponential, logarithmic and Binomial functions and their expansions, Basic ideas of Permutations and Combinations (simple problems). Matrices: Types, Addition, Subtraction, Product and Inverse of Matrices. Determinants of order 3* 3 and problem based on its properties.

Unit II **9 Hrs.**

Differential Calculus- Functional relationship between two variables.Introduction to limits, continuity and differentiability. Standard results for differential coefficients of x^n, e^x, log x etc (without proof). Rules for differentiation of sum, difference, product and Quotient and function of a function (without proof).Maxima and minima of functions of one and two variable.

Unit III **9 Hrs.**

Integral calculus: Definition and meaning of Integration. Integration as inverse of differentiation. Indefinite integral, Integration of simple function, Integration by substitution, integration by parts. Definite Integral and its properties. Beta and Gamma integral and their properties.

Unit IV **9 Hrs.**

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Census and various registration system and surveys conducted by Government of India.

Unit V **9 Hrs.**

Role of Ministry of Statistics & Program Implementation (MOSPI) Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission.

Books Recommended

- Sharma, G.C. and Jain, Madhu (2001): Essential Mathematics ,Galgotia Publications
- Pvt Ltd, 2001
- Text Books of Mathematics prescribed by NCERT for class XI and XII.
- Srivastava, S. S. and Asthana, B.N.(1965): Applied Statistics of India, Chaitnya Publishing House.
- Guide to current Indian Official Statistics, CSO, GOI, New Delhi.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. Das(1991): Fundamental of Statistics, Volume II, The World Press Pvt. Ltd. Calcutta.

PAPER CODE- STT 102
Basic Statistics and Probability
(Theory)

Credits: 3
Max. Marks: 100

Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper is designed to acquaint the students with the fundamental statistical techniques, to understand the role of statistics for analyzing and interpreting data meaningfully.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-102	**Basic Statistics and Probability (Theory)**	**The students will be able to –** **CO 5:** Ability to define and use the basic terminology of statistics. **CO 6:** Able to classify the data and prepare various diagrams and graph. **CO 7:** Good understanding of exploratory and descriptive data analysis. **CO 8:** Understand the concept of elementary probability theory and its application. **CO 9:** Ability to identify the problem and apply appropriate laws of probability and Bayes theorem.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **9 Hrs.**
Basic Concepts: Definition, scope, and limitations of statistics, Concept of statistical population. Types of data- Primary and Secondary data, Univariate and Bivariate data. Census and Sample Survey. Qualitative and Quantitative classification, discrete and continuous classification, Geographical and Chronological classification. Construction of frequency tables, frequency distribution for continuous and discrete data, cumulative frequency distributions (inclusive and exclusive methods.

Unit II **9 Hrs.**
Graphical presentation of data: Histogram, Frequency Polygon, Frequency curve and Ogives.
Univariate Data – Measures of Central Tendency – Definition, different measures of Central Tendency, merits and demerits. Measure of Dispersion- Definition, different measures of Dispersion, merits and demerits. Coefficient of variation. Relative dispersions.

Unit III **9 Hrs.**
Moments: Central moments and Non-central moments and their computation from data. Absolute and Factorial moments. Concept of Quartiles, deciles and percentiles. Measure of Skewness and Kurtosis, Sheppard’s, Correction for moments (without proof).

Unit IV **9 Hrs.**

Probability I: Set Theory, Power set, De- Morgan Law, Random Experiment, Trial, Events and their types. Classical, Statistical and Axiomatic definition of probability and its properties (simple).Addition theorem of probability and their application.

Unit V **9 Hrs.**

Probability II: Multiplication theorems of Probability and their application, Conditional Probability and complete, Independent and pairwise events. Baye's theorem and its application (simple questions).

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (1991): Fundamentals of Statistics,
- Volume I, The World Press PvtLtd , Calcutta
- Gupta, S.C. and Kapoor, V.K.: (2000) Fundamentals of Mathematical Statistics, S Chand & Company, New Delhi, tenth edition.
- Mood Alexander M., Graybill Frankline and Boes Duane C. (2007): Introduction to Theory of Statistics, McGraw Hill & Company Third Edition
- Gupta, O.P.: Mathematical Statistics, Kedarnath Publication, Meerut
- Yule, G. Udny and Kendall, M.G. (1999): An Introduction to the theory of Statistics,
- 14^{th} Edition.
- Hooda, R.P. (2002): Introduction to Statistics: Macmillan India Ltd. 1st edition.
- Speigel M.R., (1967): Theory and Problem of Statistics, Schaum's Series.
- Meyer, P.L.(1970) : Introductory Probability and Statistical Application, Addision
- Wesley.
- Rohatgi, V.K. and Saleh, A.K. Md. Ehsanes (2009): An Introduction to Probability
- Theory and Statistics, Second Edition, John Wiley and Sons.
- Bhat, B.R (1981): Modern Probability Theory, New Age Publishers, Third edition,

PAPER CODE- STT 103
Practical

Credits: 2
Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on descriptive statistics and also how to deal and analyses the secondary data statistically.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-103	**Practical**	**The students will be able to –** **CO 10:** Deal the statistical data through MS EXCEL.	**Approach in teaching:** Interactive Lectures, Group Discussion,	Software based Assignments Individual Presentation

		CO 11: Understand how to solve problems related to numeric and statistical data offline. **CO 12:** Identify the data and make appropriate graph for them. **CO 13:** Able to analyse the secondary data through descriptive statistics.	Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Class Test

CONTENTS

1) Preparation of frequency table by using exclusive and inclusive method of classification for continuous/discrete variables.

2) Graphical representation of data by:
a) Histogram
b) Frequency Polygon
c) Curve
d) Ogives

3) Diagrammatic presentation of data by: One Dimensional Diagram (Simple-Bar, Multiple-Bar and Divided) and Pie- diagram.

4) Measures of Central Tendency- Mean Median and Mode.

5) Absolute and relative Measures of Dispersion- Range, Quartile Deviation, Mean Deviation, Standard Deviation, Coefficient of variation.

6) Practical based on Deciles and percentiles.

7) Central and Non central Moments.

8) Measure of Skewness and Kurtosis.

9) A case study on secondary data.

Note: Practical exercises will be conducted on computer by using MS-Excel.

COURSE OUTCOMES - Semester II

Paper Code: STT 201
Probability Distributions
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper is aimed at teaching the students various probability distributions which are useful in day to day life.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
STT-201	**Probability Distributions (Theory)**	**The students will be able to –** **CO 14:** Able to understand the concept of random variable and their expectations. **CO 15:** Able to obtain the moments from moment generating function of various discrete and continuous distribution which helps them to study the population deeply. **CO 16:** Able to identify the behaviour of the population. **CO 17:** Gaining knowledge about how to derive the probability distribution function of random variables. **CO 18:** Analyse the behaviour of the data by Fitting discrete and continuous distributions.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **9 Hrs.**
Random Variable: Definition and types of random variables. Probability mass function and Probability density function. Distribution function with properties (without proof). Joint, Marginal and Conditional probability distributions. Independence of two variable, definition and application of Jacobian transformation for one and two variables.

Unit II **9 Hrs.**
Mathematical Expectations: Expectation of a random variable and its simple properties. Addition and Multiplication theorems of Expectations. Variance and covariance and their properties. Chebychev's inequality with simple applications. Central moments and Non-central moments, Moment generating functions and their properties. Cumulant generating functions.

Unit III **9 Hrs.**
Basic Distributions: Bernoulli, Binomial, Poisson, Normal distribution with properties and examples. Fitting of Binomial and Poisson distribution and Normal distribution.

Unit IV **9 Hrs.**
Univariate Discrete Distribution: Geometric Distribution with simple properties and applications. Hypergeometric and Negative Binomial Distribution (examples, derivations, mean and variance)

Unit V **9 Hrs.**

Univariate Continuous Distribution: Rectangular, Exponential, Cauchy, Gamma, Beta Distribution with properties. Bivariate normal distribution and its probability distribution function without proof.

Books Recommended

- Goon, A.M., Gupta, M.K. and Gupta, B. Das (1991): Outline of Statistics, Volume I,
- The World Press PvtLtd , Calcutta
- Gupta, S.C. and Kapoor ,V.K.: (2000) Fundamentals of Mathematical Statistics, S Chand
- & Company, New Delhi
- Gupta, O.P.:Mathematical Statistics, Kedarnath Publication, Meerut.
- Mood Alexander M., GraybillFrankline and Boes Duane C.:(2007) Introduction to Theory
- of Statistics, McGraw Hill & Company Third Edition
- Paul Mayor L. (1970): Introductory Probability and Statistical Application, Oxford &
- IBM Publishing Company Pvt Ltd, Second Edition.
- Yule Udny G., and Kendall,M.G. (1999): An Introduction to the theory of Statistics,
- 14^{th} Edition
- Speigel M.R., (1967): Theory and Problem of Statistics, Schaum's Series.
- Johnson Norman L., Kotz Samuel and Kemp Adriene W.: (2005) Univariate Discrete
- Distributions, Second Edition.

PAPER CODE- STT 202
Statistical Methods
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims to familiarize the students with the handling of bivariate data and numerical techniques.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-202	**Statistical Methods (Theory)**	**The students will be able to –** **CO 19:** Deeper knowledge of data reflecting quality characteristics including concepts of independence and association between two attributes. **CO 20**: Apply the least square errors method numerically and algebraically to find the curve of best fit. **CO 21:** Able to calculate and interpret the correlation between two variables.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar	Classroom Quiz Assignments Class Test Individual Presentation

		CO 22: Calculate the simple linear regression equation for a set of data and know the basic assumptions behind regression analysis. **CO 23:** Develop the mathematical skills of the students in the areas of numerical methods. **CO 24:** Apply various interpolation methods and finite difference concepts to the numerical data.	Presentation Subject based Activities	

CONTENTS

Unit I **7 Hrs.**
Theory of attributes: Class, class frequencies, order of class frequencies, Ultimate class frequency, Consistency of data (up to order 3). Independence of attributes, contingency table, Association of attributes, Measures of association.

Unit II **9 Hrs.**
Correlation: Correlation, Scatter Diagram, Karl Pearson's Coefficient of Correlation and its properties. Spearman's Rank Correlation Coefficient, partial and multiple correlation and their simple questions.

Unit III **9 Hrs.**
Curve fitting and Regression: Concept of curve fitting and Principles of Least Squares. Fitting of straight line, Parabola, Power Curves and Exponential Curves. Fitting of Regression Lines, Regression Coefficients with properties.

Unit IV **10 Hrs.**
Finite Differences: Operators E, ∇, Δ, their relationship and properties, factorial notation, Difference table and nth order difference of polynomial, Fundamental Theorem of finite differences. Estimation of one and two missing terms.

Unit V **10 Hrs.**
Interpolation and Extrapolation: Meaning, uses and assumptions of interpolation and extrapolation. Newton's Forward and Backward formulae for equal intervals, Lagrange's formula and numerical problems.

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. Das (1991): Fundamentals of Statistics,
- Volume I, The World Press Pvt Ltd, Calcutta
- Gupta, S.C. and Kapoor, V.K.: (2000) Fundamentals of Mathematical Statistics, S Chand & Company, New Delhi tenth edition.
- Bansal & Ojha (2015) Numerical Analysis, Jaipur Publishing House, Jaipur.
- Yule, G. Udny and Kendall, M.G. (1999): An Introduction to the Theory of Statistics,
- 14^{th} Edition
- Speigel M.R., (1967): Theory and Problem of Statistics, Schaum's Series.

PAPER CODE- STT 203
Practical

Credits: 2

Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on fitting of population distributions, bivariate population, fitting of different curves.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-203	**Practical**	**The students will be able to –** **CO 25:** Deal the statistical data through MS EXCEL. **CO 26:** Understand how to solve problems related to numeric and statistical data offline. **CO 27:** Identify the distribution and fit on the data and also find the outliers. **CO 28:** Able to obtain the correlation and regression by various modes. **CO 29:** ability to analyse the association between two attributes having different classes.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Software based Assignments Individual Presentation Class Test

CONTENTS

1. Exercise on raw and central moments and finding measures of central tendency, dispersion, Skewness and kurtosis of Univariate probability distributions with interpretation.

2. Fitting of Binomial distribution
3. Fitting of Poisson distribution
4. Fitting of Normal distribution.

5. Fitting of the following curves by the method of least squares:
a) Straight Line
b) Parabola
c) Exponential Curve
d) Power Curve

6. Computation of Correlation Coefficient and rank correlation.

7. Fitting of Regression lines.

8. Estimation of one or two missing values.

9. Interpolation for equal intervals by: Newton-Gregory formula (forward & backward).

10. Interpolation for equal intervals: Lagrange's formula.

11. Testing of Independence of Attributes.

12. Yule's Coefficient of Association of Attributes.

Note: Practical exercises will be conducted on computer by using MS-Excel.

COURSE OUTCOMES - Semester III

PAPER CODE- STT 301
Sampling Distributions
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims to understand the concept of hypothesis and sampling distributions and its applications.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
STT-301	Sampling Distributions (Theory)	**The students will be able to –** **CO 30:** Ability to Identify the behaviour of the sample and their distribution. **CO 31:** Ability to frame the hypothesis and give inference through probability curve **CO 32:** Analyse the behaviour of the data and also fit the appropriate sampling distributions on them. **CO 33:** Able to apply the applications of sampling distributions to the real-world problems.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I. **7 Hrs.**

Basic Concepts: Concept of statistic and sampling distribution. Sampling Distribution of sum of Binomial, Poisson and mean of Normal Distribution. Standard Error: Meaning and role. The Central Limit Theorem for identically independently distributed (i.i.d) random variable.

Unit II **10 Hrs.**

Statistical Hypothesis: Definition, Simple and Composite hypotheses. Null and Alternative Hypotheses, procedure of testing, two Types of errors, critical region , level of significance critical and p-values, statistical test: one tailed and two tailed test, Power and size of the test.

Unit III **10 Hrs.**

Chi-SquareDistribution : Definition, Derivation, Moments, Moment Generating Function, Cumulant Generating Function. Limiting and Additive property of Chi-square variates. Distribution of ratio of chi-square variates. Applications of Chi-square: Chi-square test for testing normal population variance, Test for goodness of fit, Contingency table and Test for independence of attributes, Yates correction for 2x2 contingency table conditions of Chi-square.

Unit IV **10 Hrs.**

t-Distribution: Definition of Student's-t and Fisher's-t statistics and derivation of their distributions. Limiting property of t-distribution. Applications: Testing of single mean, Difference of two means, paired t-test and test of sample correlation coefficient.

Unit V **8 Hrs.**

F-Distribution: Definition of Snedecor's F-distribution and its derivation. Applications- Testing of equality of two variance. Fisher's transformation and its uses. Relationship between 't', 'F' and chi-square statistics.

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (1991): Fundamentals of Statistics,
- Volume II, The World Press Pvt Ltd, Calcutta
- Gupta, S.C. and Kapoor, V.K. (2000): Fundamentals of Mathematical Statistics, S Chand
- & Company, New Delhi
- Mood Alexander M., Graybill Frankline and Boes Duane C.(2007): Introduction to Theory
- of Statistics, McGraw Hill & Company Third Edition
- Speigel M.R., (1967): Theory and Problem of Statistics, Schaum's Publishing Series.
- Gupta, O.P.:Mathematical Statistics, Kedarnath Publication, Meerut
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistics Volume
- II,The World Press Pvt Ltd, Calcutta

PAPER CODE- STT 302
Industrial Statistics
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper is focused on the study of different statistical techniques in psychometric analysis and statistical quality control, which involves the techniques for maintaining and improving the quality of products.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-302	**Industrial Statistics (Theory)**	**The students will be able to –** **CO 34:** Students will demonstrate their ability to apply statistics in psychological fields to calculate scores and deal with the scaling of data **CO 35:** Ability to analyse the reliability and validity of the data through various methods **CO 36:** In-depth knowledge of theoretical and practical aspects of Control charts to assess the quality of a product **CO 37:** Brief idea about the various sampling plans to assure the quality of a product.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **10 Hrs.**
Statistical Method in Psychology and Education - I: Types of scales: Nominal, Ordinal, Ratio and Interval, scaling of difficulty. Scaling of scores: Z- score, standard score, normalized score- T score, Percentile score.

Unit II **8 Hrs.**
Statistical Method in Psychology and Education - II: Intelligence test and intelligence quotient and its uses. Reliability of test scores: Concept, test retest method, parallel forms method, split half method. Validity of test scores: Concept, method of determination. Effect of length and range of test. Comparisons between reliability and validity.

Unit III **9 Hrs.**
Statistical Quality Control -I Concept of SQC, process control. Causes of variation in quality, Shewhartz Control Charts technique of rational sub groups, control limits, Natural tolerance limits, Specification limits, summary of out of control criteria.

Unit IV **10 Hrs.**
Statistical Quality Control -II : Control Charts for Variables: Construction of Mean, Range and Standard Deviation Charts. Concept of defects and defectives. Control chart for attributes: Construction of np-chart, p-chart, and c-chart.

Unit V **8 Hrs.**
Product Control (lot control) , Sampling Plan: Acceptance Sampling for Attributes, AQL, AOQL, LTPD, process average fraction defective, consumer's risk and producer's risk, ASN, ATI, Rectifying inspection plan. Concept of Single sampling Inspection plans and Double Sampling Plan. OC curve, ASN curve.

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (1991):Fundamentals of Statistics,
- Volume II, The World Press Pvt Ltd, Calcutta

- Gupta, S.C. and Kapoor, V.K.(2000): Fundamentals of Applied Statistics, S Chand
- Company, New Delhi, tenth editions.
- Montgomery, D.C. (2001): Introduction to Statistical Quality Control, John Wiley and
- Sons, Third Edition.
- Speigel M.R., (1967): Theory and Problem of Statistics, Schaum's Publishing Series.
- Guilford, J.P. and Fruchter B.(1980): Fundamental Statistics in Psychology and
- Education. Mc Graw Hill.
- Grant, E.L. (1964): Statistical Quality Control, Mc Graw Hill.

PAPER CODE- STT 303
Practical

Credits: 2
Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on fitting of sampling distributions, large samples test and also make the various control charts.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-303	**Practical**	**The students will be able to –** **CO 38:** Deal the statistical data through MS EXCEL. **CO 39:** Understand how to solve problems related to numeric and statistical data offline. **CO 40:** Able to apply the applications of sampling distributions to the real-world problems. **CO 41:** Able to solve problems and take decision regarding acceptance or rejecting the product on the basis of control charts.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Software based Assignments Individual Presentation Class Test

CONTENTS

1) Test of Significance:
a) Chi-square test for variance, goodness of fit and independence of Attributes.
b) t-test for mean and difference of means (paired and unpaired cases and for correlation Coefficient).
c) F-test for equality of population variances.
d) Use of Z-transformation.

2) Control Charts:
a) X, R chart.
b) p and np - chart for equal & unequal sample sizes.
c) c-chart.

3) Scores- Z- score, Standard score, normalized score, t- score Percentile score.

Note: Practical exercises will be conducted on computer by using MS-Excel

COURSE OUTCOMES - Semester IV

PAPER CODE- STT 401
Statistical Inferences
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper is designed to familiarize the students with concept of statistical inference which include estimation theory.

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-401	**Statistical Inference (Theory)**	**The students will be able to –** **CO 42:** Conduct hypothesis test about population mean and proportion. **CO 43:** Learn about the theory of estimation and properties of a good estimator. **CO 44:** Obtain the point estimator and interval estimator of the parameters. **CO 45:** Construct and interpret a confidence interval about the population and variances. **CO 46:** Learn non - parametric test such as run test, sign test and median test.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **10 Hrs.**
Large Sample Test of Significance**:** Testing of significance for attributes and variables, tests of significance for single mean, standard deviation and proportions, tests of significance for difference between two means, standard deviations and proportions.

Unit II **8 Hrs.**

Theory of Estimation: Point Estimation: problems of point estimation, properties of a good point estimator- unbiasedness, consistency, efficiency & sufficiency.-factorization theorem (without proof) and it applications.

Unit III **9 Hrs.**

Concept of mean square error, Minimum Variance Unbiased Estimation, Cramer Rao Inequality, Rao-Blackwell Theorem (Without proof) and Lehman scheffe theorm (Without proof). Idea of most powerful test, uniformly most powerful test, randomized and non randomized test .

Unit IV **9 Hrs.**

Methods of point estimation: Method of Maximum Likelihood and its properties of MLEs (without proof). Methods of Moments: Least Squares method. Interval Estimation: Concept, confidence interval, confidence coefficient, construction of confidence interval for population mean, variance, difference of population mean when standard deviation are known and unknown of Normal Distribution.

Unit V **9 Hrs.**

Neyman Pearson Lemma and its application for finding BCR. BCR in case of Binomial, Poisson and of Normal and Exponential Populations. Non Parametric Tests: Definition merits and limitations, Sign test for univariate and bivariate distributions, Run test and Median test for small and large samples.

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. Das (1991): An Outline of Statistics,
- Volume II, The World Press Pvt Ltd, Calcutta
- Gupta, S.C. and Kapoor, V.K.(2000): Fundamentals of Mathematical Statistics, S Chand
- &Company, New Delhi, tenth edition.
- Mood Alexander M., Graybill Frankline and Boes Duane C.(2007): Introduction to Theory
- of Statistics, Mc Graw Hill & Company Third Edition
- Rohatgi, V.K.(2009): An Introduction to Probability Theory and Statistics, John Wiley
- And Sons.
- Casella, G. and Berger, Roger L.(2002): Statistical Inference, Duxbury Thompson Learning, Second Edition.
- Snedecor, G.W. and Cochran, W.G. (1967): Statistical Methods, Iowa State University
- Press.
- Rohatgi, V.K. and Saleh, A.K. Md. Ehsanes (2001): An Introduction to Probability
- Theory and Statistics, Second Edition, John Wiley and Sons.

PAPER CODE- STT 402
Applied Statistics
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -

This paper is focused on the study of vital statistics, index numbers, demand analysis and time series. Vital Statistic deals with laws of human mortality, morbidity and fertility. Role of index number is in formulation of executive decisions. In time series analysis, we will study about different components and various methods useful in the analyzing them.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-402	**Applied Statistics (Theory)**	**The students will be able to –** **CO 47:** Utilizing information based on the population, including censuses, vital statistics and surveys, and understanding how to access and use such data. **CO 48:** Analyze the basic concepts used in the description and study of a population with a particular focus of a population: mortality, fertility. **CO 49:** Able to interpret and use a range of index numbers commonly used and also to understand other indices used in the business sector. **CO 50:** Able to define time series and its components and mathematical models. **CO 51:** Ability to apply time series methods for forecasting and also apply them on real world models.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **10 Hrs.**

Vital Statistics - I: Meaning, definition and utility. Sources of demographic data- census, registration. Indices of mortality. Measurement of mortality, crude death rate and standardization death rates. Indices of fertility, Measurement of fertility – crude birth rate, general fertility rate. Age- specific fertility rate, total fertility rate. Gross and Net Reproduction Rates.

Unit II **8 Hrs.**

Vital Statistics - II: Stationary and stable population, concept and determination of the rate of increase in a stable population.

Life table: Construction of complete life table from graduated rates of mortality and evaluation of probabilities of survival and death from a life table.

Unit III **8 Hrs.**

Demand Analysis: Demand and supply, law of demand and supply. Elasticity of demand: Price, Income and Cross elasticity. Engel's curve and Engel's law, Pareto's law of income distribution.

Unit IV **10 Hrs.**

Index Number – I: Meaning and uses of index numbers, problem in the construction of index numbers, price relatives, quantity and value relatives. Fixed base and chain base index numbers, use of averages. Weighted and unweighted index numbers- Laspeyers, Paasche's, Marshall-Edgeworth and Fisher's ideal index numbers, Dorbish, Kelly's fixed base index numbers. Test for index numbers. Base shifting, splicing and deflating. Consumer Price Index numbers, Construction of cost of living index and Whole-sale price index.

Unit V **9 Hrs.**

Time Series Analysis- Definition and its different components, additive and multiplicative models. Different methods of determining trend and seasonal fluctuations, their merits and demerits.

Books Recommended

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (1991): Fundamentals of Statistics, Volume II, The World Press Pvt Ltd, Calcutta
- Gupta, S.C. and Kapoor, V.K.(2000): Fundamentals of Applied Statistics, S Chand & Company, New Delhi
- Croxton, F.E. and Cowden, D.J. (1969): Applied General Statistics, Prentice Hall Of India
- Srivastava, O.S.(1998): A Textbook of Demography, Vikas Publishing.
- Gupta, O.P.:Mathematical Statistics, Kedarnath Publication, Meerut
- Shrinivasan, K. and Srinivasan, K.(1998): Basic Demographic Techniques and Applications.

PAPER CODE- STT 403
Practical

Credits: 2
Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on non-parametric test, vital statistics, index number, and time series.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-403	**Practical**	**The students will be able to –** **CO 52:** Deal the statistical data through MS EXCEL. **CO 53:** Understand how to solve problems related to numeric and statistical data offline. **CO 54:** Able to obtained trend and seasonal variations of data based on time series. **CO 55:** Solve the problems related to indices and also compare two different situations.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation	Software based Assignments Individual Presentation Class Test

			Subject based Activities	

CONTENTS

1) Vital Statistics:
a) CDR, CBR, Age specific death rates, standardized death rates.
b) GFR, ASFR, TFR.
c) Crude rate of natural increase GRR, NRR.
d) Life table and finding out certain values with its help.

2) Economic Statistics:
a) Laspeyres, Paasche's and Fisher's Index Numbers.
b) Fixed base and chain base index number.
c) Cost of Living Index Numbers

3) i) Measurement of Trend by method of:
a) Moving Averages.
b) Curve fitting by least squares.
ii) Measurement of seasonal fluctuations:
a) Ratio to Trend
b) Ratio to Moving Averages.
c) Link Relative Method.

4) Large sample tests for mean and proportions for one and two sample problems.

5) large sample test for attributes.

6) Non-Parametric Tests: Sign, Run, Median Tests (for large samples).

Note: Practical exercises will be conducted on computer by using MS-Excel.

COURSE OUTCOMES - Semester V

PAPER CODE- STT 501
Sample Survey
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper is aimed at teaching the students various sampling techniques.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-501	**Sample Survey (Theory)**	**The students will be able to –**	**Approach in teaching:**	Classroom Quiz Assignments Class Test

		CO 56: Identify the type of data and also able to taking decision of appropriate sampling scheme. **CO 57:** ability to decide the proper sample size **CO 58:** obtain the mean and variance for the sample and use as population estimates.	Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Individual Presentation

CONTENTS

Unit I **8 Hrs.**

Concept of population and sample, need for sampling, census and sample surveys. Advantages of sample survey over complete enumeration. Principal steps in a sample survey. Sampling and Non-sampling errors. Principles of Sample survey, Probability and Non probability Sampling.

Unit II **9 Hrs.**

Concept of Sampling Design Method of drawing a random sample from a finite population, accuracy and precision of an estimator. Estimation of sample size for a specified precision
Simple Random Sampling- Simple random Sampling with and without replacement. Probability of selecting any specified unit in the sample, variance of the estimate of population mean and population total. Estimation of the standard error of the estimate.

Unit III **10 Hrs.**

Stratified random sampling: Its advantages. Estimation of the population mean and its variance, optimum and proportional allocation and their comparisons with Simple Random Sampling without Replacement.

Unit IV **8 Hrs.**

Systematic Sampling and its advantages and disadvantages, variance of the estimated mean, comparison of systematic sampling with Simple and Stratified Random Sampling for population with linear trend. Concept of cluster sampling, mean and variance (without proof).

Unit V **10 Hrs.**

Basics of ratio and regression estimators. Introduction to ratio and regression method of estimation, first approximation to the population mean and total of SRS for large size and variance of these estimates.

Books Recommended

- Goon, A.M. Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol II, The World Press Pvt Ltd , Calcutta, VIIth Edition,
- Gupta ,S.C. & .Kapoor,V.K. (2000): Fundamentals of Applied Statistics,Sultan Chand & Sons, New Delhi, tenth edition.
- Cochran, William G. (1984): Sampling Techniques, Wiley Eastern Limited, Third Edition.
- Singh, Daroga and Chaudhary, F.S.(2002) : Theory and Analysis of Sample Survey Designs, New Age International Publisher.

- Murthy, M.N.(1967): Sampling Theory and Methods.
- Sukhatme, et al.(1984): Sampling Theory of Surveys with Applications, Piyush Publications, IInd Edition.
- Mukhopadhyay, P. (2007): Survey Sampling, Narosa Publishing House.

PAPER CODE- STT 502
Optimization Techniques
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims at teaching the students various optimization techniques and to introduce them with the concept of operational research.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-502	**Optimization Techniques (Theory)**	**The students will be able to –** **CO 59:** Understand about the scope, principles and models of Operation Research, concept of simplex, duality and able to solve linear programming problems. **CO 60:** Describe the concept of transportation and assignment problem and Discuss various methods to solve them and also obtain the optimum values for techniques. **CO 61:** Understand the concept of game theory and solve related problems.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **9 Hrs.**
Linear Programming: History and scope of operation research limitations and advantages concept of basis, basic feasible solutions, convex sets and extreme points. Definition of General L.P.P., formulation problems of L.P.P,

Unit II **9 Hrs.**

Graphical Method of solving L.P.P., bounded and unbounded solutions, Simplex Method: Theory of Simplex Method, M-Charne's simplex method. Degeneracy in linear programming.

Unit III **9 Hrs.**
Two-Phase simplex method, Duality in linear programming. Assignment problem

Unit IV **10 Hrs.**
Transportation Problem: North West Corner rule, Least-Cost method, and Vogel's approximation method (VAM) to find the starting solution (initial basic feasible solution). Procedure to find the optimal solution using MODI method.

Unit V **8 Hrs.**
Theory of games: introduction, description and characteristics of game theory, two person zero sum game, solution of pure and mixed strategy problems-principle of dominance. solution of mix game by linear programming method.

Books Recommended

- Taha, H.A. (2007**)**: Operation Research: An Introduction, Prentice Hall of India Ltd.
- Sharma, S.D. (1997): Operation Research, Kedar nath Ramnath and Co. (Publishers)
- Khandelwal R.S.: Quantitative technique, first edition

- Garvin, W.W.(1960): Introduction to Linear Programming, McGraw Hill.
- Rao, S.S.(1984): Optimization Technique and Applications, Wiley Eastern.

PAPER CODE- STT 503
Practical

Credits: 2
Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on sample selection, transportation and assignment problems.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT-503	**Practical**	**The students will be able to –** **CO 62:** Deal the statistical data through MS EXCEL. **CO 63:** Able to solve the samplings related problems and also done various comparisons between them. **CO 64:** Solve the linear problems mathematically	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:**	Software based Assignments Individual Presentation Class Test

		and obtain the optimum solution.	Assignments Seminar Presentation Subject based Activities	

CONTENTS

1) Linear Programming Problem
i) Graphical Method.
ii) Simplex Method (Big M and Two Phase).
iii) Duality in L.P.P.
iv) Degeneracy in L.P.P.

2) Transportation Problem
i) North-West Corner Rule
ii)Least- Cost Method
iii)Vogel's Approximation Method.

3) Assignment Problem.

4) Problems based on Game Theory: two person zero sum game

5) Sample Surveys: To draw a simple random sample (SRS) with & without replacement to obtain an estimate of the population mean along with estimate of their variances. To compare the efficiency of SRSWOR with respect to SRSWR.

6) To draw all the possible samples by **SRS** – technique and to show that expected value of the sample mean equals the population mean and to show the expected value of sample mean square is population mean square.

7) Stratified Sampling:
i) Estimate the sample sizes by proportional allocation and Neyman's Optimum Allocation.
ii) Estimate the mean of the population under the above scheme.
iii) Calculation of the sampling variance.
iv) Computation of relative efficiencies of the allocation scheme among themselves as well as with SRS.

8) Systematic Sampling and its comparison with SRS and Stratified Sampling.

Note: Practical exercises will be conducted on computer by using MS-Excel.

PAPER CODE- STT 601
Statistical Programming With R and C
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims at teaching the students to solve the statistical problem using computer software and C language.
Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-601	**Statistical Programming with R and C (Theory)**	**The students will be able to –** **CO 65:** Able to make the program in R and C. **CO 66:** Apply programming concept to solve the statistical techniques. **CO 67:** Understand the knowledge of statistical software for further enhancement in career.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **9 Hrs.**

Overview of C, Basic structures of c programs, sample c program, programming style, exe.a c program, data types, constants and variables, operators and expression, managing input and output operators.

Unit II **9 Hrs.**

Decision making and branching IF, IF ELSE, NESTED IF ELSE, IF ELSE ladder, SWITCH statement, ?: operator, GOTO statement, Decision making and looping: WHILE statement; DO statement, FOR statement, jumps in loops, Arrays: Introduction to arrays, single dimensional array and two dimensional arrays

Unit III **9 Hrs.**

Introduction of R: History, data types, operators, basic structure of R, Functions for reading, writing and loading and interpretation data. Import and export of data Plot a graph: histograms, frequency polygon, pie chart, ogives, scatter diagrams.

Unit IV **9 Hrs.**

Control Structures: IF, IF ELSE,FOR, WHILE. Calculation of measure of central tendency and dispersion, correlation and lines of Regression. Random number generation and sampling procedures. Fitting of Population Distribution.

Unit V **9 Hrs.**

Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals solution of applications of sampling distributions and Analysis of variance.

Books Recommended

- Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley
- Publications.
- Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R.
- Cambridge University Press. New York
- Rakshit, Sandip(2007):R Programming for Beginners
- Cotton, Richard(2016) Learning R: A Step-by-Step Function Guide to Data Analysis

- Wickham, Hadley(2010): Elegant Graphics for Data Analysis (Use R!)

PAPER CODE- STT 602
Paper Title: Analysis of Variance and Design of Experiments
(Theory)

Credits: 3
Max. Marks: 100
Contact Hrs/Week: 3
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims at teaching the students about Analysis of Variance and Design of Experiment.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT-602	**Analysis of Variance and Design of Experiments (Theory)**	**The students will be able to –** **CO 68:** Identify the behaviour of the experimental unit. **CO 69:** Able to construct the design and deal the problems of real world situation. **CO 70:** Taking decision on the output of the design and also identify the outliers.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit I **8 Hrs.**
Analysis of Variance - I: Linear Model and its different types (only introduction). Concept of ANOVA (i).One-way classified data.(ii)Two-way classification with one observation per cell. Fixed effect models of (i) and (ii) and the assumptions involved. Effects of violation of assumptions made in ANOVA.

Unit II **9 Hrs.**

Analysis of Variance – II: Estimation of treatment effects and treatment differences. Expectation of sum of squares, variance of the estimates for both one-way and two-way classified data and critical difference.

Unit III **9 Hrs.**

Design of Experiments – I: Need for design of experiments, Meaning of experiment, experimental unit, treatment, field, block, experimental error, precision, uniformity trials, choice of size and shape of plots and blocks. Fundamental principles of design of experiments- replication, randomization and local control, Efficiency of design

Unit IV **10 Hrs.**

Design of Experiments – II: Basic designs(with one observation per cell and fixed effects model)- Completely Randomized Design, Randomized Block Design - Analysis of these designs, standard error of treatment differences, efficiency of RBD over CRD, their advantages , disadvantages and usages. Missing Plot Techniques, Estimation of single and two missing values in RBD

Unit V **9 Hrs.**

Design of Experiments – III: Latin Square Design – Its analysis, least square estimates, expectation of sum of squares, efficiency of LSD over CRD and RBD. Estimators of single missing value in LSD. Factorial experiments- 2^2 and 2^3 experiments, main effects, interaction effects and their analysis.

Books Recommended

- Goon, A.M. Gupta, M.K. and Dasgupta, B. (2001): Fundamentals of Statistics (Volume II), The World Press Pvt Ltd, Kolkata, VII Edition,
- Gupta, S.C. &. Kapoor, V.K. (2000): Fundamentals of Applied Statistics,Sultan Chand & Sons, New Delhi tenth edition.
- Das, M.N. and Giri, N.C. (2002): Design and Analysis of Experiments, New Age International Publisher, Second Edition.
- Joshi, D.D. (2003): Linear Estimation and Design of Experiments, New Age International Publisher.
- Montgomery D.C.(1952): Design and Analysis of Experiments, Sixth Edition, Wiley Eastern Ltd. Limited
- Cochran, W.G. and Cox, G.M.(1997): Experimental Design, Asia Publishing House, third edition.

PAPER CODE- STT 603
Practical

Credits: 2
Max. Marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This paper is designed so that the student know how to make and run program on program window and also solve statistical problems with statistical software R.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			

STT-603	**Practical**	**The students will be able to –** **CO 71:** Deal the statistical data through R. **CO 72:** Understand how to solve problems related to numeric and statistical data on R and C. **CO 73:** Ability to make statistics related problems program in C language . **CO 74:** Able to deal with non existing and missing population values. **CO 75:** Able to analyse the population and solve the numerical problems using various design of experiments.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Software based Assignments Individual Presentation Class Test

CONTENTS

1) Analysis of Variance and Design of Experiments:
ii) One-Way and Two-Way classifications.
iii) C.R.D.
iv) R.B.D.
v) L.S.D

2) Missing Plot Technique for one missing observation in R.B.D. and L.S.D.

3) One project based on statistical analysis of primary/secondary data collected by students,

4) Practical based on different constructs of C- language, which may include problems of paper STT-601.

5) Practical based on different constructs of R, which may include problems of paper STT-601.

Note: Practical exercises will be conducted on computer by using Analysis Tool Pack.

(deemed to be UNIVERSITY) JAIPUR

Programme- B.Sc. (H) Physics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Understand, acquire, articulate, retain, apply and communicate scientific concepts, experimental results and analytical arguments to fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	Employ critical thinking, analytical reasoning and the scientific knowledge to design, carry out, record and analyze various aspects of science. It will help to develop scientific temper that will be more beneficial for the society.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Apply the knowledge of basic science, life sciences and fundamental sciences to multidisciplinary level like genetic engineering or Nanotechnology.
PO5	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO6	Demonstrate the knowledge in understanding research and addressing practical problems and to apply various scientific methods to address different questions by formulating the hypothesis, data collection and

	critically analyze the data to decipher the degree to which their scientific work supports.
PO7	Develop respect for nature by participating in various social and cultural activities voluntarily, in order to spread knowledge, creating awareness about the social evils, blind faith, etc. and analyze the impact of anthropogenic activities on environment.
PO8	Communicate effectively on various scientific issues with the with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO9	Stay firm on the value systems of their culture, including their own for a healthy socio cultural environment. Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.
PO10	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will acquire digital skills and integrate the fundamental concepts with modern tools.
PO11	Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.
PO12	Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Acquire a systematic and coherent understanding of the academic field of Physics, its different learning areas and applications to applied problems of Physics and its linkages with related disciplinary subjects like Chemistry, Mathematics, Statistics, Economics, Life sciences, Environmental sciences, Computer science, Information Technology .

PSO 2	Attain procedural knowledge that leads to different types of professional and industrial applications, and also useful to ones engaged in research and development, teaching and public service.
PSO 3	Acquire specialization in a specific fields related to current and emerging developments in Physics, such as LASER & Optical fibre, Bio-Physics Condensed Matter Physics, Electronics, Material Science, Astronomy nanotechnology etc., to name a few.
PSO 4	Recognize the importance of mathematical modeling simulation and computing, and the role of approximations and in simplification of problems appropriate mathematical approaches to describe the physical world, such as perturbation theory, one electron model etc.
PSO 5	Plan and execute Physics-related experiments or investigations, analyze and interpret data collected using appropriate methods, including the use of appropriate software, error analysis and use of statistical tools.
PSO 6	Demonstrate problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions and develop numerical solving ability.
PSO 7	Identify and apply appropriate physical principles and methodologies to solve a wide range of problems associated with fields other than Physics.
PSO 8	Develop communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner.
PSO 9	Demonstrate professional behavior such as being objective, unbiased and truthful in all aspects of work
PSO 10	Develop ability to identify the potential ethical issues in work-related situations.

PSO 11	Gain hands-on experience in a number of the practical methods and techniques used in basic science research and by conceptualizing and handling independently the projects sanctioned to them.
PSO 12	Develop basic understanding of Bio-physics as a pre-requisite to taken up higher in inter-disciplinary areas relating to application of Physics in Life Sciences.
PSO 13	Acquire basic understanding of subjects like Digital Electronics, LASER & Optical fibre, Astronomy etc. to take up higher studies or develop incubator or startups to find solution to national problems, related to information communication.
PSO 14	Acquire back ground knowledge of renewable energy sources to take up higher studies/research or develop incubators/startups to combat the energy problem of the nation.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSOS)

Course	COs	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10	PSO 11	PSO 12	PSO 13	PSO 14
PHY 111	**CO1:**	x		x			x			x					
	CO2	x								x					
	CO3	x					x			x					
	CO4	x		x						x					
	CO5	x		x			x			x					
	CO6	x		x			x			x					
PHY 112	**CO7**	x		x			x			x					
	CO8	x		x			x			x					
	CO9	x		x			x			x					
	CO10	x		x						x					
	CO11	x		x						x					
	CO12	x		x						x					
	CO13	x								x					
	CO14	x								x					
	CO15	x								x					
PHY 113	**CO16**	x		x				x		x					
	CO17	x	x				x	x		x					
	CO18	x						x	x	x					
	CO19	x					x			x					
	CO20		x							x					

PHY114	CO21		x				x			x					
	CO22		x							x					
	CO23		x				x			x					
	CO24		x		x					x					
	CO25		x		x		x			x					
	CO26		x							x					
	CO27		x							x					
	CO28		x		x		x			x					
PHY115	CO29					x	x			x					
	CO30								x	x					
	CO31								x	x		x			
	CO32					x			x	x	x	x			
	CO33					x	x		x		x	x			
PHY 116	CO34	x				x	x								
	CO35														
	CO36											x			
	CO37											x			
PHY 211	CO38	x					x			x					
	CO39	x		x			x			x					
	CO40	x		x			x			x					
	CO41	x		x			x			x					
	CO42	x		x			x			x					
	CO43	x					x			x					
PHY 212	CO44	x								x					
	CO45	x		x			x			x					
	CO46	x		x			x			x					
	CO47	x								x					
	CO48	x		x						x					
PHY 213	CO49	x					x			x					
	CO50	x	x							x					
	CO51	x	x							x					
	CO52	x	x							x					
	CO53	x	x							x					
	CO54	x	x							x					
PHY214	CO55							x		x			x		
	CO56	x	x					x		x			x		
	CO57	x						x		x			x		
	CO58	x	x					x		x			x		
	CO59							x		x			x		
PHY215	CO60	x	x			x		x		x		x			
	CO61	x	x			x		x		x		x			
	CO62	x	x			x		x		x		x			
PHY216	CO63	x				x									
	CO64	x				x									
	CO65	x													
	CO66	x													
	CO67	x										x			

PHY311	**CO68**	x					x			x					
	CO69	x	x							x					
	CO70	x					x			x					
	CO71	x								x					
	CO72	x								x					
PHY312	**CO73**	x	x				x			x					
	CO74	x				x				x					
	CO75	x		x			x			x					
PHY 313	**CO76**	x		x						x				x	
	CO77	x		x						x				x	
	CO 78	x		x			x			x				x	
	CO 79	x		x						x				x	
	CO 80	x				x				x					
	CO 81	x													
PHY 314	**CO 82**	x						x		x			x		
	CO 83	x						x		x			x		
	CO 84	x						x		x			x		
	CO 85							x					x		
	CO 86							x					x		
PHY 315	**CO 87**	x				x					x				
	CO 88	x				x						x			
	CO 89	x				x						x			
PHY 316	**CO 90**	x	x												
	CO 91						x								
	CO 92										x	x			
	CO 93								x	x	x				
PHY 401	**CO94**	x		x	x					x					
	CO95	x		x	x		x			x					
	CO96	x		x	x		x			x					
	CO97	x		x	x		x			x					
	CO98	x			x					x					
	CO99	x		x	x		x			x					
PHY 412	**CO100**	x		x						x					
	CO 101	x								x					
	CO 102	x								x					
	CO 103	x		x			x			x					
	CO 104	x								x					
	CO 105	x								x					
	CO 106	x								x					
	CO 107	x		x			x			x					
PHY 413	**CO108**	x						x							
	CO109	x						x							
	CO110	x						x							
	CO111	x						x							
	CO112	x						x							
PHY 414	**CO113**	x		x			x			x					
	CO114	x		x			x			x					

	CO115	x		x			x			x					
PHY 415	**CO116**	x	x			x				x	x	x			
	CO117	x	x			x				x	x				
	CO118	x	x			x				x	x	x			
PHY 416	**CO119**	x				x				x	x				
	CO120	x				x				x	x				
	CO121	x				x				x	x				
PHY 511	**CO122**	x		x						x					
	CO123	x		x			x			x					
	CO124	x		x			x			x					
	CO125	x								x					
	CO126	x					x			x					
PHY 512	**CO127**	x		x						x					
	CO128	x		x						x					
	CO129	x		x			x			x					
	CO130	x		x			x			x					
	CO131	x		x						x					
	CO132				x		x	x		x					
	CO133				x		x	x		x					
PHY 513	**CO134**				x		x	x		x					
	CO135				x		x	x		x					
	CO136				x		x	x		x					
	CO137				x		x	x		x					
	CO138	x								x					
	CO139	x								x					
	CO140	x								x					
PHY 514(A)	**CO141**	x								x					
	CO142	x								x					
	CO143		x	x						x					
	CO144	x		x						x					x
	CO145	x		x						x					x
PHY 514(B)	**CO146**	x		x						x					x
	CO147	x		x						x					x
	CO148	x		x			x			x					x
	CO149			x						x					x
	CO150	x	x			x		x		x		x			
PHY 515	**CO151**	x	x	x		x		x		x		x			
	CO152	x	x	x		x		x		x		x			
PHY 516	**CO153**		x			x				x		x			
	CO154		x							x		x			
	CO155		x			x				x		x			
	CO156								x		x				
	CO157	x								x					
	CO158	x								x					
PHY 611	**CO159**	x								x					
	CO160	x		x			x			x					
	CO161	x		x						x					

	CO162	x		x						x					
	CO163	x		x						x					
PHY 612	**CO164**	x		x						x		x			
	CO165	x		x						x		x			
	CO166	x		x						x		x			
	CO167	x		x						x		x			
	CO168	x		x		x	x			x		x			
PHY 613	**CO169**	x		x						x				x	
	CO170	x		x						x				x	
	CO171	x		x						x				x	
	CO172	x		x						x				x	
	CO173	x		x						x				x	
	CO174			x						x				x	
PHY 614(A)	**CO175**	x		x						x				x	
	CO176	x		x		x				x				x	
	CO177	x		x						x				x	
	CO178			x						x				x	
PHY 614(B)	**CO179**	x		x						x					x
	CO180	x		x						x					x
	CO181	x		x						x					x
	CO182	x		x						x					x
	CO183			x						x					x
PHY615	**CO184**	x				x				x		x			
	CO185	x				x				x		x			
	CO186	x				x				x		x			
	CO187	x				x				x		x			
PHY616	**CO188**	x	x			x		x		x		x			
	CO189	x	x	x		x		x		x		x			
	CO190	x	x	x		x		x		x		x			
	CO191	x	x			x		x		x		x			
	CO192	x	x	x		x		x		x		x			

B.Sc. (H) Physics (2020-2021)
COURSE OUTCOMES - Semester I

PAPER CODE-PHY 111
Mechanics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

To acquaint the students with the fundamental laws and principles involved in motion and to introduce some physical properties of matter like inertia, elasticity etc. so that they develop abilities and skills that are relevant to the study and practices of Physics related to general properties of physical bodies. After completing a course on Mechanics, the students will acquire abilities to apply its knowledge to basic problems of the physical world.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 111	**Mechanics (Theory)**	**The students will be able to –** **CO1:** Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. **CO2:** Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull. **CO3:** Understand the phenomena of collisions and idea about center of mass and laboratory frames and their correlation. **CO4:** Apply Kepler's law to describe the motion of planets and satellite in circular & elliptical orbit, through the study of law of Gravitation. **CO5:** Describe special relativistic effects and their effects on the mass and energy of a moving object. **CO6:** Understand the principles of elasticity through the study of Young Modulus, modulus of rigidity, torsion of a cylinder & Bending of beam.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Demonstration, problem solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, numerical solving ,Seminar presentation.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I: Physical Laws and Frames of Reference **9 Hrs.**

Inertial and non inertial frames, examples, Transformation of displacement, velocity and acceleration between different frames of reference involving translation in uniform motion, Galilean transformation and invariance of Newton's laws, Transformation equations of displacement velocity and acceleration for rotating frames, Fictitious forces (Coriolis force and centrifugal force), effects of Centrifugal and Coriolis forces due to earth's rotation, Focault's pendulum.

Unit II: Centre of mass **9 Hrs.**

Centre of mass of a two particle system, motion of centre of mass and reduced mass conservation of linear momentum, elastic and inelastic collision of two particles in laboratory and center of mass frames, motion of a system with varying mass, Angular momentum conservation with examples, charged particle scattering by nucleus.

Unit III: Motion under central forces **9 Hrs.**

Motion under central forces, gravitational interaction, general solution under gravitational interaction, discussion of trajectories, cases of elliptical and circular orbits, Keplers laws.

Unit IV: Special theory of relativity **9 Hrs.**

Postulates of special theory of relativity, Lorentz transformations, length contraction, Time dilation, transformation and addition of velocities, Relativistic Doppler's effect, space- like space time interval, time-like space time interval.

Unit V: Elastic Properties of Matter: **9 Hrs.**

Elastic constants: Young's Modulus, Bulk Modulus, Modulus of Rigidity, Poisson's ratio. Relations between the elastic constants, torsion of a cylinder.Bending of beams: Bending moment, Cantilever, Potential energy and oscillation of a loaded cantilever, cantilever loaded at one end (i) when weight of beam is negligible (ii) When weight is considered, Beam supported at both ends and loaded in the middle, Experimental determination of elastic constants (Y, η ,σ).

BOOKS RECOMMENDED:

- "Elements of Mechanics", Gupta, Prakash and Agrawal, Pragati Prakashan, Meerut.
- "Elements of Mechanics", J.C.Upadhyaya ,Himalaya Publishing House,2006.
- Fundamental University Physics", Vol. I and II, Addison Wesley, Reading Mars, LISA.
- "Berkley Physics Course", Vol. I, Mc. Graw Hill, New York.
- "The Feynmann Lectures in Physics", Vol. 1, R. P. Feynman, R.B. Leighton and M. Sands , B.I. Publications, Bombay, Delhi, Calcutta, Madras.
- "Physics",Part 1, David Halliday and Resnick , John Wiley and Sons, Inc. Newyork.
- "Properties of Matter", D.S.Mathur, S.Chand & Company.

PAPER CODE-PHY 112
Electromagnetism
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to
This course will acquaint the students with the scalar and vector fields, gradient, divergence, curl and their physical significance. Students will also learn about the fields produced by moving charges and magnetic fields in matter, electromagnetic induction, Maxwell's equations and electromagnetic waves. This course will provide the student the ability to apply its knowledge to problems related to electromagnetic fields and waves.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 112	**Electromagnetism (Theory)**	**The students will be able to –** **CO7:** Explain and evaluate the Gradient of a scalar quantity, Divergence and Curl of a vector quantity. **CO8:** Apply Poisson's and laplace's equation to solve a variety of problems. **CO9:** Articulate knowledge of magnetic forces to calculate various forces between different types of static and moving charges. **CO10:** Derive Biot Savart's law and apply it to find the magnetic field due to various types of current carrying elements. **CO11:** Describe the moments of charge distribution and the effect of dielectrics on different system of charges. **CO12:** Explain the relation between atomic polarizability and electric susceptibility.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Demonstration, problem solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, numerical solving	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO13: Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media. **CO14:** Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density. **CO15:** Course will equip the students with required prerequisites to understand electrodynamics phenomena.	,Seminar presentation.	

CONTENTS

Unit I: Scalar and vector fields **9 Hrs.**

Partial derivatives, Gradient of a scalar function. Line integral of a vector field, Divergence and Curl of a vector field, Physical significance of divergence & curl and their expressions in Cartesian coordinates, Gauss divergence theorem, Stokes curl theorem, Laplacian operator, Poisson's and Laplace's equation.

Unit II: Dynamics of a charged particle **9 Hrs.**

Magnetic forces, Invariance of charge, Electric field measured in different frames of reference, Field of a point charge moving with constant velocity, Interaction between a moving charge and other moving charges.

Unit III: Magnetostatics: **9 Hrs.**

Ampere's law in differential form, Magnetic Vector Potential, Poisson's equation for vector potential, magnetic field due to a current carrying wire and deduction of Biot-Savart's law.

Electric current due to an orbiting electron, Bohr Magneton, Orbital gyro magnetic ratio, Electron spin and spin magnetic moment, magnetic susceptibility, magnetic field caused by magnetized matter, Magnetization current, Free current its H field.

Unit IV: Electrostatics and dielectrics: **9 Hrs.**

Moments of a charge distribution, Atomic and molecular dipoles, Atomic Polarizability, Permanent dipole moment, Dielectrics, capacitor filled with dielectric, the potential and field due to a polarized sphere, dielectric sphere in a uniform electric field, The electric field of charge in dielectric medium and Gauss law, Relation between electric susceptibility and atomic polarizability, Polarization due to changing electric field. The bound charge current.

Unit V: Maxwell's equations and electromagnetic waves: **9 Hrs.**

Faraday's laws of electromagnetic induction, its integral and differential form, Maxwell's displacement current, Maxwell's equations in differential and integral form. Poynting's theorem ,Wave equation , EM waves in a non-conducting dielectric medium, Plane monochromatic waves in a non-conducting medium, Energy flux in a plane electromagnetic wave, Radiation pressure.

BOOKS RECOMMENDED:

- "Electricity and Magnetism with Electronics", K.K.Tewari, S.Chand & Co. Ltd. (2001)
- "Electricity and Magnetism", D.Chattopadhyay, P.C.Rakshit, New Central Book Agency (P) Ltd.
- "Elements of Electromagnetics", Mathew, N.D. Sadika, New Delhi, Oxford University Press.
- "Electricity and Magnetism", W.J.Duffin , Mc Graw Hill Book Co., Fourth edition.
- "Electromagnetics", B.B.Laud ,New Age International Publishers, Second edition.
- "Electromagnetic theory and electrodynamics", Satya Prakash, Kedar Nath Ram Nath & Co. Publishers, Meerut, Ninth edition.
- "Physics Part 2",D.Halliday and R.Resnick, John Wiley and Sons, Inc. Newyork.
- "Principles of Electricity and Magnetism",S.Palit, Narosa Publishing House.

PAPER CODE-PHY 113
Electrical Technology
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to

This course aims to develop the fundamental knowledge of electrical technology by learning various topics viz. DC circuits, Electromagnetism, AC fundamental, Transformers, DC Machines. Students develop ability to deal with electrical circuits and appliances.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 113	**Electrical Technology (Theory)**	**The students will be able to –** **CO16:** Understand the concepts of open and short circuit and apply	**Approach in teaching:** Interactive Lectures,	Class test, Semester end

		different network theorems to solve or analyze the basic electrical circuits. **CO17:** Analyze the response of series and parallel circuits and Phasor diagram. **CO18:** Learn the three phase AC circuits, Transformer and the working of various DC machines. **CO19:** The student will develop capability of designing A.C. and D.C. electric circuits for specific purposes and study the same and put to application.	Discussion, Tutorials, Reading assignments, Demonstration, problem solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation.	examinati ons, Quiz, Solving problems , Assignme nts, Presentat ions

CONTENTS

Unit I **9 Hrs.**

Open and short circuits, Kirchoff's laws, DC Networks: Node Voltage and Mesh Current Analysis; Source Conversion. Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power Transform

Unit II **9 Hrs.**

Single Phase AC Circuits:, EMF Equation, Average, RMS and Effective Values. RLC Series,

Parallel and Series, Parallel Circuits, Complex Representation of Impedances. Phasor Diagram, Power and Power Factor

Unit III **9 Hrs.**

Three Phase A.C. Circuits: Delta-Star and Star-Delta Transformation, Line & Phase Quantities, 3-Phase Balanced Circuits, Phasor diagram, Measurement of Power in Three Phase Balanced Circuits

Unit IV **9 Hrs.**

Transformer: Magnetic coupled circuits, Dot convention for coupled circuits, coefficient of coupling, mutual inductance, EMF Equation, Voltage & Current, Relationship and Phasor Diagram of Ideal Transformer

Unit V **9 Hrs.**

Introduction to principle of DC Machines, synchronous machines and induction motors, single phase and three phase induction motor, dynamo, alternator, inverter

BOOKS RECOMMENDED

- Valkenburg Van M.E.: Networks and Analysis: PHI Pvt. Ltd. New Delhi, 3rd Edition 1998.
- Choudhary D Roy: Network and system: New Age International (P) Ltd. 1st Edition 1991.
- Edminister Joseph A. : Theory and problem of Electrical Circuits in SI Units:

PAPER CODE-PHY 114
Computer Programming
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This module is designed to acquaint the students with the basics of C++ programming language, a useful tool to investigate theoretically problems in different areas of Physics.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 114	**Computer Programming** **(Theory)**	**The students will be able to –** **CO20:** Describe and compare machine language and a high level language; source code, object code and executable code. **CO21:** Understand the concept of data abstraction and encapsulation and describe the function of the compiler in the language translation process. **CO22:** Demonstrate an understanding of algorithms in the problem-solving process, Identify the	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration. Solving problems in tutorials. **Learning activities for the students:** Self-learning assignments,	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		necessary properties of good problem-solving techniques. **CO23:** Create and analyze algorithms for solving simple problems. **CO24:** Apply techniques of structured (functional) decomposition to decompose problem and a program solution into smaller pieces. **CO25:** Design and implement code that includes the reuse of both existing code and calling functions in the C/C++ libraries. **CO26:** Demonstrate an understanding of scope, lifetime and duration rules for variables and functions. **CO27:** Learn how to overload functions and operators in C++. **CO28:** The student will develop sufficient knowledge of programming with C/C++, so as to write down programs for different Physics related problems and run to same to obtain useful output.	Effective questions, Simulation, Seminar presentation, performing given tasks, practicals, small animated games develop Additional learning through MOOCs course on SWAYAM/NPTEL	

CONTENTS

Unit I **9 Hrs.**

Introduction to OO Paradigm, Structured Versus object oriented programming, Objects and Class, features of object oriented language(encapsulation ,data abstraction ,inheritance, Object composition, Polymorphism)Merits & demerits of OO methodology, Hello World Program and C++ program structure.

Data Types, Operators: Tokens ,identifiers and keywords, data types and size, Variables , Variable definition and initialization, constants, Operators (Arithmetic, Relational ,logical , Compound assignment, Increment ,decrement and conditional operator).

Unit II **9 Hrs.**

Expression and Precedence : Arithmetic, Relational, logical Expression, Operator Precedence and associatively, promotion and type casting, Different types of comments

Control Flow: Statement and blocks, if statement, if–else statement, Nested if–else statement, Switch statement, Break, continue statement, While, for and do-while loops, Scope and Visibility control Modifier.

Arrays and Functions: Arrays, operations on Arrays, Multi-Dimensional Arrays, Strings, Strings manipulations and Arrays of strings, functions, Parameter passing, Return by reference, inline functions, Arrays and functions. Library functions.

Unit III **9 Hrs.**

Data Structure: One and two Dimensional arrays: Sequential allocation and address calculation; One dimensional array: Traversal, Searching (Linear, Binary Search), Insertion of an element in an array, deletion of an element from an array, Sorting (Insertion,Selection, Bubble sort), concatenation of two linear arrays, merging of two sorted arrays; Two-dimensional arrays: Traversal, Finding sum/difference of two nxm arrayscontaining numeric values, Interchanging Row and Column elements in a twodimensional array;

Stack (Array and Linked implementation of Stack):Operations on Stack (PUSH and POP) and its Implementation in C++,Converting expressions from INFIX to POSTFIX notation and evaluation of Postfix expression.

Queue: (Circular Array and Linked Implementation):Operations on Queue (Insert and Delete) and its Implementation in C++.

Unit IV **9 Hrs.**

Classes and Objects: Class specification, Class Objects, Accessing Class Members, Constructors, parameterized constructors, constructor overloading, copy constructor, Order of Constructor and destructor, Static data members. Defining member function outside member function as inline, Accessing Member function within class, Data Hiding ,Passing object to functions and returning Objects from functions, friend functions and friend classes.

Unit V **9 Hrs.**

Inheritance: Introduction, Form of inheritance, Derive class declaration, inheritance and member accessibility, Constructor invocation, Function overloading, Member function overloading, Multi level inheritance, Multiple inheritance, Multi path inheritance, Hybrid Inheritance.

BOOKS RECOMMENDED

- SumitaArora&GautamSarkar, "Computer Science C++" ,DhanpatRai& Co,1999.
- A.R.Venugopal, Rajkumar, T. Ravishanker, "Mastering C++", TMH, 1997.
- YashwantKanetkar , "Let us C++", BPB Publications
- R. Lafore, "Object Oriented Programming using C++", Galgotia Publications, 2004.
- D .Parasons, "Object Oriented Programming with C++", BPB Publication.
- Schildt Herbert, "C++: The Complete Reference", 4th Ed., Tata McGraw Hill, 1999.
- S. B. Lippman& J. Lajoie, "C++ Primer", 3rd Edition, Addison Wesley, 2000.

PAPER CODE-PHY 115
Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course will enhance the basic learning skills of students. This will enable them to plan and execute experiments, handle scientific equipment safely and to the appropriate limit of accuracy. It will provide students the knowledge of errors committed and precision of measurements.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 115	**Lab Course I (Practical)**	**The students will be able to –** **CO29:**Demonstrate measurement skills in a physics laboratory **CO30:** Analyze the measurement results to draw valid conclusions with honesty. **CO31:** Have oral and written scientific communication, and think critically and work independently. **CO32**: Develop the skill to determine elastic constants like Young's modulus , modulus of rigidity etc by different methods **CO33:** Understand the concept of conversion of galvanometer to ammeter and voltmeter ,R-C circuit, LR circuit, specific resistance ,electromagnetic induction ,charging and discharging of a condenser, Carey Foster's bridge and	**Approach in teaching:** Demonstration, Group activity, Discussion, Conduction of Experiments, asking Viva-voce questions. **Learning activities for the students:** Performing Experiments, observations, Analysis and interpretation of results	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		Faraday's Law by performing experiments.		

CONTENTS

List of Experiments

1. Study of bending of a beam and determination of Young's modulus.
2. Determine the modulus of rigidity using Maxwell's needle.
3. Elastic constants by Searl's method.
4. Determine specific resistance of wire and low resistance using Careyfoster's bridge.
5. Conversion of Galvanometer into an ammeter and to calibrate it.
6. Conversion of Galvanometer into an voltmeter and to calibrate it.
7. To study the characteristics of a Junction Diode.
8. Determine the surface tension of a given liquid at room temperature using Jaeger's method.
9. To determine the height of a building using a sextant.
10. To determine self- inductance of a coil by Rayleigh's method

PAPER CODE-PHY 116
Lab Course II
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course will enable students to do experiments on the fundamental laws and principles, and gain experience of using a variety of measuring instruments and develop experimental skills. This course also introduces to them the basics of programming in C++. The student develops the ability to write programs in C++ on problems related to Physics.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY-116	**Lab Course II** **(Practical)**	**The students will be able to –** **CO34:** To understand the given concepts and its physical	**Approach in teaching:** Demonstration, Group activity,	Class test, Semester end examinations, Quiz, Solving

		significance also to acquire problem solving skills and to create more problems based on physical concepts of capacitor and Galvanometer. **CO35:** To understand the concept of operators, arrays and role of structure and pointer in the program. **CO36:** To develop a greater understanding of the issues involved in programming language design and implementation. **CO37:** To Write C program for simple applications of real life using array and structure and to run the same on computer.	Discussion ,Conduction of Experiments, asking Viva-voce questions. **Learning activities for the students:** Performing Experiments, observations, Analysis and interpretation of results, Performing experiments ,Team activity, simulation, small animated games to develop Additional learning through MOOC courses.	problems , Assignments, Presentations

CONTENTS

List of Experiments

1. Study of a charging and discharging of a capacitor through a resistance.
2. Study the Electromagnetic induction and to verify Faraday's law.
3. To study the random error in observations.
4. Determine a high resistance by leakage method using Ballistic Galvanometer.
5. Measurement of field strength B and its variation in a Solenoid (determine dB/dx).
6. Loop statement using for, while, do-while statement, conditional checking using if statement, nested if statement, switch statement and unconditional goto.
7. Problems based on array data types. Problems on One Dimensional array searching (Linear, Binary) sorting (bubble, selection, insertion), Merging.
8. Problems on two dimensional Array-Matrix Operation: Addition, Subtraction, multiplication etc.
9. Problems based on pointers, parameter passing in functions, Recursion.
10. Declaration, reading, writing and manipulation on struct and union data type, File handling, Command Line Arguments

COURSE OUTCOMES - Semester II

PAPER CODE-PHY 211
Oscillations and Waves
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
To familiarize the students with motion of different types of oscillators and also with wave motion in different medium. This will enable the students to develop abilities and skills to solve problems related to waves and oscillations and apply the same to practical situations.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 211	**Oscillations and waves (Theory)**	**The students will be able to –** **CO38:** Understand physical characteristics of SHM, and obtaining solution of the oscillator using differential equations **CO39:** Solve for the solutions and describe the behavior of a damped, driven and coupled harmonic oscillator in both time and frequency domains. **CO40:** Understand and implement Fourier series. **CO41:** Calculate logarithmic decrement relaxation factor and quality factor of a harmonic oscillator.	**Approach in teaching:** Demonstration , Group activity, Discussion ,Conduction of Experiments, asking Viva-voce questions. **Learning activities for the students:** Performing Experiments, observations, Analysis and interpretation of results, Performing experiments ,Team activity, simulation,	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO42: Solve wave equation and understand significance of electromagnetic waves . **CO43:** Gain knowledge on applications of transverse and longitudinal waves.	small animated games to develop Additional learning through MOOC courses.	

CONTENTS

Unit I: Simple harmonic and damped oscillator **9 Hrs.**

Simple harmonic motion, Differential equation of simple harmonic motion, examples:-mass on a spring, Torsional oscillator. LC Circuit, Potential energy curve and small oscillations in one dimensional potential well, Energy of oscillations, mass and two spring system.

Damped harmonic oscillator, Mathematical formulation of damped harmonic oscillator, Energy of damped oscillator, Power dissipation, Relaxation time, Quality factor of damped harmonic oscillator

Unit II: Driven harmonic oscillator: **9 Hrs.**

Driven harmonic oscillator , Mathematical formulation of driven harmonic oscillator , Frequency response on amplitude and phase, Quality factor of driven oscillator, Resonance, Sharpness of resonance, Power absorption by forced oscillator, Series and parallel LCR circuit.

Unit III: Coupled oscillators **9 Hrs.**

Equation of motion of two coupled simple harmonic oscillators, Normal modes, motion in mixed modes ,dynamics of a linear chain of coupled oscillators with nearest neighbor interaction, Energy transfer between modes, Electrically coupled circuits (capacitive and inductive), Reflected impedance, effect of coupling and resistive load.

Unit IV: Lattice vibrations and Fourier analysis: **9 Hrs.**

Equation of motion for one dimensional monatomic and diatomic lattice, acoustic and optical modes, dispersion relation, concept of group and phase velocities, Fourier Analysis of square, saw tooth and triangular wave forms.

Unit V: Wave motion: **9 Hrs.**

Wave equation, Transverse waves in a string, Elastic waves in a solid rod, Pressure waves in a gas column, Plane electromagnetic waves, Energy and Momentum of EM waves, Radiation pressure,Radiation resistance of free space.

BOOKS RECOMMENDED

- "The Physics of Waves and Oscillations", N.K.Bajaj, Tata Mc Graw Hill Publishing Co., 2003.
- "Oscillations, waves and electromagnetism", Satya Prakash, Pragati Prakashan, Meerut.

- "Fundamental University Physics", Vol I and II , M.Alonso & J.Finn, Addisson Wiesley.
- "Vibrations and Waves", A.P. French, CBS Publication and Distributors.
- "Berkeley Physics Course", Vol. I , New York, Mc Graw Hill.
- "Vibrations and waves", I.G. Main ,Cambridge University Press.
- "The Physics of Vibrations and Waves", H.J.Pani, John Wiley & Sons.
- "Fundamentals of vibrations and Waves", S.P.Puri, Tata Mc. Graw Hill Pub. Co.,NewDelhi.
- "Oscillations and Waves",K.S.Sharma, M.K.Saxena and G.R.Chhabra ,Rajasthan Hindi Granth Academy, Jaipur.
- "Waves and Oscillations",N.Subramanyam,Vikas Publishing house.

PAPER CODE-PHY 212
Optics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course familiarizes the students with the phenomenon of interference, diffraction, polarization, LASER and holography to enable them to acquire sufficient understanding and knowledge to recognize the usefulness of these phenomena of light in everyday life and to stimulate their interest in Physics. Further, the students also acquire knowledge of working principles and applications of LASER in Industry, Science and Technology.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 212	**Optics** **(Theory)**	**The students will be able to –** **CO44:** Understand the concept of Fermat's principle and apply it to prove laws of reflection and refraction, Refraction at a spherical surfaces and cardinal points. **CO45:** Acquire Knowledge of interference and learn about	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		Young's double slit experiment, Newton's rings, Michelson interferometer and its Applications. **CO46:** A brief idea about Fresnel and Fraunhoffer diffraction, zone plate and a convex lens and their relations to solve the problems. **CO47:** Knowledge of electromagnetic waves, Polarization and Optical activity to solve the problems. **CO48:** Differentiate ordinary ray from LASER ray, knowledge about lasers and Holography .	**Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation.	

CONTENTS

Unit I: Geometrical Optics **9 Hrs.**
Fermat's principle extremum path, Laws of reflection and refraction from Fermat's principle, Refraction at a spherical surfaces (convex surface and concave surface) cardinal points ,construction of a image using cardinal points, Newton's formula; Relationship between f_1 and f_2 ;Relationship between f_1 , f_2 , μ_1 and μ_2, Cardinal points of a coaxial system of two thin lens.

Unit II: Interference: **9 Hrs.**
Young's double slit experiment, types of interference: division of amplitude, division of wave front, Coherence: temporal and spatial coherence, Interference in thin films, colour in thin films, Newton's rings, Determination of wavelength and refractive index of liquid by Newton's rings, Michelson interferometer, Applications of Michelson interferometer: determination of wavelength, difference of wavelength and thickness of thin films.

Unit III: Diffraction: **9 Hrs.**
Fresnel diffraction: Fresnel's assumptions, Half period zones, Distinction between interference and diffraction, Difference between Fresnel and Fraunhoffer diffraction, , diffraction at a circular aperture, straight edge and thin slit, zone plate, difference between zone plate and a convex lens.
Franunhoffer diffraction: Diffraction at single slit, Diffraction at double slit, Diffraction at N slits(simple derivation), plane diffraction grating, dispersion by a grating, resolving power of a grating.

Unit IV: Polarization: **9 Hrs.**
Plane electromagnetic waves. E and B of linearly, circularly, elliptically polarized electromagnetic waves.
Polarization by reflection, Huygens theory of double refraction, production and Analysis of plane, circularly and elliptically polarized light, Quarter and half wave plate.
Optical activity, specific rotation, Biquartz and half shade polarimeters.

Unit V: LASER and holography: 9 Hrs.

Difference between ordinary and LASER source, stimulated and spontaneous emission, Einstein A and B coefficients, Population inversion, Principle of laser action, Metastable states, Pumping, types of LASER, construction, working and energy levels schemes of He-Ne and Ruby laser, Applications of LASER.
Basic concepts of holography, construction of hologram and reconstruction of image, important features of hologram and uses of holography.

BOOKS RECOMMENDED

- "A textbook of Optics", Brijlal and Subramaniam, S.Chand & Company Ltd.,23rd edition.
- "Essentials of Lasers and non-linear Optics",G.D.Baruah, Pragati Prakashan, Meerut.
- "Text books of Optics and Atomic Physics", D.P. Khandelwal, Himalaya Publishing House.
- "Optics", Ajoy Ghatak ,Tata Mc Graw Hill Pub.Co. Ltd, 2007.
- "Physics Part II", D.Halliday and R.Resnick, John Wiley & Sons, Inc., Newyork.
- "LASERS: Theory and Applications", K.Thyagrajan, A.K.Ghatak, Macmillan India Ltd.

PAPER CODE-PHY 213
Basic Instrumentation
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course is to get exposure with various aspects of instruments and their usage through hands-on mode. The student learns working of various sophisticated and electronic measuring instruments like, C.R.O., VTUM, Conversion of Galvanometer in to Ammeter and Voltmeter, multi-meter, colour codes of resistance, capacitors etc., so that he/she can design their own electronic circuits.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 213	**Basic Instrumentation (Theory)**	**The students will be able to –** **CO49:** Expected to have the necessary working knowledge on accuracy, precision, resolution, range and	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments,	Class test, Semester end examinations, Quiz, Solving problems ,

		errors/uncertainty in measurements. **CO50:** Will acquire knowledge of the usage of oscilloscopes, multimeters, rectifiers, amplifiers, oscillators and high voltage probes. **CO51:** Would have gained knowledge on the working and operations of LCR Bridge, generators, multimeter, electronic voltmeter, cathode ray oscilloscope, digital meters and counters **CO52:** Acquire efficiency in understanding the working of signal generators and analysis of output signals. **CO53:** Learn to understand various types of digital instruments. **CO54:** Develop knowledge of measurements with Impedance Bridges and Q meters. **CO54:** This course helps the student to learn handling and proper usage of different types of instruments, understand their working and also to learn to some extent the fault finding and repair of some instruments.	Demonstration. Problem solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation.	Assignments, Presentations

CONTENTS

Unit I: Basic of Measurement **9 Hrs.**

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

UnitII: Electronic Voltmeter **9 Hrs.**

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters. Block diagram ac millivoltmeter, specifications and their significance.

UnitIII:Oscilloscope **9 Hrs.**

Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance. Use of CRO for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: principle of working.

Unit IV: Signal and pulse Generators **9 Hrs.**

Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. Impedance Bridges: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q-Meter. Digital LCR bridges.

Unit V: Digital Instruments **9 Hrs.**

Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time-base stability, accuracy and resolution.

BOOKS RECOMMENDED:

- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

PAPER CODE-PHY 214
Bio Physics I
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course provides knowledge of the operation and principles used in the systems and procedures associated with the clinical track. It acquaints the students with radiation and radioactivity, its properties, units of measure, dosimetry measurement concepts and methods, safe limits of radiations exposure and precautions to work with e.m. radiation and nuclear radiation etc.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 214	**Bio Physics-I** **(Theory)**	**The students will be able to –** **CO55:** Learn about the human body, its anatomy, physiology and bio Physics, exploring its performance as a physical machine. **CO56:** Understand the working of various diagnostic tools , medical imaging techniques and therapeutic applications. **CO57:** Know about the units of radiations and their safety limits, the devises to detect and measure radiation, such as the Geiger-Mueller counter and scintillation counter.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, Power point presentations, Problem solving in tutorials, visit to a medical college/university. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Additional learning	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO58: Learn about radiation safety management, biological effects of ionizing radiation, radiation protection standards, 'International Commission on Radiological Protection' (ICRP) its principles. **CO59:** The student develops background knowledge to take up higher studies/research in inter-disciplinary areas such as application of Physics in Life Sciences etc.	through online Video MOOCs courses .	

CONTENTS

UNIT I **9 Hrs.**

Acoustics of the body : Nature and characteristics of sound, Production of speech, Physics of the ear, ear defects and their corrections.

Optical system of the body: Physics of the eye. Eye defects and their correction

UNIT II **9 Hrs.**

Modern medical imaging systems and therapeutic equipments: Ultrasonic imaging system-principles of ultra sound imaging system, biological effects of ultrasound,haemodialysis machine, portable kidney machine, anaesthesia machine, ventilators.

UNIT III **9 Hrs.**

Biomedical recorders and patient monitoring systems: Electrocardiograph (ECG), Electroencephalograph (EEG),Electromyography (EMG), cardiac monitor,cardiac pacemakers measurement of heart rate, measurement of pulse rate, measurement of blood pressure, blood flow meter, measurement of temperature, blood gas analysers, blood cell counters, oximetry, audiometers and hearing aids.

UNIT IV **9 Hrs.**

Laser applications in biomedical field: radiotherapy and telemedicine LASER- principles of operation, use, types and LASER safety, Radiotherapy- principles, dosage data for clinical applications, Gamma Camera, Positron Emission Tomography, Cobalt-60 machine, Therapeutic application of radio isotopes, application of UV radiation for treatments, biological effects of radiation and ultrasound,

UNIT V **9 Hrs.**

Radiation Safety Management: Principles of radiation protection. Biological effects of radiation, Radiation monitors, Steps to reduce radiation public. International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management.

BOOKS RECOMMENDED

- Medical Physics – J. R. Cameron & J. G. Skofronick.
- Basis Radiological Physics – Dr. K. Thayalam.
- Christenson's Physics of Diagnostic Radiology : Curry, Dowday&Murry.
- Physics of Human body – Irering P. Herman
- Pysics of Radiation Therapy – F M Kahn
- Essential Physics of Medical Imaging
- C. H. Best and N. B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1999.
- C. K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 2001.

PAPER CODE-PHY 215
Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course aims to provide practical knowledge of Physics concepts by applying the Physics theory to different experimental methods and to make them learn the usage of electrical and optical instruments for various measurements. The students will be able to apply the analytical techniques and graphical analysis to the experimental data.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 215	Lab Course I (Practical)	**The students will be able to –** **CO60:** Demonstrate laboratory skills in physics laboratory and analyze the	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments	Class test, Semester end examinations, Quiz, Solving problems ,

		measurements to draw valid conclusions honestly. **CO61:** Have oral and written scientific communication, and to think critically and work independently. **CO62:** Have a deep knowledge of fundamentals of optics and electric circuits.	**Learning activities for the students:** Performing Experiments, observations, Analysis and interpretation of results, Additional learning through online Videos and Virtual Labs.	Assignments, Presentations

CONTENTS

List of Experiments

1. To determine wavelength of sodium light by Grating.
2. To determine wavelength of sodium light by Fresnel's biprism.
3. To determine wavelength of sodium source using Michelson's interferometer.
4. To determine dispersive power of a prism using Mercury light.
5. To determine wavelength of sodium light using Newton's ring.
6. To determine Brewster's angle and refractive index of a glass by using spectrometer and polaroides.
7. To study resonance in a series LCR circuit and determine Q factor of the circuit.
8. To study the variation of magnetic field along the axis of a current carrying circular coil. Plot the necessary graph and hence determine the radius of circular coil.
9. To study the variation of reflection coefficient of nature of termination using torsional wave apparatus.
10. To study dependence of velocity propagation on line parameter using torsional wave apparatus.

PAPER CODE-PHY 216
Lab Course II
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 02
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course will enhance the basic learning skills of students. This will enable them to plan and execute experiments, handle scientific equipment safely and to the appropriate limit of accuracy.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 216	**Lab Course II (Practical)**	**The students will be able to –** **CO63:** Apply knowledge of mathematics and physics fundamentals and instrumentation to arrive at solution for various problems. **CO64:** Learn the Basics Of Instrumentation, Data Acquisition and interpretation of results. **CO65:** Know about accuracy and precision, different types of errors and statistical analysis of data. **CO66:** Apply the analytical techniques and graphical analysis to the experimental data. **CO67:** Practice different types of wiring and instruments connections keeping in mind technical, Economical and safety issues.	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, Observations, Analysis and interpretation of results, Additional learning through online Video and Virtual Labs.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

List of Experiments:

1. To study damping of a compound pendulum and determine the damping coefficient.
2. To determine the value of e/m by magnetic focusing using Thomson's experiments.
3. Familiarization with Geiger-Muller (GM) Counter and to measure background radiation.
4. To determine the mutual inductance of two coils by Absolute method.
5. To study resonance in a parallel LCR circuit and determine Q factor of the circuit.
6. To study the charging of the condenser by unidirectional varying voltage pulses/alternating voltage pulses and then to integrate them.
7. To perform the direct load test on the transformer and plot the curve between efficiency and voltage.
8. Study of frequency of energy transfer as a function of coupling strength using coupled oscillator.
9. To investigate the motion of coupled oscillator and study Lissajous Figures.

10. To determine the charge of an electron by Millikan's Oil drop apparatus.

COURSE OUTCOMES - Semester III

PAPER CODE-PHY 311
Thermodynamics & Statistical Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
To acquaint the students with basic laws of thermodynamics and statistical physics, methods of producing low temperatures, Carnots engine so that they develop the scientific attitude to relate this knowledge to their daily life experiences. They learn about the efficiency and develop an aptitude to design more efficient systems.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 311	**Thermodynamics and Statistical Physics** **(Theory)**	**The students will be able to –** **CO68:** Acquire working knowledge of the zeroth and first law of thermodynamics, identify the relationship and correct usage of infinitesimal work, work, energy, heatcapacity, specific heat, latent heat, and enthalpy. **CO69:** Identify which procedure to be used to produce low temperature and to analyze the difference between Liquid He I and He II. **CO70:** Understand the concepts of microstate, macrostate,	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, Team teaching **Learning activities for the students:** Self learning assignments, Effective questions, Simulation, Seminar presentation, Giving tasks.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		ensemble, phase space, thermodynamic probability and partition function. **CO71:** Learn advanced topics related to Quantum Statistical Mechanics and use the partition function for calculations about the canonical ensemble. **CO72:** Get acquainted with advanced topics such as the Fermi energy of a system of Non-interacting Fermions and its relation to the chemical potential		

CONTENTS

Unit I: Basic Thermodynamics **9 Hrs.**

The Zeroth law, Various indicator diagrams(P-V diagram), First law of thermodynamics, Reversible and irreversible processes, Carnot's engine, Carnot's cycle and efficiency of Carnot's engine, reversibility of Carnot's engine, Carnot's theorem. Second law of thermodynamics, (different statements and their equivalence) Entropy, Principle of increase of entropy, Thermodynamic scale of temperature, Thermodynamic scale as an absolute scale, Third law of thermodynamics.

Unit II: Thermodynamic Relations **9 Hrs.**

Maxwell's thermodynamic relations, Triple point, Clausius Clapyron latent heat equation,Effect of pressure on boiling point of liquids, Helmholtz free energy, Enthalpy, Gibbs function,Internal energy,Thermodynamic potentials, Deduction of Maxwell's relations from thermodynamic potentials.

Unit III: Production of low temperatures: **9 Hrs.**

Joule Thomson expansion and JT coefficient for ideal as well as Vander Waals gas, Porous plug experiment, Temperature of inversion, Regenerative cooling, cooling by adiabatic expansion and demagnetization, liquid He, He I and He II, Peculiar properties of He II, Nernst heat theorem.

Unit IV: Distribution of molecular velocities: **9 Hrs.**

Distribution law of molecular velocities, Most probable, Average and RMS velocities, energy distribution function, Experimental verification of Maxwell velocity distribution, Principle of equipartition of energy.

Mean free path and collision cross section, distribution of mean free path, Transport of mass, momentum and energy and their interrelationship, (coefficient of viscosity ,thermal conductivity & diffusion)

Unit V: Classical Statistics **9 Hrs**

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Phase space, micro and macro states, Thermodynamic probability, relation between entropy and thermodynamic probability, Monatomic ideal gas, specific heat capacity of diatomic gas and specific heat of solids.

Quantum Statistics:

Failure of classical statistics (Blackbody radiation and various laws of distribution of radiation, qualitative discussion of Weins and Rayleigh Jeans Law) Postulates of quantum statistics, Indistinguishability of wave function and exchange degeneracy, Bose Einstein statistics and its distribution function,. Planck's distribution function and radiation formula, Fermi Dirac statistics and its distribution function.

BOOKS RECOMMENDED

- "Heat and Thermodynamics", Singhal, Agarwal and Prakash , Pragati Prakashan.
- "Heat and Thermodynamics", Brijlal and Subramaniam, S. Chand & Sons.
- "Thermodynamics and Statistical Mechanics", S.L.Kakani, Sultan Chand & Sons.
- "Statistical and Thermal Physics", S. Loknathan and R.S. Gambhir, Prentice Hall, New Delhi 1991.
- "Thermodynamics, kinetic theory of gases and Statistical Mechanics", F.W.Sears, G.L.Salinger, Narosa Pub. House.
- "Introduction to Statistical Mechanics", B.B. Laud, Mc Milan India Ltd.
- "Fundamentals of Statistical and Thermal Physics", Federick Reif, Tata Mc Graw Hill, 1992.
- "Heat and Thermodynamics", M.S.Yadav, Anmol Publications.
- "Fundamentals of Statistical Physics", A.K. Das Gupta, New Central Book Company, Calcutta, 2003.

PAPER CODE-PHY 312
Electronics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course aims to develop the fundamental knowledge of electronics by learning various topics viz. circuit analysis**,** network theorems, P-N diode equation, rectifiers, filters, transistors and transistor amplifiers and

their analysis. Students will also learn feedback amplifiers, logic gates and fabrication of IC's. The course helps them to develop skills to design electronic circuits for various applications.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 312	**Electronics (Theory)**	**The students will be able to –** **CO73:** A systematic and coherent understanding of basic Electronics including the concepts and theories. **CO74:** A broad and fundamental understanding of electric circuit elements, dc power sources, diodes, rectifiers, filters, transistors, amplifiers, logic gates and basics of electrical wiring. **CO75:** Knowledge with reference to working of various tools like inductors, capacitors, multi-meter, voltmeter, ammeter etc..	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, problem solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation. Additional learning through online Videos and MOOCs Courses.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I

Basic Circuit Analysis: **9 Hrs.**

Open and short circuits, Impedance, Admittance and Hybrid parameters of any four terminal network, Kirchoff's laws, Mesh and Node analysis.

Various Circuit theorems:

Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transformer theorem and Reciprocity theorem.

Unit II

Semi conductor diode and rectification: **9 Hrs.**

p-n junction diodes, I-V characteristics, diode as a rectifier, half-wave and full-wave rectifiers : calculations of ripple factor, efficiency and regulation , bridge rectifiers.

Filters: Series inductor, shunt capacitor, L-section and π section filters.

Voltage regulation : Zener diode, breakdown voltage (avalanche and zener effect), voltage regulation, voltage multipliers.

Unit III
BJT and amplifiers: **9 Hrs.**

Basic construction of pnp and npn transistors and their operation, Input and output characteristics of CB, CC and CE configurations, active, saturation and cut-off regions, Load line and Q-point, Two-port analysis of a transistor using h-parameters, Analysis of CB, CE and CC amplifier for current gain, voltage gain, input and output impedances using h-parameters,Gain-frequency response of an amplifier.

Unit IV
Feed-back amplifier: **9 Hrs.**

Concept of feed-back, positive and negative feedback, voltage and current feedback circuits (series and parallel circuits).

Advantages of negative feedback: Stabilization of gain, effect on input and output impedances, reduction of non-linear distortion, effect on gain-frequency response.

Oscillators: Barkhausen criterion, RC oscillators, Colpitt's oscillator, Hartley oscillator, crystal oscillators and its advantages.

Unit V
Digital Electronics: **9 Hrs.**

Transistors as a switch, Logic fundamentals: AND, OR, NOT, NAND, NOR, XOR gates. Boolean algebra, De Morgan's theorem, positive and negative logic, Logic gates circuit realization using DTL and TTL logic, Simplification of Boolean expressions.

Integrated Circuit Technology:

Integrated circuit vs. discrete components, Integrated circuit processing, Oxidation, diffusion, photolithography, epitaxy, chemical vapour deposition, Bipolar transistor fabrication.

BOOKS RECOMMENDED:

- "Electronic Devices and Circuits", Jacob Millman and Christos Halkias, TMH , 9th edition.
- "Electronic Fundamentals and Applications", John D. Ryder, Prentice Hall of India Pvt. Ltd.,(1983) New Delhi.
- "Digital Computer Electronics", Albert Paul Malvino, Tata Mc Graw Hill Pub. Co. Ltd., New Delhi.
- "Hand book of Electronics", Kumar and Gupta, Pragati Prakashan, Meerut.
- "Basic Electronics and Solid State", B.L. Theraja, S.Chand, 2002.
- "Integrated Electronics, Analog and Digital circuits and systems", Millman & Halkias, Mc Graw Hill Ltd. (1972).
- "Electronic devices and circuits" , Soni and Gupta, Dhanpat Rai and Sons.
- "Basic Electronics and Linear circuits", Bhargava and Kulshreshtha, TMH ,1984.

- "Principle of Electronics" (for numerical problems) V.K. Mehta, S.Chand ,2002.
- "Basic Electronics", Kal, Prentice Hall of India, 2002.
- "Electronic Devices and Circuit Theory", Robert Boylestad and Nashelsky, Prentice Hall of India, Fifth edition.
- "Engineering Electronics", John D Ryder, Mc Graw Hill Book Co.

PAPER CODE-PHY 313
Laser & Optical Fiber
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to –
This paper introduces the principles of lasers. The use of lasers in different areas of physics, and spectroscopy with lasers compared to other forms of spectroscopy, optical fibers and fiber optic communication. The student learns principles of LASER and its generation to a greater depth and applications of LASER in different fields, including scientific experiments. Further the study of Fibre optics helps them to learn the basics of optical communications, replacing the earlier methods of electronic communication all over the world.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 313	**Laser & Optical Fiber** **(Theory)**	**The students will be able to –** **CO76:** Understanding above the Laser, Optical Resonators, Three level and four level systems. **CO77:** A brief idea about Types of LASER and output modulation methods to use in various Principles and applications.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, problem solving in tutorials. **Learning activities for the students:**	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO78: Understanding above Application of laser and Holography to solve problems. **CO79:** Learn about the Basic characteristics of optical fiber, classification of fibers and fabrication techniques of fibers to solve problems. **CO80:** Knowledge of Optical Fiber Communication used in various systems and applications. **CO81:** The student acquires the required knowledge to work with LASERs for various scientific experiments and use of optical fiber in communications.	Self learning assignments, Effective questions, Seminar presentation. Additional learning through online Videos and MOOCs Courses.	

CONTENTS

Unit-I : LASER Physics **9 Hrs.**

Basic Principle of Laser, Einstein Coefficients, condition for light amplification, Population Inversion, Threshold Condition, Line shape function, Optical Resonators, Three level and four level systems.

Unit-II: Types of LASER and output modulation methods **9 Hrs.**

Solid State lasers, Ruby and Nd-YAG Laser, Gas lasers, He-Ne and Co2 lasers, semiconductor lasers, Heterojunction lasers, Liquid Dye lasers, Q switching and mode locking.

Unit-III: Applications of LASER **9 Hrs.**

Application of laser in industry, cutting and welding, Drilling, surface Hardening, Medical applications, laser as diagnostic and therapeutic tool, Holography, Theory of recording and reconstruction, application of Holography.

Unit-IV: Optic fiber **9 Hrs.**

basic characteristics of optical fiber, acceptance angle, numerical aperture, propagation of light through optical fiber, theory of mode formation, classification of fibers, step index and graded index fibers, single mode and multi mode fibers , losses in fibers, fabrication techniques of fibers.

Unit-V: Optical Fiber Communication **9 Hrs.**

Source and detectors for Optical Fiber communication, Laser and LED, Analog and digital modulation methods, Principle of optical detection, pin and APD photodetectors, Noise, Design consideration of a Optical Fiber communication system.

BOOKS RECOMMENDED:

- "Laser theory and applications" by K. Thyagarajan and Ajoy Ghatak, Cambridge University Press, 1999.
- "An Introduction to laser: Theory and Applications" by M. N. Avadhanulu, S. Chand and Co., New Delhi 2001.
- "Introduction to Fiber optics" by K. Thyagarajan and Ajoy Ghatak, Cambridge University Press, 1999.
- "Optical Fiber communications" by John M. Senior, Cambridge University Press, 1996
- "Fiber-Optic communication systems", Govind P. Agrawal, John-Willey & Sons.

PAPER CODE-PHY 314
Bio-Physics II
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper provides opportunity to student to learn various aspects of X-ray imaging, radio-isotopes and radio-activity, eye defects etc. The student can make use of this knowledge in practical life and professionally if put on duty in a hospital or a diagnostic centre after completions of graduation.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 314	**Bio Physics-II** **(Theory)**	**The students will be able to –** **CO82:** Focus on the application of Physics to clinical medicine **CO83:** study diagnostic and therapeutic applications like the X-ray technology and magnetic resonance imaging.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, Power point presentations, Problem solving in tutorials, visit to a	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO84: Gain knowledge of theoretical and experimental approaches to study protein folding , Structure of Proteins and Nucleic Acids. **CO85:** Have an introduction to Membrane Biophysics and Molecular Forces in Biological Structures **CO86:** The student acquires enough background knowledge to take up higher studies/research in inter-disciplinary areas involving Physic and Life Sciences.	Medical College/University. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation. Additional learning through Online Videos and MOOCs Courses.	

CONTENTS

Unit I **9 Hrs.**

principles of NMR imaging systems, biological effect of NMR imaging, advantages of NMR imaging system, cryo electron microscopy; High resolution light microscopy, Atomic Force Microscopy, Single molecule manipulation.

Unit II **9 Hrs.**

X-Rays: Electromagnetic spectrum. Production and Properties of X-rays, harmful effects of X-rays. X-Ray Imaging, Construction, function and operation of compute and digital radiographic systems.X ray tube and x-ray beam.Image receptors for computed and digital radiography.Scatterrejection.Contrast media – iodine, barium and air.Dual energy radiography.Film screen radiography,Mammography,Radiographictomography and tomosynthesis

Unit III **9 Hrs.**

Theoretical and experimental approaches to study protein folding; Introduction to Membrane Biophysics.Structure and function of membranes, experimental and theoretical tools for studying biological membrane.

Unit IV **9 Hrs.**

Structure of Proteins and Nucleic Acids**:** Primary and secondary structure, Ramachandran plot, conformational analysis, tertiary structure, structure of a nucleotide chain, the DNA double helix model, polymorphism.

Unit V **9 Hrs.**

Molecular Forces in Biological Structures: Electrostatic interactions, hydrophobic and hydrophilic forces, hydrogen bonding interactions, ionic interactions, stabilizing forces in proteins and nucleic acids, steric interactions.

BOOKS RECOMMENDED

- Spectroscopy for the Biological Sciences: Gordon G; Wiley-Interscience; 1st edition; 2005.
- Biophysical Chemistry: Part II: Techniques For The Study Of Biological Structure and Function by Charles R. Cantor and Paul Reinhart Schimmel; pp 503. W H Freeman and Co, Oxford. 1980.
- Cantor, C. R., and Schimmel, P., Biophysical Chemistry (parts I, II and III), W. H. Freeman, 1980.
- Serdyuk, I. N., Zaccai, N. R.,andZaccai, J.,Methods in Molecular Biophysics: Structure, Dynamics, Function, Cambridge, 2007

PAPER CODE-PHY 315
Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course will enhance the basic practical learning skills of students-learning by doing. This will enable them to plan and execute experiments, handle scientific equipment safely and to the appropriate limit of accuracy.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 315	**Lab course I (Practical)**	**The students will be able to –** **CO87:** Assess the validity of physical theories through the design and execution of an	**Approach in teaching:** Demonstration, Group activity, Discussion	Class test, Semester end examinations, Quiz, Solving problems ,

		experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). **CO88:** Be able to demonstrate lee's method and platinum resistance thermometer. **CO89:** Be able to handle useful equipment's relate8 to electronics like transistor, Amplifier, logic gates.	,Conduction of Experiments **Learning activities for the students:** Performing Experiments, Observations, Analysis and interpretation of results, Additional learning through online Video/ Virtual Labs.	Assignments, Presentations

CONTENTS

List of Experiments

1. Using platinum resistance thermometer, find the melting pint of a given substance.

2. To determine thermal conductivity of a bad conductor by Lee's method.

3. To determine 'J' by Calender and Barne's method.

4. Determine the thermodynamic constant = C_p/C_v using Clement's and Desorm's method.

5. Study of variation of total thermal radiation with temperature.

6. To plot thermo emf versus temperature graph for Cu-Fe thermo couple and to determine temperature of a hot source (use sand bath).

7. To study the variation of power transfer to different loads by a D. C. source and to verify maximum power transfer theorem.

8. To study characteristics of a given transition PNP/NPN (CE, CB & CC configuration).

9. To verify laws and network theorems in D C circuits.
10. Study of half wave rectification using single diode and application of L & π section filters.

PAPER CODE-PHY 316
Communication Skills: Seminar
(Seminar)

Credits: 02
Max Marks: 100
Contact Hrs/week: 02
Total Hrs: 30

Course Objectives:

This course will enable the students to -
This course aims to develop necessary skills in the following areas :

- Written Communication
- Oral Communication
- Critical Thinking
- Quantitative Analysis
- Research Methodology
- Information and Communication
- Use of Computer & ICT

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 316	**Seminar**	**The students will be able to –** **CO90:** understand the importance of experimental and theoretical analysis. **CO91:** develop a Scientific approach in solving problems related to physics. **CO92:** Conceptualize and implement the project independently and give presentation on findings **CO93:** Write scientific papers	**Approach in teaching:** Interactions, Discussion. **Learning activities for the students:** Making working models, Power point presentation, Preparation of report.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**

Grammar

Conditionals/Tenses, Relative Clauses, Subject – Verb Agreement, Passive Voice

Unit II **9 Hrs.**

Written Communication

Discuss a topic of general interest, but related to science in about 300 words. (Analyse, Comment, Argue, Reflect, Persuade, etc.)

(can also be used for oral presentations by the students, followed by discussion)

Unit III **9 Hrs.**

Scientific Writing

Writing a Scientific Report on a project undertaken or an experiment conducted (Theory + Practice)

Unit IV **3 Hrs.**

Oral Communication I

a) Consulting a dictionary for correct pronunciation (familiarity with Phonetics Symbols and Stress-marks only)

b) Dialogue

Unit V **9 Hrs.**

Soft Skills

1. **Gestures/ postures** – Body language, gesture, posture.

2. **Group discussion** – Giving up of PREP, REP Technique, how body language during group discussion.

3. **Presentation Skills**

a) How to make power point presentation

b) Body language during presentation

4. **Resume writing**

a) Cover letter, career objective

b) Resume writing (tailor made)

5. **Mock Interview**

Each student to face an interview and to demonstrate the above taught skills.

6. **Positive Attitude**

Positive skills enhancement with power point presentation.

BOOKS RECOMMENDED

- Advanced English Usage; Quirk & Greenbaum; Pearson Education.
- Developing Communication Skills; Banerjee Meera & Mohan Krishna; Macmillan Publications, 1990.
- Business Communication; Chaturvedi, P.D.; Pearson Publications.
- Business Communication; Mathew, M.J.; RBSA Publications, 2005.
- Communication of Business; Taylor, Shirley; Pearson Publications.
- Soft Skills : ICFAI Publication
- Dictionary Oxford

COURSE OUTCOMES - Semester IV

PAPER CODE-PHY 411
Mathematical Physics & Numerical Methods
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to –
The objectives of this paper are to acquaint the students with different types of coordinate systems, and to train them to solve problems related to tensors, four vectors etc. The students will also learn to make Fourier analysis of complex functions and use various numerical methods for solving different types of Physical Science problems.

Course Outcomes (COs):

Course			

Paper Code	Paper Title	Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
PHY 411	**Mathematical Physics And Numerical Methods** **(Theory)**	**The students will be able to –** **CO94:** Find the divergence, gradient or curl of a vector or scalar field expressed in terms of orthogonal curvilinear coordinates, Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries, to understand and apply concept of tensor in real life problems and Learn the Dirac delta function its properties, which have applications in various branches of Physics, especially quantum mechanics. **CO95:** To analyze the application of Doppler's and Compton Effect in day to day life. **CO96:** Apply a range of techniques to solve first & second order partial differential equations and Model physical phenomena using partial differential equations such as the heat and wave equations. **CO97:** Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc. **CO98:** Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics, Understand problems, methods and techniques of calculus of variations, Find numerical solutions of system of linear equations and check the	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration **Learning activities for the students:** Self-learning assignments, Effective questions, Seminar presentation.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		accuracy of the solutions and Learn about various interpolating and extrapolating methods. **CO99:** Solve initial and boundary value problems in differential equations using numerical methods and apply various numerical methods in real life problems.		

CONTENTS

UNIT I

Orthogonal curvilinear coordinate system : 12 Hrs.

Orthogonal curvilinear coordinate system, scale factors, Expressions for gradient, divergence and curl and their application to Cartesian, Circular Cylindrical and Spherical polar coordinate systems.

Tensors:
Coordinate transformations, Transformation of covariant, contra variant and mixed tensors. Addition, subtraction, outer product , contraction and inner product of tensors, Quotient law, Symmetric and antisymmetric tensors, Metric tensor.
Dirac delta function and its properties.

UNIT II
Four vectors: 8 Hrs.

Four vector formulation, four velocity vector, energy-momentum four vector, relativistic equation of motion; invariance of rest mass, orthogonality of four force and four velocity, Lorentz force as an example of four force, transformation of four frequency vector, longitudinal and transverse Doppler's effect, Compton effect.

UNIT III
Boundary value problems: 10 Hrs.
Techniques of separation of variables and its application to the following boundary value problems (i) Laplace's equation in three dimensional Cartesian coordinate system – line charge between two earthed parallel plates, (ii) Helmholtz equation in circular cylindrical coordinates-Cylindrical resonant cavity, (iii) Wave equation in spherical polar coordinates-the vibrations of a circular membrane, (iv) Diffusion equation in two dimensional Cartesian coordinate system-heat conduction in a thin rectangular plate.

UNIT IV
Fourier Series and Integrals: 8 Hrs.
Introduction, Fourier series and coefficients, functions with point of discontinuity, arbitrary period, even and odd functions, half range expansion, Parseval's theorem.

UNIT V

Numerical Methods: **7 Hrs.**
Introduction, Finite-Difference Operators, Differential Operator related to the Difference Operator, Truncation error, Numerical interpolation, Roots of equations, Initial-value problems –Ordinary Differential equations: Taylor's method, Euler's method and direct method. Trapezoidal and Simpson's rule for numerical integration.

BOOKS RECOMMENDED:

- "Mathematical Methods" , Potter and Goldberg, Prentice Hall of India (1998).
- "Mathematical methods in Physics", D.Biswas, New Central Book Agency (P) Ltd.
- "Mathematical Physics", M.P.Saxena, P.R.Singh, S.S.Rawat, P.K.Sharma, CBH, Jaipur.
- "Applied Maths for Engineers and Physicists",Pipes and Harvill, McGraw Hill.
- "Advanced Engineering Mathematics", Ervin Kreyzig 5th Edition, Wiley Eastern Ltd.
- "Numerical Methods", S. Balachandra Rao, C.K. Shantha, University Press, 1992.
- "Mathematical Physics",Ellgnine Butkon, Addisson Wiesley.
- "Mathematical Physics",Gupta, Vikas Publishing House.

PAPER CODE-PHY 412
Condensed Matter Physics and Devices
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
To familiarize the students with the basics of condensed matter physics which form the basis for further studies in condensed matter physics. The students get acquainted with the crystal structure, properties of solids, superconductivity and magnetism which strengthens the theoretical base for research in contemporary fields of condensed matter physics, like imperfect solids and nano particle physics. The students acquire abilities to undergo research or involve in business related to material science.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 412	**Condensed Matter**	**The students will be able to –** **CO100:** A brief idea about crystalline and amorphous substances, about lattice, unit	**Approach in teaching:** Interactive Lectures, Discussion,	Class test, Semester end examinations, Quiz, Solving problems ,

	Physics And Devices **(Theory)**	cell, miller indices, Crystal structure, diffraction of X-rays by crystalline materials. **CO101:** Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids. **CO102:** Understanding of the band theory of solids and must be able to differentiate between insulators, conductors and semiconductors. **CO103:** Knowledge about experimental techniques to measure electrical conductivity .and the hall set up to determine the hall coefficient of a semiconductor. **CO104:** Comprehend the basic theory of superconductors, Type I and II superconductors, their properties and physical concept of BCS theory. **CO105:** Acquire knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss. **CO106:** Understanding of working of LEDs, photodiode and solar cells. **CO107:** Knowledge of Operational amplifiers , its characteristics and various applications	Tutorials, Power point presentation, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical	Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**

Crystal structure: Symmetry elements in crystal, Unit cell, Wigner Seitz cell, fundamental lattice system and types, Miller indices, crystal structures of simple cubic, FCC, BCC, HCP, diamond.

Crystal Diffraction: Bragg's law, X-ray and neutron diffraction, Rotating crystal method, laue Method and Powder method.

Unit II **9 Hrs.**

Thermal Properties of solids: Concepts of thermal energy and Phonons, Einstein theory of specific heat, Debye model of lattice specific heat.

Band theory of solids: Formation of bands, distinction between metals, insulators and semiconductors, periodic potential of a solid, wave function in a periodic lattice and Bloch theorem, Physical origin of effective mass,negative effective mass and holes.

Unit II **9 Hrs.**

Electrical conductivity: Drude Lorentz theory of electrical conductivity. Sommerfield theory of conduction in metals, Mathiessen's Rule, Thermal conductivity and Wiedemann – Franz law, The Hall effect.

Superconductivity: Zero resistivity, Critical temperature, critical magnetic field, Meissner effect, Type I and type II superconductors, BCS theory (Basic idea),High Tc superconductors.

Unit IV **9 Hrs.**

Magnetic Properties: Classification of magnetic material, Diamagnetism, Paramagnetism due to free ions and conduction electrons, Curie's law, ferromagnetism

Nature and Origin of Weiss molecular field. Domains, hysterisis loop, outline of antiferromagnetism and ferrimagnetisms, ferrites.

Unit V **9 Hrs.**

Solid State Devices: Light emitting diode (LED) and its application, Solar cell, SCR.

Operational amplifier: Differential amplifiers, differential gain and CMRR, inverting and non-inverting configurations Applications of op-amp: adder, subtractor, differentiator and integrator.

Field affect Transistor (FET): Classification of various types of FET, constructional details of FET, drain characteristics and baising of FET, operating regions, pinch-off voltage, idea of metal oxide semiconductor field effect transistor (MOSFET).

BOOKS RECOMMENDED

- "Introduction to Solid State Physics", C. Kittel, Wiley Eastern, New Delhi, Seventh Edition.
- "Solid State Physics", S.O. Pillai, 3rd edition 1999, New Age International, New Delhi.
- "ElectronicDevices &Circuit Theory",Boylestad & Nashelsky , Prentice Hall of India.
- "Solid state physics", A.J Dekker ,Macmilan India Ltd.
- "Solid state Physics", R.L. Singhal, Kedar Nath Ram Nath Publishers, 2001.
- "Theory of solids", L. Azaraf, Tata Mc.Graw Hill Publishing Co.
- "Solid State Physics", S.L. Gupta and V.Kumar, Kedar Nath RamNath & Co., Meerut

- "Electronic Devices and Circuits" , Soni,Gupta , Dhanpat Rai and Sons.
- "Elements of Solid State Physics", J.P.Srivastava, Prentice Hall of India, New Delhi.

PAPER CODE-PHY 413
Chemistry of Materials
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course deals with the chemistry behind the materials that society depends on, metals, polymers and ceramics. Materials chemistry is an active area of scientific research and one with many practical applications.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 413	Chemistry of materials (Theory)	**The students will be able to –** **CO108:** Know the fundamentals of the atomic structure and ionic bonding. **CO109:** Understand about molecular and crystal structures. **CO110:** Understand the methods for expressing concentrations in Compounds. **CO111:** Understand the one and two component systems. **CO112:** Understand about phase equilibrium, chemical reactions etc.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar	Class test, Semester end examinations, Quiz, Solving problems , Assignments , Presentations

			presentation, Solving numerical. Additional learning through online Videos and MOOCs Courses.	

CONTENTS

Unit I **9 Hrs.**

Atomic Structure-Schrodinger wave equation, significance of ·, ·*·, quantum numbers, shapes of s, p, d and f orbitals, Aufbau and Pauli principles, Hund's multiplicity rule, exchange energy, pairing energy, symmetrical distribution of charge, extra stability of half-filled and completely-field orbitals, electronic configurations, effective nuclear charge, shielding effect, Slater's rules for evaluation of shielding constant.

Unit II **9 Hrs.**

Ionic Bonding: Formation of ionic bonds, factors affecting the formation of ionic bonds; calculation of lattice enthalpy. Covalent Bonding: Concept of electronegativity, Fajan's rule, dipole moment; Valence Shell Electron Pair Repulsion (VSEPR) theory and shapes of simple molecules. Quantum mechanical approach to covalent bonding: Valence bond theory - Its important features, concept of hybridization involving s, p and d orbitals; Resonance. Molecular Orbital Theory - Its important features, LCAOs, types of molecular orbitals (bonding, antibonding), sigma and pi-bonds, molecular orbital electronic configurations of homonuclear diatomic molecules, concept of bond order, bond length and bond energy. Elementary idea of metallic bonding. Hydrogen bonding and its applications.

Unit III **9 Hrs.**

Different methods for expressing concentration of solution - molality, molarity, mole fraction, percentage (by volume and mass both), vapour pressure of solutions and Raoult's Law Ideal and non-ideal solutions, vapour pressure - composition, plots for ideal and non-ideal solutions; Colligative properties of dilute solutions - relative lowering of vapour pressure, depression of freezing point, elevation of boiling point and osmotic pressure; Determination of molecular mass using colligative properties; Abnormal value of molar mass, van't Hoff factor and its significance.

Unit IV **9 Hrs.**

Introduction to chemical kinetics, measurement of reaction rate, integration and determination of rate laws, rate constant, unit of rate constant for zero order, first order and second order reactions, order of reaction, molecularity of reaction, difference between order and molecularity of reaction, chemical kinetics and its scope, factors influencing the rate of a reaction-concentration, temperature, pressure, solvent, light, catalyst; concentration dependence of rates.

Unit V **9 Hrs.**

Phase Equilibrium-Introduction, terminology: - phase, component, degree of freedom or variance; phase diagram of one-component system: -water system, sulphur system, CO2 system, phase rule for two-components system: - Pb-Ag system and its applications, reduced phase rule, eutectic point.

BOOKS RECOMMENDED

- Lee, J. D. "Concise Inorganic Chemistry", Blackwell Publication.
- Atkins, P. W. "Physical Chemistry", ELBS.
- Material Science & Engineering, A first course, V Raghavan, PHI, New Delhi.
- Material Science & Engineering an introduction, William D Callister Jr., John Wiley & Sons.

PAPER CODE-PHY 414
Digital Electronics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course aims to develop the knowledge of electronics by learning various topics viz. digital electronics, Sequential Logic Circuits, their Design and study, Semiconductor Memories, D/A Converter and A/D Converter.The student acquires abilities to design various types of digital circuits for various applications.

Course Outcomes (COs):

Course		**Learning outcome**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**	**(at course level)**		
PHY 414	**Digital Electronics** **(Theory)**	**The students will be able to –** **CO113:** Understand the fundamentals of the digital electronics. **CO114:** Understand the Boolean algebra and number system that forms the basics of any electronic device. **CO115:** Understand the Gates and Sequential logic circuits and their operations	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials. **Learning activities for the students:** Self learning assignments,	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

			Effective questions, Seminar presentation, Solving numerical Additional learning through MOOCs Courses.	

CONTENTS

Unit I **9 Hrs.**

Logic Gates : Logic Gates and Boolean Algebra Representation and Simplification of functions by Karnaugh Maps. Combinational Circuits design. Combinational circuits - adder, subtractor, decoder, demultiplexer, encoder, multiplexer, comparator, Multivibrators

Unit II **9 Hrs.**

Sequential Logic Circuit & Design-flip flop, shift register, asynchronous and synchronous counters, Digital Logic Families and Their Charactersistic : RTL, DTL, TTL, Schotlky TTL, ECL, MOS and CMOS, Fan in, Fan out

Unit III **9 Hrs.**

Semiconductor Memories : RAM, ROM, PROM, EPROM, BJTRAM Cell, MOS RAM Cell, Organization of RAM, Charge Coupled devices (CCD), storage of charge and transfer of charge in CCD

Unit IV **9 Hrs.**

D/A Converter : Weighted resistance D/A, R-2R Ladder Converter. DAC 0800 D/A Chip, D/A Converter specification,

Unit V **9 Hrs.**

A/D Converter : Analog to Digital Converter, Parallel Comparator Converter, Counting Converter, Successive Approximation Converter, Dual Slop converter A/D converter specification, sampling and hold circuit, ADC 0804 Converter chip

BOOKS RECOMMENDED:

- Digital Principles and Applications by C. P. Malvino and D. P. Leach, Mc-Graw Hill,
- 1985.
- Digital logic and computer design by M. M. Mano, Tata Mc-Graw Hill.
- Digital Integrated Circuits by Taub and Shilling, Tata Mc-Graw Hill

- Computer Architecture and Organization by J. P. Hayes, Mc-Graw Hill 1988.
- Digital Fundamentals by Floyd, Mc-Graw Hill.
- Digital IC by K. R. Botkar, Mc-Graw Hill.

PAPER CODE-PHY 415
Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course aims to provide practical knowledge of Physics concepts by applying the Physics theory to different experimental methods and to make them learn the usage of electrical and optical instruments for various measurements. The students will be able to apply the analytical techniques and graphical analysis to the experimental data. The will develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 415	**Lab course I** **(Practical)**	**The students will be able to –** **CO116:** Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). **CO117:** Be able to understand and demonstrate functions of CRO. **CO118:** Be able to handle useful equipments related to	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, Analysis and interpretation of observations	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		electronics like diode, FET, gates, and transistor.	Additional learning through online Videos/Virtual Labs.	

CONTENTS

List of Experiments:

1. To determine band gap using a junction diode.

2. To study the Zener regulated power supply with different loads.

3. To study the characteristics of F E T.

4. Study of the temperature dependence of resistance of a semiconductor (four probe method) and to determine its band gap.

5. To study FET as an amplifier.

6. To study a voltage multiplier circuit to generate high voltage DC from AC

7. Using discrete components, study OR, NOT, AND logic gates.

8. Study of single stage transistor audio amplifier (variation of Gain with Frequency).

9. To test a Diode and Transistor using (a) Multimeter and (b) CRO.

10. To measure (a) Voltage, (b) Frequency and (c) Phase Difference using a CRO.

PAPER CODE-PHY 416
Lab Course II
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course will enhance the basic learning skills of students. This will enable them to plan and execute experiments , handle scientific equipment safely and to the appropriate limit of accuracy.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcome (at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>PHY 416</td><td>Lab Course II
(Practical)</td><td>The students will be able to –
CO119: Develop skills for team work and technical communication and discussions.
CO120: Apply theoretical principles of Digital electronics to analysis and measurements performed in the laboratory.
CO121: Develop competence in Combinational Logic Problem formulation and Logic Optimization.</td><td>Approach in teaching: Demonstration, Group activity, Discussion ,Conduction of Experiments

Learning activities for the students:
Performing Experiments, Analysis and interpretation of observations, Additional learning through online Videos/Virtual Labs.</td><td>Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations</td></tr>
</table>

CONTENTS

List of Experiments

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.
2. To design a combinational logic system for a specified Truth Table.
3. To study TTL ICs of (a) Binary Decoder, (b) 7-segment Decoder, and (c) Schmit Trigger.
4. To Study Half Adder, Full Adder and 4-bit Binary Adder.
5. To study Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.
6. To study and verify the S-R flip-flop & J-K flip-flop.
7. To Study an Astable and Monostable Multivibrator.
8. To study Adder & Subtractor operations for Operational Amplifier
9. Using python programming solve differential equations.
10. Evaluate the Fourier coefficient of a given periodic function using python programming.

COURSE OUTCOMES - Semester V

PAPER CODE-PHY 511
Quantum Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This paper aims to develop the basic knowledge of quantum mechanics and its application to various problems. It also deals with the techniques of wave mechanics like Schrödinger equation and its solution, angular momentum and spin. The student develops the understanding of quantum nature of e.m. radiations or light and wave nature associated with microscopic particles, the notion of quantum states, operators etc.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

PHY 511	**Quantum Physics** **(Theory)**	**The students will be able to –** **CO122:** Understand the concept of Wave mechanics and Schrodinger equation to solve problems. **CO123:** Knowledge of Quantum mechanics operators and Ehrenfest's theorem to solve problems. **CO124:** Apply Schrödinger equation to solve problems using Boundary condition and continuity condition . **CO125:** Apply Schrodinger equation to determine the solution of Simple harmonic oscillator and Rigid rotator. **CO126:** Know the basics of Angular momentum, momentum operators and and commutation relations .	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**
Introduction to Wave mechanics :

Duality of radiation and matter, De broglie's hypothesis, justification for the relation, Experimental confirmation of λ = h/p (Davission and Germer experiment).

Uncertainty principle relating to position and momentum, relating to energy and time, its applications to various quantum mechanical problems such as:

(i) Non-existence of electrons in nucleus
(ii) Ground state energy of H-atom
(iii) Ground state energy of Harmonic oscillator
(iv) Natural width of spectral line

Schrodinger equation:
Wave function and its interpretation, Schrödinger time dependent and time independent one-dimensional equation, three-dimensional Schrödinger wave equation, probability current density, physical meaning of ψ, conditions to be satisfied by ψ.

Unit II **9 Hrs.**

Operator formulation in Quantum mechanics:

Operators, algebra of operators, commutative property, linear operators, Commutator operator, eigen values and eigen functions, operators for momentum, K.E., Hamiltonian, total energy and angular momentum, Fundamental postulates of Q.M.

Hermitian operators, orthonormality, degeneracy, Commutation relations, Ehrenfest's theorem, Bohr's principle of complementarity, principle of superposition.

Unit III

Simple solutions of Schrödinger equation: **9 Hrs.**

Boundary and continuity conditions on the wave function. Particle in one dimensional box, eigen function and eigen values, discrete energy levels, generalization to 3-D and degeneracy of levels

Boundary value problems:

Step potential, Penetration through rectangular barrier, calculation of reflection and transmission coefficients. Quantum mechanical tunneling. Square well potential problem, reflection and transmission coefficient and resonant scattering.

Unit IV **9 Hrs.**

Simple harmonic oscillator (1-D Case): Schrödinger equation and its solutions, eigen function, energy eigen values. Zero point energy, parity, symmetric and anti-symmetric wave functions with graphical representation.

Rigid rotator: Schrodinger equation and its solution.

Unit V **9 Hrs.**

Angular Momentum

Introduction: orbital angular momentum,Operators for its Cartesian components, commutation relations, mutual as well as with L^2 ,L^+ and L^- operators , their interpretation as step operators, eigen values of L_z, Total angular momentum operators, commutation relations obeyed by the components of generalized momentum operator. Commutation relation of J_z with J_+ and J_- , J_+ and J_- ,commutation relation of J^2 with J_+ and J_-.

BOOKS RECOMMENDED:

- "Quantum mechanics" L.L. Schiff, Tata Mc Graw Hill.
- "Quantum mechanics", Chatwal and Anand, Himalaya Publishing House.

- "Elementary Quantum Mechanics and Spectroscopy" Kakani, Hemrajani and Bansal, College Book House Jaipur.

- "Introduction to Modern Physics",H.S. Mani and G.K. Mehta, East West Press Pvt. Ltd., New Delhi.
- "Quantum Mechanics", S.P. Singh, M.K. Bagde and Kamal Singh,S. Chand & Co.
- "Quantum Mechanics", A Listair, I M Rac, ELBS (low price edition).
- "Quantum Mechanics", S.N.Biswas, Books & Allied,Calcutta (P) Ltd.
- "Perspectives of Modern physics", A.Beiser, Mc Graw Hill.
- "Problems on Quantum Mechanics", Dr. S.L.Kakani, Arihant Publishing House.

PAPER CODE-PHY 512
Nuclear & Particle Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -

To give the students insight into the fundamentals of structure of nucleus nuclear binding energy, radioactive decay, nuclear reactions, fission, fusion etc. and particle physics

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 512	**Nuclear and Particle Physics** **(Theory)**	**The students will be able to –** **CO127:** Have a basic knowledge of nuclear size ,shape , bindingenergy.etc and also the characteristics of nuclear force in detail. Gain knowledge about liquid drop model and semi empirical mass formula. **CO128:** Grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics. **CO129:** Understand the basic forces in nature and classification	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving **Learning activities for the students:** Self learning assignments,	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		of particles and study in detail conservations laws . **CO130:** Understand the structure and working of different accelerators and compare them. **CO131:** Describe the construction and working of nuclear detectors and analyze them.	Effective questions, Seminar presentation, Solving numerical	

CONTENTS

Unit I **9 Hrs.**

Nuclear Properties: Rutherford's theory of α particle scattering, Basic properties: charge, mass, size, spin, magnetic moment, electric quadrupole moment, Parity, Binding energy per nucleon and its observed variation with mass number of the nucleus. Semi empirical mass formula –coulomb energy, volume energy, surface energy, other corrections, explanation of binding energy curve, Liquid drop model ,Nuclear forces and their properties, Theory of nuclear forces.

Unit II **9 Hrs.**

Nuclear Fission: Energy release in fission, Theory of nuclear fission and liquid drop model, Barrier penetration – Theory of spontaneous fission, Nuclear chain reaction, condition of controlled chain reaction, Principle of nuclear reactors, classification of reactors.

Nuclear Fusion: Energy release in fusion, fusion reactions in stars : carbon and pp cycle.

Unit III **10 Hrs.**

Particle Physics: Classification of elementary particles, properties of particles. Fundamental interactions, Conservation laws : Energy ,momentum, angular momentum, charge, lepton number, Baryon number, isospin, strangeness, Invariance under charge,parity,C.P.,time and C.P.T.,(Qualitative discussion).
Cosmic rays: Properties of cosmic rays ,properties of secondary radiation, electronic showers ,geomagnetic effects, cosmic ray stars, the origin of cosmic rays.

Unit IV **9 Hrs.**

Accelerators: Need for accelerators, Ion sources, Van De graff generator, Drift tube, linear accelerator, Wave guide accelerator, cyclotron ,synchrocyclotron, electron synchrotron, proton synchrotron.

Unit V **8 Hrs.**

Detectors: Ionization chamber , Proportional Counter, Geiger Muller Counter, Scintillation counter, Cloud chamber, Bubble chamber, Spark chamber , Solid state detectors.

Nuclear mass spectroscopy: Basic components of mass spectroscope.

BOOKS RECOMMENDED:

- "Nuclear Physics", D.C. Tayal, 4th rev. edition. 1992,, Himalaya Publishing, House, Bombay.
- "Nuclear physics", Irving Kaplan, 2nd edition, Addition Wiesley Publishing Company.
- "Atomic Nucleus", R.D. Evans ,Mc Graw Hill, New York.
- "Introduction to Elementary Particles", D. Griffiths, Harper and Row, New York, 1987.
- "Elements of Nuclear Physics", Pandey and Yadav, Kedar Nath Ram Nath, Meerut, Seventh Edition .
- "Nuclear Physics : Theory and experiments", R.R. Roy and B.P. Nigam, New Age International (P) Limited.
- "Radiation Detectors and Measurement", F.Knoll, John Wiley & Sons, Second Edition.

PAPER CODE-PHY 513
Application of MATLAB in Physics
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
To gain an understanding of the mathematical software, Matlab and its applications to solve various types of problems in Physics. Its a strong mathematical tool that provides easy method for finding solution of differential equations, matrix algebra, vector algebra, integration, solving energy-eigen problems diagonalization of matrics, plotting various types of graphs and simulation studies etc.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY-513	**Application of Matlab In Physics** **(Theory)**	**The students will be able to –**	**Approach in teaching:** Interactive Lectures,	Class test, Semester end examinations, Quiz, Solving

		CO132: Use MATLAB effectively to analyze and visualize data. **CO133:** Apply numeric techniques and computer simulations to solve Physics or engineering-related problems. **CO134:** Apply a top-down, modular, and systematic approach to design, write, test, and debug sequential MATLAB programs to achieve computational objectives. **CO135:** Design and document computer programs and analysis in a careful and complete manner so as to effectively communicate results, to facilitate evaluation and debugging by another programmer, and to anticipate and resolve user errors. **CO136:** Demonstrate understanding and use of fundamental data structures (classes) and their applications in Physics. **CO137:** Create and control simple plot and user-interface graphics objects in MATLAB.	Discussion, Tutorials, demonstration **Learning activities for the students:** Self-learning assignments, Effective questions, Simulation, Seminar presentation. Additional learning through online Videos and MOOCs Courses.	problems , Assignments, Presentations

CONTENTS

UNIT- I **9Hrs.**

Introduction of MATLAB

Introduction of MATLAB, Commands for managing a session, Input and output commands, Some primary mathematical operations (Arithmetic operations, trigonometric functions, logarithm and exponent functions), Commonly used operators and special characters, Introduction of M-Files in MATLAB, M-File scripts and M-File functions, Creating and running scripts files, Editing and existing M-File.

UNIT-II **9 Hrs.**

Plotting GRAPHS Plotting commands, Create 2D graph , Plot multiple graphs, Scaling, coloring and line styles in 2D graphs, Adding title axis labels and legends to graphs, 3D graph plotting, Scaling, coloring and line styles in 3D graphs, Adding title axis labels and legend to graph.

UNIT-III **9 Hrs.**

Creating sounds and Nuclear Physics

Creating a simple GUI with input boxes: Simple Harmonic Oscillator and the Sine Function

Creating and Saving Sounds: BEATS , Solving SHM ,BEATS: Superposition of two sinusoidal waves of slightly different frequencies: Creating and saving sounds Uranium decay

UNIT-IV **9 Hrs.**

Data Analysis and Mathematical Routines

Curve Fitting: Linear regression, Least squares fit to a straight line, power and exponential relationships Solving Quadratic Equations: GUI and Function call.

UNIT-V **9 Hrs.**

Thermal Physics

Thermal Conduction: Temperature gradient and energy flux calculations through a composite rod Blackbody Radiation Second Law of Thermodynamics – Carnot's cycle and Calculating efficiency of an engine, Drawing P-V diagram.

BOOKS RECOMMENDED:

- Physical Modeling in MATLAB by Allen B. Downey, Grean Tea Press.
- Computational Physics using MATLAB by Nicholas J. Giordano , Hisan Nakanishi
- Optics using Matlab by Scott W. Teare ,SPIE Digital Library.

PAPER CODE-PHY 514(A)
Material Science
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -

To gain an understanding of the relationships between the structures, properties, processing and applications of various engineering materials. The student learns various process and techniques involving both the chemical and engineering methods.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 514(A)	**Material Science** **(Theory)**	**The students will be able to –** **CO138:** Ability to understand Classification of materials & bond formation **CO139:** To understand phase transformation in materials. **CO140:** Understand Vacuum technology & applications **CO141:** Acquire basic knowledge of diffusion in solid **CO142:** Ability to understand electrical & magnetic properties of materials & applications **CO143:** Student acquires ability to take up higher studies/research in material science/ condensed matter physics.	**Approach in teaching:** Interactive Lectures, Discussion, Problem solving in Tutorials, Demonstration, problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical. Additional learning through online Videos and MOOCs Courses.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

UNIT- I **9 Hrs.**

Types of materials and bonding

Classification of materials, Materials Structure, Types of Bonds, Bonds formation, Ionic Bond, Covalent Bond, Metallic Bond, Comparison of Bonds, Secondary Bonds, Crystals systems, Crystals Imperfection, Point, line and surface Imperfection.

UNIT-II **9 Hrs.**

Solid solutions and phase transformation

Solid solution, Hume - Rothery's rule, Intermediate Phase, Phase Diagrams, Gibb's Phase rule, Time-Temperature cooling curves, Construction of Phase Diagrams, The Lever Rule, Equilibrium Binary system, Eutectic systems, Mechanism of Phase Transformation, Types of Nucleation, Application of Phase Transformation

UNIT-III **9 Hrs.**
Vacuum, Oxidation and Corrosion

History of vacuum technology, units of Vaccum, Kinetic aspects of Gases, Application of Vaccum, Gas flow in vaccum systems, production of vaccum, Measurement of vaccum, Thermal conductivity gauges, Penning Gauge, Oxidation, Oxidation Resistant Materials, Corrosion, Principle, Types of Corrosion, Prevention against corrosion.

UNIT-IV **9 Hrs.**
Non-Destructive Testing (NDT)
NDT and its advantages, Defects in materials, Selection of the NDT Method, Visual Inspection, Basic Principle, Liquid Penetration Testing, Physical Principle, Magnetic Particle Testing (MPT), Principle of MPT, Sensitivity, Limitation, Eddy Current Testing (ECT), Principle, Instrument for ECT, Applications, Limitations.

UNIT –V **9 Hrs.**
Electrical and Magnetic properties of materials
Dielectrics, Polarization, Temperature and frequency effects, Electric Breakdown, Ferroelectric materials, Electrostriction, Piezoelectricity, Uses of Dielectrics, Magnetic Properties, Classification, Magnetostriction, Soft and Hard magnetic materials.

BOOKS RECOMMENDED:

- Materials Science by G.K. Narula, K.S. Narula, V.K. Gupta, Tata McGraw Hill Publishing, 1994.
- Materials Science and Engineering by V. Raghavan, Prentice Hall of India, 2004.
- Practical Non-Destructive Testing by Baldevraj, T. Jayakumar, M. Thanvasimuthu, Narosa Publishing House, Chennai, 2002.
- Testing of Metallic Materials by A.V.K. Suryanarayana, B.S. Publications, Giriraj lane, Sultan Bazar, Hyderabad - 95, 2003.

PAPER CODE-PHY 514(B)
Renewable Energy-I
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -

The students are expected to learn about the new methodologies/technologies for generation of electricity not depends on fossil fuel; effective utilization of renewable energy sources.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcome (at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>PHY 514(B)</td><td>Renewable Energy-I

(Theory)</td><td>The students will be able to –

CO144: Know basic properties of different renewable sources of energy and technologies for their utilization.

CO145: Understand main elements of technical systems designed for utilization of renewable sources of energy.

CO146: Able to interpret advantages and disadvantages of different renewable sources of energy.

CO147: To undertake simple analysis of energy potential of renewable sources of energy like Solar energy, Wind energy, Ocean energy etc.

CO148: Understand the correlation between different operational parameters.

CO149: The student acquires necessary skills to set up a unit for solar energy/wind energy in the State of Rajasthan where there is ample scope for such ventures.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Tutorials, Demonstration, problem Solving in tutorials.

Learning activities for the students:

Self learning assignments, Effective questions, Seminar presentation, Solving numerical.

Additional learning through online Videos and MOOCs Courses.</td><td>Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations</td></tr>
</table>

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Unit I **9 Hrs.**

SOLAR ENERGY

Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.

Unit II **9 Hrs.**

WIND ENERGY

Wind Energy Estimation, Types of Wind Energy Systems, Wind measurement techniques, Wind resource assessment, Wind mill site selection, Wind Turbine Generator.

Unit III **9 Hrs.**

OCEAN ENERGY

Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.

Unit IV **9 Hrs.**

BIO-MASS

Principles of Bio, Conversion, Anaerobic/aerobic digestion, types of Bio gas digesters, gas yield, combustion characteristics of biogas, utilization for cooking.

Unit V **9 Hrs.**

GEOTHERMAL ENERGY

Hydrothermal Resources, Geopressured Resources, Hot Dry Rock Resources, Magma Resources, types of wells, Advantages & Disadvantages of Geothermal Energy, applications of geothermal energy in Electric Power Generation,Industrial Process Heat, Space Heating for various kinds of Buildings

BOOKS RECOMMENDED:

- Reneweble energy resources: Tiwari and ghosal, Narosa publication.
- Non conventional Energy Sources, Khanna Publication
- Renewable Energy Sources:Twidell& Weir, CRC Press.
- Solar Energy/ S.P. Sukhatme, Tata McGraw Hill.
- 5.Non Conventional Energy Systems: K M. Mittal, A H Wheeler Publishing Co Ltd.
- Renewable Energy Technologies: Ramesh & Kumar, Narosa publication.
- Biomass Energy, Oxford & IBH Publication Co.

PAPER CODE-PHY 515

Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
This course aims to provide practical knowledge of Physics concepts by applying the Physics theory to different experimental methods and to make them learn the usage of electrical and optical instruments for various measurements. The students will be able to apply the analytical techniques and graphical analysis to the experimental data.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY 515	Lab Course I (Practical)	**The students will be able to –** **CO150:** Knowledge of Stefan's constant, Planck's constant using a Photocell, Planck's constant using a solar cell, ballistic constant, self-inductance of a given coil by Anderson's bridge using AC.to determine constant values. **CO151:** Learn about the gates, diodes/bridge rectifier to perform various logic functions using NOR and NAND, to measure CMRR and input bias current and offset current using OP-AMP, to rate performance of power supply. **CO152:** Understanding about GM counter to determine range of X particles from a radio-active source in air and verification of inverse square law for same strength of	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:** Performing Experiments, observations, Analysis and interpretation of results, Additional learning through online Videos and Virtual Labs.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		radioactive sources, absorption of β-rays in Aluminum foil and absorption coefficient.		

CONTENTS

List of Experiments

1. Determination of Stefan's constant.
2. Determination of Planck's constant using a Photocell.
3. Determination of Planck's constant using a solar cell.
4. Study of power supply using two diodes/bridge rectifier with various filter circuits.
5. To perform various logic functions using NOR and NAND gates, i.e., OR, NOT, AND, NOR, NAND, X-OR gates.
6. To measure CMRR and input bias current and offset current using OP-AMP.
7. Study of characteristics of GM counter and verification of inverse square law for same strength of a radioactive source.
8. Study of absorption of β-rays in Aluminum foil using GM counter and to determine its absorption coefficient.
9. Determine ballistic constant of a ballistic galvanometer.
10. To determine self-inductance of a given coil by Anderson's bridge using AC.

PAPER CODE-PHY 516
Project
(Project)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to –

The student learns to plan a project, develop its methodology, implement the same under guidance of a supervisor, derive conclusions and check their validity/deviation in results from the standard or expected outcomes and find out the courses of deviation, if any. This component will help to create research aptitude in the students and help them to develop a Scientific approach in solving problems related to physics.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
PHY-516	**PROJECT**	**The students will be able to –** **CO153:** An introduction to the pursuit of Physics, its history and methodology. The students also learn the importance of measurement and the methodology of using different measuring devices which is central to physics. **CO154:** Ability to develop plans with the guidance of supervisor to achieve the project's goals. **CO155:** To estimate and cost the human and physical resources required, and make plans to obtain the necessary resources. **CO156:** Perform the project work , Analyse the results and prepare a report on it	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, Team teaching **Learning activities for the students:** Study visits to Science Park, universities and national research institutes.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

Details of Project

Students of semester V are required to choose a topic for the project and get it approved by the assigned supervisor of the department. They are required to perform a new experiment or carry out studies for writing a review article on a subject. At the end of the semester, a project report shall be submitted by each student. This project will be assigned to them in the beginning of the V semester.

Evaluation of Project:

A midterm evaluation of the project will be made along with the CA test. This will carry 30 % of the total marks assigned for the project. At the end of the semester, the student shall be examined on the basis of project report submitted by her by a panel of external and internal examiners. The evaluation of project will be based on presentation / viva-voce.

COURSE OUTCOMES - Semester IV

PAPER CODE-PHY 611
Atomic & Molecular Spectroscopy
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course aims to introduce various types of spectra for hydrogen, alkali and alkaline earth atoms. It also gives an introduction to X-ray spectra. Techniques of Molecular spectroscopy are also discussed in this paper, which include IR and Raman spectra. After learning this course student develops capabilities of making spectroscopic analysis of materials and draw conclusions from the same regarding nature of material.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 611	**Atomic and Molecular Spectroscopy** **(Theory)**	**The students will be able to –** **CO157.** Explain the different types of spectra. **CO158.** Discuss Hydrogen ,Alkali metals and alkali metal atom spectra . **CO159.** Describe Stern-Gerlach experiment, spectral terms and their notations.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration. **Learning activities for the students:**	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		CO160. Understand X-Ray spectra and Applications of Moseley's law. **CO161.** Learn the salient features of IR spectra and its experimental arrangements. **CO162.** Understand the Raman spectra along with its classical and quantum theories. **CO163.** Apply the results of Raman spectra to determine the structure of molecules.	Self learning assignments, Effective questions, Seminar presentation.	

CONTENTS

Unit I **8 Hrs.**

Introduction to Atomic Spectra

Types of spectra, spectrum of Hydrogen atom, spectral lines, the spinning electron, space quantization, quantum numbers and their physical interpretation, quantum numbers for complete atom, magnetic moments of an atom and Landes 'g' factor, Larmor's theorem, Stern and Gerlach experiment, fine structure of the Hydrogen lines, spectral terms and their notation.

Unit II **9 Hrs.**

Spectra of alkali and alkaline atoms

Different series in alkali spectra, Ritz combination formula, spin orbit interaction, explanation of salient features of alkali spectra, doublet structure in alkali spectra (fine structure), Transition rules, intensity rules, spectra of alkaline earth metals, coupling schemes: L.S and j-j coupling, selection rules in atoms of two valence electrons, singlet and triplet series, spectrum of Helium atom.

Unit III **9 Hrs.**

X-ray spectra

Continuous x-ray spectrum, characteristic emission and absorption spectrum and their explanation, energy levels, Moseley's law, combination principle, fine structure of x-ray lines, fluorescence yield and Auger effect, soft x-ray emission and structure of absorption edges.

Unit IV **9 Hrs.**

Infra red spectroscopy (vibrational and rotational spectra)

Salient features of vibrational rotational spectra, vibrating diatomic molecules as a harmonic oscillator, fine structure of vibrational rotational bands, interaction of vibrational and rotational energies, experimental arrangements for studying IR spectra.

Unit V **10 Hrs.**

Raman Spectra

Raman effect and its salient features, Observation of Raman spectra, classical theory of Raman effect, quantum theory of Raman effect, probability of energy transition in Raman effect, vibrational Raman spectra, Pure rotational Raman spectra, structure determination from Raman and infra red spectroscopy.

BOOKS RECOMMENDED:

- "Elements of Spectroscopy", Gupta, Kumar, Sharma, Pragati Prakashan, 2006.
- "Fundamentals of molecular spectroscopy", Collin N. Banwell and Elaine M. McCash, Tata McGraw Hill Publishing Company Ltd. New Delhi, 2005.
- "Atomic Spectra and Atomic structure", Gerhard Herzberg , Kreiger Pub.Co.,Second Edition.
- "Molecular Spectra and Molecular structure: Spectra of diatomic Molecules", Gerhard Herzberg, Dover Publications.
- "Introduction to Atomic Physics", Enge, Wehr and Richards, Addison Wiesley, London.
- "Atomic and Nuclear Physics", A.B. Gupta, New Central book agency Pvt. Ltd.

PAPER CODE-PHY 612
Information CommunicationTechnology
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
Information Communications Technology - or technologies (ICT) is an umbrella term that includes all technologies for the communication of information. This course gives a brief idea of the technology of wireless communication and networks. The objective of this course is to provide a comprehensive technical survey of wireless communication, fundamentals, of mobile communications, wireless networks and protocols wireless applications, 3G and higher communication systems.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

PHY 612	**Information Communication Theory** **(Theory)**	**The students will be able to –** **CO164:** Understand the fundamentals of transmission and wireless systems. **CO165:** Explain the working of cellular wieless networks and compare different generations. **CO166:** Have knowledge of different parameters of satellite communication. **CO167:** Know about the antenna, its types and wave propagation. **CO168:** Learn about optical fibers and analyse intermodal dispersion.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I **9 Hrs.**

Introduction and Transmission Fundamentals:

Introduction: Wireless comes of age, The Cellular revolution, The global Cellular network, Broadband, Future trends.

Transmission Fundamentals: Signals for conveying information: Time domain concepts, Frequency domain concepts, Relationship between data rate and bandwidth.

Analog and Digital data transmission: Analog and digital data, analog and digital signaling, Analog and digital transmission.

Channel Capacity: Nyquist bandwidth, Shannon capacity formula.

Transmission Media: Terrestrial microwaves, Satellite microwaves, Broadcast radio, Infrared.

Unit II **9 Hrs.**
Cellular Wireless Networks:

Principles of Cellular networks: Cellular network organization, operation of cellular systems, mobile radio propagation effects, power control; First generation analog : spectral allocation, operation, AMPS control channels.

Second generation TDMA: Time division multiple access, Mobile wireless TDMA design considerations, Global system for mobile communications, GSM network architecture.

Second generation CDMA: CDMA, Mobile wireless CDMA design considerations.

Third generation mobile technology ,fourth generation mobile technology , Introduction to fifth generation systems.

Unit III **9 Hrs.**
Satellite Communication:

Satellite parameters and configurations: Satellite Orbits, GEO, LEO, MEO satellites, frequency bands, transmission impairments, satellite network configurations, Capacity allocation – Frequency division : Frequency division multiplexing, Frequency division multiple access(FAMA,DAMA); Capacity Allocation-Time division

Unit IV **9 Hrs.**
Antennas and Propagation:

Antennas: Radiation patterns, Antenna types, Antenna Gain.

Propagation Modes: Ground Wave propagation, Sky Wave propagation, Line of Sight propagation.

Line of Sight Transmission: Attenuation, Free Space loss, Noise, The expression E_b / N_0, Atmospheric absorption, Multipath, Refraction.

Fading in the Mobile Environment: Multipath propagation, Error compensation Mechanisms.

Unit V **9 Hrs.**
Optical Fibres:

Total internal reflection, Optical fibre, Coherent bundle, Classification of optical fibres, Advantages of optical fibres, Types of rays, Modes of propagation of optical fibres, Dispersion-inter model dispersion: for multimode step index fibre and for graded index multimode fibre, Losses in optical fibre, Fibre cable, Optical fibre communication system, Optical fibre cable construction, Applications of optical fibre.

BOOKS RECOMMENDED:

- "Wireless Communication and Networks", William Stallings, Prentice Hall of India,2005.
- "Modern Physics", S.L. Kakani, Shubhra Kakani , Viva Books private Ltd.,2007
- "Electronic communication systems", George Kennedy, Mc Graw Hill, 3rd edition 1985.

- "Principles of communications – Systems, Modulation and Noise", R.E. Ziemer and W.H. Tranter, Jaico Publishing House 1996.
- "Wireless Communication", Reppaport, Pearson Education
- "Digital Satellite Communications", Tri, Tata Mc Graw Hill International
- "Mobile Cellular Telecommunications", William C.Y. Lee, Mc Graw Hill International Edition.
- "Satellite Communication System", M. Richharia, Mac Millan.
- "Introduction to Optical Fiber", Allen H Cherin, Mc Graw Hill.
- Principles of communication systems", Taub. Schilling ,Mc. Graw Hill 2nd edition 1986.

PAPER CODE-PHY 613
Astronomy
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -

This paper is designed to develop knowledge of Stars & stellar systems, Stellar Evolution, White dwarfs, neutron stars and black holes, Pulsars, The sun and solar system. This paper provides general information about the universe and equilibrium dynamics of planets and starts and develops necessary background for further studies and research programmes in astronomy and astrophysics.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 613	**Astronomy (Theory)**	**The students will be able to –** **CO169:** Ability to comprehend astronomical scales and understand basic concepts of positional astronomy like astronomical coordinate system and	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		measurement of distances, time and temperature and radius of star. **CO170:** Understand about star evolution & supernova . **CO171:** Understanding Physics of Dwarfs, neutron stars and black hole. **CO172:** Acquire basic knowledge of Pulsars and binary stars. **CO173:** Understanding Physics of sun and solar system. **CO174:** The student acquires abilities to take up higher studies/research in Astro-Physics.	Solving in tutorials, Visit to Birla Platenorium & Swai Man Singh Jantar-Mantar the Astronomical open Lab. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical Additional learning – Online Videos.	

CONTENTS

UNIT- I **9 Hrs.**

Stars & stellar systems: Introduction, stars, stellar magnitudes & colours, pulsars, stellar binaries, theoretical constraints on astronomical observations.

Stellar structure: introduction, equation of stellar structure, solutions to equations, toy stellar models, observational aspects of stellar atmospheres.

UNIT- II **9 Hrs.**

Stellar Evolution: Introduction, pre-main sequence collapse, evolution of high mass stars, evolution of low mass stars, late stage evolution of stars.

Supernova: Introduction, Formulation of iron cores & neutrino cooling, core collapse, supernova luminosity & light curves.

UNIT- III **10 Hrs.**

White dwarfs, neutron stars and black holes: introduction, structure of white dwarfs, surface structure & thermal evolution of white dwarfs, neutron star models, mass bounds for neutron stars, internal structure of neutron stars, gravitational collapse & black holes, rotating black holes.

UNIT- IV **9 Hrs.**

Pulsars: Introduction, EM field around the pulsar, glitches in pulsars, pulsar timing, pulsar scintillation.

Binary stars & Accretion: Introduction, low mass and high mass X-ray binaries, accretion disks, general relativistic effects in binary systems.

UNIT- V **8 Hrs.**

The sun and solar system: Introduction, the standard solar model, solar neutrinos, solar oscillations, the atmosphere and corona of the sun, solar wind, brief description of the solar system, aspects of solar system dynamics.

BOOKS RECOMMENDED:

- Green, S.F. & Jones, M.H., An Introduction to the Sun and Stars (Cambridge University Press)
- Jones, M.H. & Lambourne, R.J.A., An Introduction to Galaxies & Cosmology (Cambridge
- University Press)
- Carroll, B.W. & Ostlie, D.A., An Introduction to Modern Astrophysics (Pearson)
- Shu, F.H., The Physical Universe, An Introduction to Astronomy, (University Science Books)
- Motz, L. & Duveen, A., The Essentials of Astronomy, (Colombia University Press)
- T. Padmanabhan, Theoritical Astrophysics, volume II, (Cambridge University Press)

PAPER CODE-PHY 614(A)
Elements of Nanoscience and Nanotechnology
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
This course will make students learn about the change in properties of materials when subjected to nano-scale dimension. They also learn about basics of Nano-science and Nanotechnology and develop an understanding of various analytical techniques used in Nano science. It will also introduce them to the applications of nano-materials.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcome (at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>PHY 614(A)</td><td>Elements of Nanoscience and Nanotechnology
(Theory)</td><td>The students will be able to –

CO175: Understand basic properties of nanoparticle & applications.

CO176: Understand about synthesis of Carbon Nanotubes & Nanoelectronics.

CO177: Ability to understand the different analysis techniques for nano materials.

CO178: The student acquires necessary background to take up higher studies/research in the field of Nano Science & Nano-technology.</td><td>Approach in teaching:
Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving
in tutorials,

Learning activities for the students:
Self learning assignments, Effective questions, Seminar presentation, Solving numerical
Additional learning through online Videos, MOOCs Courses.</td><td>Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations</td></tr>
</table>

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Unit-I **9 Hrs.**

Types and Properties of Nanomaterials

Clusters and their types, Semiconductor Nano-particles, Effective Mass of nanoparticles Approximations, Optical Properties of Semiconductor nanoparticles, Surface plasmon Polariton, Nano-magnetism and Types of magnetic material, Mechanical and Structural Properties of Nano-materials.

Unit-II **9 Hrs.**

(a) **Nanomaterials:** Carbon Nanotubes, types of Carbon Nanotubes (CNT's), Synthesis and Properties and Structure of CNT's, Synthesis, Properties & Structure of Porus Silicon, Aerogels and Zeolites.

(b) **Nanoelectronics:** Coulomb Blockade, Single Electron Transistor (SET), Sprintonics- Gaint magneto Resistance, Spin Valve, Magnetic Tunnel Junction (MTJ), Spin Field Effect Transistor (SFET).

Unit-III **9 Hrs.**

Analysis Techniques- I (Microscopy)

Microscopy-Optical and Confocal Microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Atomic Force Microscope (AFM), Scanning Near-Field Optical Microscope (SNOM)

Unit-IV **9 Hrs.**

Analysis Technique –II (Spectroscopy)

Spectroscopy- Optical Absorption Spectrometer, Infrared Spectrometer, Fourier Transform Infrared Spectrometer (FTIR), Raman Spectroscopy, Photoluminescence Spectrometer, X-Ray Photoelectron Spectrometer (XPS), Auger Electron Spectroscopy.

Unit-V **9 Hrs.**

Applications of nanomaterials

Molecular and Nanoelectronics, Nanobots, Quantum dot devices, Photovoltaics, Fuel Cell, Hydrogen Strorage, Hybrid Energy Cells, Automobiles, Textiles, Medical Field, Space, defence and Engneering, Polymer LED, Organic LED, Spin based data storage.

BOOKS RECOMMENDED:

- Nanotechnology: Principle and Practices, S.K. KulKarni, Capital Publishing Company (2015).
- Physics of Semiconductor Nanostructures, K. P. Jain, Narosa Publishers (1997).
- Nanostructures: theory and modeling, C. Delerue and M. Lannoo, Springer Verlag (2006).
- Nanotechnology: An Introduction to Nanostructring techniques, M. Kohler, W. Fritzche, Wiley-VCH (2007).
- Carbon Nanotubes: Synthesis,Structure, Properties and Applications, M.S. Dresselhaus, G. Dresselhaus, Ph.Avouris, Springer (2001).
- Carbon Nanotubes; Properties and Applications, Michael J.O. Connell, CRC Press (2006).

- Nanostructure and Nanomaterials:Synthesis, Properties and Applications, G. Cao and Ying Wang, World Scientific Publishing (2011)
- Characterization of Nanophase material, Zhong lin Wang, Wiley-VCH Verlag (2001).
- Introduction to Magnetic Materials, B.D. Cullity and C.D. Graham; Wiley, A John (2011).
- Nanotechnology: Basic Science & Emerging Technologies, M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Chapman & Hall/CRC Press (2002)

PAPER CODE-PHY 614(B)
Renewable Energy-II
(Theory)

Credits: 03
Max Marks: 100
Contact Hrs/week: 03
Total Hrs: 45

Course Objectives:

This course will enable the students to -
The students are expected to identify the new methodologies/technologies for effective utilization of renewable energy sources, like Fuel Cell Technology, Hydrogen processing and Storage, Nuclear Power Plant, efficiency of solar cells, solar energy etc.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY 614(B)	**Renewable Energy-II** **(Theory)**	**The students will be able to –** **CO179:** Acquire the knowledge of fuel cells technology and applications. **CO180:** Appreciate the need of Nuclear Power Plants and the use in energy generation and know the classifications. **CO181:** Understand the concept of Hydrogen Production & storage and their classification, types of applications. **CO182:** Ability to understand the use of solar energy	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		technology and the various components used in the energy production with respect to applications like - heating, cooling etc. **CO183:** The student acquires ability to take up higher studies/research or a R & D project in energy production and its storage.	presentation, Solving numerical Additional learning through online Videos and MOOCs Courses.	

CONTENTS

Unit I **9 Hrs.**

Energy Conservation

Principles of energy conservation, energy conservation in air conditioning system, Electrical energy conservation in building lighting, heating, ventilating and air conditioning, Energy conservation through latent heat thermal energy storage systems.

Unit II **9 Hrs.**

Fuel Cell Technology

Fuel cells- definition, relevance and importance, classification of fuel cells. Electrochemistry basis of fuel cells. Alkaline fuel cells (AFC): Description, working principle, components, general performance characteristics, Ammonia as AFC fuel. Phosphoric Acid fuel cell. Solid oxide fuel cell (SOFC): History, benefits and limitations, cell components, Cathode and Anode materials, configuration and performance of fuel cell, Environmental impact of SOFC. Application and future of SOFC.

Unit III **9 Hrs.**

Hydrogen processing and Storage

Hydrogen Production: Electrolysis, Catalytic Methods, Thermo-chemical Methods, Fossil Fuel Methods, Solar Energy Method.

Hydrogen Storage: Hydrogen Storage Methods, Utilization of Hydrogen Gas, Hydrogen as an Alternative Fuel, Hydrogen Transportation, Utilization of Hydrogen Gas.

Unit IV **9 Hrs.**

Nuclear Power Plants

Types of nuclear reactors. Heat generation in fuel elements and temperature distributions. Heat removal, Reactor coolants. Reactor core. Shielding. Introduction to reactor reliability and safety analysis. Radioactive waste disposal. Economics of nuclear power. Introduction to nuclear fuel cycles.

Unit V **9 Hrs.**

Advanced applications in Solar energy technology

Building orientation and design, passive heating and cooling concepts, thumb rules, heat transfer in buildings. Potential and scope of solar cooling. Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air-conditioning.

BOOKS RECOMMENDED:

- Rai G.D. , Non-Conventional Energy Sources, Khanna Publishers, 2011
- Twidell and Wier, Renewable Energy Resources, CRC Press (Taylor and Francis), 2011
- Tiwari and Ghosal, Renewable energy resources, Narosa Publishing House, 2007
- Ramesh R and Kumar K.U , Renewable Energy Technologies,Narosa Publishing House, 2004
- Mittal K M , Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, New Delhi, 2003
- Kothari D.P, Singhal, K.C., Renewable energy sources and emerging technologies, P.H.I, New Delhi, 2010

PAPER CODE-PHY 615
Lab Course I
(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to -
The students will be able to plan and execute experiments. They will be able to handle scientific equipment safely and to the appropriate limit of accuracy.This course will make the students learn to handle simple treatment of errors.

Course Outcomes (COs):

Course		**Learning outcome (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
PHY 615	**Lab Course I** **(Practical)**	**The students will be able to –** **CO184:** Knowledge of Iodine Spectrum and to determine the experimental	**Approach in teaching:** Demonstration, Group activity, Discussion	Class test, Semester end examinations, Quiz, Solving problems ,

		values of energy bands with the help of a grating, spectrometer and ordinary bulb and to find the specific rotation of sugar, using a polarimeter. **CO185:** Understanding about monel alloy and Malus cosine law. To determine Curie temperature and verify of curie law with the help of a photo-voltaic cell. **CO186:** Understanding about Circuit components - capacitance, resistance, electronic charge and R-C, L-C Circuits Operational amplifier to Measurement and determine the values of De-Sauty bridge, Millikans's oil drop method, inverting amplifier and non-inverting amplifier. **CO187:** Skills to take observations, analyse them and do error analysis.	,Conduction of Experiments **Learning activities for the students:** Performing Experiments, Observations, Analysis and interpretation of results.	Assignments, Presentations

CONTENTS

List of Experiments

1. Study of Iodine Spectrum with the help of a grating, spectrometer and ordinary bulb.

2. To determine the specific rotation of sugar by polarimeter.

3. To verify Malus cosine law with the help of a photo-voltaic cell.

4. To determine curie temperature of monel alloy.

5. Measurement of capacitance by De-Sauty bridge.

6. Measurement of electronic charge by Millikans's oil drop method.

7. Study of R-C Transmission Line.

8. Study of L-C Transmission Line.

   a. At definite frequency

   b. At variable frequency

9. Application of operational amplifier as (a) inverting amplifier and (b) non inverting amplifier

PAPER CODE-PHY 616
Lab Course II

(Practical)

Credits: 02
Max Marks: 100
Contact Hrs/week: 04
Total Hrs: 60

Course Objectives:

This course will enable the students to –
This course introduces students to the methods of experimental physics. Emphasis is given on laboratory techniques such as accuracy of measurements and data analysis. The concepts that are learnt in the lecture sessions are translated to the laboratory sessions thus providing a hands-on learning experience.

Course Outcomes (COs):

Course		Learning outcome (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
PHY-616	**Lab Course II** **(Practical)**	**The students will be able to –** **CO188:** Apply knowledge of mathematics and physics fundamentals and an instrumentation technique to arrive at solution for various problems. **CO189:** Learn about the Basics Of Instrumentation, Data	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments **Learning activities for the students:**	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

		Acquisition And Interpretation of results. **CO190:** Learn about accuracy and precision, different types of errors and statistical analysis of data. **CO191:** Understand the behaviour of electronic components and perform analysis and design of bias circuits for diodes, transistors etc. **CO192:** To analyze nanoparticles spectra by FTIR, UV-VIS and XRD Spectra.	Performing Experiments, Observations, Analysis and interpretation of results.	

CONTENTS

List of Experiments

1. To study amplitude modulation and demodulation and measure modulation index.
2. To study single side band AM using balanced modulator.
3. Study the frequency response of a transistor wide band amplifier with and without feedback. Also obtain input and output impedance of the amplifier.
4. To determine the recovery time of a diode.
5. Demonstration of Training modules on Solar energy, wind energy, etc.
6. To study Hall Effect and to determine Hall coefficient.
7. To analyze nanoparticles spectra by FTIR spectroscopy.
8. To study the optical properties of nanoparticles by UV-VIS spectroscopy.
9. To study the structural properties of nanoparticles by XRD Spectra.

Programme- M.Sc. Geography

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Analyse the given scientific data critically and systematically and will have the ability to draw the objective conclusions. Know basics of cognitive biases, mental models, logical thinking, scientific methodology and constructing cogent scientific arguments. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
PO2	Keenly observe about what is going on in the natural surroundings to awake their curiosity and design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find emPSOyment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO5	Students are trained to be an individual with concern for the society they live and to contribute at maximum, their skills and

	knowledge in the broadest context, for the development of the nation.
PO6	Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Students are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
PO7	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will also enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will gain knowledge and skills for further higher studies, competitive examinations and emPSOyment.
PO8	Digitally literate to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
PO9	Students will learn team workmanship with productive cooperations involving members from diverse socio-cultural backgrounds in order to serve efficiently institutions, industry and society.
PO10	Develop various skills like Use of IT (word-processing, use of internet, statistical packages and databases), Communication of scientific ideas in writing and orally,. Ability to work as part of a team, Ability to use library resources,Time management and Career planning.
PO11	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and development of the information to provide valid conclusions.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Ability of Problem Analysis: Student will be able to analyses the problems of physical as well as cultural environments of both rural and urban areas. Moreover, they will try to find out the possible measures to solve those problems.
PSO 2	Conduct Social Survey Project: They will be eligible for conducting social survey project, which is needed for measuring the status of development of a particular group or section of the society.
PSO 3	Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PSO 4	Application of modern instruments: Students will be able to learn the application of various modern instruments and by these; they will be able to collect primary data.
PSO 5	Application of GIS and modern Geographical Map Making Techniques: They will learn how to prepare map based on GIS by using the modern geographical map-making techniques.
PSO 6	Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions from different perspectives.
PSO 7	Development of Observation Power: As a student of Geography Course, they will be capable to develop their observation power through field experience and in future, they will be able to identify the socio-environmental problems of a locality.
PSO 8	Development of Communication Skill and Interaction Power: After the completion of the course, they will be efficient in their communication skill as well as power of social interaction. Some of the students are being able to understand and write effective reports and design credentials, make effective demonstrations, and give and receive clear instructions.
PSO 9	Effective Citizenship: Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.
PSO 10	Enhancement of the ability of Management: Demonstrate knowledge and understanding of the management principles and apply these to theirs own work, as a member and leader in a team, to manage projects. They will perform effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PSO 11	Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.
PSO 12	Understand Environmental Ethics and Sustainability: Understand the impact of the acquired knowledge in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
PSO 13	Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context social, environmental and technological changes

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSO)

Course	**COs**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**	**PSO11**	**PSO12**	**PSO13**
GEO 121	CO 01					x		x					x	x
GEO 122	CO 02					x		x					x	x
	CO 03	x				x		x					x	x
GEO 123	CO 04	x	x	x			x	x		x	x	x	x	x
	CO 05	x	x	x			x	x		x	x	x	x	x
	CO 06	x	x	x		x	x	x		x	x	x	x	x
GEO 124	CO 07	x	x	x		x	x	x		x	x	x	x	x
	CO 08	x	x	x		x	x	x		x	x	x	x	x
	CO 09	x	x	x		x	x	x		x	x	x	x	x
GEO 125	CO 10	x			x			x					x	x
GEO 126	CO 11	x					x	x	x					x
GEO 221	CO 12					x		x					x	x
	CO 13	x	x	x	x	x	x	x	x	x	x	x	x	x
GEO 222	CO 14	x	x	x	x	x	x	x	x	x	x	x	x	x
	CO 15	x	x	x	x	x	x	x	x	x	x	x	x	x
	CO 16	x	x	x	x	x	x	x	x	x	x	x	x	x
GEO 223	CO 17	x	x	x		x	x	x		x	x	x	x	x
GEO 224	CO 18	x	x	x		x	x	x		x	x	x	x	x
	CO 19	x	x	x		x	x	x		x	x	x	x	x
	CO 20	x	x	x		x	x	x		x	x	x	x	x
GEO 225	CO 21	x	x	x		x	x	x	x	x	x	x	x	x
GEO 226	CO 22	x					x	x	x					x
GEO 321	CO 23	x	x	x	x	x	x	x	x	x	x	x	x	x
	CO 24	x	x	x	x	x	x	x	x	x	x	x	x	x
	CO 25	x	x	x	x	x	x	x	x	x	x	x	x	x
GEO 322	CO 26	x	x	x		x	x	x		x	x	x	x	x
	CO 27	x	x	x		x	x	x		x	x	x	x	x

	CO 28	x	x	x		x	x	x		x	x	x	x	x
	CO 29	x	x	x		x	x	x		x	x	x	x	x
	CO 30	x	x	x		x	x	x		x	x	x	x	x
GEO 323	CO 31	x	x	x		x	x	x		x	x	x	x	x
	CO 32	x	x	x		x	x	x		x	x	x	x	x
GEO 324	CO 33	x					x	x	x					x
GEO 325	CO 34	x	x		x	x	x	x						x
GEO 326	CO 35	x	x	x			x	x	x	x		x		x
GEO 421	CO 36	x				x		x					x	x
GEO 422	CO 37	x	x	x		x	x	x		x	x	x	x	x
	CO 38	x	x	x		x	x	x		x	x	x	x	x
	CO 39	x	x	x		x	x	x		x	x	x	x	x
GEO 423	CO 40	x				x		x					x	x
	CO 41	x				x		x					x	x
	CO 42	x				x		x					x	x
GEO 424	CO 43	x	x	x			x	x	x	x		x		x
GEO 425	CO 44	x	x		x	x	x	x						x
GEO 426	CO 45	x	x	x			x	x	x	x		x		x

M.Sc. GEOGRAPHY (2020-2021)

COURSE OUTCOMES - Semester I

Paper code-GEO 121
Geomorphology
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. The course aims to acquit the student with the conceptual framework for understanding the existing geomorphological landscapes and related processes.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 121	**Geomorphology (Theory)**	**The students will be able to –** **CO01:** On completion of the course the students should be able to describe the exogenous and endogenous process in the land scope, landform development and distinguish mechanisms that control these processes.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments,Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Fundamental in geomorphology. Evolution of geomorphological Thoughts**.**Relationship between process and landform.

Unit II **15 Hrs.**

Morphogenetic processes. Continental drift theory of wegener.Plate tectonic theory.Earth movements: epeirogenic, orogenic.Folding and Faulting

Unit III **15 Hrs.**

Drainage system and patterns. Morphometry of drainage basin.River valleys, graded river and profile.Channel morphology.

Unit IV **15 Hrs.**

Geomorphological Processes and their Landforms.Underground topography.Fluvial. Aeolian .Glacial.Marine.

Unit V **15 Hrs.**

Models of landscape evolution and slope development: Ideas of Davis, Penck, and King.Multicyclic and polygenetic evolution of landscapes.

BOOKS RECOMMENDED

- Chorley. R. J.; Spatial Analysis in Geomorphology, Methuen, Londan, 1972.
- Garner, H. F. ; The Origin of landscape – A Synthesis Geomorphology, Oxford University
- Press,London, 1974.
- Thornbury, W. D. Principles of Geomorpholgy, john Wiley, New York, 1960.
- Bloom,Arthur L., Geomorphology:A systematic analysis of late cenozoic landforms Prentice Hall of Delhi :2002

- Singh S, Geomorphology, Prayag Publication, Allahabad, 1998.
- Sparks, B. W. Geomorphology, Longman, London, 1960.
- 7.Khullar D.R.: Physical GeographY, Kalyani Publishers, 2012
- Strahler, A.M.: Modern Physical Geography. John Wiley and Sons. 1983
- Gurjar,R.K ; Jat,B.C, Geography of Water Resources, Rawat Publications, Jaipur, 2008
- Sharma, H. S. (ed.) Perspectives in Geomorphology. Concepts, New Delhi, 1980.

Paper code-GEO 122
Climatology
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. The course aims to acquit the student with the conceptual framework for understanding the Climatological processes.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
GEO 122	**Climatology (Theory)**	**The students will be able to –** **CO02:** The study of the climate system refers to making the students enable in seeking the knowledge of dynamics of the weather and atmospheric phenomenon to project the future climate. **CO03:** They are also able to analyze the observation of modeling the physical laws that determine the climate and its	**Approach in teaching:**Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

		changes and afterwards effects over the planet.		

CONTENTS

Unit I **15 Hrs.**

Basic concepts of climatology.composition s and structure of Atmospheric.Temperature, Insolation and heat budget of earth **,**Atmospheric pressure, Distribution and general circulation of winds

Unit II **15 Hrs.**

Atmospheric moisture: humidity, evoporation.Condensation: - forms of condensation; adiabatic temperature changes, hydrological cycle Precipitation: formation, types, Global pattern of precipitation

Unit III **15 Hrs.**

Airmasses: origin, growth and classification.Tropical and Temperate CyCOnes. Frontogenesis. Associated Weather Conditions.Frontogenesis

Unit IV **15 Hrs.**

Concept of climatic classification.Major climatic regions of the World : Classification by Koppen, Thornthwaite, Trewartha.

Unit V **15 Hrs.**

Climatic changes: Factors responsible for climate changes,Anthropogenic urban climate change,Micro-climatic changes,Global warming, Ozone depletion, Acid rain.

BOOKS RECOMMENDED:

- Khullar D.R.: Physical GeographY, Kalyani Publishers, 2012
- Bunnett,R.B Physical Geography in Diagrams, Delhi : Pearson Education, 2006
- Strahler, A.N. and Strahler, A.H.: Elements of Physical Geography, Johan Wiley & Sons, 1984
- Ahamed, E. Geomorphology, Kalyani Publishers, New Delhi, 1985
- Singh, Savinder : Climatology, Pravalika Publications, Allahabad, 2019
- Strahler, A.M.: Modern Physical Geography. John Wiley and Sons. 1983
- Prajapati,R.V: EncyCOpedia of Outline Physical Geography, New Delhi : Cyber Tech Publications,
- Critchfield, J.H.: General Climatology, Prentice Hall, India, New Delhi, 1993.
- Das, P.K.: Monsoons National Book Trust, New Delhi, 1987.
- India Met. Deptt.: Climatological Tables of Observatories in India, Govt. of India, 1968.
- Lal, D.S.: Climatology, Chaitanya Publications, Allahabad, 1986.
- Kumar, B and Singh, R.B. Urban Development and Anthropogenic Climate Change, Mahak Pub, New Delhi, 2001.
- Sen Roy., S. and Singh, R. B. Climate Variability, Extremes Events and Agricultural
- Productivity in mountain Resgion, Oxford & IBN Pub, New Delhi, 2002.

Paper code-GEO 123
REGIONAL DEVELOPMENT AND PLANNING
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to-

1. To understand and evaluate the concept of region in geography and its role and relevance in regional planning;
2. To identify the issues relating to the development of the region through the process of spatial organization of various attributes and their inter relationship.
3. To identify the causes of regional disparities in development, perspectives and policy imperatives.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
GEO 123	**REGIONAL DEVELOPMENT AND PLANNING (Theory)**	**The students will be able to –** **CO04:** The students will develop a critical understanding of key themes, concepts, and theoretical approaches related to regional development and planning. **CO05:** They will be able to summarize the history and context of regional development and planning in India and formulate policy recommendations regarding regional development and planning efforts. **CO06:**They will develop a set of analytical and practical skills (e.g., writing skills, ability to formulate policy recommendations) that will assist not only with the analysis of the material in the course but throughout their academic and professional careers.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Regional concept in Geography:-Types, hierarchy and characteristics of regions,Delineation methods of regions – Formal, Functional and Nodal. Geography and regional planning.Concept and scope of Regional Planning.Regional Approaches-Principles and techniques of regional planning,Need for planning.

Unit II **15 Hrs.**

Conceptual and theoretical frame work of regional planning:Growth pole and growth foci.Planning Processes:-Multilevel, decentralized planning. Integrated Area Development Planning (IADP).Planning for :Tribal and hilly areas,Drought prone areas,Command areas, Watershed.Planning for Metropolitan Region: CBD, satellite towns, urban green belt.

Unit III **15 Hrs.**

Concept of Development.Indicators of development.Regional imbalance.Planning for sustainable development.Regionalization of India:Based on natural, economic and administration (macro and meso levels only). Planning Regions in India (according to Town and Country Planning)

Unit IV **15 Hrs.**

Theories of regional development: Central Place Theory.An evaluation of regional disparities / imbalances:backward regions of India.Identification of backward areas,Planning backward area,Causes and consequences regional of disparities,Measures of disparities.

Unit V **15 Hrs.**

Regional Development in Rajasthan: Introduction physical regions resource regions and cultural regions,Factors influencing Connectivity and regional development,Factors responsible regional disparity,Regional development strategies in Rajasthan.

BOOKS RECOMMENDED

- Mishra,R.P: Regional Planning (New Delhi :Concept Publishing Company, 2002)
- Chandna,R.C.: Regional Planning and Development (New Delhi: Kalyani Publishers,2012)
- Chand,mahesh ; Puri,V.K : Regional Planning in India (New Delhi: Allied Publishers Ltd.,2010)
- Thakur,Rameshwar, Jeet,Inder ; Abay ; Resources and Regional Development in India (New Delhi: Rawat Publications, 2014)
- Sreedher G ; Rajasekhar,D :Rural Development in India (New Delhi : Concept Publishing Company, 2014)

Paper code-GEO 124
URBAN GEOGRAPHY
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. understand the process of urbanization and origin, growth and classification of urban settlements with relevant theories and models;
2. examine the changing economic base and structure of the contemporary cities;
3. relate urbanization process and the evolution of urban system;
4. examine the contemporary urban issues and suggest new urban planning and urban policy perspectives.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO124	**URBAN GEOGRAPHY (Theory)**	**The students will be able to –** **CO07:** The students would acquire knowledge of urban systems and will understand, and critique key paradigms and approaches in urban geography (e.g., industrial location, urban form, urban growth, recent trends, inequality, etc.). **CO08:** They will be able to link these topics and approaches to specific cases. **CO09:** They will develop skills in the critical analysis of urban hierarchies, process of urbanization, and urban problems and will apply that knowledge in an analysis of urban social or public policy with special reference to India.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **15 Hrs.**
Nature and Scope of Urban Geography.Different Approaches and Recent Trends in Urban Geography**.**Growth of Urban Settlements and Process of Urbanization.Classification of Urban Settlements on the basis of Size and Function.
Unit II: **15 Hrs.**

Urban Economic Base: Basic and Non-basic Functions,Concept of Dualism:Colonial and Postcolonial Structure, Metropolitan City and Changing Urban Function; Role of Informal Sector in Urban Economy.

Unit III: **15 Hrs.**
Organization of Urban Space:Urban Morphology and Landuse Structure: City Core, Commercial,Industrial,Residential Areas. Morphology of Indian Urban Settlements Umland,City Sprawl,Urban Rural Fringe **.**

Unit IV: **15 Hrs.**
Organization of Urban Space:Urban Morphology and Landuse Structure: City Core, Commercial,Industrial,Residential Areas. Morphology of Indian Urban Settlements. Umland,City Sprawl,Urban Rural Fringe.

Unit V: **15 Hrs.**

Urban Policy and Planning in India: Urban Policy,Contemporary Issues in Urban Planning,Globalization and Urban Planning, JNUNURM,Garden Cities, Sustainable Cities, Smart City and Resilient Cities,

BOOKS RECOMMENDED

- Siddhartha,K, Mukherjee,Subrata: Cities Urbanisation and Urban System (New Delhi : Kisalaya Publication Pvt.Ltd, 2000)
- Carter: The Study of Urban Geography (New Delhi: Rawat Publications, 2010)
- Bhattacharya, B :Urban Development in India(Since Pre- historic Times) (New Delhi : Concept Publishing Company, 2006)
- Bansal : Urban Geography (Meerut : MeenakshiPrakashan, 2010)
- Ayyer,Kamal: Urban Geography (RituPublications,Jaipur, 2015)
- Mandal,R.B: Urban Geography : A Textbook (New Delhi : Concept Publishing Company, 2000)
- Singh,Om: Urban Geography (Jaipur : DND Publications, 2018)
- Rao, Prakasa VLS: Urbanization in India(Spatial Dimensions) (New Delhi Concept Publishing Company, 2013)
- Ramachandran,R: Urbanization and Urban Systems in India (Oxford University Press, 2008)

Paper code-GEO 125
Practical in Interpretation of Topographical and Weather Maps
(Practical)

Credits: 8
Maximum marks: 100
Contact Hrs/Week: 12
Total Hrs: 180

Course Objectives:

This course will enable the students to –

1. To make students aware of the practical aspect of the subject.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 125	**Practical in Interpretation of Topographical and Weather Maps (Practical)**	**The students will be able to –** **CO10:** To attain the basic skills regarding interpretation and construction of Maps.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

1. Introduction to SOI topographical maps - numbering, scales, grid reference, signs and symbols, colour system, etc.
2. Preparation of sets of thematic maps - relief, drainage, land use, railroad, and settlement maps from toposheets
3. Instrumentation and measurement techniques of weather elements and processing of weather data
4. Study of Indian Daily Weather Report (IDWR)
5. Preparation of Report about the monsoon activity during a particular week with respect to temperature, rainfall.

BOOKS RECOMMENDED

- Gupta, K. K. and Tyagi, V. C. (1992): Working with maps. Survey of India Publication.
- WMO No. 8 (1983): Guide to Meteorological Instruments and Methods of Observation

- Daily and weekly weather reports of IMD.

Paper code-GEO 126
Seminar: Review of Literature
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Produce effective Research papers

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 126	**Seminar: Review of Literature (Seminar)**	**The students will be able to:** **CO11:** The students will be promoted to do original research work and will learn the basic step of Review of Literature	**Approach in teaching:** Discussion, Demonstration, Library and online Research. **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Practical assignments, seminar/ presentations and viva voce

CONTENTS

The students shall select a particular theme on which they will be guided as to how to effectively do a review of the published research works. For the examination purpose the students will present their work in form of a power point presentation, under the guidance of a particular Supervisor. At the end of the Semester the students will also select a Topic of Research.

BOOKS RECOMMENDED

- Ridley, Diana (2008): The Literature Review-A-Step-by-Step Guide for Students. SAGE, Publication, London.
- Jesson, Jill, Lydia Matheson and Fiona M. Lacey (2011): Doing Your Literature Review: traditional and Systematic Techniques.

M.Sc. GEOGRAPHY (2020-2021)

COURSE OUTCOMES - Semester II

Paper code-GEO 221
Oceanography
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. The course aims to acquit the student with the conceptual framework for understanding the Oceanographic processes.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 221	**Oceanography (Theory)**	**The students will be able to:** **CO12:** The students will be able to get the knowledge of the foundation of science of oceanography. **CO13:** They can explain the ocean floor, current sea satellite system, the chemistry of the oceans and the processes that led to its formation.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	**Assessment Strategies** Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **15 Hrs.**
Basic of oceanography, Origin of ocean basins: theory of plate tectonics and seafloor spreading;Ocean morphology and bottom relief: Pacific Ocean, Atlantic Ocean and Indian

Unit II: **15 Hrs.**

Origin and evolution of island arcs; Estuarine & coastal processes and landforms.Topography of the ocean floor: continental shelf, slope, rise, submarine channels, hills, ridges, trenches and abyssal plains;Physical and chemical properties of sea water: temperature, Density, Salinity Relation between temperature, Density, Salinity.

Unit III: **15 Hrs.**

Air-sea interaction and ocean circulation: currents, waves and tides.Ocean current: cause, types, currents of Pacific, Atlantic and Indian Ocean, Effects of ocean currents

Unit IV: **15 Hrs.**

Origin and growth of coral reefs; Ocean deposits: origin, type and distribution;Thermohaline circulation and the oceanic conveyor belt.

Unit V: **15 Hrs.**
Ocean and global environment: El Nino and Sea level changes; Oceanic regions & Marine resources. Marine pollution

BOOKS RECOMMENDED:

- Pinder, G.F., and Celia, M.A. (2006): *Subsurface Hydrology*, Wiley, Hoboken, New Jersey, 485pp.
- Pinet, P.R. (2009): *Invitation to Oceanography (5th Ed.)*, Jones and Bartlett Publishers, Sudbury, Massachusetts, 609pp.
- Raghunath, H.M. (2006): *Hydrology: Principles, analysis and Design (2nd Ed.)*, New age International, New Delhi, 477pp.
- Davis Richard J.A.: "Oceanography - An Introduction to the Marine Environment" Wm. C. Brown Lowa. 1986.
- Garrison, T.: "Oceanography - An Introduction to Marine Science. Books/Cole, Pacific Grove, USA, 2001.
- Gross, M. Grant: Oceanography, A View of the Earth, Prentice Hall Inc. New Jersey, 1987.
- King, C.A.M. Oceanography for Geogrphers, 1962.
- Sharma, R.C. "The Oceans" Rajesh N. Delhi, 1985.
- Singh, R.B. Natural Hazards and Disaster Management, Rawat Publication, Jaipur, 2006
- Ummerkutty, A.N.P. Science of the Oceans and Human Life, NBT, New Delhi, 1985.
- Singh, Savinder : Oceanography, Pravalika Publications, Allahabad, 2019

Paper code-GEO 222
Quantitative Geography
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. To provide geography a sound philosophical and theoretical base, and to make its methodology objective and scientific.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 222	**Quantitative Geography (Theory)**	**The students will be able to –** **CO14:** The students will be able to explain the role of quantitative information in geographic research and applications and can demonstrate an understanding of basic descriptive statistics and regression methods as they apply to problem solving in Geography. **CO15:** They would be able to perform basic data manipulation, statistical calculations and can give diagrammatic and graphical presentation by hand. **CO16:** They will evaluate the sampling distributions in drawing inferences about populations based on samples and can identify when and where statistical procedures are appropriate.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **15 Hrs.**

Quantification in Geography : Types of spatial data (point, line and area) and levels of their measurement (nominal, ordinal, interval and ratio),Collection of data, Censusand sample investigation, Editing of collected data, TabulationProbability: Theory of probability - law of addition and multiplication. Sampling frame and procedures, Standard error.Sampling designs (with special reference to spatial data). concept and types, Sample units and design

Unit II: **15 Hrs.**

Frequency distributions, Measures of central tendency - Mean, Median, Mode, mean centre, median point,Point of minimum aggregate travel distance, and population potential

Unit III: **15 Hrs**

Measures of dispersion : Range, quartile deviation, mean deviation, standard deviation and variance; coefficient of variability and Lorenz Curve.Index of spatial dispersion, median distance, standard distance**.**Nearest neighbor analysis.

Unit IV: **15 Hrs.**

Correlation and Regression : Scatter diagram, correlation by Spearman's Rank Difference and Karl.Pearson's Product Moment Methods,

Unit V: **15 Hrs.**

Regression analysis, construction of regression line; Coefficient of.Areal correspondence. Least square method, Chi-square test. Models – Gravity, Potential etc.Diagrammatic and Graphical representation of data

BOOKS RECOMMENDED:

- Elhance, D.N., Fundamentals of Statistics, KitabMehal, Allahabad, 1972.
- Peter, J. Taylor, Quantitative Methods in Geography, Houghton Mifflin Company, Boston, 1977.
- Robert Hammond and PatrikMcCullagh, Quantitative Methods in Geography, Clarendon Press,Oxford, 1974.
- Gupta, C.B., An Introduction to Statistical Methods, Ram Prasad and Sons, Agra, 1971.
- Peter Haggett, Andrew D. Cliff and Allan Frey, Locational Models, Vols. I and II, Arnold
  Heinemann, New Delhi, 1977.

Paper code-GEO 223
SOCIAL GEOGRAPHY
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. to familiarize the students with the understanding of the society through concepts and social theory, philosophical approaches and spatial processes;
2. to examine the process of social region formats in India with the help of social cultural and historical factors;
3. to examine social distortion and regionalize the various components of social well-being in India; to review problems and suggest alternatives to improve the social well-being in environmentally problematic areas.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 223	**SOCIAL GEOGRAPHY (Theory)**	**The students will be able to –** **CO17:** After completion the course students are able to understand the divisions within the society i.e. clam, ethnicity, religion, gender, sexual orientation, age and their common activity in both the rural and urban areas in reference to different social processes and their spatio-temporal effects over the region.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz,Assignments, Presentation, Individual and group projects

CONTENTS

Unit I: **15 Hrs.**

Nature, Scope and Evolution of Social Geography; Social Geography in the Realm of Social Sciences, Evolution of Social Geography in India, Contemporary Relevance of Social Geography

Unit II : **15 Hrs.**

Geography and Social Space with special reference to India.Geographical Factors in Social Formations.Evolution of Regions of Various Types in India.Unity in Diversity.

Unit III: **15 Hrs.**

Social and Cultural Factors of Diversity and Region Formation in India.Ethnicity. Tribes and Castes.Religion and Belief Systems.Languages.

Unit IV: **15 Hrs.**

Changing Dimension in Social Geography: Modernization,Urbanization.Social Identity on the basis of Class.Identity in Urban Space: Power and Space.Social Transformation and Changing Physical and Cultural Landscapes.Mobility and Changing Identities.

Unit V: **15 Hrs.**

Emerging Issues and Trends in Social Geography: Social Geographies of Inclusion and Exclusion,Slums,Communal Conflicts and Crime.

Concept of Social Well-Being: Well-being and Gross National Happiness, Quality of Life, Human Development Index,Issues of Health, Education and Gender**,**Policy and Planning of Social Development in India. .

BOOKS RECOMMENDED:

- Mandal,R.B :Statistics for Geographers and Social Scientists (New Delhi : Concept Publishing Company, 2014)

- Dutt,Ashok,K: Facets of Social Geography : International and Indian Perspectives (Delhi: Foundation Books, 2012)
- Saxena; M.H.: Indian and world Geography: Physical, Social and Economic Study (Rawat Publications, 2016)
- Mohanthy,G.S,: Social & Cultural Geography (Delhi : Isha Books, 2005)
- Mehtani,Subhah, Sinha,Amarjit : Social Geography (New Delhi, Common Wealth Publishers, 2010)
- Casino,VincentJ.Del: Social Geography (USA : Wiley-Blackwell,2009)

Paper code-GEO 224
Medical Geography
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. The study of medical geography or geography of health is essential to portray an understanding and prevailing of the patterns of diseases over locations and time. Analysis of the links between the migration of people and spread of diseases and environment and health is by its very nature a spatial problem.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 224	**Medical Geography (Theory)**	**The students will be able to –** **CO18:** The students will be able to provide a critical understanding of key concepts related to medical and health geography and will be able to examine the role of societal structures and human behaviour in creating and sustaining health inequalities and differences in access to health care. **CO19:** Along with that they will provide a set of analytical skills to evaluate the demographic, social, economic and political relationships that can explain health inequalities and differences in access to health care. **CO20:** They will understand how spatial analysis using Remote Sensing and GIS	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

		can benefit health care systems to enhance health access to health care.		

CONTENTS

Unit I: **15 Hrs.**

Introduction to Medical Geography and epidemiology. Scope of medical geography. Basics of epidemiology. Disease ecology.

Unit II : **15 Hrs.**

Infectious and Non infectious diseases: social and ecological origin.Social context of health inequalities.Species transfer and health.

Unit III: **15 Hrs.**

Demographic and Epidemiological Transitions, Migration, Mobility and Globalization.Slum health and its problems

Unit IV: **15 Hrs.**

Food, Nutrition and Health.Environmental Exposure and Health: Climate and Weather, pollution and hazards

Unit V: **15 Hrs.**

Remote Sensing and Health Applications. Spatial analysis: Infectious and chronic diseases of Tropics**.**

BOOKS RECOMMENDED:

- Maantay, J. (2007). "Asthma and air pollution in the Bronx: methodological and data considerations in using GIS for environmental justice and health research." Health Place 13(1): 32-56.
- Oliver, M. N., K. A. Matthews, et al. (2005). "Geographic bias related to geocoding in epidemiologic studies." Int J Health Geogr 4: 29.
- Mishra R.P, Medical Geography of India,, Lawrence Verry Incorporated, 1972
- AkhtarRais, leamonth Amos Thomas Andrew,Geographical Aspects of Health and Disease in India, Concept Publishing Company Pvt. Limited, 2018

Paper code-GEO 225
Practical in Geography of Tourism
(Practical)

Credits: 8
Maximum marks: 100
Contact Hrs/Week: 12
Total Hrs: 180

Course Objectives:

This course will enable the students to –

1. Career oriented practical paper.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 225	**Practical in Geography of Tourism (Practical)**	**The students will be able to –** **CO21:** There are many new and up-coming branches of Geography. One such is Tourism Geography. This paper will help students understand practical usage of the subject along with a practical ground.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

1. Definition, nature and scope Relation between geography and tourism
2. Factors affecting tourism
3. Globalization and tourism
4. Tourism development in India
5. Case Study: Analysis of tourism impacts and report writing
6. Including - Infrastructure and support system for tourism: Economic, social, physical and cultural impacts of tourism,Evaluation of tourism potential.

BOOKS RECOMMENDED:

- Kaul, R. K. (1985): Dynamics of Tourism and Recreation, Inter India, New Delhi
- Pearce, D. (1987): Tourism Today: A Geographical Analysis, Longman Scientific and Technical, New York
- Smith, L. J. S. (2010): Practical Tourism Research, CABI, Wallinford
- Robinson, H. (1996): A Geography of Tourism, Macdonald and Evans, London
- Das, M. (1999): India: A Tourist Paradise, Sterling Publishers, New Delhi

Paper code-GEO 226
Seminar: Research Methodology
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. To understand and learn the right methods of selecting the methodology for their research work.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 226	**Seminar: Research Methodolog y (Seminar)**	**The students will be able to –** **CO22:** From the review of Literature and with the guidance of the Supervisor the students will understand and learn to apply the appropriate Methodology for their works.	**Approach in teaching:** Discussion, Demonstration, Library and online Research. **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Practical assignments, seminar/ presentations and viva voce

CONTENTS

From the review of Literature and with the guidance of the Supervisor the students will understand and learn to apply the appropriate Methodology for their works.

BOOKS RECOMMENDED:

- Kothari, C. R. (2004): Research Methodology: Methods and Techniques, New Age International.

M.Sc. GEOGRAPHY (2020-2021)
COURSE OUTCOMES - Semester III

Paper code-GEO 321
BIOGEOGRAPHY
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. The paper will help sensitize the students with the biogeographical domain of their surroundings as Biogeography is important as a branch of geography that sheds light on the natural habitats around the world.
2. It is also essential in understanding why species are in their present locations and in developing protecting the world's natural habitats.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
GEO 321	**BIOGEOGRAPHY (Theory)**	**The students will be able to –** **CO23:** After completion of the course students are able to comprehend the composition of flora and fauna over the continents. **CO24:** They are able to know how distribution Patterns of plants and animal forms are the result of climatic and geographical conditions and how their evolution of Texan (genus or species) has taken place on the earth surface in different bio geographic regions. **CO25:** Moreover they can enhance their knowledge about the evolution, dispersal and impact of flora and fauna in different biomes of the world.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Biogeography and Ecosystem: Definition, scope and significance of biogeography;Basic ecological principles; Geo-biochemical cycles: carbon, nitrogen, oxygen and phosphorus cycles; Biome and biomass; Biodiversity: depletion and conservation.

Unit II **15 Hrs.**

Plant Geography :scope and development,Functioning and development of ecosystem,Evolution of plants **,**Plants and their classification: Climatic.

Unit III **15 Hrs.**

Plants and their environment.Plants and atmospheric factors.Plants and edaphic factors.Major biomes of the world: forests.grasslands and deserts.

UnitIV **15 Hrs.**

Zoogeography: Scope and development,Evolution of animals **,**Environmental adaptations.

Unit V **15 Hrs.**

Zoo-geographical regions of the world.Dispersal of- Mammals,Birds,Reptiles. Anthropogenic effects on animals.

BOOKS RECOMMENDED:

- Mandal, R.K.: Biodiversity and Ecology (New Delhi : Discovery Publishing House, 2012)
- Mehtani, Subhash: Biogeography (New Delhi, Common Wealth Publishers; 2010)
- Singh,R.B.: Biogeography and Biodiversity (New Delhi, Rawat Publications, 2009)
- Munir ; Rahman,Hifzur: Resource Development and Environmental Change Volume (New Delhi, Concept Publishing Company, 2012)
- Munir ; Rahman,Hifzur: Biogeography and Environmental Change (New Delhi, Concept Publishing Company, 2012)
- Harcourt, Alexander H.: Human Biogeography (New Delhi, Rawat Publications, 2012)

Paper code-GEO 322
Agriculture Geography
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. To provide the students with the basics in agricultural geography, starting from its nature, contents, progress, approaches, determinants and also provide them with

the understanding of agricultural regionalization, land use and land capability classifications as well as classification of agricultural types.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 322	**Agriculture Geography (Theory)**	**The students will be able to** **CO26:** The students will be able to learn about the different types of economic activities with the development of agriculture. They will be able to appreciate the factors responsible for the location and distribution of agriculture. **CO27:** They will also examine the significance and relevance of theories in relation to the different agricultural activities. **CO28:** They shall conceptualize the agricultural mapping techniques and its determinants along with the overview of Indian and World agriculture regions and systems. **CO29:** They will have sound knowledge about food security and appreciate the concepts, needs and various approaches to rural development. **CO30:** They will appreciate the area based and target group based approaches and provision of services along with various future prospects.	**Approach in teaching:**, Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Concept, origin and dispersal of agriculture, Development of agriculture through the age in important agricultural areas of the world, Modern with special reference to India and Rajasthan, trends and Practice, Factors influencing patters and farm techniques.

Unit II **15 Hrs.**

Soil: Major soil types: distribution, characteristics, their main use and problems for agricultural use, Soil nutrients: mineral and organic, Use of fertilizers and manures to improve agricultural productivity. Cultural practices influencing the soil characteristics. Soil Problems: Erosion and exhaustion-cause. Soil conservation: Physical and biological measures.

Unit III **15 Hrs.**

Types of agriculture shifting cultivation, plantation agriculture, Mediterranean type, collective and state farming extensive and intensive agriculture and their characteristics. Agricultural land use: concept and history, land use surveys, principles, objectives, policies and planning of land use surveys, land classification: need and basis of land classification

Unit IV **15 Hrs.**

Agricultural statistics and their mapping. Measurements of the levels of agricultural development-Concept and methodology. Agricultural regionalization-Concept, methods of delimitation Traditional and statistical methods. Crop-ranking, Crop-combination regions-meaning.

Unit V **15 Hrs.**

Preparation, planning and monitoring of a detailed Performa for land use surveys. Food storage technology.Green revolution in India. Live-stock combination, Diary development.Agro forestry importance, status and scope in India.

BOOKS RECOMMENDED:

- Mohammad Ali: Situation of Agricultural Geography, Rajeshpublication, New Delhi, 1981.
- ICAR: Soil and water Conservation Research (1956-71).
- SymonLesin:AgriculturalGeography,G.Gell and Sons Ltd.,London,1967.

Paper code-GEO 323
POPULATION GEOGRAPHY
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to-

1. Describe the complex dimensions of population.
2. Evaluate the association between demographic and socio-economic attributes of population and the resultant levels of social well- being and economic development.
3. Analyze the problems of population growth and environmental degradation.
4. Evaluate international and national population issues.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 323	**POPULATION GEOGRAPHY (Theory)**	**The students will be able to –** **CO31:** Students are able to know the ways in which spatial variations in the distribution, composition, migration, density and growth of the population are related to the nature of places. **CO32:** They can visualize that geographical study of population is involved in different aspects of demography and its impact on natural resources and finally in the development process of the country.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Introduction to Population Geography, its relation with other disciplines, population structure and characteristics .Importance of research in Population Geography .

Unit II **15 Hrs.**

Concept of mortality and theories in population growth.Concept and theories of fertility. Concept and theories of migration.

Unit III **15 Hrs.**

Population projection.Population policies.Population issues : Indian scenario Population issues : World scenario .Demographic transition in present situation.

Unit IV **15 Hrs.**

Geography of Population Resources Introduction: definition, nature and scope.Role of population resource in geography.Manpower planning: sector wise.Manpower management in India.Models for development of human resources in India.

Unit V **15 Hrs.**

Case studies of manpower development in Japan and Switzerland.Scarcity and unemployment of manpower.Status and roles of women and men. Demographic implications of recent changes in gender roles, families and household .Poverty and wealth.Technology and population development.

BOOKS RECOMMENDED:

- Singh,P.Diwan: Geography of Population, Delhi : Rajat Publications, 2018.

- Bashford,Alison : Global Population :History, Geopolitics and life on Earth (New York : Columbia University Press, 2013)
- Ameri : India's Population Problem (New Delhi , Anmol Publications, 2013)
- Hassan, Mohammad Izhar : Population Geography (New Delhi , Rawat Publications, 2005)
- Pandey,Akhilesh K: Population Geography (India : Ancient Publishing House, 2015)
- Tripathi, R.K.: Population Geography (New Delhi: Common Wealth Publishers; 2000)
- Newbold,K.Bruce : Population Geography: Tools & Issues (New Delhi, Rawat Publications, 2012)
- Sharma, Seema: Demographic Transition in India (Jaipur : Aavishkar Publishers Dis, 2016)
- Sharma,Rajendra Kumar: Demography and Population Problems (New Delhi : Atlantic Publishers And Distributors, 2007

Paper code-GEO 324
Dissertation
(Dissertation)

Credits: 6
Maximum marks: 100
Contact Hrs/Week: 12
Total Hrs: 180

Course Objectives:

This course will enable the students to –

1. Field Survey is an important and essential part of Geography. This paper acquaints the students with the same, specifically on the techniques of Field Surveying.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 324	**Dissertation (Dissertation)**	**The students will be able to –** **CO33:** To provide some skill specifically in field work and its related operations.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic and computer based (GIS) exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

Field Work in Geographical Studies: Geographic Enquiry and Field Survey, Preparation for Field Survey, Field Survey Procedures, Post Field Survey.

Selection of Problem, Area of Study and Field Instruments : Problem Identification and Field Selection, Questionnaire and Schedule for Field Work.

BOOKS RECOMMENDED:

- Gomez, B. and Jones, J.P. III (Ed.) (2010). *Research Methods in Geography: A Critical Introduction,* Wiley-Blackwell, New York
- Mishra, R.P. (1989). *Research Methodology: A Handbook*, Concept Publishing House, New Delhi.
- Stoddart, R. (1982). *Field Techniques and Research Methods in Geography,* University of Nebraska, Lincoln, http://digitalcommons.unl.edu/geographyfacpub .

Paper code-GEO 325
Practical in Cartography
(Practical)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 10
Total Hrs: 150

Course Objectives:

This course will enable the students to –

1. To enhance the practical skill and to illustrate both physical and cultural features on map and map projections.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 325	**Practical in Cartography (Practical)**	**The students will be able to –** **CO34:** To impart basic knowledge in Cartography and Toposheet and the basic understanding and construction of Projections.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

1. **Introduction to Cartography:**Nature and Scope and History of Cartography,History of Maps, Types and Uses of Maps**,**Concepts, Types, Construction and Reading of Map Scales.
2. **Map Projections:**Geographical Coordinates, Properties of Graticules, Classification of Projections,Terminologies, Properties and Uses.
3. **Cylindrical Projections**:Attributes and Properties: Cylindrical Equal Area and Mercator's Projection.
4. **Conical Projections:**Attributes and Properties: Conical Projection with Two Standard Parallel and Bonne's Projection.
5. **Zenithal Projections:** Attributes and Properties: Zenithal Gnomonic Polar Projection and Zenithal.Stereographic, Polar Projection.
6. **Toposheet Interpretation:**Topographical Maps, Representation of Relief by Contours, Identification of Physical and Cultural Features.

BOOKS RECOMMENDED:

- Singh, R.L. and Singh, R.P.B. (1999). *Elements of Practical Geography*, Kalyani Publishers, New Delhi.
- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*, Mothuen and Co. Ltd., London.
- Mishra, R.P. and Ramesh, A. (1989). *Fundamentals of Cartography*, Concept Publishing, Delhi.
- Sharma, J.P. (2010). *PrayogicBhugol*, Rastogi Publishers, Delhi.

Paper code-GEO 326
Seminar: Data Collection and Analysis
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Enhance the understanding of Data collection and analysis.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
GEO 326	**Seminar: Data Collection and Analysis (Seminar)**	**The students will be able to:** **CO35:** To create interest in Research and introduce the application of software for data collection and analysis.	**Approach in teaching:** Discussion, Demonstration, Library and online Research. **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Practical assignments, seminar/ presentations and viva voce

CONTENTS

The relevant data collection and its Analysis will be done with the help of SPSS and Ms-Excel.

BOOKS RECOMMENDED:

- Kothari, C. R. (2004): Research Methodology: Methods and Techniques, New Age International.

M.Sc. GEOGRAPHY (2020-2021)
COURSE OUTCOMES - Semester IV

Paper code-GEO 421
Remote Sensing and Geographic Information System
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. To make the students understand the principles, applications, trends, and pertinent issues of geographical information systems and sciences, including remote sensing (RS), Photogrammetry, cartography, and global positioning systems (GPS) and also to increase awareness of GIS and modeling tools for improving competition and business potential.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
GEO 421	**Remote Sensing and Geographic Information System (Theory)**	**The students will be able to –** **CO36:** Students will be able to recognize and explain at a basic level fundamental physical principle of remote sensing, including the electromagnetic spectrum; the emission, scattering, reflection, and absorption of electromagnetic (EM) radiation; how EM radiation interactions vary across a limited number of substances, geometries, and temperatures; and geometric properties of photographs and imagery.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Introduction to Remote Sensing; Fundamental principles, Electromagnetic radiation,EMR spectrum, EMR interaction with atmosphere and earth surface features.Photogrammetry; Aerial photographs: Types Characteristics; Scale and Geometry Aerial photographs, Relief displacement.

Unit II **15 Hrs.**

Definition and scope of GIS; Components of GIS; development of GIS. Implications of spherical and planar coordinate systems and their transformations in GIS; Georeferencing and implications of Earth's shape and datum in GIS.Data model: Raster and Vector models for geographic data representation; GIS data standards—concepts and components; Digital Elevation Model (DEM): process, derivatives and applications.

Unit III **15 Hrs.**

Introduction to GPS; GPS, Remote sensing and GIS integration; Remote Sensing Platform; Application of remote sensing, GPS and GIS in Urban planning, rural planning, water resource, environment, land use and land cover mapping.

UnitIV **15 Hrs.**

Graphic User Interface of RS Software – GIS Software.Data Input: Spatial and Non-Spatial; Scanning, Digitizing and; Data Import and Export; Data Registration, Georeferencing; Mosaic preparation.

Unit V **15 Hrs.**

Topology Building, Data Editing and Cleaning; Geo-Referencing; Projection and Datum; Coordinate Transformation; Linking Spatial and Non-Spatial. Data; Data Base Creation; Attribute Handling.

BOOKS RECOMMENDED:

- Adrados, C., Girard, I., Gendner, J., &Janeau, G. (2002). Global Positioning System (GPS) location accuracy due to selective availability removal. *C. R. Biologies*, 325, 165-170.
- Arvanitis, L., Ramachandran, B., Brackett, D., Rasoul, H., & Du, X. (2000). Multiresource inventories incorporating GIS, GPS and database management systems: A conceptual model. *Computers and Electronics in Agriculture*, 28, 89-100.
- Ellis, E. A., Nair, P. K. R., Linehan, P. E., Beck, H. W. &Blance, C. A. (2000). A GIS-based database management application for agroforestry planning and tree selection. *Computers and Electronics in Agriculture*, 27, 41-55.
- Lillesand, Remote Sensing and Image Interpretation, 5th Edn. , John Wiley & Sons, 2007.
- Walsh, A. and J. C. Ollenburger, 2000: Essential Statistics for the Social and Behavioral Sciences: A Conceptual Approach. Prentice Hall, pp. 320. ISBN-13: 978-0130193391

Paper code-GEO 422
ADVANCED GEOGRAPHY OF INDIA
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. To understand India in terms of its complexities especially at the level of historically evolved regional identities. It would help in comprehending India better in terms of its diverse personality with regards to regional issues and provide basis for better appreciation of unity in diversity for national integration. Intra-regional issues and linkages would help in analysing natural and human resource endowments at sub-national level.
2. To provide foundation to subsequently sensitize students towards development issues and programmes designed for holistic development of the country.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 422	**ADVANCED GEOGRAPHY OF INDIA (Theory)**	**The students will be able to –** **CO37:** Students are able to know the cultural aspects of different societies and their regional identities with their status of development through literacy, sex-ratio, and associated problems. **CO38:** They can comprehend the pattern of settlement, their connectivity with other regions and different types of communication and role of political behaviour in their social structure. **CO39:** They must be aware of environmental hazards, contemporary issues and their solutions.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

Cultural Setting: Historical Perspective of Indian Society: Racial, linguistic and ethnic diversities.Major tribal areas and their problems.Growth, distribution and density of population;Demographic attributes: sex-ratio, age structure, literacy rate, work-force, dependency ratio, longevity; migration (inter-regional, intra- regional and international) and associated problems;Population problems and policies; Health indicators.

Unit II **15 Hrs.**

Settlements: Types, patterns and morphology of rural settlements; Morphology of Indian cities; Functional classification of Indian cities;Conurbations and metropolitan regions; urban sprawl; Slums and associated problems;Town planning;Problems of urbanization and remedies.

Unit III **15 Hrs.**

Transport, Communication and Trade: Road, railway, waterway, airway and pipeline networks and their complementary roles in regional development; Growing importance of ports on national and foreign trade; Trade balance; Trade Policy; Export processing zones; Developments in communication and information technology and their impacts on economy and society; Indian space Programme.

Unit IV **15 Hrs.**

Political Aspects: Geographical basis of Indian federalism; State reorganization;Emergence of new states;Regional consciousness and interstate issues; Cross border terrorism; India's role in world affairs; Geopolitics of South Asia and Indian Ocean realm.

Unit V **15 Hrs.**

Contemporary Issues: Environmental hazards: landslides, earthquakes, Tsunamis, floods and droughts, epidemics.Issues relating to environmental pollution and degradation.Linkage of rivers.Globalization and Indian economy.

BOOKS RECOMMENDED:

- Sharma, T.C: Economic Geography of India (New Delhi, Rawat Publications, 2013)
- Singh: A Geography of India (Delhi : Atma Ram and Sons, 2006)
- Sengupta, Smita; Nag, Prithvish ; Geography of India (New Delhi : Concept Publishing Company, 1992)
- Tirtha,Ranjit: Geography of India (New Delhi, Rawat Publications, 2008)
- Qazi: Geography of India (Delhi : A.P.H. Publishing Corporation, 2011)
- Bansal: Geography of India (Hindi- Bharat kaaBhugol) (Meerut : MeenakshiPrakashan, 2004)
- Gautam, Alka: Advanced Geography of India (Allahabad ,ShardaPustakBhavan, 2006)
- Khullar,D.R.: India : A Comprehensive Geography (New Delhi, Kalyani Publishers, 2005)
- Deshpande,C.D.: India : a Regional Interpretation (Indian Council of Social Science Research; New Delhi, 1992)

Paper code-GEO 423
WATER RESOURCE GEOGRAPHY
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to-

1. to acquaint the learners with the basic concepts along with various techniques to estimate water resources meaningfully.
2. to enable the learners to carry out statistical calculations and methodologies in relation to water resource conservation and planning.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>GEO 423</td><td>WATER RESOURCE GEOGRAPHY (Theory)</td><td>The students will be able to –

CO40: Students can visualize the water scarcity on the planet. In this context they are able to know the availability of potable water, quality of water and cultivation of water.

CO41: Management of water resources through GIS and other Remote Sensing techniques are required for this purpose.

CO42: They are capable to prepare the project report on Drought & Flood prone area for the benefit of the society.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration,

Learning activities for the students:
Self learning assignments, Effective questions, Seminar presentation</td><td>Class test, Semester end examinations, Quiz,

Assignments, Presentation, Individual and group projects</td></tr>
</table>

CONTENTS

Unit I **15 Hrs.**

Water as a resource to human society: Changing perspective in uses of water. The Hydrologic Cycle.Global Water Balance.Water Flow through Aquifers.Human Interface on Hydrological Cycle.Inventory and Distribution of World's Water Resources

Unit II **15 Hrs.**

Water Availability and Water situation: Water uses in rural areas and associated problems. Water uses in urban areas and associated problems. Contemporary water wars Global and Indian context:Water politics in Rajasthan, Right to water,Role of Government and NGOs in mitigating water conditions.

Unit III **15 Hrs.**

Water Resource Management in India: Need and methods for conservation of water resources. Water Future: Challenges and Strategies Development In India.National water Policy- Integrated water resource development Action Plan.Urban surface runoff models: Management and Quality Models.

Unit IV **15 Hrs.**

Management of Water Quality: Water quality and pollution, types and sources of pollution, Water quality modeling, environmental guidelines for water quality.

Storm Water and Flood Management: Storm water management, design of drainage system, Flood routing through channels and reservoir, flood control and reservoir operation.

Drought Management: Drought assessment and classification, drought analysis techniques, drought mitigation planning.Water Conservation and Recycling: Perspective on recycle and reuse, Waste water reclamation

Unit V **15 Hrs.**

Application of Advanced Geographical Techniques for Water resources management and Development: Spectral properties of water- Geo informatics based site selection for river valley Projects, surface water harvesting structures: check dam and Nala bunds.Application of remote sensing in hydro geomorphological interpretation for Ground water exploration, Water Quality monitoring through remote sensing. Urban Hydrological cycle, urban surface runoff models: Management and Quality Models. GIS applications in water resources development and management.Flood and Drought hazard assessment and risk analysis using RS and GIS

BOOKS RECOMMENDED:

- Bhat,LS: Economic Geography Vol-1:Land, Water and Agriculture (Oxford University Press, 2016).
- Gurjar,R.K ; Jat,B.C: Geography of Water Resources (New Delhi, Rawat Publications, 2008)
- Reddy, Srinivasa: Groundwater Governance; Development, Degradation & management (New Delhi, Rawat Publications, 2016)
- Amresh: Handbook of Water and Wastewater Treatment (Delhi : Swastik Publishers & Distributors, 2011)
- Singh,Gurmel : Manual of Soil and Water(New Delhi, Oxford University Press,2011)

Paper code-GEO 424
Dissertation
(Dissertation)

Credits: 6
Maximum marks: 100
Contact Hrs/Week: 12
Total Hrs: 180

Course Objectives:

This course will enable the students to –

1. To create interest in the Geographical researches amongst the students.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
GEO 424	Dissertation (Dissertation)	**The students will be able to –** **CO43:** To provide some skill specifically in report writing and presentation.	**Approach in teaching:** Discussion, Demonstration, Action Research, Project, Field Trip **Learning activities for the students:** Field activities, Simulation, Presentation, Giving tasks	Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic and computer based (GIS) exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce

CONTENTS

A dissertation work has to be submitted in hard copy and presented in a Power-point presentation.

Paper code-GEO 425
Practical in Application of Remote Sensing
(Practical)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 10
Total Hrs: 150

Course Objectives:

This course will enable the students to –

1. To makes the students understand the application of Remote Sensing and Spatial Analysis Mapping.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>GEO 425</td><td>Practical in Application of Remote Sensing (Practical)</td><td>The students will be able to –

CO44: Students will demonstrate proficiency and conceptual understanding in using software or manual techniques to carry out remote sensing image processing and analysis through a series of laboratory exercises and reports</td><td>Approach in teaching:

Discussion, Demonstration, Action Research, Project, Field Trip

Learning activities for the students:
Field activities, Simulation, Presentation, Giving tasks</td><td>Class test, Semester end examinations, Observations of practical skills, Presentation, Cartographic and computer based (GIS) exercises, Practical assignments, Project and field work reports, seminar/ presentations and viva voce</td></tr>
</table>

CONTENTS
Identification and mapping of elements of natural and cultural landscape including topography.drainage, vegetation, settlements, transport networks, land use and field pattern.Application of remote sensing in management of environmental problems and natural hazards, such as floods, earthquakes, cyclones, forest fire, and droughts.

BOOKS RECOMMENDED:

- Fazal, S. and Rahman, A. : Geographic Information System (GIS) Terminology, New Age International Publishers, New Delhi, 2007.
- Heywood, Ian Cornelius, Sarah and Steve Carver.:An Introduction to Geographical Information Systems, 2nd ed.,Pearson Education Limited, Toronto, 2006.
- Siddiqui, M.A. : Introduction to Geographical Information Systems, ShardaPustakBhavan, Allahabad, 2006.
- Lo, C.P and Albert K.W.,Yeung: Concepts and Techniques of Geographic Information Systems, 2nd ed., Pearson Education Inc., Toronto, Canada, 2007.

Paper code-GEO 426
Seminar: References and Bibliography
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. Citation: Referencing and Bibliography form a very essential part of any research work. Also with this all the major topics relating to research will be covered.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>GEO 426</td><td>Seminar: References and Bibliography (Seminar)</td><td>The students will be able to:

CO45: This component along with the previous practical ones will make the students ready for research work.</td><td>Approach in teaching: Discussion, Demonstration, Library and online Research.

Learning activities for the students: Field activities, Simulation, Presentation, Giving tasks</td><td>Assessment Strategies Class test, Semester end examinations ,Observations of practical skills, Presentation, Practical assignments, seminar/ presentations and viva voce</td></tr>
</table>

CONTENTS

1. Citation: Referencing and Bibliography form a very essential part of any research work. They will be discussed with the students here.
2. Referencing and Bibliography on the topic on which the student has worked since the I Semester has to be submitted in hard-copy. In the presentation the student will depict the various types of sources used and how it's Referencing and Bibliography has been done using the format followed in the University.

(deemed to be UNIVERSITY) JAIPUR

Programme- M.Sc. Mathematics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Analyse the given scientific data critically and systematically and will have the ability to draw the objective conclusions. Know basics of cognitive biases, mental models, logical thinking, scientific methodology and constructing cogent scientific arguments. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
PO2	Keenly observe about what is going on in the natural surroundings to awake their curiosity and design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO5	Students are trained to be an individual with concern for the society they live and to contribute at maximum, their skills and knowledge in the broadest context, for the development of the nation.
PO6	Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Students are expected to possess basic psychological skills required to face the world at large, as

	well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
PO7	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will also enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will gain knowledge and skills for further higher studies, competitive examinations and employment.
PO8	Digitally literate to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
PO9	Students will learn team workmanship with productive cooperation's involving members from diverse socio-cultural backgrounds in order to serve efficiently institutions, industry and society.
PO10	Develop various skills like Use of IT (word-processing, use of internet, statistical packages and databases), Communication of scientific ideas in writing and orally,. Ability to work as part of a team, Ability to use library resources, Time management and Career planning.
PO11	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and development of the information to provide valid conclusions.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Communicate mathematical ideas effectively, in writing as well as orally. Have sound knowledge of mathematical modeling, programming and computational techniques as required for employment in industry.
PSO 2	Read, analyze, and write logical arguments to prove mathematical concepts.
PSO 3	Be able to apply mathematical skills and logical reasoning for problem solving.
PSO 4	Perform research in conjunction with others as well as individually.
PSO 5	Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.

PSO 6	Communicate mathematical ideas with clarity and coherence, both written and verbally.
PSO 7	Prepare students for pursuing research or careers in industry in mathematical sciences and allied fields
PSO 8	Imbibe effective scientific and/or technical communication in both oral and writing.
PSO 9	Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.
PSO 10	Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.
PSO 11	Nurture problem solving skills, thinking, creativity through assignments, project work.
PSO 12	Prepare and motivate students for research studies in mathematics and related fields.
PSO 13	Provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains.
PSO 14	Provide advanced knowledge on topics in pure mathematics, empowering the students to pursue higher degrees at reputed academic institutions.
PSO 15	Have a strong foundation in core areas of Mathematics, both pure and applied.
PSO 16	Assist students in preparing (personal guidance, books) for competitive exams e.g. NET, GATE, etc.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

Course	COs	PSOs															
		PSO 1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO 12	PSO13	PSO14	PSO 15	PSO16
MAT 121	**CO1**		X	x						x			x		x	x	x
	CO2		X	x		X				x			x			x	x
	CO3					X				x			x			x	x
	CO4					X				x			x			x	x
	CO5												x			x	x
MAT 122	**CO6**						x				x		x		x	x	x
	CO7				x					x			x		x	x	x
	CO8				x										x	x	x
	CO9				x										x	x	x
	CO10				x										x	x	x
MAT 123	**CO11**			x			x					X				x	x
	CO12			x								X		x		x	x
	CO13			x								X	x			x	x
	CO14			x								X	x			x	x
	CO15			x								X	x			x	x
MAT 124	**CO16**				x			x					x	x		x	
	CO17				x			x					x	x		x	
	CO18				x			x					x	x		x	
	CO19				x			x					x	x		x	
	CO20				x			x				X	x	x		x	

MAT 125	**CO21**	x				X		x				X	x	x			
	CO22	x				x		x				X	x	x			
	CO23	x				x		x				X	x	x			
	CO24	x				x		x				x	x	x			
	CO25	x				x		x				x	x	x			
MAT 126	**CO26**							x					x	x	x		
	CO27											x	x	x	x		
	CO28						x	x	x	x							
MAT 221	**CO29**		X										x		x	x	x
	CO30		X										x		x	x	x
	CO31		X										x		x	x	x
	CO32		X										x		x	x	x
	CO33		X										x		x	x	x
MAT 222	**CO34**		X	x												x	x
	CO35		X	x												x	x
	CO36		X	x												x	x
	CO37		X	x												x	x
	CO38		X	x												x	x
MAT 223	**CO39**			x	x							x	x	x			
	CO40			x	x							x	x	x			

	CO41			x	x							x	x	x			
	CO42			x	x							x	x	x			
	CO43			x	x							x	x	x			
	CO44			x	x							x	x	x			
MAT 224	**CO45**				x	x			x				x				
	CO46				x	x			x				x				
	CO47				x	x			x				x				
	CO48				x	x			x				x				
	CO49				x	x				x			x				
	CO50				x	x				x			x				
	CO51				x	x				x			x				
MAT 225	**CO52**	x						x		x				x			
	CO53	x						x		x				x			
	CO54	x						x		x				x			
	CO55	x						x		x				x			
	CO56	x						x		x				x			
	CO57							x					x	x	x		
MAT 226	**CO58**											x	x	x	x		
	CO59						x	x	x	x							
MAT 321	**CO60**		X										x		x	x	X

	CO61		X										x		x	x	X
	CO62		X										x		x	x	X
	CO63		X										x		x	x	X
	CO64		X										x		x	x	X
MAT 322	**CO65**	x			x			x	x					x			
	CO66	x			x			x	x					x			
	CO67	x			x			x	x					x			
	CO68	x			x			x	x					x			
MAT 323A	**CO69**	x		x				x	x	x		x		x			
	CO70	x		x				x	x	x		x		x			
	CO71	x		x				x	x	x		x		x			
	CO72	x		x				x	x	x		x		x			
	CO73	x		x				x	x	x		x		x			
MAT 323B	**CO74**	x	X	x					x			x		x			
	CO75	x	X	x					x			x		x			
	CO76	x	X	x					x			x		x			
	CO77	x	X	x					x			x		x			
MAT 323C	**CO78**	x						x		x		x		x			
	CO79	x						x		x		x		x			

	CO80	x						x		x		x		x			
	CO81	x						x		x		x		x			
MAT 324A	**CO82**	x				x								x			X
	CO83	x	X			x								x			x
	CO84	x				x								x			x
	CO85	x		x		x								x			x
MAT 324B	**CO86**		X	x							x						x
	CO87		X	x							x						x
	CO88		X	x							X						x
	CO89		X	x			x				X						x
	CO90		X	x			x				X						x
	CO91		X	x			x				X						x
	CO92		X	x			x				X						x
MAT 324C	**CO93**		X			x									x	x	x
	CO94		X			x									x	x	x
	CO95		X			x									x	x	x
	CO96		X			x									x	x	x
	CO97		X			x									x	x	x
MAT 325A	**CO98**	x			x	x			x								

	CO99	x			x	x			x								
	CO100	x			x	x			x								
	CO101	x			x	x			x								
	CO102	x			x	x			x								
MAT 325B	**CO103**	x		x	x			x				x		x			
	CO104	x		x	x			x				x		x			
	CO105	x		x	x			x				x		x			
	CO106	x		x	x			x				x		x			
	CO107	x		x	x			x				x		x			
MAT 325C	**CO108**			x			x				x				x		
	CO109			x			x				x				x		
	CO110			x			x				x				x		
	CO111			x			x				X				x		
	CO112			x			x				X				x		
MAT 326	**CO113**	X		X					X	x							
	CO114	X		X					X	X							
	CO115	X		X					X	X							
MAT 421	**CO116**		X	x		x									x		x
	CO117		X	x		x									x		x
	CO118		X	x		x									x		x

	CO119		X	x		x									x		x
	CO120		X	x		x									x		x
MAT 422	**CO121**	x			x			x	x				x	x			
	CO122	x			x			x	x				x	x			
MAT 423A	**CO123**	x			x							x		x		x	x
	CO124	x			x							x		x		x	x
	CO125	x			x							x		x		x	x
	CO126	x			x							x		x		x	x
	CO127	x			x							x		x		x	x
MAT 423B	**CO128**	x			x							x		x			
	CO129	x			x							x		x			
	CO130	x			x							x		x			
	CO131	x			x							x		x			
	CO132	x			x							x		x			
MAT 423C	**CO133**	x					x	x				x		x			
	CO134	x					x	x				x		x			
	CO135	x					x	x				x		x			
	CO136	x					x	x				x		x			
MAT 424A	**CO137**	x		x		x			x			x	x				x
	CO138	x		x		x			x			x	x				x

	CO139	x		x		x			x			x	x				x
	CO140	x		x		x			x			x	x				x
	CO141	x		x		x			x			x	x				x
MAT 424B	**CO142**		X		x				x			x		x			
	CO143		X		x				x			x		x			
	CO144		X		x				x			x		x			
	CO145		X		x				x			x		x			
	CO146		X		x				x			x		x			
MAT 424C	**CO147**		X	x						x					x	x	x
	CO148		X	x						x					x	x	x
	CO149		X	x						x					x	x	x
	CO150		X	x						x					x	x	x
	CO151		X	x						x					x	x	x
MAT 425A	**CO152**	x				x		x			x		x			x	
	CO153	x				x		x			x		x			x	
	CO154	x				x		x			x		x			x	
MAT 425B	**CO155**	x				x		x				x			x	x	
	CO156	x				x		x				x			x	x	
	CO157	x				x		x				x			x	x	
	CO158	x				x		x				x			x	x	

	CO1 59	x				x		x				x			x	x	
MAT 425C	**CO1 60**			x		x					x				x		x
	CO1 61			x		x					x				x		x
	CO1 62			x		x					x				x		x
	CO1 63			x		x					x				x		x
	CO1 64			x		x					x				x		x
MAT 426	**CO1 65**	X		X					X	x	X						
	CO1 66	X		X					X	X	X						
	CO1 67	X		X					X	X	X						
	CO1 68	X		x					X	x	X						
	CO1 69	x		X					x	X	X						

M.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE - MAT 121
Advanced Algebra
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Demonstrate knowledge of conjugacy relation and class equation.
2. Identify the irreducibility of polynomials.
3. Develop the concepts of extension fields.
4. Find the splitting field for a given polynomial.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 121	**Advanced Algebra (Theory)**	**The students will be able to –** **CO1:** Understand and introduce the language and precision of abstract algebra. **CO2:** The course is proof-based, in the sense that students will be expected to understand, construct, and write proofs. **CO3**: The course will create the tendency to think of why a mathematical statement is true or false. **CO4:** In fact the course inculcates the way thoughts because constructing a legitimate proof involves different skills and expertise than the discovery part of the process. **CO5:** In this course both angles of problem-solving will be stressed.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Direct product of groups (external and internal), Isomorphism theorems, Diamond isomorphism theorem, Butterfly lemma, Conjugate classes.

Unit II **15 Hrs.**

Commutators, Derived subgroups, Normal series and solvable groups, Composition series, Refinement theorem and Jordan-Holder theorem for infinite groups.

Unit III **15 Hrs.**

Modules, Submodules, Quotient modules, Direct sums and module homomorphisms, Generation of modules, Cyclic modules.

Unit IV **15 Hrs.**

Field theory: Extension fields, Algebraic and transcendental extensions, Separable and inseparable extensions, Normal extensions, Splitting fields.

Unit V **15 Hrs.**

Galois Theory: Elements of Galois Theory, Fundamental theorem of Galois Theory, Solvability by radicals.

BOOKS RECOMMENDED

- Dileep S. Chauhan and K.N. Singh, Studies in Algebra, JPH, Jaipur, 2011.
- P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1995.
- I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
- Knapp, W. Anthony, Advanced Algebra, Springer, 2008.

- Deepak Chatterjee, Abstract Algebra, PHI. Ltd. New Delhi, 2015.
- John B. Fraleigh, A First Course in Abstract Algebra, Narosa Publishing House, New Delhi, 2002.
- S. David, Richard M. Foote Dummit, Abstract Algebra, John Wiely & Sons Inc. USA, 2003.
- S. Hang, Algebra, Addison Wesley, 1993.
- N. Jacobson, Basic Algebra, Hindustan Publishing Co, 1988.
- M. Artin, Algebra, Prentice Hall India, 1991.
- C. Musili, Introduction to Rings and Modules, Narosa Publishing House, New Delhi, 1994

PAPER CODE - MAT 122
Measure Theory
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. Understand the concept of the abstract measure theory, definition and main properties of the integral.
2. Construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.
3. Learn the advanced directions of measure theory.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 122	**Measure Theory (Theory)**	**The students will be able to –** **CO6:** Students get ideas about the theory of measure. **CO7:** Student know how to develop the ideas of Lebesgue integration and its properties **CO8:** Students know how to show that certain functions are measurable: • construct the Lebesgue integral • understand properties of the Lebesgue integral **CO9:** Students know about Lebesgue theorem on the passage to the limit under the integral sign for bounded measurable functions, Summable functions: Space of square summable functions. Fourier series and coefficients, Parseval's identity, Riesz-Fisher Theorem. **CO10:** Students know about Lp-spaces, Holder - Minkowski inequalities, Completeness of Lp-spaces.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Team teaching **Learning activities for the students:** Self learning assignments, Effective questions, , Topic presentation, Giving tasks,	Class test, Semester end examinations, Quiz, Presentation

CONTENTS

Unit I **15Hrs.**

Algebra and algebras of sets, Algebras generated by a class of subsets, Borel sets, Lebesgue measure of sets of real numbers, Measurability and measure of a set, Existence of non-measurable sets.

Unit II **15Hrs.**

Measurable functions: Realization of non-negative measurable function as limit of an increasing sequence of simple functions, Structure of measurable functions, Convergence in measure, Egoroff's theorem.

Unit III **15Hrs.**

Lebesgue integral of bounded measurable functions, Lebesgue theorem on the passage to the limit under the integral sign for bounded measurable functions.

Unit IV **15Hrs.**

Summable functions: Space of square summable functions. Fourier series and coefficients, Parseval's identity, Riesz-Fisher Theorem.

Unit V **15Hrs.**

L^p-spaces, Holder-Minkowski inequalities, Completeness of L^p-spaces.

BOOKS RECOMMENDED:

- Shanti Narayan, A Course of Mathematical Analysis, S.Chand & Co.New Delhi, 2005.
- T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1996.
- Walter Rudin, Real and Complex Analysis, McGraw-Hill Education, 1986.
- P.K. Jain and S.K. Kaushik, An Introduction to Real Analysis, S.Chand & Co, New Delhi, 2000.
- R.R. Goldberg, Real Analysis, Oxford and IBH publishing Company, New Delhi, 1970.
- Halsey Royden, Patrick Fitzpatrick, Real Analysis, Pearson's United States Edition, 2010.
- G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book, New Delhi, 1963.
- G. De. Barra, Measure Theory and Integration, Wiley Eastern, 1981.
- S.K. Berberian, Measure and Integration, McMillan, New York, 1965.
- I.K. Rana, An Introduction to Measure and Integration, Narosa Publishing House New Delhi, 1997.

PAPER CODE - MAT 123
Advanced Differential Equations
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the fundamentals of ordinary and partial differential equations and its applications to calculating boundary value problems.
2. Aware about the concept of heat and wave equations, conditions at the boundary of the spatial domain and initial conditions at time zero.
3. Learn technique of separation of variables to solve PDE's and analyze the behavior of solutions in terms of Eigen function expansions.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 123	**Advanced Differential Equations (Theory)**	**The students will be able to –** **CO11:** The students will get the Competence in solving applied problems which are linear and nonlinear form. **CO12:** Solve the problems choosing the most suitable methods. **CO13:** Determine the solutions of differential equations with initial and boundary conditions **CO14:** Enhance and develop the ability of using the language of mathematics in analysing the real-world problems of sciences and engineering. **CO15:** Techniques to predict the behaviour of certain phenomena.	**Approach in teaching:** Discussion, Demonstration, Team teaching, Presentation **Learning activities for the students:** Self learning, Presentation, Effective questions, Giving tasks	Observation, Presentation, Report writing,

CONTENTS

Unit I **15 Hrs.**

Non-linear ordinary differential equations of particular forms, Riccati's equation: General solution and the solution when one, two or three particular solutions are known, Total differential equations.

Unit II **15 Hrs.**

Second order partial differential equations: Formulation and classification of second order partial differential equations, Monge's methods: Canonical forms, classification of second order partial differential equations of the type Rr+Ss+Tt+ f (x,y,z,p,q)=0 and second order partial differential equations in more than two independent variables, Method of separation of variables, Laplace, Wave and diffusion equations.

Unit III **15 Hrs.**

Linear homogeneous boundary value problems, Eigen values and eigen functions, Strum-Liouville boundary value problems, Orthogonality of eigen functions, Reality of eigen values, Series solution (all four cases).

Unit IV **15 Hrs.**

Calculus of variation: Functionals, Variation of a functional and its properties, Variational problems with fixed boundaries, Euler's equation and it's alternative forms, Extremals, Functionals dependent on several unknown functions and their first order derivatives, Functionals dependent on higher order derivatives, Functionals dependent on the function of more than one independent variable.

Unit V **15 Hrs.**

Variational problem in parametric forms, Isoperimetric problem and conditions, Geodesic problems, Variational problems with moving (or free) boundaries: One sided variations only for a functional dependent in one or two functions.

BOOKS RECOMMENDED

- Z. Ahsan, Differential Equations & Their Applications, PHI, New Delhi, 2016.
- J. L. Bansal and H. S. Dhami, Differential Equations, Jaipur Publishing House, Jaipur, 2014.
- M. D. Raisinghania, Advanced differential equation, S. Chand and Co. Ltd., 2012.
- R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd, London, 1956.
- Frank Ayres, Schaum's Theory and Problems of Differential Equations, McGraw Hill, 2012.
- D. A. Murray, Introductory Course in Differential Equations, University of Michigan Library, 1902.
- W. E. Boyce and P. C. Diprima, Elementary Differential Equations and Boundary Value Problems, John Wiley, 1986.
- E. A. Coddington, An Introduction to Ordinary Differential Equations, PHI New Delhi, 2003.
- G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill, New York, 1972.
- E. D. Ranville, Elementary Differential Equations, Macmillan Company New York, 1964.
- N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, 2006.

PAPER CODE - MAT 124
Differential Geometry-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Acquaint with the fundamentals of differential geometry primarily by focusing on the theory of curves and surfaces in three spaces.
2. Compute quantities of geometric interest such as curvature, as well as develop a facility to compute in various specialized systems, such as semi geodesic coordinates or ones representing asymptotic lines or principal curvatures.
3. Learn about tangent spaces, Surfaces, Gauss map, Geodesics on surfaces and curvature of plane curve.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT124	**Differential Geometry-I (Theory)**	**The students will be able to –** **CO16**: The theory of curves studies global properties of curves such as the four vertex theorem. Study the concept of Curvature of plane curves and surface **CO17:** The theory of surfaces introduces the fundamental quadratic Forms of a surface, intrinsic and extrinsic geometry of surfaces, and the Gauss-Bonnet theorem. **CO18:** Analyse the equivalence of two curves by applying some theorems. **CO19:** Understand Gauss map-Geodesics. Express definition and parameterization of surfaces. **CO20:** Integrate differential forms on surfaces.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, Team teaching, PowerPoint presentations. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Posters and Charts preparation.	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual

CONTENTS

Unit I **15 Hrs.**

Theory of curves: Space curves, Tangent, Contact of curve and surface, Osculating plane, Principal normal and binormal, Curvature, Torsion, Serret-Frenet's formulae.

Unit II **15 Hrs.**

Osculating circle and osculating sphere, Existence and uniqueness theorems for space curves, Bertrand curves, Involutes, Evolutes.

Unit III **15 Hrs.**

Envelops and edge of regression, Ruled surfaces, Developable surfaces, Tangent plane to a ruled surface, Necessary and sufficient condition that a surface $\zeta = f\ (\xi, \eta)$ should represent a developable surface, Metric of a surface: First, second and third fundamental forms.

Unit IV **15 Hrs.**

Fundamental magnitudes of some important surfaces, Orthogonal trajectories, normal curvature, Meunier's theorem, Principal directions and principal curvatures, First curvature, Mean curvature, Gaussion curvature, Umbilics.

Unit V **15 Hrs.**

Radius of curvature of any normal section at an umbilic on $z = f\ (x, y)$, Radius of curvature of a given section through any point on $z = f(x, y)$, Lines of curvature, Principal radii, Relation between fundamental forms, Curvature of the normal section.

BOOKS RECOMMENDED

- J.L. Bansal and P.R. Sharma, Differential Geometry, Jaipur Publishing House Jaipur, 2013.
- P.P. Gupta and G.S. Malik, Differential Geometry, Pragati Prakashan, Meerut, 2012.
- Prasun Kumar Nayak, Tensor Calculus and Differential Geometry, PHI Learning Pvt. Ltd., 2012.
- Raj Bali, Differential Geometry, Navkar Publication, Ajmer, 2012.
- T. J. Willmore, An Introduction to Differential Geometry, Oxford University Press, London, 1972.
- Dirk J. Struik, Lectures on Classical Differential Geometry, Addison Wesley Publishing Company, London, 1961.
- Erwin Kreyszig, Differential Geometry, Dover Publishing, 1991.
- H.K. Pathak and J.P. Chauhan, Differential Geometry, Shiksha Sahitya Prakashan, 2012.
- Clifford Henry Taube’s, Differential Geometry, Oxford university press, 2011.
- B. D. Neill, Elementary Differential Geometry, Academic Press, London, 1996.
- Nirmala Prakash, Differential Geometry, Tata McGraw Hill, 1981.
- Millan and G. D. Parker, Elements of Differential Geometry, PHI, 1977.
- D. Somasundaram, Differential Geometry, Narosa Publishing House, New Delhi, 2005.

PAPER CODE - MAT 125
Dynamics of a Rigid Body
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Acquaint the students with mechanical systems under generalized coordinate systems, virtual work, energy and momentum.
2. Aware about the mechanics developed by Newton, Lagrange's, Hamilton.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT125	**Dynamics of a Rigid Body (Theory)**	**The students will be able to –** **CO21:** Understand D'Alembert's Principle and its simple applications. Able to construct General equation of motion of a rigid body under fixed force, no force and impulsive force. **CO22:** Describe the concept of Motion of a rigid body in two dimensions, Rolling and sliding friction, rolling and sliding of uniform rod and uniform sphere. **CO23**: Able to Describe Motion in three dimensions with reference to Euler's dynamical and geometrical equations, Motion under no forces, Motion under impulsive forces. **CO24:** Analyze the Derivation of Lagrange's Equations to holonomic Systems. Understand the motion of top. **CO25:** Distinguish the concept of the Hamilton Equations of Motion and the Principle of Least Action.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, power point presentation **Learning activities for the students:** Self learning assignments, Effective questions, Simulation, Seminar presentation	Class test, Semester end examinations, Quiz, Solving problems in tutorials, Assignments, Presentation, Individual and group projects

CONTENTS

Unit I **15 Hrs.**

D'Alembert's principle, General equations of motion of a rigid body, Motion of centre of inertia and motion relative to centre of inertia, Motion about a fixed axis: Finite forces moment of effective forces about a fixed axis of rotation, Angular momentum, Kinetic energy of a rotating body about a fixed line, Equation of motion of the body about the axis of rotation, Principle of conservation of energy.

Unit II **15 Hrs.**

Motion of a rigid body in two dimensions: Equations of motion in two dimensions, Kinetic energy of a rigid body, Moment of momentum, Rolling and sliding friction, Rolling of a sphere on a rough inclined plane, Sliding of a rod, Sliding and rolling of a sphere on an inclined plane, Sliding and rolling of a sphere on a fixed sphere, Equations of motion of a rigid body under impulsive forces, Impact of a rotating elastic sphere on a fixed horizontal rough plane, Change in kinetic energy due to the action of impulse.

Unit III **15 Hrs.**

Motion in three dimensions with reference to Euler's dynamical and geometrical equations, Motion under no forces, Motion under impulsive forces, Conservation of momentum (linear and angular) and energy for finite as well as impulsive forces.

Unit IV **15 Hrs.**

Lagrange's equations for holonomous dynamical system, Energy equation for conservative field, Small oscillations, Motion under impulsive forces, Motion of a top.

Unit V **15 Hrs.**

Hamilton's equations of motion, Conservation of energy, Hamilton's principle and principle of least action.

BOOKS RECOMMENDED

- M.D. Raishinghania, Dynamics, S.Chand & Co. New Delhi, 2016.
- J.L. Bansal and P.R. Sharma, Dynamics of a Rigid Body, Jaipur Publishing House, Jaipur, 2009.
- P.P. Gupta and G.S. Malik, Rigid Body of Dynamics-I, Krishna Prakashan, 2014.
- S.L Loney, The Elementary on the Dynamics of a Particle and the Rigid Bodies, GK Publications Ltd., 2012.
- J.L. Synge and B.A. Griffith, Principles of Mechanics, McGraw-Hill, New York, 1942.
- M.Ray and H.S. Sharma, Text Book on Dynamics of Rigid Body, Student's friend &Company, 1960.
- Patrick Hamill, Intermediate Dynamics, Jhones & Barlett Publication, 2010.
- S.L. Loney, Dynamics of a Particle and Rigid body, Maxford Books Pub, 2003.
- S.L. Loney, A Text Book on Dynamics of Particle and Rigid Body, AITBS Publishers & Distributers, 1991.
- E.T. Whittaker, A Teatise on the Analytical Dynamics of Particles and Rigid Bodies, Cambridge University Press, 1965.

PAPER CODE – MAT126
Seminar
(Seminar)

Credits: 2
Maximum marks: 100

Course Objectives:

This course will enable the students to –

1. Understand the history of mathematics and its recent areas.
2. Understand the diverse role of mathematics in social and economic areas through independent learning.
3. Identify, understand and discuss current, real-world issues.
4. Improve oral and written communication skills.

5. Apply principles of ethics and respect in interaction with others.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT126	**Seminar (Seminar)**	**The students will be able to –** **CO26:** Use multiple thinking strategies to examine real-world issues, explore creative avenues of expression, solve problems, and make consequential decisions. **CO27:** Acquire, articulate, create and convey intended meaning using verbal and non-verbal method of communication that demonstrates respect and understanding in a complex society. **CO28:** Apply principles of ethical leadership, collaborative engagement, socially responsible behavior, respect for diversity in an interdependent world, and a service-oriented commitment to advance and sustain local and global communities.	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing

M.Sc. /M.A. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester II

PAPER CODE - MAT 221
Linear Algebra
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Understand the concept of systems of linear equations, linear span, linear independence, basis and dimension.
2. Understand how to apply these concepts in various vector spaces and subspaces.

3. Understand Compute and use eigenvectors and eigen values.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT221	**Linear Algebra (Theory)**	**The students will be able to:** **CO29:** Identify and construct linear transformations of a matrix. **CO30:** Characterize linear transformations as onto, one-to-one. **CO31:** Solve linear systems represented as linear transforms. **CO32:** Express linear transforms in other forms, such as matrix equations and vector equations. **CO33:** Characterize a set of vectors and linear systems using the concept of linear independence.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstrations, Team teaching, Teaching using advanced IT audio-video tools **Learning activities for the students:** Self-learning assignments, Effective questions, Simulation, Seminar presentation, Giving tasks	**Assessment Strategies** Class test, Semester end examinations, Quiz, Solving problems in tutorials, Assignments, Presentation.

CONTENTS

Unit I **15 Hrs.**

Linear transformation of vector spaces, Dual spaces, Dual basis and their properties, Dual maps, Annihilator.

Unit II **15 Hrs.**

Matrices of a linear map, Matrices of composition maps, Matrices of dual map, eigen values, eigen vectors, Rank and nullity of linear maps and matrices, Invertible matrices, Similar matrices, Diagonalization of matrices.

Unit III **15 Hrs.**

Determinants of matrices and its computations, Characteristic polynomial and eigenvalues, Minimal polynomial, Cayley-Hamiltton theorem.

Unit IV **15 Hrs.**

Bilinear forms: Definition and examples, Matrix of a bilinear form, Orthogonality, Classification of bilinear forms, Quadratic forms.

Unit V **15 Hrs.**

Real inner product space, Schwartz's inequality, Orthogonality, Bessel's inequality, Adjoint, Self-adjoint linear transformations and matrices, orthogonal linear transformation and matrices, Principal axis theorem.

BOOKS RECOMMENDED

- Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice-Hall of India Pvt. Ltd., 1971.
- K.B. Datta, Matrix and Linear Algebra, Prentice-Hall of India Pvt., Limited, 2004.

- Ramachandra Rao and Bhimasankaram, Linear Algebra, Second Edition, Hindustan Book Agency, 2017.
- M. Artin, Algebra, Prentice-Hall of India, 1994.
- Ben Noble, James W. Daniel, Applied Linear Algebra, Prentice-Hall of India, 1987.
- I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
- I.S. Luther and I.B.S. Passi, Algebra, Vol. I Groups, Narosa Publishing House, Vol. I, 1996.
- Seymour Lipschutz, Linear Algebra, McGraw Hill, 2001.
- Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice –Hall of India, Pvt. Ltd., 1971.

PAPER CODE - MAT 222
Topology
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. Understand the concept of fundamentals of point set topology.
2. Understand the introduction to topological spaces.
3. Aware about the need of the topology in Mathematics.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 222	**Topology (Theory)**	**The students will be able to –** **CO34:** Analyze properties of topological spaces and construct various topologies on a general set. **CO35:** Apply the topological concepts and constructions to some chosen real world problems. **CO36:** Correlate the concept of continuity to compact and connected spaces. **CO37:** Categorize the separation axioms and produce examples for different topological spaces. **CO38:** Understand the concept of product spaces and quotient spaces.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Team teaching **Learning activities for the students:** Self learning assignments, Effective questions, , Topic presentation, Giving tasks,	Class test, Semester end examinations, Quiz, Presentation

CONTENTS

Unit I **15 Hrs.**

Topological Spaces: Definition and examples, Closed sets, Neighborhood, Open base and sub base, Limit points, Adhere points and derived sets, Closure of a set.

Unit II **15 Hrs.**

Subspaces, Continuity and homeomorphism, Nets, Filters.

Unit III **15 Hrs.**

Compact and locally compact spaces Connected and locally connected spaces, Continuity and compactness, Continuity and connectedness.

Unit IV **15 Hrs.**

Separation axioms: T_0 space, T_1 space, T_2 space or Hausdroff space, Regular and T_3 spaces, Normal and T_4 spaces.

Unit V **15 Hrs.**

Product spaces: Product space of two spaces, Product invariant properties for finite products, Quotient spaces.

BOOKS RECOMMENDED

- George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.
- Colin Adams and Robert Franzosa, Introduction to Topology, Pearsons united edition press, 2007.
- K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd., 1983.
- Dugundji. J, Topology, Prentice Hall of India, New Delhi, 1975.
- Munkers R James, A first Course in Topology, Pearson Education Pvt. Ltd., Delhi, 2015.
- Terry Lawson, Topology: A Geometric Approach, Oxford University press, 2003.
- John L. Kelley, General Topology, Dover Publications; Reprint edition , 2017
- Stephen Willard, General Topology, Wesley Publishing Company, Reading, Massachusetts, 1970.
- Tej Bahadur Singh, Introduction to Topology, Springer Singapore, 2019.
- W.J. Pervn, Foundation of General Topology, Academic Press Ltd., 1996.
- M.G. Murdeshevar, Topology, Wiley Eastern Ltd, 1983.

PAPER CODE - MAT 223
Special Functions
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to

1. Understand the properties of special functions like Gauss hypergeometric, Legendre functions with their integral representations.
2. Understand the concept of Bessel's function, Hermite function etc, with its properties like recurrence relations, orthogonal properties, generating functions etc.
3. Understand how special function is useful in differential equations.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 223	**Special Functions (Theory)**	**The students will be able to –** **CO39:** Explain the applications and the usefulness of these special functions. **CO40:** Classify and explain the functions of different types of differential equations. **CO41:** To determine types of PDEs which may be solved by application of special functions? **CO42:** To analyse properties of special functions by their integral representations and symmetries. **CO43:** Identified the application of some basic mathematical methods via all these special functions. **CO44:** Apply these techniques to solve and analyse various mathematical problems.	**Approach in teaching:** Discussion, Demonstration, Team teaching, Presentation **Learning activities for the students:** Self learning, Presentation, Effective questions, Giving tasks	Observation, Presentation, Report writing,

CONTENTS

Unit I **15 Hrs.**

Gauss hypergeometric functions: Definition and its properties, Condition of convergence, Integral representation, Gauss theorem, Vandermonde's theorem, Kummer's theorem, Linear transformation, Differentiation formulae, Relations of contiguity.

Unit II **15 Hrs.**

Gauss's hypergeometric differential equation and its solution, relation between the solutions of hypergeometric equation, Two summation theorems, Kummer's confluent hypergeometric function: Definition and differential equation, Integral representation, Differentiation, Kummer's first and second transformations, contiguous relations.

Unit III **15 Hrs.**

Legendre polynomials and functions: Definition, Solution of Legendre's equation, Legendre functions of the first and second kind, Generating functions(first formula), Rodrigue formula for $P_n(x)$, Orthogonality of Legendre polynomials, Recurrence relations for $P_n(x)$, Beltrami's result, Christoffel expansion, Christoffel's summation formula, Relation between $P_n(x)$ and $Q_n(x)$, Laplace first and second integrals for Legendre polynomials.

Unit IV **15 Hrs.**

Bessel Functions: Bessel's equation and its solution, Recurrence relations, Generating function, Integral representations of Bessel function, Integrals involving Bessel's functions.

Unit V **15 Hrs.**

Hermite polynomials**:** Definition, Generating function, Recurrence relations, Orthogonality of $H_n(x)$, Rodrigue formula, Hermite's differential equation and it's solution, Laguerre polynomials: Laguerre's differential equation and it's solutions, Generating function, Rodrigue formula, Orthogonality of Laguerre polynomials, Recurrence relations.

BOOKS RECOMMENDED

- R.K Saxena and D. C. Gokhroo, Special Functions, Jaipur Publishing House, 2014.
- M. A. Pathan, V. B. L. Chaurasia, J. Banerji and S. P. Goyal, Special Functions and Calculus of Variations, RBD, Jaipur, 2004.
- E. D. Rainville, Special Functions, Macmillan, New York, 1989.
- I. N. Sneddon, Special Functions, McGraw Hill, New Delhi, 1956.
- N. N. Lebedev, Richard A. Silverman, Special Functions and Their Application, Dover Publications INC, 1972.
- Z.X. Wang and D. R. Guo, Special Functions, World Scientific books, 1989.
- G.E. Andrews, R. Askey and R. Roy, Special Functions, Cambridge University, 2000.

PAPER CODE - MAT 224
Differential Geometry-II & Tensor Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Understand the role of tensors in differential geometry.
2. Understand the interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae.
3. Learn and apply problem-solving with differential geometry to diverse situations.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT224	**Differential Geometry-II & Tensor Analysis (Theory)**	**The students will be able to –** **CO45:** To get introduced to geodesics on a surface and their characterization. Discuss the fundamental Theorem for regular surfaces. **CO46:** To understand geodesics as distance minimizing curves on surfaces and find geodesics on various surfaces. **CO47:** To be introduced to Christoffel symbols and their expression in terms of metric coefficients and their derivatives. **CO48:** To Discuss Gauss Bonnet theorem and its implication for a geodesic **CO49:** Understand concepts of tensor variables and difference from scalar or vector variables. **CO50:** Understand the reason why the tensor analysis is used and explain usefulness of the tensor analysis. **CO51:** Derive base vectors, metric tensors and strain tensors in an arbitrary coordinate system.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration, Team teaching, PowerPoint presentations. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Posters and Charts preparation.	Class test, Semester end examinations, Quiz, Assignments, Presentation, Individual

CONTENTS

Unit I **15 Hrs.**

Asymptotic lines: Definition, Differential equation of a asymptotic lines, Theorems on asymptotic lines, Curvature and torsion of an asymptotic line, Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces.

Unit II **15 Hrs.**

Parallel surfaces, Gaussian and mean curvature for a parallel surface, Bonnet's theorem on parallel surfaces, Geodesics: Definition, General differential equation of a geodesic on a surface $\vec{r} = \vec{r}(u, v)$, Single differential equation of a geodesic, Geodesic on a surface of revolution, Geodesic on a conoidal surface, Geodesics on conicoids (Joachimsthal theorem).

Unit III **15 Hrs.**

Geodesic curvature, Geodesic curvature in form of Gauss coefficient, Bonnet's formula for Geodesic curvature and torsion of a Geodesic, Normal angle, Geodesic torsion, Gauss-Bonnet Theorem (Joachimsthal theorem).

Unit IV **15 Hrs.**

Tensor Analysis: Definition, Kronecker delta, Symmetric tensor, Skew Symmetric tensor, Quotient law of tensor, Relative tensor, Metric tensor, Indicator, Permutation symbols and Permutation tensor, Christoffel symbols and their properties, Covariant differentiation of tensor, Ricci's theorem.

Unit V **15 Hrs.**

Intrinsic derivative, Differential equation of geodesic of a metric, Geodesic coordinates,Reimann-Christoffel tensor and its properties, Covariant curvature tensor, Einstein space, Bianchi's identity, Einstein tensor, Flat space, Isotropic point, Schur's theorem.

BOOKS RECOMMENDED

- J.L. Bansal, Differential Geometry, Jaipur Publishing House, Jaipur, 2014.
- J.L. Bansal, Tensor Analysis, Jaipur Publishing House, Jaipur, 2012.
- P.P. Gupta and G.S. Malik, Differential Geometry, Pragati Prakashan, 2012.
- Raj Bali, Tensor Analysis, Navkar Publication, Ajmer, 2012.
- Clifford Henry Taube’s, Differential Geometry, Oxford University Press, 2011.
- Dirk J. Struik, Lectures on Classical Differential Geometry, Addison Wesley Publishing Company, London, 1961.
- H.K. Pathak and J.P. Chauhan, Differential Geometry, Shiksha sahitya Prakashan, 2012.
- Erwin Kreyszig, Differential Geometry, Dover Publishing,1991.
- B.D. Neill, Elementary Differential Geometry, Academic Press, London, 1996.
- Nirmala Prakash, Differential Geometry, Tata McGraw Hill, 1981.
- Millan and G.D. Parker, Elements of Differential Geometry, PHI, 1977.
- D.Somasundaram, Differential Geometry, Narosa Publishing House, New Delhi, 2005.
- Prasun Kumar Nayak, Tensor Calculus and Differential Geometry, PHI Learning Private Limited, 2012.

PAPER CODE - MAT 225
Hydrodynamics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Understand the motion of fluid and develop concept, models
2. Understand the techniques which enable us to solve the problems of fluid flow.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT225</td><td>Hydrodynamics (Theory)</td><td>The students will be able to –

CO52: Understand the basic principles of ideal fluid, such as Lagrangian and Eulerian approach, conservation of mass etc.
CO53: Use Euler and Bernoulli's equations and the conservation of mass to determine velocity and acceleration for incompressible and non-viscous fluid.
CO54: Understand the concept of rotational and irrotational flow, stream functions, velocity potential, complex potential due to sink, source and doublets.
CO55: Understand the motion of a fluid element, Vorticity, Body forces, Surface forces, Stress & Strain analysis, Flow and circulation, Connectivity, Irrotational motion in multiple connected space,
CO56: Distinguish the concept of Irrotational motion of a cylinder in two dimensions, Motion of a circular cylinder in a uniform stream and two co-axial cylinders, Streaming and circulation for a fixed circular cylinder.</td><td>Approach in teaching:
Interactive Lectures, Discussion, Tutorials, Reading assignments, power point presentation

Learning activities for the students:
Self learning assignments, Effective questions, Simulation, Seminar presentation</td><td>Class test, Semester end examinations, Quiz, Solving problems in tutorials, Assignments, Presentation, Individual and group projects</td></tr>
</table>

CONTENTS

Unit I **15 Hrs.**

Kinematics of ideal fluid, Lagrange's and Euler's methods, Equation of continuity in cartesian, cylindrical and spherical polar coordinates, Boundary surface, Stream-lines, path-lines and stream lines velocity potential irrotational motion.

Unit II **15 Hrs.**

Euler's hydrodynamic equations, Bernoulli's theorem, Helmholtz equations, Cauchy's integral, Motion due to impulsive forces.

Unit III **15 Hrs.**

Motion in two-dimensions, Stream function, Complex potential, Sources, Sinks, Doublets, Images in two dimensions: image of a source with regard to a plane, image of a source with regard to a circle.

Unit IV **15 Hrs.**

Irrotational Motion: Motion of a fluid element (General and Cartesian coordinates), Vorticity, Body forces, Surface forces, Stress analysis at a point, Strain analysis, Flow and circulation, Kelvin’s circulation theorem, Connectivity, Irrotational motion in multiple connected space, Acyclic and cyclic motion, Kelvin’s minimum energy theorem.

Unit V **15 Hrs.**

Irrotational motion in two dimensions: Introduction, General motion of a cylinder in two dimensions, Motion of a circular cylinder in a uniform stream, Liquid streaming past a fixed circular cylinder, two co-axial cylinders, Circulation about a circular cylinder, Blasius’s theorem, Streaming and circulation for a fixed circular cylinder, Equation of a motion of a circular cylinder.

BOOKS RECOMMENDED

- M.D. Raisinghania, Fluid Dynamics, S. Chand & Co. New Delhi, 2016.
- Shanti Swarup, Hydrodynamics, Krishana Prakashan, 2016.
- K.P. Goyal and J.K. Gupta, Fluid Dynamics, Pragati Prakashan, Meerut, 2011.
- H.K. Pathak, Fluid Dynamics, Shiksha Sahitya Prakasha, 2013.
- Schaum's Outlines, Fluid Mechanics, McGraw-Hill Education, 1 edition, 2007.
- G.K. Batchelor, An Introduction to Fluid Mechanics, Cambridge University Press, 2000.
- F. Chorlton, Text book of Fluid Dynamics, CBS Publications, New Delhi, 2004.
- Milne Thomson, Theoretical Hydrodynamics, Macmillan, 3rd Edition, 1955.

PAPER CODE – MAT226
Seminar
(Seminar)

Credits: 2
Maximum marks: 100

Course Objectives:

This course will enable the students to –

1. Understand the history of mathematics and its recent areas.
2. Understand the diverse role of mathematics in social and economic areas through independent learning.
3. Identify, understand and discuss current, real-world issues.
4. Improve oral and written communication skills.
5. Apply principles of ethics and respect in interaction with others.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes (at course level</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT226</td><td>Seminar (Seminar)</td><td>The students will be able to –

CO57: Use multiple thinking strategies to examine real-world issues, explore creative avenues of expression, solve problems, and make consequential decisions.

CO58: Acquire, articulate, create and convey intended meaning using verbal and non-verbal method of communication that demonstrates respect and understanding in a complex society.

CO59: Apply principles of ethical leadership, collaborative engagement, socially responsible behavior, respect for diversity in an interdependent world, and a service-oriented commitment to advance and sustain local and global communities.</td><td>Approach in teaching:
Group Discussion, Classroom Problem Solving Sessions

Learning activities for the students:
Field activities
Seminar Presentation
Subject based Activities</td><td>Presentation
VIVA
report writing</td></tr>
</table>

M.Sc. /M.A. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester III

PAPER CODE - MAT 321
Functional Analysis-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Cover theoretical needs of Partial Differential Equations and Mathematical Analysis.
2. Inter-relate the problems arising in Partial Differential Equations, Measure Theory and other branches of Mathematics.
3. Know about various spaces such as Normed Linear Spaces, Banach spaces.
4. Use the operators on these spaces.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 321	**Functional Analysis-I (Theory)**	**The students will be able to –** **CO60:** Explain the fundamental concepts of functional analysis in applied contexts. **CO61:** Use elementary properties of Banach space and Hilbert space. **CO62:** Identify normal, self adjoint or unitary operators. **CO63:** Communicate the spectrum of bounded linear operator. **CO64:** Construct orthonormal sets.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Normed linear spaces, Quotient space of normed linear spaces and its completeness, Banach spaces and examples, Bounded linear transformations.

Unit II **15 Hrs.**

Normed linear space of bounded linear transformations, Equivalent norms, Basic properties of finite dimensional normed linear spaces and compactness, Riesz lemma.

Unit III **15 Hrs.**

Open mapping theorem, Closed graph theorem, Uniform boundness theorem, Continuous linear functional, Hahn-Banach theorem and its consequences.

Unit IV **15 Hrs.**

Hilbert space and its properties, Orthogonality and functionals in Hilbert spaces, Phythagorean theorem, Projection theorem, Orthonormal sets.

Unit V **15 Hrs.**

Bessel's inequality, Complete orthonormal sets, Parseval's identity, Structure of a Hilbert space, Riesz representation theorem.

BOOKS RECOMMENDED

- G.F. Simmons, Topology and Modern Analysis, Mc-Graw Hill, 1963.
- G. Bachman, Lawrence Narici, Functional Analysis, Academic Press, 1966.
- Dileep S. Chauhan, Functional Analysis and calculus in Banach space, Jaipur Publishing House, 2013.
- B.V. Limaye, Functional Analysis, New Age International, New Delhi, 2017.
- Erwin Kreyszig, Introductory Functional Analysis with Application, Willey, 2007.
- A.E. Taylor, Introduction to Functional analysis, John Wiley and Sons, 1958.
- Graham Allan and H. Garth Dales, Introduction to Banach Spaces and Algebras, Oxford University Press, 2010.
- Reinhold Meise, Dietmar Vogt and M. S. Ramanujan, Introduction to Functional analysis, Oxford University Press, 1997.
- A.L. Brown and A. Page, Elements of Functional Analysis, Van Nostrand Reinhold, 1970.
- F. Riesz and B. Sz. Nagay, Functional Analysis, Dover Publications, 1965.

PAPER CODE - MAT 322
Fluid Dynamics-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Provide a treatment of topics in fluid mechanics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems.
2. Provide the students with knowledge of the fundamentals of Fluid Dynamics and an appreciation of their application to real world problems

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 322	**Fluid Dynamics-I (Theory)**	**The students will be able to –** **CO65:** To understand the basic principles of fluid mechanics, such as the concept of rotational and irrotational flow, stream functions, velocity potential, vortex, Newtonian and non-Newtonian fluids etc. **CO66:** To analyze simple fluid flow non dimensional parameters. **CO67:** To establish the different laws like law of conservation of mass, energy and momentum etc. **CO68**: To study the exact solutions of the problems (flow between parallel plates, flow through pipe, over sphere etc.) with Navier -Stoke's equation of motion.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Basic concepts: Fluid, Continuum hypothesis, Viscosity, General motion of a fluid element, Analysis of stress and rate of strain, Stress in a fluid at rest, Stress in a fluid in motion, Stokes' law of friction, Thermal conductivity and generalized law of heat conduction.

Unit II **15 Hrs.**

Fundamental equations of the flow of viscous fluids: Introduction, Equations of state and continuity, Navier-Stokes' equations of motion, Equation of energy, Vorticity and circulation.

Unit III **15 Hrs.**

Dynamical similarity, Inspection and dimensional analysis, Buckingham π-theorem and its application, Non-dimensional parameters and their physical importance, Reynolds number, Froude number, Mach number, Prandtl number, Eckart number, Peclet number, Grashoff number, Brinkmann number, Non–dimensional coefficients: Lift and drag coefficients, Skin-friction, Nusselt number, Temperature recovery factor.

Unit IV **15 Hrs.**

Exact Solutions of Navier-Stokes' equations**:** Velocity and temperature distributions for the flow between two parallel plates, Plane Couette flow, Plane Poiseuille flow, Generalized plane Couette flow, Velocity and temperature distributions for the flow in a circular pipe (Hagen- Poiseuille flow).

Unit V **15 Hrs.**

Flow in tubes of uniform cross-sections: Circular, Annular and Elliptic, Equilateral triangular and Rectangular cross-sections. Flow between two concentric rotating cylinders, Flow in convergent and divergent channels, Stagnation point flows: Hiemenz flow, Homann flow.

BOOKS RECOMMENDED

- R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Co., 1976.
- F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, Delhi, 2004.
- L.D. Landau and E.N. Lipschitz, Fluid Mechanics, Pergamon Press, London, 1985.
- J.L. Bansal, Viscous Fluid Dynamics, Oxford Publication, 2013.
- Schaum's Outlines, Fluid Mechanics, McGraw-Hill Education, 1st edition, 2007.
- G.K. Batchelor, An Introduction to Fluid Mechanics, Cambridge University Press, 2000.
- M.D. Raisinghania, Fluid Dynamics, S. Chand & Co., 2003.
- Pradip Niyogi, S.K. Chakrabartty and M. K. Laha, Introduction to Computational Fluid Dynamics, Pearson Education, 2006.

PAPER CODE - MAT323A
Advanced Operations Research-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. To teach the methods to solve linear programming problems, integer programming problems as well as the methods to solve goal programming problems and Inventory problems.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 323A	**Advanced Operations Research-I (Theory)**	**The students will be able to –** **CO69:** Identify the optimization techniques suitable for the real time problems. **CO70:** Solve linear programming by Revised simplex method and solve integer programming also. **CO71:** Solve goal programming problems, multi-objective programming problems. **CO72:** Compare Determine the inventory level of an industry for the smooth functioning. **CO73:** Understand the concept of probability inventory problems.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

(Note: Non-Programmable scientific calculator up to 100 MS is permitted)

CONTENTS

Unit I **15 Hrs.**

Revised simplex method: Standard form I and II, Computational procedure, Bounded variable problems in linear programming, Dual simplex method.

Unit II **15 Hrs.**

Integer linear programming: Gomory's cutting plane method for all integer and mixed integer, Branch and bound algorithm.

Unit III **15 Hrs.**

Goal programming: Definition, Formulation and graphical solution of goal programming models, Methodology of solution procedure of goal programming algorithm, Extended simplex method.

Unit IV **15 Hrs.**

Dynamic demand models (IV and V), Deterministic model with price break: one, two and any price break.

Unit V **15 Hrs.**

Probabilistic inventory models: Instantaneous demand and no set up cost model, Uniform demand and no setup cost model, Probabilistic order level system with constant lead time, Multi period probabilistic model with constant lead time.

BOOKS RECOMMENDED

- S. D. Sharma, Operations Research, Kedar Nath Ram Nath and Co., 1992.
- Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, S. Chand & Company, New Delhi, 2007.
- Hamady A. Taha, Operations Research an Introduction, Prentice Hall, 2007.
- B.S. Goel and S.K. Mittal, Operation Research, Pragati Prakashan, 2014.
- S. I. Gauss, Linear Programming, McGraw Hill Book Co., 1958.
- F.S.Hiller and G.J. Lieberman, Introduction to Operations Research, Addison Wesley, 2011.
- R.S. Garfinkel and G.L. Nemhauser, Integer Programming, Wiley, New York, 1972.
- G. Hadley, Linear Programming, Oxford and IBH Publishing, New Delhi, 1962.
- P.K. Gupta and D.S. Hira, Problem in Operation Research, S. Chand & Co., 2010.

PAPER CODE - MAT323B
Computational Methods of Ordinary Differential Equations
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. To enable students to design and analyze numerical methods to approximate solutions to differential equations for which finding an analytic (closed-form) solution is not possible.
2. To teach basic scientific computing for solving differential equations.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 323B	**Computational Methods of Ordinary Differential Equations (Theory)**	**The students will be able to –** **CO74:** Understand the key ideas, concepts and definitions of the computational algorithms, sources of errors, convergence theorems. **CO75:** Implement a given algorithm in Matlab (or related software package) and test and validate codes to solve a given differential equation numerically. **CO76:** Choose the best numerical method to apply to solve a given differential equation and quantify the error in the numerical (approximate) solution. **CO77**: Analyze an algorithm's accuracy, efficiency and convergence properties	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Initial value problem (IVPS) for the system of ordinary differential equation (ODEs) difference equations numerical methods, Local truncation error, Stability analysis, Interval of absolute stability, Convergence and consistency.

Unit II **15 Hrs.**

Single step method: Taylor series method, Explicit and implicit Runga-Kutta method and their stability and convergence analysis, Extrapolation method, Runga–Kutta method for first order initial value problems, Runga-Kutta method for the second order initial value problems and their stability analysis, Stiff system of differential equation.

Unit III **15 Hrs.**

Multi-step methods: Explicit and implicit multi-step methods, General linear multi-step method and their convergence analysis, Adams-Moulton method, Adams-Bashforth method, Nystorm- method, Multi-step methods for the second order IVPS.

Unit IV **15 Hrs.**

Boundary value problem (BVP): Two point nonlinear BVPs for second order ordinary differential equation, Shooting method, Finite difference methods, Convergence analysis, Difference scheme based on quadrature formula, Difference scheme for linear eigen value problems, Mixed boundary condition.

Unit V **15 Hrs.**

Finite element methods: Assemble of element equations, Variational formulation of BVPs and their solutions, Galerikin method, Ritz method, Finite element solution of BVPs.

BOOKS RECOMMENDED

- J.C. Butcher, Numerical Method for Ordinary Differential Equations, John Wiley & Sons, New York, 2003.
- J.D. Lambert, Numerical Method for Ordinary Differential Systems: The initial Value Problem, John Wiley & Sons, New York, 1991.
- M. K. Jain, S.R.K. Iyenger and R. K. Jain, Numerical methods and Solution, New Age Publications, 2004.
- K. Atkinson, W. Han and D.E. Stewart, Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, New York, 2009.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
- H.T.H. Piaggio, Elementary Treatise on Differential Equations and Their Applications, C.B.S. Publisher & Distributors, Delhi, 1985.
- M.K. Jain, Numerical Solution of Differential Equations: Finite difference and Finite Element Approach, New Age Publications, 2018.
- E.A. Codington, An Introduction to Ordinary Differential Equation, Prentice Hall of India, 1961.

PAPER CODE - MAT323C
Magnetohydrodynamics-I
(Optional Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Prepare a foundation for advanced study of fluid motion in electromagnetic field, magnetohydrodynamics theory.
2. Develop concepts, models and techniques which enable us to solve the problems and help in research in these broad areas.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 323C	**Magnetohydrodynamics-I (Theory)**	**The students will be able to –** **CO78:** Understand the interaction between hydrodynamic process and electromagnetic phenomena in terms of Maxwell electromagnetic field equation. **CO79:** Formulate the basic equations of motion in inviscid and viscous conducting fluid flow and be familiar with the Alfven's wave and magneto-hydrodynamic wave. **CO80:** Concept of dynamical similarity, non-dimensional parameters, Formulation of exact equations of MHD flow. **CO81:** Formulate velocity distribution & temperature distribution for MHD flow between parallel plates and coaxial cylinders.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Maxwell electromagnetic field equations: Coulomb's law, Gauss' law, Energy of electrostatics field, Conservation of charge, Ohm's law, Magnetic field, Ampere's law Biot-Savart law, Ampere's force law magnetic field continuity equation, Energy of magnetostatic field, Hall current, Electromagnetic induction. Maxwell equations for electromagnetism, Electromagnetic wave equations.

Unit II **15 Hrs.**

Constitutive equation of fluid motion: Continuum hypothesis, Rate of strain quadric, Stress quadric, Relation between stress and rate of strain component, Maxwell stress tensor, Thermal conductivity, Generalized law of heat conduction, Entropy, Fundamental equations of magnetofluiddynamics: Electromagnetic field equations, Fluid dynamic field equations, Magnetofluiddynamic equations.

Unit III **15 Hrs.**

Dynamical similarity, Inspection analysis, Dimensional analysis, Buckingham π–theorem (proof and applications), Physical importance of non-dimensional parameters, Exact solutions of MHD equations: Velocity distribution for MHD flow between two parallel plates (Hartmann plane Poiseuille flow, Hartmann plane Couette flow).

Unit IV **15 Hrs.**

Temperature distribution for MHD flow between two parallel plates(Hartmann plane Poiseuille flow, Hartmann plane Couette flow),MHD flow in tube of rectangular cross-section, MHD flow in pipes, MHD flow in an annular channel.

Unit V **15 Hrs.**

MHD flow between two rotating coaxial cylinders, MHD flow near a stagnation point, MHD flow due to a plane wall suddenly set in motion, MHD slow motion: MHD Stoke's flow of viscous fluid past a sphere.

BOOKS RECOMMENDED

- J. L. Bansal, Magnetofluiddynamics of Viscous Fluids, Jaipur Publication House, 1994.
- Charndra Shekhar S., Hydrodynamic and Hydromegnatic Stability, Oxford University Press. 1961.
- K.R Cramer and S.I. Pai, Magnetofluidodynamics for Engineers and Applied Physicists, McGraw-Hill, New York, 1973.
- V.C.A Ferraro, C. Plumpton, An Introduction to Magnetofluid Mechanics, Clarendon Press, Oxford, 1966.
- A. ZJeffreys, Magnetohydrodynamics, Oliver and Boyd, New York, 1966.
- S.I. Pai, Magnetogasdynamics and Plasma Dynamics, Springer-Verlag, Vienna, 1963.
- J.A. Shercliff, A Text Book of Magnetohydrodynamics, Pergamon Press, Oxford, 1965.

PAPER CODE - MAT324A
Integral Transform
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the concept of popular and useful transformations techniques like; Laplace and inverse Laplace transform, Fourier transform, Hankel transform, Mellin transform with its properties and applications.
2. Procure knowledge to solve ordinary and partial differential equations with different forms of initial and boundary conditions.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 324A	**Integral Transform (Theory)**	**The students will be able to –** **CO82:** Gain the idea that by applying the theory of Integral transform the problem from its original domain can be mapped into a new domain where solving problems becomes easier. **CO83:** Apply these techniques to solve research problems of signal processing, data analysis and processing, image processing, in scientific simulation algorithms etc. **CO84:** Develop the ability of using the language of mathematics in analysing the real-world problems of sciences and engineering. **CO85:** Think logically and mathematically and apply the knowledge of integral transform to solve complex problems.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Laplace transform: Definition, Basic properties, Laplace transform of derivatives and integrals, Multiplication and division by power of independent variable, Evaluation of integrals by using Laplace transforms, Periodic functions, Initial-value and Final value theorem.

Unit II **15 Hrs.**

Inverse Laplace transform: Definition, Basic properties, Inverse Laplace transform of derivatives and integrals, Multiplication and division by power of independent variable, Convolution theorem for Laplace transform, Evaluation of integrals by using inverse Laplace transform, Use of partial fractions, Heaviside expansion formula.

Unit III **15 Hrs.**

Fourier transform: Definition and properties of Fourier complex sine, cosine and complex transforms, Inversion theorem, Relationship between Fourier transform and Laplace transform, Modulation theorem, Convolution theorem for sine, cosine and complex transforms, Parseval’s identity, Fourier transform of derivatives.

Unit IV **15 Hrs.**

Mellin transform: Definition and elementary properties, Mellin transforms of derivatives and integrals, Inversion theorem, Convolution theorem, Inverse Mellin transform of two functions, Infinite Hankel transform: Definition and elementary properties, Hankel transform of elementary function like exponential functions, Inversion formula, Hankel transform of derivatives, Basic operational property of Hankel transform, Parseval's theorem.

Unit V **15 Hrs.**

Solution of ordinary differential equations with constant and variable coefficients by Laplace transform, Application to the simple boundary value problem by Laplace, Fourier and infinite Hankel transforms.

BOOKS RECOMMENDED

- S.P. Goyal and A.K. Goyal, Integral Transforms and its Applications, Jaipur Publishing House, Jaipur, 2014.
- D.C. Gokhroo and J.P.N. Ojha, Integral Transforms, Jaipur publishing House, Jaipur, 2000.
- M. D. Raisinghania, Integral Transform, S. Chand & Co., New Delhi, 2013.
- K. P. Gupta and J. K. Goyal, Integral Transforms, Pragati Prakashan, New Delhi, 2015.
- Mohamed F. EL. Hewie, Laplace Transform, Createspace Independent Pub., 2013.
- Joel L. Schiff, The Laplace Transform: Theory and Application, Springer Science & Business Media, 1999.

PAPER CODE - MAT324B
Advanced Complex Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. To learn mapping properties of hypergeometric and some other special transcendental functions.
2. Students also know about infinite product of analytic functions, entire and meromorphic function.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 324B	**Advanced Complex Analysis (Theory)**	**The students will be able to –** **CO86:** Determine whether a sequence of analytic functions converges uniformly on compact sets. **CO87:** Acquire knowledge about different types of functions viz. analytic, entire and meromorphic functions occur in complex analysis along with their properties **CO88:** Describe conformal mappings between various plane regions. **CO89:** Utilize the concepts of complex analysis to specific research problems in mathematics or other fields. **CO90:** Enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering. **CO91:** Express some functions as infinite series or products **CO92:** Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Conformal mapping, bilinear transformation mappings, Special mappings:

$$W(z)=\frac{1}{z},\ z+\frac{1}{z},\ z^2,\ e^z\ ,Sin(z),Cos(z)$$

Unit II **15 Hrs.**

Power Series: Absolute convergence, Cauchy's Hadamard theorem, Circle and radius of convergence, Analyticity of the sum function or a power series, Complex inversion formula for inverse Laplace transform and related problems.

Unit III **15 Hrs.**

Schwarz's lemma and its consequences, Doubly periodic entire functions, Fundamental theorem of algebra, Zeros of certain polynomials.

Unit IV **15 Hrs.**

Meromorphic functions, Essential singularities and Picard's theorem, Analytic continuation, Monodrmy theorem, Poisson integral formula, Analytic continuation via reflexion.

Unit V **15 Hrs.**

Infinite sums and infinite product of complex numbers, Infinite product of analytic functions, Factorization of entire function.

BOOKS RECOMMENDED

- S. Ponnusamy, Foundation of Complex Analysis, Narosa Publishing House, 2011.
- L. R. Ahlofrs, Complex Analysis, Mc-Graw Hill, 1979.
- A.S.B. Holland, Introduction to the Theory of Entire Functions, Academic Press, 1973.
- H.S. Kasana, Complex Variables: Theory and Applications, Prentice-Hall, New Delhi, 2005.
- Mark J. Ablowitz and A.S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press South Asian Edition, 1998.
- J.W. Brown and R.V. Churchil, Complex Variables and Applications, McGraw Hill, New York, 1990.
- R. Murray Spiegel, Theory and Problems of Complex variables, Schaum Outline Series, 1974.
- K.K. Dubey, Fundamentals of Complex Analysis Theory and Applications, International Publishing House, 2009.
- Joseph Bak and Donald J. Newman, Complex Analysis, Springer, 2010.

PAPER CODE - MAT324C
Advanced Real Analysis-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Explore their knowledge in the area of real analysis.
2. Get sufficient knowledge of the subject which can be used by students for further applications in their respective domains of interest.
3. Understand the Introduction of Ordinal number, perfect sets, Borel measureable functions.
4. Get ideas about approximate continuous function, Henstock integration.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes

(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment

Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT 324C</td><td>Advanced Real Analysis-I

(Theory)</td><td>The students will be able to –

CO93: Introduce the concept of ordinal numbers.
CO94: Describe properties of perfect set and prove related theorems.
CO95: Discuss properties of Borel measurable functions and Darbous function of Baire class one
CO96: Analyze characteristics of approximate continuous function.
CO97: Understand the concept of Henstock integration on the real line.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Power Point Presentations, Informative videos

Learning activities for the students:

Self learning assignments, Effective questions, presentations, Field trips</td><td>Quiz, Poster Presentations,

Power Point Presentations, Individual and group projects,

Open Book Test,
Semester End Examination</td></tr>
</table>

CONTENTS

Unit I **15 Hrs.**

Ordinary number**:** Order types, Well-ordered sets, Transfinite induction, Ordinal numbers, Comparability of ordinal numbers, Arithmetic of ordinal numbers, First uncountable ordinal Ω.

Unit II **15 Hrs.**

Descriptive properties of sets: Perfect sets, Decomposition of a closed set in terms of perfect sets of first category, 2nd category and residual sets, Characterization of a residual set in a compete metric space, Borel sets of class α, ordinal $\alpha < \Omega$, Density point of a set in R, Lebesgue density theorem.

Unit III **15 Hrs.**

Functions of some special classes: Borel measurable functions of class α ($\alpha < \Omega$) and its basic properties, Comparison of Baire and Borel functions, Darboux functions of Baire class one.

Unit IV **15 Hrs.**

Continuity: Nature of the sets of points of discontinuity of Baire one functions, Approximate continuity and its fundamental properties, Characterization of approximate continuous functions.

Unit V **15 Hrs.**

Henstock integration on the real line:Concepts of δ-fine partition of the closed interval [a,b] where δ is a positive function on [a,b], Cousin's lemma, definition of Henstock integral of a functions over the interval [a,b] and its basic properties, Saks-Henstock lemmas and its applications, Continuity of the indefinite integral, Fundamental theorem, Convergence theorems, Absolute Henstock integrability, Characterization of Lebesgue integral by absolute Henstock integral.

BOOKS RECOMMENDED

- A.M. Bruckner, J.B. Bruckner and B.S. Thomson, Real Analysis, Prentice-Hall, New York 1997.
- H.S. Gakill and P.P. Narayanswami, Elements of Real Analysis, PHI, 1988.
- W.P. Parzynski and P.W. Zipse, Introduction to Mathematical Analysis, MC Graw-Hill Company, 1982.
- I.P. Natanson, Theory of Functions and Real Variable, Vol. I& II, Frederic Ungar Publishing, 1955.
- C. Goffman, Real Functions, Rinehart Company, N.Y. 1953
- P.Y. Lee, Lanzhou Lectures on Henstock Integration, World Scintific Press, 1990.
- J.F. Randolph, Basic Real and Abstract Analysis, Academic Press, N.Y. 1968.
- S.M. Srivastava, A Course on Borel Sets, Springer,N.Y. 1998.
- R.G. Rartle, Introduction to Real Analysis, John Willey and Sons, 2000.
- A.J. Kosmala, Introductory Mathematical Analysis, WCB Company, 1995.

PAPER CODE - MAT325A
Relativistic Mechanics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Acquaint them with mechanical systems under generalized coordinate systems.
2. Understand Virtual work, energy and momentum.
3. Make them aware about the mechanics developed by Newton, Lagrange's, Hamilton spaces.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 325A	**Relativistic Mechanics (Theory)**	**The students will be able to –** **CO98:** Give coherent explanations of the principles associated with: special relativity, general relativity and cosmology. **CO99:** Interpret observational data in terms of the Standard Model of the evolution of the universe. **CO100:** Describe experiments and observational evidence to test the general theory of relativity, explain how these	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:**	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

		support the general theory and can be used to criticise and rule-out alternative possibilities. **CO101:** Apply tensors to the description of curved spaces **CO102:** Solve problems by applying the principles of relativity.	Self learning assignments, Effective questions, presentations, Field trips	

CONTENTS

Unit I **15 Hrs.**

Relative character of space and time, Principle of relativity and its postulates, Derivation of special Lorentz transformation equations, Composition of parallel velocities, Lorentz-Fitzgerald contraction formula.

Unit II **15 Hrs.**

Time dilation, Simultaneity, Relativistic transformation formulae for velocity, Lorentz contraction factor, Particle acceleration, Velocity of light as fundamental velocity.

Unit III **15 Hrs.**

Relativistic aberration and its deduction to Newtonian theory. Variation of mass with velocity, Equivalence of mass and energy, Transformation formulae for mass, Momentum and energy, Problems on conservation of mass, Momentum and energy.

Unit IV **15 Hrs.**

Problems on conservation of mass, Momentum and energy, Relativistic Lagrangian and Hamiltonian, Minkowski space, Space-like, Time-like and light-like intervals.

Unit V **15 Hrs.**

Null cone, Relativity and causality, Proper time, World line of a particle, Principles of equivalence and general covariance.

BOOKS RECOMMENDED

- Bernard F. Schutz, A First Course in General Relativity, Cambridge University Press, 2010.
- Sushil Kumar Srivastava, General Relativity and Cosmology, Prentice hall India, 2008.
- Raj Bali, General Relativity, Jaipur Publishing House, 2005.
- David Agmon and Paul Gluck, Classical and Relativistic Mechanics, 2009.
- Jayant V. Narlikar, An Introduction to Relativity, Cambridge University Press, 2010.
- Robert J. A. Lambourne, Relativity, Gravitation, and Cosmology, Cambridge University Press, 2010.
- J.L. Synge, Relativity the General Theory, North Holland Publishing Company, Amsterdam, 1971.
- A.S. Eddention, The Mathematical Theory of Relativity, Cambridge University Press, 2010.
- S. Aranoff, Equilibrium in Special Relativity: The Special Theory, North Holland Publication. Amsterdam, 1965.

PAPER CODE - MAT325B
Probability and Statistics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Get knowledge about the foundations of probabilistic and statistical analysis.
2. Use probabilistic and statistical analysis in various applications in engineering and science.
3. Get an idea about Random variable.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 325B	**Probability and Statistics (Theory)**	**The students will be able to –** **CO103:** Learn the concepts of random variables as outcomes of random experiments are introduced and the key properties of the commonly used standard univariate random variables are studied. Emphasis is placed on learning the theories by proving key properties of each distribution. **CO104:** Students get a good understanding of exploratory data analysis. **CO105:** A good understanding of elementary probability theory and its application. **CO106:** Students get ideas about the discrete and continuous distribution. **CO107:** Students understand Some special mathematical expectations and study Marginal and conditional distributions, the correlation coefficient.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Classical theory of probability, Laws of total and compound probability, Conditional probability, Baye's theorem and related problems, Random variable, Discrete and continuous random variables.

Unit II **15 Hrs.**

Distribution function, Probability mass function and probability density function, Bi-variate distributions, Conditional and marginal distributions, Conditional expectation and variance, Co-variance, Analysis of bi-variate data.

Unit III **15 Hrs.**

Mathematical expectation and moment generating functions, Theoretical discrete distributions: Binomial and Poisson distributions with mean and variance, Poisson distribution as limiting case of binomial distribution.

Unit IV **15 Hrs.**

Theoretical continuous distribution: Normal distribution with its properties related problems, Fitting of curves: Principle of curve fitting, Fitting of straight line and second degree parabola by least squares method.

Unit V **15 Hrs.**

Correlation: Definition and types, Properties of correlation, Methods of studying correlation: Karl Pearson's coefficient of correlation, Spearman Rank Correlation, Linear Regression: Definition, Fitting of two lines of regression, Regression coefficients with simple properties.

BOOKS RECOMMENDED

- S.C. Gupta and V.K. Kapoor, Fundamentals of Statistics, S.Chand & Sons, 2014.
- J.N. Kapoor and H.C. Saxena, Mathematical Statistics, S.Chand & Co. Publications, 1960.
- I. M. Chakravarthy, Handbook of Applied Statistics, Willey, 1967.
- A. M. Mood and F. Graybill, Introduction to the Theory of Statistics, McGraw Hill, 1974.
- B. Gnedenko, The Theory of Probability (MIR, Moscow), 6th Edition,1988.
- Pappu Kousalya, Probability, Statistics and Random Processes, Pearson, 2013.
- Vijay K. Rohatagi, A. K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, Wiley, Second edition, 2008.
- William Feller, An Introduction to Probability Theory and its Applications, Vol. 1, Wiley, Third edition, 2008.
- A.M. Gun, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics-Vol-II, World Press, 2016.

PAPER CODE - MAT325C
Modules and Rings-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

1. Understand the importance of a ring as a fundamental object in algebra.
2. It also gives ideas about module and represents fundamental algebraic structures used in abstract algebra.
3. Understand a module over a ring is a generalization of the notion of vector space over a field, wherein the corresponding scalars are the elements of an arbitrary given ring (with identity) and a multiplication (on the left and/or on the right) is defined between elements of the ring and elements of the module.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 325C	**Modules and Rings-I (Theory)**	**The students will be able to –** **CO108:** Students get an introduction to module theory and the related part of ring theory. Starting from a basic understanding of linear Class Tests at Periodic algebra the theory is presented with complete proofs. From the beginning the approach is categorical. **CO109:** Students get idea about types of modules. **CO110:** Students understand the structure theory of modules over a Euclidean domain along with its implications. The material underpins many later courses in algebra and number theory, and thus should give students a good background for studying these more advanced topics. **CO111:** Students know about Divisible groups, Jordon-Holder theorem, Indecomposable modules, Krull–Schmidt theorem, images and direct sum of semi-simple modules. **CO112:** Students know about Prime ideals, m-system, Prime radical of an ideal, Prime radical of a ring, Semiprime ideal, n-system, Representation of a ring as a subdirect sum of rings, Subdirectly irreducible ring, Birkhoff theorem on subdirectly irreducible ring, Subdirectly irreducible boolean ring.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Morphisms, Exact sequences, The three lemma, The four lemma, The five lemma, Butterfly of zausenhauss theorem, Product and co-product of R-modules, Free modules.

Unit II **15 Hrs.**

Noetherian module and Artinian module, Composition series. Projective modules, Injective modules, Direct sum of projective modules, Direct product of injective modules.

Unit III **15 Hrs.**

Divisible groups, Embedding of a module in an injective module, Tensor product of modules, Noetherian module and Artinian module, Finitely generated modules, Jordon-Holder theorem, Indecomposable modules, Krull–Schmidt theorem, Semi-simple modules, Submodules, Homomorphic images and direct sum of semi-simple modules.

Unit IV **15 Hrs.**

Prime ideals, m-system, Prime radical of an ideal, Prime radical of a ring, Semiprime ideal, n-system, Prime rings, Semiprime ring as a subdirect product of a prime ring, Prime ideals and prime radical of matrix ring.

Unit V **15 Hrs.**

Subdirect sum of rings, Representation of a ring as a subdirect sum of rings, Subdirectly irreducible ring, Birkhoff theorem on subdirectly irreducible ring, Subdirectly irreducible Boolean ring.

BOOKS RECOMMENDED

- T. S. Blyth, Module Theory, Clarendon Press, London, 1989.
- T. Y. Lam, Non commutative Rings, Springer-Verlag, 1991.
- I. N. Herstein, Non commutative Rings, C. Monographs of AMS, 1968.
- T. W. Hungerford, Algebras, Springer, 1980.
- B. Hartley and T.O. Hauvkes, Rings, Modules and Linear Algebra, Chapman and Hall Ltd., 1970.
- R. B. Allenly, Rings Fields and Graphs: An Introduction of Abstract Algebra, Edward Arnold, 1989.
- T. W. Hungerford, Algebras, Springer, 1980.
- J. Rose, A Course on Ring Theory, Cambridge University Press, 1978.
- L. H. Rowen, Ring Theory (Student Addition), Academic Press, 1991.
- N. Jacobson, Structure of Rings, AMS, 1970,
- P. M. Cohn, Basic Algebra, Springer; Corrected 2003.

PAPER CODE – MAT326
Synopsis for Dissertation /Project
(Synopsis)

Credits: 2
Maximum marks: 100
Contact Hrs/Week:
Total Hrs: 90

Course Objectives:

This course will enable the students to –

1. To provide a capacity to learn continually and interact with multidisciplinary groups.
2. To provide innovative methods and techniques to solve research problem.
3. To interpret the research material of dissertation (synopsis) in a critical manner and to proceed with an analysis/simulation/experimentation and critical review.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT326	**Synopsis for Dissertation /Project (Synopsis)**	**The students will be able to –** **CO113:** Identify key research questions within the field of Mathematics on which student can carry out independent research. **CO114:** Manage the time effectively whilst working on your independent research. **CO115:** Use and develop written and oral presentation skills.	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing

M.Sc. MATHEMATICS (2020-2021)

COURSE OUTCOMES - Semester IV

PAPER CODE - MAT 421
Functional Analysis-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

- Understand the concept of Normed linear spaces, Banach spaces, Hilbert Spaces, and operators on these spaces.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 421	Functional Analysis-II (Theory)	**The students will be able to –** **CO116:** Explain the fundamental concepts of functional analysis in applied contexts. **CO117:** Use elementary properties of Banach space and Hilbert space. **CO118:** Identify normal, self adjoint or unitary operators. **CO119:** Communicate the spectrum of bounded linear operators. **CO120:** Construct orthonormal sets.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Adjoint of an operator on a Hilbert space: Self-adjoint, positive, normal and unitary operators and their properties, Projection on a Hilbert space.

Unit II **15 Hrs.**

Derivatives of a continuous map from an open subset of Banach space to a Banach space, Rules of derivation, Derivative of a composite, Directional derivative.

Unit III **15 Hrs.**

Mean value theorem and its applications, Partial derivatives and Jacobian Matrix.

Unit IV **15 Hrs.**

Continuously differentiable maps, Higher derivatives, Taylor's formula, Inverse function theorem, Implicit function theorem.

Unit V **15 Hrs.**

Step function, Regulated function, Primitives and integrals, Differentiation under the integral sign, Riemann integral of function of real variable with values in normed linear space.

BOOKS RECOMMENDED

- G.F. Simmons, Topology and Modern Analysis, McGraw Hill, 1963.
- George Bachman and Lawrence Narici, Functional Analysis, Academic Press, 1964.
- Dileep S. Chauhan, Functional Analysis and calculus in Banach space, JPH, 2016.
- B.V. Limaye, Functional Analysis, New age international, 2017
- B.V. Limaye, Linear Functional Analysis for Scientists and Engineers, Springer, 2016.
- Erwin Kreyszig, Introductory Functional Analysis with Application, Willey, 2007.
- A.E. Taylor, Introduction to Functional Analysis, John Wiley and sons, 1958.
- Graham Allan and H. Garth Dales, Introduction to Banach Spaces and Algebras, Oxford University Press, 2010.
- Reinhold Meise, Dietmar Vogt and M. S. Ramanujan, Introduction to Functional Analysis, Oxford University Press, 1997.
- A.L. Brown and A. Page, Elements of Functional Analysis, Van Nostrad Reinlold, 1970.
- Walter Rudin, Functional Analysis, McGraw- Hill, 1973.
- Barbara D. Maccluer, Elementary Functional Analysis, Springer, 2009.

PAPER CODE - MAT 422
Fluid Dynamics-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the fundamentals of Fluid Dynamics and an appreciation of their application to real world problems.
2. Apply the techniques used in deriving a range of important results and in research problems.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 422	**Fluid Dynamics-II (Theory)**	**The students will be able to –** **CO121:** To analyze simple fluid velocity and temperature fields problems flow through pipe, over sphere etc. with Navier -Stoke's equation of motion. **CO122:** To understand the phenomenon of flow separation and boundary layer theory.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Variable viscosity plane Couette flow, Variable viscosity plane Poiseuille flow, Flow due to plane wall suddenly set in the motion (Stokes' first problem), Flow due to an oscillating plane wall (Stokes' second problem), Starting flow in plane Couette motion.

Unit II **15 Hrs.**

Starting flow in a pipe, Plane Couette flow of a viscous compressible fluid, Plane Couette flow with transpiration cooling steady incompressible flow with fluid suction/injection through porous wall on the boundaries.

Unit III **15 Hrs.**

Theory of very slow motion: Stokes' and Oseen's flows past a sphere, Lubrication theory.

Unit IV **15 Hrs.**

Derivation of two-dimensional boundary layer equation for flow over a plane wall, Boundary layer on flat plate, Characteristic boundary layers parameters, Similar solutions of the boundary layer equations, Boundary layer flow past a wedge, Separation of boundary layers.

Unit V **15 Hrs.**

Derivation of two-dimensional thermal boundary layer equation for flow over a plane wall, Forced convection in laminar boundary layer on a flat plate, Free convection from a heated vertical plate.

BOOKS RECOMMENDED

- J. L. Bansal, Viscous Fluid Dynamics, Jaipur Publishing House Jaipur, 2013.
- R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Co. 1976.

- F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers, Delhi, 2004.
- L.D.Landau and E.N. Lipschitz, Fluid Mechanics, Pergamon Press, London, 1985.
- Schaum's Outlines, Fluid Mechanics, McGraw-Hill Education, 1st edition, 2007.
- G.K. Batchelor, An Introduction to Fluid Mechanics, Cambridge University Press, 2000.
- M.D. Raisinghania, Fluid Dynamics, S. Chand&Co. Pvt. Ltd., New Delhi, 2003.
- Pradip Niyogi, S.K. Chakrabartty and M. K. Laha, Introduction to Computational Fluid Dynamics, Pearson Education, 2006.

PAPER CODE - MAT 423A
Advanced Operations Research-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the basic concepts of non-linear programming problems.
2. Understand the quadratic programming problems, Geometric programming problems, Replacement problems, Dynamic programming problems, network analysis problems.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 423A	**Advanced Operations Research-II (Theory)**	**The students will be able to –** **CO123:** Understand and Solve Replacement problems. **CO124:** To derive the necessary conditions (KT conditions) for constrained nonlinear optimization problems and able to solve quadratic programming problems. **CO125**: Derive methods to solve separable, geometric programming problems. **CO126:** Discuss various methods to solve linear fractional programming problems and dynamic programming problems.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

		CO127: Explain problems related to sequencing and PERT-CPM to solve network analysis problems.	questions, presentations, Field trips	

(Note: Non-Programmable scientific calculator up to 100 MS is permitted)

CONTENTS

Unit I **15 Hrs.**

Replacement models: Gradual failure, Sudden failure, Replacement due to efficiency deteriorate with time, Staffing problems, Equipment renewal problems.

Unit II **15 Hrs.**

Nonlinear Programming: Formulation and graphical method for unconstrained problem of maxima and minima, Constrained problem of maxima and minima Lagrangian method, Khun-Tucker condition. Quadratic programming: Wolf and Beals method.

Unit III **15 Hrs.**

Separable programming: Definition, Reduction to separable programming problem to LPP, Separable programming algorithm. Geometric programming: Formulation and solution of GPP (Unconstraint type and with quality constraint).

Unit IV **15 Hrs.**

Linear fractional programming: Definition, Linear fractional algorithm, Computational procedure of fractional algorithm. Dynamic programming: Introduction, Bellman principle of optimality model –I, II and III, Solution of LPP by dynamic programming.

Unit V **15 Hrs.**

Network Scheduling by PERT-CPM, Network logical sequencing, Concurrent activities, Critical path analysis, Probability consideration in PERT, Distinction between PERT and CPM.

BOOKS RECOMMENDED

- S. D. Sharma, Operations Research, Kedar Nath Ram Nath and Co. 1992.
- Kanti Swarup, P.K.Gupta and Manmohan, Operations Research, S. Chand and Company Ltd, New Delhi, 2007.
- Hamady A. Taha, Operations Research an Introduction, Prentice Hall.2007.
- B.S. Goel and S.K. Mittal, Operation Research, Pragati Prakashan, 2014.
- S. I. Gass, Linear Programming, McGraw Hill Book Co.1958.
- F.S. Hiller and G.J. Lieberman, Introduction to Operations Research, Addison Wesley, 2011.
- R.S. Garfinkel and G.L. Nemhauser, Integer Programming, Wiley, New York, 1972.
- G. Hadley, Linear programming, Oxford and IBH Publishing, New Delhi, 1962.
- P.K. Gupta and D.S. Hira, Problem in Operation Research, S. Chand and Co. New Delhi, 2010.

PAPER CODE - MAT 423B
Computational Methods of Partial Differential Equations
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand various numerical methods.
2. Understand the finite difference schemes for the solution of partial differential equations along with analyzing them for consistency, stability and convergence.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes

(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment

Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>MAT 423B</td><td>Computational Methods of Partial Differential Equations (Theory)</td><td>The students will be able to –

CO128: Use discretization methods for solution of PDEs using finite difference schemes.
CO129: Analyze the consistency, stability and convergence of a given numerical scheme.
CO130: Apply various iterative techniques for solving system of algebraic equations.
CO131: Know the basics of finite element methods for the numerical solution of PDEs.
CO132: Construct computer programme using some mathematical software to test and implement numerical schemes studied in the course.</td><td>Approach in teaching:
Interactive Lectures, Discussion, Power Point Presentations, Informative videos
Learning activities for the students:
Self learning assignments, Effective questions, presentations, Field trips</td><td>Quiz, Poster Presentations,
Power Point Presentations, Individual and group projects,
Open Book Test,
Semester End Examination</td></tr>
</table>

CONTENTS

Unit I **15 Hrs.**

Elliptic equations: Finite difference method on 2D and 3D elliptic equation on non-uniform mesh, Finite difference methods for 2D and 3D Poisson's equations of second and fourth order approximations, Iterative methods for 2D and 3D elliptic equations, Solution of large system of algebraic equations corresponding to discrete problems and iterative methods (Jacobi, Gauss-Seidel and SOR), Numerical methods extended method 2D and 3D bi-harmonic problems.

Unit II **15 Hrs.**

Heat Equations: Compatibility, Consistency and convergence of the difference method, Numerical methods for one dimensional heat conduction equation: Schmidth scheme, Laasonen scheme, Cranck Nicholson Scheme, Alternating direction implicit (ADI) methods for 2D and 3D heat conduction equations, Stability analysis (Energy method , Matrix method and Von-Neumann method).

Unit III **15 Hrs.**

First order hyperbolic equation: Conservation laws, Explicit and implicit methods for diffusion equations, Explicit and implicit difference scheme for first order hyperbolic equations and their stability analysis, System of equation for first order hyperbolic equation, Conservative form, Alternating direction implicit (ADI) methods for 2D and 3D first order hyperbolic equation.

Unit IV **15 Hrs.**

Second order hyperbolic equations: Methods of characteristic for evolution problem of hyperbolic type, Von-Neumann method for stability analysis, Explicit and implicit method for second order hyperbolic equation, Operator splitting methods for 2D and 3D wave equations and their stability analysis, Unconditional stability analysis for second order hyperbolic equations.

Unit V **15 Hrs.**

Finite element method: Finite element method for second order elliptic BVPS, Finite element equation, Variational problems, Triangular and rectangular finite elements, Standard examples of finite elements, Mixed finite element methods.

BOOKS RECOMMENDED

- J.C. Strickwerda, Finite Difference Schemes and Partial Differential Equations, SIAM Publications, 2004.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
- M.K. Jain, S.R.K. Iyenger and R.K. Jain, Computational Methods for Partial Differential Equations, New Age Publications, 2015.
- M.K. Jain, Numerical Solution of Differential Equations: Finite difference and Finite Element Approach, New Age Publications, 2018.
- J.W. Thomas, Numerical Partial Differential Equation: Finite Difference Method, Springer and Verlag Berlin, 1998.
- J.W. Thomas, Numerical Partial Differential Equations: Conservation Laws and Elliptical Equations, Springer and Verlag Berlin, 1999.
- K.J. Bathe and E.L. Wilson, Numerical Methods in Finite Element Analysis, Prentice-Hall India 1987.
- D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Oxford University Press, 1993.

PAPER CODE - MAT 423C
Magnetohydrodynamics-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Prepare a foundation for advanced study of fluid motion in electromagnetic field, Magnetohydrodynamics and boundary layer theory.
2. Develop concepts, models and techniques which enable us to solve the problems and help in research in these broad areas.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 423C	**Magnetohydrodynamics-II (Theory)**	**The students will be able to –** **CO133:** Understand the two dimensional MHD flow over and flow past a plane, oseen's flow. **CO134:** Formulate the basic equations of motion of MHD boundary layer flow in presence of magnetic field, jet flow, rotating flow, free convection flow etc. **CO135:** Describe the difference between MHD and MFD boundary layer flows. **CO136:** Formulate the basic equations of motion of MFD boundary layer flow in presence of magnetic field.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

MHD Oseen flow of a viscous liquid past a sphere, MHD Oseen's flow past a circular cylinder (exact solution), MHD Oseen's flow past a circular cylinder(series solution). Derivation of two dimensional MHD Boundary layer equations for flow over a plane surface, MHD boundary layer flow past a flat plate.

Unit II **15 Hrs.**

Derivation of two dimensional thermal boundary layer equation for MHD flow over a plane surface, Heat transfer in MHD boundary layer flow past a flat plate, Two dimensional MHD boundary layer equations for flow over a plane surface, MHD Boundary layer flow past a flat plate in a transverse magnetic field.

Unit III **15 Hrs.**

MHD plane free jet flow, MHD plane wall jet flow, MHD curved wall jet flow, MHD circular free jet flow, MHD boundary layer flow due to impulsive motion of a plane wall.

Unit IV **15 Hrs.**

MHD boundary layer flow due to an accelerated flat plate, MHD boundary layer growth on a body placed symmetrical to the flow, MHD boundary layer growth in a rotating flow, heat, mass and momentum transfer in unsteady MHD free convection flow on an accelerated vertical plate. Unsteady boundary layer flow past a flat plate in an aligned magnetic field, Derivation of two-dimensional MFD boundary layer equation for flow over a plane surface.

Unit V **15 Hrs.**

Similarity solutions for MFD steady boundary layer flow in an aligned magnetic field, two dimensional MFD boundary layer equations for flow over a plane surface, similarity solutions for MFD steady boundary layer flow in a transverse magnetic field, Magnetogas dynamic plane free jet flow.

BOOKS RECOMMENDED

- J.L. Bansal, Magnetofluiddynamics of Viscous Fluids, Jaipur Publication House, 1994.
- Chandra Shekhar, Hydrodynamic and Hydromagnetic Stability, Oxford University Press. 1961.
- K.R Cramer and S.I. Pai, Magnetofluidodynamics for Engineers and Applied Physicists, McGraw-Hill, New York, 1973.
- V.C.A Ferraro and C. Plumpton, An Introduction to Magnetofluid Mechanics, Clarendon Press, Oxford, 1966.
- A. Jeffreys, Magnetohydrodynamics, Oliver and Boyd, New York, 1966.
- S.I. Pai, Magnetogasdynamics and Plasma Dynamics, Springer-Verlag, Vienna, 1963.
- J.A. Shercliff, A Text Book of Magnetohydrodynamics, Pergamon Press, Oxford, 1965.

PAPER CODE - MAT 424A
Integral Equations
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the concept of the relationship between the integral equations and ordinary differential equations.
2. Understand the linear and nonlinear integral equations by different methods with some problems which give rise to integral equations.

3. Learn different types of solution methods like successive approximation, resolvent kernel and iteration method, integral transform method and which method is applicable for which type of integral equation.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 424A	**Integral Equations (Theory)**	**The students will be able to –** **CO137:** Acquire knowledge of different types of Integral equations: Fredholm and Volterra integral equations. **CO138:** Obtain integral equations from ODE and PDE arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation. **CO139:** Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces. **CO140:** Think logically and mathematically and apply the knowledge of transforms to solve complex problems **CO141:** Construct Green functions in solving boundary value problem by converting it to an integral equation.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Linear integral equations: Definition and classification, Conversion of initial and boundary value problems to an integral equation, Eigen values and Eigen functions, Solution of homogeneous and general Fredholm integral equations of second kind with separable kernels.

Unit II **15 Hrs.**

Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations, Resolvent kernel and its result, Conditions of uniform convergence and uniqueness of series solution.

Unit III **15 Hrs.**

Integral equations with symmetric kernels: Orthogonal system of functions, Fundamental properties of eigen values and eigen functions for symmetric kernels, Hilbert-Schmidt theorem, Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.

Unit IV **15 Hrs.**

Solution of Fredholm integral equation of second kind by using Fredholm first theorem, Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform, Solution of singular integral equations by Fourier transform.

Unit V **15 Hrs.**

Green's function: Definition, Construction, Properties, Green's function approach for integral equation formulation of ordinary differential equation of any order, Laplace and Poission's equations.

BOOKS RECOMMENDED

- Shanti Swaroop, Integral Equations, Krishna Publication, Meerut, 2014.
- S.P. Goyal and A.K. Goyal, Integral Equations, Jaipur publishing House, Jaipur, 2013.
- R. P. Kanwal, Linear Integral Equations, Academic Press, 1974.
- J. L. Bansal and H.S. Dhami, Differential Equations, JPH Vol. I & II, 2014.
- M.D. Raisinghania, Advanced Differential Equation, S. Chand and Company ltd., 2012.
- S. K. Pundir and R. Pundir, Integral Equations and Boundary Value Problems, Pragati Prakashan, 2014.
- K. E. Atkinson, The Numerical Solution of Integral Equations of the Second Kind, Cambridge Monographs on Applied and Computational Mathematics, 1997.
- A. D. Polyanin and A. V. Manzhirov, Handbook of Integral Equations. CRC Press, Boca Raton, 1998.
- W. V. Lovitt, Linear Integral Equations, Dover Publication, 2005.

PAPER CODE - MAT 424B
Advanced Studies of special Functions and Integral Transforms
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Aware about properties of special functions, generalized hypergeometric, Legendre functions etc. by their integral representations and symmetries.
2. Understand Laplace transform, Z transforms.
3. Learn about its applications in partial differential equations of mathematical physics.
4. Apply these techniques to solve and analyze various mathematical problems.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 424B	**Advanced Studies of special Functions and Integral Transforms (Theory)**	**The students will be able to –** **CO142:** Know the concept of Z-transforms and Properties and its importance in engineering like Digital signal processing and digital filters. **CO143:** Understand and find Solutions Heat, Wave, Laplace equation under initial and boundary conditions. **CO144:** Think logically and mathematically and apply the knowledge of integral transform to solve complex problems. **CO145:** Learn properties of the generalised hypergeometric function and its convergence. **CO146:** Explain the applications and the usefulness of these special functions.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Associated Legendre polynomials of first and second kind: Differential equation, Relation between solutions of associated Legendre equation, Recurrence relation, Orthogonal properties, Hyper geometric forms.

Unit II **15 Hrs.**

Chebyshev polynomials: Chebyshev equation and its solutions, Expansions, Generating relations and orthogonal property.

Unit III **15 Hrs.**

Generalized Hypergeometric Function: Definition, Special cases, Series, integral and contour representations, Convergence conditions of these representations, Saalssutz, Whipple theorems, Contiguous function relations, Differentiation and integral formulas.

Unit IV **15 Hrs.**

Laplace Transforms: Complex inversion formula, Use of residue theorem in calculation of inverse Laplace transform including the functions with branch points and infinitely many singularities, Solution of Heat conduction and Wave problems by using complex inversion formula for Laplace transform.

Unit V **15 Hrs.**

Z-Transforms: Definition, Inverse, Images of elementary functions, Basic operational properties, Partial derivatives, Initial and Final value theorems and applications.

BOOKS RECOMMENDED

- E.D. Rainville, Special Functions, Macmillan, New York, 1989.
- K. P. Gupta and J. K. Goyal, Integral Transforms, Pragati Prakashan, New Delhi,2015
- Z.X. Wang and D.R. Guo, Special Functions, World Scientific publishing Ltd., 1989.
- George E. Andrews, Richard Askey and Ranjan Roy**,** Special Functions, Cambridge University, 2000**.**
- N. N. Lebedev and Richard A. SilverMan, Special Functions and Their Application, Dover Publications INC, 1972.
- I.N. Sneddon, Special Functions, TMH, New Delhi, 1956.
- Mohamed F. EL-Hewie, Laplace Transform, Create space Independent Publication, 2013.
- Joel L. Schiff, The Laplace Transform: Theory and Application, Springer Science & Business Media, 1999.
- John Miles, Integral Transform in Applied Mathematics, Cambridge University Press, 1971.

PAPER CODE - MAT 424C
Advanced Real Analysis-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understand the advanced concept of real analysis and give sufficient knowledge of the subject which can be used by students for further applications in their respective domains of interest.
2. An introduction to derivative and integrability of absolutely continuous functions, general measure and integration, Fourier series of functions of class L, distribution theory.

Course Outcomes (COs):

Course		**Learning outcomes**	**Learning and teaching strategies**	**Assessment**
Paper Code	**Paper Title**	**(at course level)**		**Strategies**
MAT 424C	**Advanced Real Analysis-II**	**The students will be able to –** **CO147:** Analyze properties derivative and integrability of absolutely continuous functions. **CO148:** Describe properties of measure and integration.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations,	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects,

	(Theory)	**CO149:** Understand the concept of Fourier series of functions of class L and prove related theorem. **CO150:** Discuss operation , properties and convergence of distribution's **CO151:** Apply differentiation on distribution and define direct product of distributions.	Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Derivative: Banach-Zarecki theorem, Derivative and integrability of absolutely continuous functions, Lebesgue point of a function, Determining a function by its derivative.

Unit II **15 Hrs.**

General Measure and Integration**:** Additive set functions, Measure and signed measure, Limit theorems, Jordan and Hahn decomposition theorems, Complete measures, Integrals of non- negative functions, Integrable functions, Absolute continuous and singular measures, Radon-Nikodym theorem, Radon-Nikodyn derivative in a measure space.

Unit III **15 Hrs.**

Fourier series: Fourier series of functions of class L, Fejer-Lebesgue theorem, Integration of Fourier series, Cantor- Lebesgue theorem on trigonometric series, Riemann's theorem on trigonometric series, Uniqueness of trigonometric series.

Unit IV **15 Hrs.**

Distribution Theory: Test functions, Compact support functions, Distributions, Operation on distributions, Local properties of distributions, Convergence of distributions.

Unit V **15 Hrs.**

Differentiation of distributions and some examples, Derivative of locally integrable functions, Distribution of compact support, Direct product of distributions and its properties, Convolution and properties of convolutions.

BOOKS RECOMMENDED

- A.M. Bruckner, J.B. Bruckner and B.S. Thomson, Real Analysis, Prentice-Hall, N.Y. 1997.
- H.S. Gakill and P.P. Narayanswami, Elements of Real Analysis, Prentice-Hall India, 1988.
- W.P. Parzynski and P.W. Zipse, Introduction to Mathematical Analysis, Mc Graw-Hill Company, 1982.
- C. Goffman, Real Functions, Rinehart Company, N.Y. 1953.
- J.F. Randolph, Basic Real and Abstract Analysis, Academic Press, N.Y. 1968.
- Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, John Wiley & Sons Canada, 2011.
- A.J. Kosmala, Introductory Mathematical Analysis, WCB Company, 1995.

PAPER CODE - MAT 425A
General Relativity & Cosmology
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Provide a detailed knowledge of the general relativity and its applications in Cosmology.
2. Solve the problems and help in research in these broad areas.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 425A	**General Relativity & Cosmology (Theory)**	**The students will be able to –** **CO152:** Formulate Einstein field equation for matter and empty space. **CO153:** Understand the concept of clock paradox in general relativity. **CO154:** Derive the differential equation for planetary orbit, analogues of kepler's law.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Mach's principle, Newtonian approximation of equation of motion, Einstein's field equation for matter and empty space, Reduction of Einstein's field equation to Poisson's equation.

Unit II **15 Hrs.**

Removal of clock paradox in General Relativity, Schwarzschild exterior metric and its isotropic form, Singularity and singularities in Schwarzschild exterior metric, Derivation of the formula $\mathrm{GM} = \mathrm{m\,c}^2$, Mass of sun in gravitational unit.

Unit III **15 Hrs.**

Relativistic differential equation for the orbit of the planet, three crucial tests in general relativity and their detailed descriptions, Analogues of Kepler's laws in general relativity.

Unit IV **15 Hrs.**

Trace of Einstein tensor, Energy-momentum tensor and its expression for perfect fluid, Schwarzschild interior metric and boundary condition.

Unit V **15 Hrs.**

Cosmology - Einstein's field equation with cosmological term, Static cosmological models (Einstein & de-Sitter models) with physical and geometrical properties, Non-static form of de-Sitter line-element and red shift in this metric, Einstein space, Hubble's law, Weyl's postulate.

BOOKS RECOMMENDED

- Jayant V. Narlikar, Introduction to Cosmology, CambridgeUniversity Press, 2002.
- Bernard F. Schutz, A First Course in General Relativity, CambridgeUniversity Press, 2010.
- Sushil Kumar Srivastava, General Relativity and Cosmology, Prentice hall India, 2008.
- Raj Bali, General Relativity, JPH, 2005.
- David Agmon, Paul Gluck, Classical and Relativistic Mechanics,2009.
- Jayant V. Narlikar, AnIntroduction to Relativity, CambridgeUniversity Press, 2010.
- Robert J. A. Lambourne, Relativity, Gravitation, and Cosmology, Cambridge University Press, 2010.
- R.C. Tolman, Relativity, Thermodynamics and Cosmology, Oxford University Press, 1934.
- J.L. Synge, Relativity the General Theory, North Holland Publishing Company, Amsterdam, 1971.
- A.S. Eddention, The Mathematical Theory of Relativity, Cambridge University Press, 2010.
- S. Aranoff, Equilibrium in Special Relativity: The Special Theory, North Holland Pub. Amsterdam, 1965.

PAPER CODE - MAT 425B
Modeling and Simulation
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Provide knowledge about Modeling and Simulation (M & amp; S) which is the use for different models (e.g., physical, mathematical, or logical representation of a system, entity, phenomenon, or process) as a basis for simulations to develop data utilized for managerial or technical decision making.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
MAT 425B	**Modeling and Simulation (Theory)**	**The students will be able to –** **CO155:** Students will get ideas about the individual-based models of infectious diseases. These models allow us to incorporate stochastic effects, and individual-scale detail in ways that cannot be captured in more traditional models. **CO156:** Students review a framework based on directed random networks that unifies a range of individual-based models in closed populations, simplifying their analysis. We then show how this framework provides a new and potentially useful perspective on the design of vaccination strategies. Student will also get idea about reproduction number which is used to control epidemics. **CO157:** Students get ideas about The types of simulations, simulation languages, pseudo-random numbers, Marcov chain and variants from different probability distributions. **CO158:** Students learn about the systems and its type, mathematical modeling, simulation there advantages and drawbacks. **CO159:** Students learn how to do modelling through graph, LPP.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

(Note: Non-Programmable scientific calculator up to 100 MS is permitted)

CONTENTS

Unit I **15 Hrs.**

Introduction to modeling and simulation, Definition of System, Type of System: Discrete system and continuous system, classification of systems, Modeling process, Advantage and disadvantage of simulation, Classification and limitations of mathematical models and its relation to simulation.

Unit II **15 Hrs.**

Modeling through differential equation: Linear growth and decay models, Nonlinear growth and decay models, Logistic model, Basic model relevant to population dynamics (Prey-Predator model, Competition model), Volterra's principle.

Unit III **15 Hrs.**

Compartment models: One-Compartment models and Two-Compartment models, Equilibrium solution, Stability analysis, Model validity and verification of models (Model V&V), Modeling through graph (in terms of weighted graph, In terms of signed graph, in terms of directed Graph).

Unit IV **15 Hrs.**

Mathematical modeling through ordinary differential equation: SI model, SIR model with and without vaccination. Partial differential equation: Mass and momentum balance equations, wave equation.

Unit V **15 Hrs.**

Basic concepts of simulation languages, Overview of numerical methods used for continuous simulation, Stochastic Process (Marcov process, Transition probability, Marcov chain, Steady state condition, Marcov analysis), Discrete system simulation (Monte Carlo method, Random number generation).

BOOKS RECOMMENDED

- D. N. P. Murthy, N. W. Page and E. Y. Rodin, Mathematical Modeling, Pergamum Press, 2013.
- J. N. Kapoor, Mathematical Modeling, Wiley Eastern Ltd., 2015
- P. Fishwick, Simulation Model Design and Execution, PHI, 1995.
- Brian Albright, Mathematical Modeling with Excel, Jones & Bartlett, 2012.
- A. M. Law and W. D. Kelton, Simulation Modeling and Analysis, McGraw-Hill, 2007.
- J. A. Payne, Introduction to Simulation, Programming Techniques and Methods of Analysis, Tata McGraw Hill Publishing Co. Ltd., 1988.
- V.P. Singh, System Modeling & Simulation, New Age International Publishers, 2009.

PAPER CODE - MAT 425C
Modules and Rings-II
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to -

1. Understanding a ring is an important fundamental concept in algebra and includes integers, polynomials and matrices as some of the basic examples.
2. Understand the study of modules over a ring R provides students with an insight into the structure of R.
3. Develop ring and module theory leading to the fundamental theorems of Wedderburn and some of its applications.
4. Understanding a module over a ring is a generalization of vector space over a field.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
MAT 425C	**Modules and Rings-II (Theory)**	**The students will be able to –** **CO160:** Understand the concept of a module as a generalisation of a vector space and an Abelian group. **CO161:** Constructions such as direct sum, product and tensor product, Simple modules, Semisimple modules, artinian modules, their endomorphisms and examples. **CO162:** Radical, simple and semisimple artinian rings, examples and the Artin-Wedderburn theorem. **CO163:** The concept of central simple algebras, the theorems of Wedderburn and Frobenius. **CO164:** Student will understand The Jacobson radical, Jacobson radical of matrix ring, Jacobson semisimple ring.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit I **15 Hrs.**

Local ring, Characterization of local ring, Local ring of formal power series.

Unit II **15 Hrs.**

Semisimple module, Semisimple ring, Characterizations of semisimple module and semisimple ring, Wedderburn-Artin theorem on semisimple ring.

Unit III **15 Hrs.**

Simple ring, Characterization of Artinian simple ring.

Unit IV **15 Hrs.**

The Jacobson radical, Jacobson radical of matrix ring, Jacobson semisimple ring, Relation between Jacobson semisimple ring and semisimple ring, Hopkins-Levitzki theorem, Nakayama's lemma, Regular ring, Relation among semisimple ring, Regular ring and Jacobson semisimple ring.

Unit V **15 Hrs.**

Lower nil radical, Upper nil radical, Nil radical, Brauer's lemma, Kothe's conjecture, Levitzki theorem.

BOOKS RECOMMENDED

- T.S. Blyth, Module Theory, Clarendon Press, London, 1989.
- T.Y. Lam, Noncommutative Rings, Springer-Verlag, 1991.

- I.N. Herstein, Noncommutative Rings, C. Monographs of AMS, 1968.
- T.W. Hungerford, Algebras, Springer, 1980.
- B. Hartley, T.O.Hauvkes, Rings, Modules and Linear Algebra, Chapmann and Hall Ltd., 1970.
- R.B. Allenly, Rings Fields and Graphs: An Introduction of Abstract Algebra, Edward Arnold, 1989.
- T.W. Hungerford, Algebras, Springer, 1980.
- J. Rose, A Course on Ring Theory, Cambridge University Press, 1978.
- L.H. Rowen, Ring Theory (Student Addition), Academic Press, 1991.
- N. Jacobson, Structure of Rings, AMS, 1970.
- P.M. Cohn, Basic Algebra, Springer; Corrected 2003. edition 2002.

PAPER CODE – MAT426
Dissertation/Project
(Dissertation)

Credits: 4
Maximum marks: 100

Course Objectives:

This course will enable the students to –

1. Provide innovative methods and techniques to solve research problem.
2. Interpret the research material of dissertation in a critical manner and to proceed with an analysis, simulation and critical review.
3. Understand and provide a framework within which research review is conducted so that student's answers are fact based and backed-up by solid information.
4. Craft an extensive and comprehensive piece of written work so as to convey her/his views in the most efficient and effective way.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
MAT 426	**Dissertation/ Project (Dissertation)**	**The students will be able to –** **CO165:** Identify, analyse and interpret suitable data to enable the research question to be answered. **CO166:** Understand and apply theoretical frameworks to the chosen area of study. **CO167:** Demonstrate appropriate referencing and develop skills in other aspects of academic writing. **CO168:** Demonstrate knowledge and understanding of report writing. **CO169:** Describe the process of carrying out independent research in written format and report your results and conclusions with reference to existing literature.	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing

Programme- M.Sc. Physics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Analyse the given scientific data critically and systematically and will have the ability to draw the objective conclusions. Know basics of cognitive biases, mental models, logical thinking, scientific methodology and constructing cogent scientific arguments. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
PO2	Keenly observe about what is going on in the natural surroundings to awake their curiosity and design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find emPSOyment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.
PO5	Students are trained to be an individual with concern for the society they live and to contribute at maximum, their skills and

	knowledge in the broadest context, for the development of the nation.
PO6	Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Students are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
PO7	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will also enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will gain knowledge and skills for further higher studies, competitive examinations and emPSOyment.
PO8	**D**igitally literate to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
PO9	Students will learn team workmanship with productive cooperations involving members from diverse socio-cultural backgrounds in order to serve efficiently institutions, industry and society.
PO10	Develop various skills like Use of IT (word-processing, use of internet, statistical packages and databases), Communication of scientific ideas in writing and orally,. Ability to work as part of a team, Ability to use library resources,Time management and Career planning.
PO11	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and development of the information to provide valid conclusions.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	In depth knowledge of various physical theories, models and methods. Students will be able apply this theoretical knowledge of principles and concepts of Physics to practical problems in daily life.
PSO 2	Broad knowledge of relevant experimental, analytical and computational methods in Physics.
PSO 3	An academic intuition and comprehensive understanding to present and discuss physical concepts, results and uncertainties.
PSO 4	Ability to apply physics principles along with other scientific conceptual attitude to analyze the problems related to society and to show the caliber for finding the solution.
PSO 5	Professional maturity and can work independently in other allied fields, associated with Physics, like Bio Physics.
PSO 6	Ability to demonstrate efficient planning including time management, resource management and organization skills.
PSO 7	Expertise in new and advanced techniques of computational Physics based on softwares like WIEN 2k, Quantum Espresso, pspice etc.
PSO 8	Understand the value of research and applied research through dissertation/project component of the programme

PSO 9	Have leadership skills with high regard for ethical values and social responsibilities through learning of time management and team work skill.
PSO 10	Ability to explain the understanding of impact of physics study on the society including pollution, environment, health and ecosystem. In addition, the students will be able to propagate their knowledge to address problems of social relevance, such as energy, and environment through their specific electives
PSO 11	Possess effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate the role of physics to address environmental issues.
PSO 12	Possess the knowledge of current issues and ability to engage in life-long learning.
PSO 13	Ability to conceptualize and implement project/dissertation on advance topic as part of curriculum, thereby acquiring skills and ability to work independently.
PSO 14	Acquire training on research based learning, a pre-requisite to take up research, theoretical or experimental, after obtaining M.Sc. degree.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH PSO)

Course	COs	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10	PSO 11	PSO 12	PSO 13	PSO 14
PHY-121	**CO 1**	x	x	x	x								x	x	x
	CO 2	x	x	x	x				x				x	x	x
	CO 3	x	x	x	x									x	x
	CO 4	x	x	x	x								x	x	x
	CO 5	x	x	x	x								x	x	x
PHY-122	**CO 6**	x	x	x	x								x	x	x
	CO 7	x	x	x	x								x	x	x
	CO 8	x	x	x	x								x	x	x
	CO 9														
	CO 10														

PHY-123	**CO 11**	x	x	x	X				x				x	x	x
	CO 12	x	x	x	X				x				x	x	x
	CO 13	x	x	x	X				x				x	x	x
	CO 14	x	x	x	X				x				x	x	x
	CO 15	x	x	x	X				x				x	x	x
	CO 16	x	x	x	X				x				x	x	x
	CO 17	x	x	x	X				x				x	x	x
	CO 18	x	x	x	X				x				x	x	x
	CO 19	x	x	x	X				x				x	x	x
PHY-124	**CO 20**	x	x	x	X				x				x	x	x
	CO 21	x	x	x	X				x				x	x	x
	CO 22	x	x	x	X				x				x	x	x
	CO 23	x	x	x	X				x				x	x	x
	CO 24	x	x	x	X				x				x	x	x
PHY-125	**CO 25**	x	x	x	X		x			x		x	x	x	x
	CO 26	x	x	x	X		x			x		x	x	x	x
	CO 27	x	x	x	X		x			x		x	x	x	x
PHY-126	**CO 28**									x		x			x
	CO 29									x		x			x
	CO 30									x		x			x
	CO 31									x		x			x
	CO 32									x		x			x
	CO 33									x		x			x
PHY-127	**CO 34**	x	x	x	x				x				x	x	x
	CO 35	x	x	x	x				x				x	x	x
	CO 36	x	x	x	x				x				x	x	x
	CO 37	x	x	x	x				x				x	x	x
	CO 38	x	x	x	x				x				x	x	x
PHY-221	**CO 39**	x	x	x	x				x				x	x	x
	CO 40	x	x	x	x				x				x	x	x
	CO 41	x	x	x	x				x				x	x	x
	CO 42	x	x	x	x				x				x	x	x
	CO 43	x	x	x	x				x				x	x	x
	CO 44	x	x	x	x			x	x		x		x	x	x
	CO 45	x	x	x	x			x	x		x		x	x	x
PHY-222	**CO 46**	x	x	x	x			x	x		x		x	x	x
	CO 47	x	x	x	x			x	x		x		x	x	x
	CO 48	x	x	x	x			x	x		x		x	x	x
	CO 49	x	x	x	x			x	x		x		x	x	x
	CO 50	x	x	x	x			x	x		x		x	x	x
	CO 51	x	x	x	x			x	x		x		x	x	x
	CO 52	x	x	x	x			x	x		x		x	x	x
	CO 53	x	x	x	x			x	x		x		x	x	x
	CO 54	x	x	x	x			x	x		x		x	x	x
PHY-223	**CO 55**	x	x	x	x			x	x		x		x	x	x
	CO 56	x	x	x	x			x	x		x		x	x	x
	CO 57	x	x	x	x			x	x		x		x	x	x
	CO 58	x	x	x	x			x	x		x		x	x	x
	CO 59	x	x	x	x			x	x		x		x	x	x

	CO 60	x	x	x	x			x	x		x		x	x	x
	CO 61	x	x	x	x			x	x		x		x	x	x
	CO 62	x	x	x	x			x	x		x		x	x	x
PHY-224	CO 63	x	x	x	x								x	x	x
	CO 64	x	x	x	x								x	x	x
	CO 65	x	x	x	x								x	x	x
	CO 66	x	x	x	x								x	x	x
	CO 67	x	x	x	x								x	x	x
	CO 68	x	x	x	x								x	x	x
	CO 69	x	x	x	x								x	x	x
PHY-225	CO 70	x	x	x	x		x			x		x	x	x	x
	CO 71	x	x	x	x		x			x		x	x	x	x
	CO 72	x	x	x	x		x			x		x	x	x	x
PHY-226	CO 73									x		x			x
	CO 74									x		x			x
	CO 75									x		x			x
	CO 76									x		x			x
PHY-227	CO 77	x	x	x	x	x			x		x		x	x	x
	CO 78	x	x	x	x	x			x		x		x	x	x
	CO 79	x	x	x	x	x			x		x		x	x	x
	CO 80	x	x	x	x	x			x		x		x	x	x
	CO 81	x	x	x	x	x			x		x		x	x	x
PHY-321	CO 82	x	x	x	x				x				x	x	x
	CO 83	x	x	x	x				x				x	x	x
	CO 84	x	x	x	x				x				x	x	x
	CO 85	x	x	x	x				x				x	x	x
	CO 86	x	x	x	x				x				x	x	x
PHY-322	CO 87	x	x	x	x				x				x	x	x
	CO 88	x	x	x	x				x				x	x	x
	CO 89	x	x	x	x				x				x	x	x
	CO 90	x	x	x	x				x				x	x	x
	CO 91	x	x	x	x				x				x	x	x
	CO 92	x	x	x	x				x				x	x	x
PHY-323	CO 93	x	x	x	x			x	x				x	x	x
	CO 94	x	x	x	x			x	x				x	x	x
	CO 95	x	x	x	x			x	x				x	x	x
	CO 96	x	x	x	x			x	x				x	x	x
	CO 97	x	x	x	x			x	x				x	x	x
	CO 98	x	x	x	x			x	x				x	x	x
	CO 99	x	x	x	x			x	x				x	x	x
PHY-324A	CO 100	x	x	x	x			x					x	x	x
	CO 101	x	x	x	x			x					x	x	x
	CO 102	x	x	x	x			x					x	x	x
	CO 103	x	x	x	x			x					x	x	x
	CO 104	x	x	x	x			x					x	x	x
PHY-324B	CO 105	x	x	x	x			x					x	x	x
	CO 106	x	x	x	x			x					x	x	x
	CO 107	x	x	x	x			x					x	x	x
	CO 108	x	x	x	x			x					x	x	x
	CO 109	x	x	x	x			x					x	x	x
	CO 110	x	x	x	x			x					x	x	x

PHY-324C	CO 111	x	x	x	x				x		x		x	x	x
	CO 112	x	x	x	x				x		x		x	x	x
	CO 113	x	x	x	x				x		x		x	x	x
	CO 114	x	x	x	x				x		x		x	x	x
	CO 115	x	x	x	x				x		x		x	x	x
PHY-325	CO 116	x	x	x	x	x		x		x		x	x	x	x
	CO 117	x	x	x	x	x		x		x		x	x	x	x
	CO 118	x	x	x	x	x		x		x		x	x	x	x
	CO 119	x	x	x	x	x		x		x		x	x	x	x
PHY-326	CO 120				x	x		x	x	x	x	x	x	x	x
	CO 121				x	x		x	x	x	x	x	x	x	x
	CO 122				x	x		x	x	x	x	x	x	x	x
PHY-421	CO 123	x	x	X	x				x				x	x	x
	CO 124	x	x	X	x				x				x	x	x
	CO 125	x	x	X	x				x				x	x	x
	CO 126	x	x	X	x				x				x	x	x
	CO 127	x	x	X	x				x				x	x	x
PHY-422	CO 128	x	x	X	x				x				x	x	x
	CO 129	x	x	X	x				x				x	x	x
	CO 130	x	x	X	x				x				x	x	x
	CO 131	x	x	X	x				x				x	x	x
	CO 132	x	x	X	x				x				x	x	x
	CO 133	x	x	X	x				x				x	x	x
	CO 134	x	x	X	x				x				x	x	x
PHY-423	CO 135	x	x	X	x				x				x	x	x
	CO 136	x	x	x	x				x				x	x	x
	CO 137	x	x	x	x				x				x	x	x
	CO 138	x	x	x	x				x				x	x	x
	CO 139	x	x	x	x				x				x	x	x
	CO 140	x	x	x	x				x				x	x	x
	CO 141	x	x	x	x				x				x	x	x
	CO 142	x	x	x	x				x				x	x	x
PHY-424A	CO 143	x	x	x	x			x	x		x		x	x	x
	CO 144	x	x	x	x			x	x		x		x	x	x
	CO 145	x	x	x	x			x	x		x		x	x	x
	CO 146	x	x	x	x			x	x		x		x	x	x
	CO 147	x	x	x	x			x	x		x		x	x	x
	CO 148	x	x	x	x			x	x		x		x	x	x
PHY-424B	CO 149	x	x	x	x				x				x	x	x
	CO 150	x	x	x	x				x				x	x	x
	CO 151	x	x	x	x				x				x	x	x
	CO 152	x	x	x	x				x				x	x	x
	CO 153	x	x	x	x				x				x	x	x
PHY-424C	CO 154	x	x	x	x				x				x	x	x
	CO 155	x	x	x	x				x				x	x	x
	CO 156	x	x	x	x				x				x	x	x
	CO 157	x	x	x	x				x				x	x	x
PHY-425	CO 158	x	x	x	x	x		x		x		x	x	x	x
	CO 159	x	x	x	x	x		x		x		x	x	x	x
	CO 160	x	x	x	x	x		x		x		x	x	x	x
	CO 161	x	x	x	x	x		x		x		x	x	x	x

M.Sc. PHYSICS (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE-PHY 121
Classical Mechanics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to -

1. The student will be able to apply knowledge to calculate the Calculus of variation and its application to simple problems, formulation of Lagrangian and Hamiltonian for a problem, Canonical transformation and Action angle variable.
2. The student shall acquire ability to differentiate between problems of classical and quantum nature and apply classical methods to solve the relevant problems.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 121	**Classical Mechanics (Theory)**	**The students will be able to –** **CO1:**Understand the basic concepts of coordinate systems and degrees of freedom and will be able to apply the same in various problems. **CO2:**Learn about Hamilton's and Lagrange's Equations using calculus of variation and apply them to solve problems of mechanics. **CO3**:Gain Knowledge of Conservation principles, Noether's theorem, Eulerian angles and Euler's theorem and will be able to apply these concepts to relevant problems.	**Approach in teaching:** Interactive Lectures, Discussion, problem solving in Tutorials, Demonstration **Learning activities for the students:** Self learning assignments, Effective questions, Simulation, Seminar presentation, Solving numerical.	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		CO4: Understand Canonical transformation and Lagrange's and Poisson’s brackets and be able to analyze their relations. **CO5:**Learn about the Action angle variables and their applications		

CONTENTS

Unit I **12 Hrs.**

Basic concepts of coordinate systems and degrees of freedom; Holonomic and non-holonomic constraints; D-Alembert's Principle; Generalized coordinates; Principle of virtual work;Lagrangian, Lagrange's equation and its applications; Velocity dependent potential in Lagrangian formulation; Generalized momentum; Hamilton's Principle; Lagrange’s equation from Hamilton's Principle.

Unit II **12 Hrs.**

Calculus of variation and its application to simple problems: Hamilton's Equations; Applications of Hamilton’s equation; Hamilton’s canonical equation in different coordinate systems; Calculus of Variation and Euler-Lagrange’s equations; Brachistochrone Problem; Derivation of Lagrange's and Hamilton’s canonical equation from Hamilton’s variational principle; Method of Lagrange's undetermined multipliers; Principle of least action.

Unit III **11 Hrs.**

Conservation principle and Noether's theorem; Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space respectively.

Eulerian angles; Euler’s theorem; Angular momentum and Inertia Tensor; Euler’s equations; Euler’s equation of motion for a rigid body.Levels of biological diversity: genetic, species and ecosystem diversity

UnitIV **13 Hrs.**

Canonical transformation: Legendre transformations; Generating functions; Conditions for Canonical transformation; Bilinear invariant conditions; Lagrange's and Poisson’s brackets and their relations; Angular momentum and Poisson Brackets; equation of motion in Poisson bracket formulation; Invariance of Poisson’s and Lagrange’s Brackets under canonical transformations; Liouville's theorem.

Unit V **12 Hrs.**

Action angle variable: Hamilton Jacobi equation and its applications; adiabatic invariance of action variable**;** The Kepler problem in action angle variables; theory of small oscillations in Lagrangian formulation; theory of small oscillations in normal coordinates and normal modes; Two coupled oscillator and solution of its differential equation; Two coupled pendulum; Double pendulum.

BOOKS RECOMMENDED

- "Classical Mechanics", Goldstein, Addison Wesley.
- "Mechanics-VolumeI",Landau.AndLifshiz.
- "ClassicalMechanics",A.Raychoudhary.
- "Classical Mechanics" N.C. Rana and P.S. Joag, Tata Mc Graw Hill
- "Classical Mechanics" J.C. Upadhyaya, Himalaya Publishing House.

PAPER CODE-PHY 122
Mathematical Methods in Physics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to

1. The main objective of this course is to impart knowledge about various mathematical tools emPSOyed to study physics problems.
2. This course will familiarize students with a range of mathematical methods. They will study different types of tensors and their algebra, Christoffel's symbol, Equation of Geodesic and application of tensors to various problems of Physics, Fourier and Laplace transforms.
3. The student will learn significance of point groups and space groups and their relevance in the study of condensed matter Physics, in particular Crystal Physics.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 122	**Mathematical Methods in Physics** **(Theory)**	**The students will be able to –** **CO6:**Further extend the knowledge of tensors acquired at Graduation level, through learning of their symmetric and antisymmetric nature, contravariant, covariant and mixed tensors and their transformation	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Reading assignments, Demonstration.	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		properties , physical examples of tensors such as stress tensor, strain tensor etc. **CO7:** Learn the equation of Geodesic and use it to derive Ricci's theorem. **CO8:**Understand elementary group theory, i.e., definition and properties of groups, subgroups, Homomorphism, isomorphism, normal and conjugate groups, representation of groups, Reducible and Irreducible groups. Crystallographic point groups, reciprocal lattice etc. and to use it to various situations in physical systems. **CO9:** Evaluate the Fourier transform, the inverse Fourier transform and their applications in physical problems. **CO10:**Solve various differential equations using Laplace and inverse Laplace transforms.	**Learning activities for the students:** Learning activities for the students:Self learning assignments, Effective questions, Simulation, Seminar presentation, Solving numerical, problems	

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Unit I **12 Hrs.**

Coordinate transformation in N-dimensional space: Contravariant and covariant tensor, Jacobian, pseudo tensors , Algebra of tensors, Metric tensors, Associated tensors, Christoffel symbols, transformation of Christoffel symbols.

Unit II **11 Hrs.**

Equation of Geodesic, Covariant differentiation, Ricci's theorem, Divergence, Curl and Laplacian in tensor form, Stress and Strain tensors, Hooke's law in tensor form, Lorentz Covariance of Maxwell equation

Unit III **13 Hrs.**

Group of transformations, (Example: symmetry transformations of a square), Generators of a finite group, Normal subgroup, Direct product of groups, Isomorphism and Homomorphism, Representation theory of finite groups, Invariant subspace and reducible representations, irreducible representations, Crystallo-graphic point groups, Irreducible representation of C_{4v}, Translation group and the reciprocal lattice.

Unit IV **12 Hrs.**

Development of the Fourier integral from the Fourier series, Fourier and inverse Fourier transform, Fourier transform of Derivatives, Solution of wave equation as an application, Convolution theorem, intensity in terms of spectral density for quasi-monochromatic EM waves, momentum representation, Application of Fourier Transform to Diffraction Theory, Diffraction pattern of single and double slits.

Unit V **12 Hrs.**

Laplace transforms and their properties, Laplace transform of derivatives and integrals of Laplace transform, Laplace convolution theorem, Impulsive function , Application of Laplace transform in solving linear differential equations with constant coefficient, with variable coefficient and linear partial differential equation.

BOOKS RECOMMENDED:

- "Mathematical physics", Satya Prakash, Pragati Prakashan.
- "Mathematical Methods for Physicists", George Arkfen ,Academic Press.
- "Applied Mathematics for Engineers and Physicists", L. A. Pipe and L.R. Harvill, McGraw Hill
- "Mathematical Methods", Potter and Goldberg ,Prentice Hall of India.
- "Elements of Group Theory for Physicists: A. W. Joshi (Wiley Eastern Ltd.)
- "Vector Analysis", Schuam Series, Mc Graw Hill.

PAPER CODE-PHY 123
Quantum Mechanics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to

1. To provide an understanding of the formalism and language of quantum mechanics.
2. To learn perturbation method to find out energy eigen states and wave functions for a system.
3. To understand the concepts of transition between stationary states, symmetries and angular momentum.
4. To apply quantum mechanical procedures for solving different types of problems.
5. To understand C.G. coefficients and time reversal symmetry.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 123	**Quantum Mechanics (Theory)**	**The students will be able to –** **CO11:**Develop knowledge of quantum theory formulation through Schrodinger equation and Heisenberg's matrix mechanics after an exposition of inadequacies of classical mechanics in explaining microscopic phenomena. **CO12:**Learn bra and ket formalism due to Dirac and apply the same to various problems. **CO13:** Diagonalize the matrix and find energy eigen values in simple cases. **CO14:** Interpret wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena. **CO15:** Develop a knowledge and understanding of perturbation theory, level splitting, and radiative transitions. **CO16:** Learn about time dependent perturbations and significance of Fermi golden role **CO17:** Develop a knowledge and understanding of the relation between conservation laws and symmetries. **CO18:**Learn about angular momentum operators and C.G. Coefficients. **CO19:** Analyze quantum many body problems.	**Approach in teaching:** Interactive Lectures, Discussion, Solving problems in tutorials, Demonstration. Power point Presentation **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation. Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

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Unit I **12 Hrs.**

I(a) **States, Amplitude and Operators:** Hermitian operators and their properties,Unitary operators, Dirac's Bra and Ket notation: Normalization and orthogonality conditions; Orthonormality; Eigen states and eigen values of an operator; Degeneracy.

States of a quantum mechanical system, Representation of quantum-mechanical states, Properties of quantum mechanical amplitudes, Operators and change of state, a complete set of basis states, product of linear operators.

I (b) **Observables and Description of Quantum Systems:**.
Process of measurement; Expectation values; Time dependence of quantum mechanical amplitudes; Observables with no classical analogue: spin; Dependence of quantum mechanical amplitude on position: the wave functions; Super position of amplitudes: interference.

Unit II **12 Hrs.**

II (a) **Stationary States of a Quantum System:** Hamiltonian matrix and the time evolution of Quantum mechanical States; Hermiticity of the Hamiltonian matrix; Time independent perturbation of an arbitrary system; Harmonic Oscillator and simple matrix examples of time independent perturbation;

II(b) **Two State Systems**: Energy eigen states of a two state system; Diagonalizing the energy matrix, Time independent perturbation of a two state system, the perturbation solution: weak field and strong field cases; General description of a two state system: Pauli matrices; Ammonia molecule as an example of two state system.

Unit III **12 Hrs.**

III(a) **Transition between Stationary States:** Transitions in a two state system; Time dependent perturbations: The Golden Rule; Phase space, Emission and absorption of radiation; Induced dipole transition and spontaneous emission of radiation energy; Energy width of quasi stationary states.

III(b) **The co-ordinate Representation:** Compatible observables; Quantum conditions and uncertainty relation; Coordinate representation of operators: position, momentum and angular momentum; Time dependence of expectation values.

Unit IV **10 Hrs.**

IV (a) **Symmetries**: Compatible observables and constants of motion; Symmetry transformation and conservation laws; Invariance of the Hamiltonian; Invariance under space and time translations and space rotation and conservation of momentum, energy and angular momentum. Space inversion, Time Reversal.

IV(b) Angular momentum; Components of angular momentum operator in Cartesian and spherical polar coordinates, Commutation relations.

Unit V **14 Hrs.**

V(a) **Angular momentum :** Angular momentum operators and their eigen values; Matrix representation of the angular momentum operators and their eigen states; Coordinate representation of the orbital angular momentum operators and their eigen states (Spherical Harmonics).

V(b) Composition of angular momenta; Clebsch-Gordon Coefficients; Recursion relations; Construction procedure; C.G. Coefficients for simple cases ($j_1 = ½$, $j_2 = ½$; $j_1=1$, $j_2 = ½$; $j_1=1$, $j_2=1$), Irreducible spherical tensor operators, Wigner-Eckart theorem.

BOOKS RECOMMENDED

- "Quantum Mechanics - A modern approach ", Ashok Das and A.C. Melissinos ,Gordon and Breach Science Publishers (1990)
- "Quantum Mechanics" L.I. Schiff, Mc Graw Hill Book company (1968)
- "Perspective of Quantum Mechanics" S.P. Kuila, New Central Book Agency(P) Ltd. London (2011)
- "Quantum Mechanics - Theory and Applications", A. Ghatak and S. Lokanathan, V Edition, Mc Millan, India Ltd. (2010)
- "The principles of Quantum Mechanics", P.A.M. Dirac, IV Edition, Ox Ford University Press (2008)
- "Quantum Mechanics", E. Merzbecher, Third Edition, Wiley India (2012)
- "Quantum Mechanics - Relativistic theory ",L.P. Landau and E.M. Lifshitz ,Pergamon Press.
- "Modern Quantum Mechanics", J. J. Sakurai , Pearson (1994)
- "A text book of Quantum Mechanics" P.M. Mathews & K. Venkatesan, Tata Mc Graw Hill, New Delhi IV Edition (2012)
- "Quantum Mechanics", John L. Powell & B.Crasemann, Addison Wesley (1963)

PAPER CODE-PHY 124
Electronics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students able to design electronic circuits and analyze the output.
2. To analyze logic processes and implement logical operations using combinational logic circuits.
3. To make students understand concepts of sequential circuits and to analyze them.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			

PHY124	**Electronics (Theory)**	**The students will be able to –** **CO20:** Have a understanding of the concepts of Op-amps and its applications. **CO21:** Understandworking of oscillators and Multi-vibrators and their types used in circuits. **CO22:** Understand Boolean algebra, K-mapping and analyze and design various combinational circuits like multiplexer, de-multi-plexer, encoder, decoder. **CO23:** Have knowledge ,analyze and design various Sequential circuits like flip-flops, registers, counters, and converters. **CO24:** Develop skills to build digital circuits. Have a thorough understanding of the concepts of integrated circuits, and fabrication techniques used in IC's.	**Approach in teaching:** Interactive Lectures, Discussion, problem solving in tutorials, Demonstration. **Learning activities for the students:** Self learning assignments, Effective questions, Simulation, Seminar presentation, Solving numerical.Additional learning through online videos and MOOC corses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: 13 Hrs.

Operational Amplifiers: Differential amplifier, CMRR, ideal operational amplifier, Block diagram of typical OP-Amplifier, Open loop configuration : inverting and non-inverting amplifiers, Op-Amp with negative feedback, Practical Op-Amp parameters : input offset voltage, input bias current , input offset current, output offset voltage, Frequency response and stability, Applications of operational amplifier: adder, subtractor, voltage follower, integrator ,differentiator.

Unit II: 12 Hrs.

Oscillators : Oscillator Principle , Oscillator types, Hartley oscillator, Colpitt oscillator, Phase shift oscillator, Wein bridge oscillator, Crystal Oscillator

Multivibrators: Monostable and Astable multivibrators, Bistable multivibrators, Square wave and triangle wave generation.

Unit III: 11 Hrs.

Digital Electronics: Combinational logic: Transistor as a switch, circuit realization of OR, AND, OR, NOR, NAND gates, Exclusive OR gate, Boolean algebra , De-Morgan

Theorems, Simplification using Karnaugh map, Adder, subtractor, comparator, encoder, decoder, demultiplexer , data selector, multiplexer.

Unit IV: **12 Hrs.**

Sequential Logic: Flip-Flops, one - bit memory, RS flip-flop, J K flip flop, JK master slave flip-flop, T flip-flop, D flip-flop, shift registers , synchronous and asynchronous counters, Binary counter, Decade counter**,** Analog to Digital converter, Digital to Analog Converter

Unit V: **12 Hrs.**

Introduction of IC and its fabrication techniques : Introduction of IC, classification of ICs, features of ICs. Fabrication techniques: Diffusion, Oxidation, Ion Implantation, Chemical vapour Deposition and Epitaxy. IC technology : NMOS, CMOS, Bipolar.

BOOKS RECOMMENDED

- "Electronic Devices and Circuit Theory" ,Robert Boylested and Louis Nashelsky, PHI, New Delhi - 110001, 1991.
- "OP-AMP and Linear Integrated Circuits" Ramakanth, A. Gayakwad, PHI, Second Edition 1991.
- " A Handbook of Electronics" Gupta and Kumar, Pragati Prakashan
- "Digital Principle and Applications" A.P. Malvino and Donald P. Leach, Tata McGraw Hill Company, New Delhi, 1993.
- "Microprocessors Architecture, Programming and Applications with 8085/8086" by Ramesh S Gaonkar, Wiley - Eastern Ltd., 1987.

PAPER CODE-PHY 125
Practical
(Practical)

Credits: 8
Maximum marks: 100
Contact Hrs/Week: 16
Total Hrs: 240

Course Objectives:

This course will enable the students to –

1. To enable students to do experiments on the fundamental laws and principles, and gain experience of using a variety of measuring instruments.
2. To enhance basic learning skills of the students.
3. To give students opportunity of learning by doing and develop a correlation between theory and practical.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>PAPER CODE</th><th>Paper Title</th></tr>
<tr><td>PHY 125</td><td>Physics Practical (Practical)</td><td>The students will be able to –

CO25:To study about of solid state power supply, simple rectifier circuit, different filter circuits, regulator circuit, two stage transistor amplifier and effect of feedback to determine experimental values.

CO26: Knowledge to design & study of transistor/ operational amplifier on a bread board for Hartley oscillator, Colpitt oscillator, Wein bridge oscillator, Phase shift oscillator and to analyze the output waveforms in each case.

CO27: Learn about the Experiments like Fresnel's biprism, Michelson interferometer, Multiplexer-Demultiplexer, Flip-Flop, Operational-Amplifier, 8 bit analog to digital converter to determine experimental values.</td><td>Approach in teaching:
Demonstration, Group activity, Discussion ,Conduction of Experiments

Learning activities for the students:
Performing Experiments, Analysis and interpretation of observations,</td><td>Class test, Semester end examinations, Viva voce, Practical record file</td></tr>
</table>

CONTENTS
The students will be required to perform 8 experiments in each semester from the following list of experiments

1. Study of solid state power supply.
   a. Study of simple rectifier circuit configuration.
   b. Study the different filter circuits and find the ripple factor in each case.
   c. Study of regulator circuit and find the percentage regulation in the two cases-
      i. with load variation.
      ii. with input ac variation.
2. Fresnel's biprism.
   a. To determine the wavelength of sodium light with the help of fresnel's biprism.
   b. To determine the thickness of mica sheet.
3. Michelson interferometer.
   a. To determine the wavelength of monochromatic sodium light.
   b. To determine the difference in wavelength between sodium D lines.

4. Study of two stage transistor amplifier and effect of feedback.

a. Frequency response of a transistorised RC coupled amplifier with no feedback.

b. Frequency response of the amplifier with negative feedback.

c. Frequency response of the amplifier with positive feedback.

5. Multiplexer-Demultiplexer.

a. To verify the operation of 16 line to 1 line multiplexer.

b. To study the operation of a digital demultiplexer.

6. Flip-Flop.

To study and verify the following-

a. S-R flip-flop

b. Type 'D' flip-flop

c. J-K flip-flop

d. Master slave J-K flip-flop

7. Operational-Amplifier.

To study the following mathematical operations-

a Adder

b. Subtractor

c. Integrator (for ac i/p and dc i/p signal)

d. Differentiator

.

8. 8 bit analog to digital converter.

a. To study the basic principle of conversion of analog to digital binary signal using comparator (LTB-812).

b. To study the conversion of analog signal to 8 bit digital signal using IC ADC 0800 based on SAR (LTB-833).

9. To verify Fresnel's formula for the reflection of light.

10. To design & study any one of the following using transistor/ operational amplifier on a bread board:

i) Hartley oscillator

ii) Colpitt oscillator

iii) Wein bridge oscillator

iv) Phase shift oscillator

PAPER CODE-PHY 126
Communication Skills
(Seminar)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

The objective of this paper is to develop the following six skills areas:

1) Written Communication

2) Oral Communication

3) Critical Thinking

4) Quantitative Analysis

5) Research

6) Information and Computer Literacy

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
PHY 126	**Communication Skills (Seminar)**	**The students will be able to:** **CO28 :**Students will be able to understand and apply knowledge of communication and language processes to technologically mediated communication. **CO29:** Students will be able to understand and evaluate key theoretical approaches used in the interdisciplinary field of communication. i.e., students will be able to explain major theoretical frameworks, constructs, and concepts for the study of communication and language, and begin to evaluate the strengths and weaknesses of their approaches. **CO30:** Students will be able to understand the research methods	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials,, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation.	**Assessment Strategies** Class test, Semester end examinations, Power point Presentation, Report , Viva Voce

		associated with the study of communication. **CO31:** Students will be able to find, use, and evaluate Scientific report writing. **CO32:** Students will develop soft skills and will be able to face an interview confidently. **CO33:**Students will be able to communicate effectively orally and in writing.		

CONTENTS

Unit I: **6 Hrs.**

Grammar

Conditionals/Tenses, Relative Clauses, Subject – Verb Agreement, Passive Voice

Unit II:

6 Hrs.

Written Communication

Discuss a topic of general interest, but related to science in about 300 words. (Analyse, Comment, Argue, Reflect, Persuade, etc.)

(can also be used for oral presentations by the students, followed by discussion)

Unit III **5 Hrs.**

Scientific Writing

Writing a Scientific Report on a project undertaken or an experiment conducted (Theory + Practice)

Unit IV: **3 Hrs.**

Oral Communication I

a) Consulting a dictionary for correct pronunciation (familiarity with Phonetics Symbols and Stress-marks only)

b) Dialogue

Unit V **10 Hrs.**

Soft Skills

1. **Gestures/ postures** – Body language, gesture, posture.

2. **Group discussion** – Giving up of PREP, REP Technique, how body language during group discussion.

3. **Presentation Skills**

a) How to make power point presentation

b) Body language during presentation

4. **Resume writing**

a) Cover letter, career objective

b) Resume writing (tailor made)

5. **Mock Interview**

Each student to face an interview and to demonstrate the above taught skills.

6. **Positive Attitude**

Positive skills enhancement with power point presentation.

BOOKS RECOMMENDED

- Advanced English Usage; Quirk & Greenbaum; Pearson Education.
- Developing Communication Skills; Banerjee Meera & Mohan Krishna; Macmillan Publications, 1990.
- Business Communication; Chaturvedi, P.D.; Pearson Publications.
- Business Communication; Mathew, M.J.; RBSA Publications, 2005.
- Communication of Business; Taylor, Shirley; Pearson Publications.
- Soft Skills : ICFAI Publication
- Dictionary Oxford

PAPER CODE-PHY 127
Astrophysics
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. To show how basic phyical principles can be applied to understand a variety of astrophysical objects and phenomena.
2. To study the physics of Celestial sphere, Basic stellar parameters, Optical telescopes, Sun, Solar system & Milkyway.
3. To enable the students to take up independently studies of astronomy and work further in Astro-physics.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 127	**Astrophysics (Theory)**	**The students will be able to:** **CO34:** Ability to comprehend astronomical scales and understand basic concepts of positional astronomy, like astronomical coordinate system and measurement of distances, time and temperature and radius of star. **CO35:** Understand basic parameters of stars like brightness, radiant flux, luminosity, magnitude, orbits, spectral classification. H-R diagram **CO36:** Understand astronomical techniques, various types of optical telescopes and telescope mountings. Various types of detectors and their use with telescopes. **CO37:** Understanding Physics of sun and solar system: photosphere, chromosphere, corona, solar activity. Solar MHD, helioseismology, solar system and its origin. **CO38:** Acquire basic knowledge of galaxies and Milky Way. Morphology and classification of galaxies, intrinsic stages of galaxies, galactic halo, milky way, gas and dust in galaxy, spiral arm, rotation of galaxy and dark matter. Star clusters in Milky Way, galactic nucleus and its properties.	**Approach in teaching:** Interactive Lectures, Discussion, Solving problems in tutorials, Demonstration **Learning activities for the students:** Self learning assignments, Effective questions, Simulation, Seminar presentation.Additional learning through online videos	**Assessment Strategies** Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: 5 Hrs.

Celestial sphere, spherical geometry – spherical triangles, astronomical cordinate systems, coordinate conversions, Measurement of time, sidereal time, mean solar time, equation of time, calendars (lunar, Julian, solar).

Unit II: 7 Hrs.

Basic stellar parameters, stellar magnitude scale (apparent, absolute), distance modulus, stellar distance determination using parallax method, determination of temeperature and radius of a star, determination of stellar masses from binary orbits, stellar spectral classification, effective temperature, H-R diagram.

Unit III: **6 Hrs.**

Optical telescopes – different types, mountings, detectors and their use (astrometry, photometry, spectroscopy), magnification and light gathering power, resolving power and diffraction limit, limiting magnitude, atmospheric windows.

Unit IV: **7 Hrs.**

The Sun: photosphere, chromosphere, corona, prominences, sunspots, sunspot cycle, solar flares, solar wind, solar terrestrial relations (space weather), energy transport from the core to surface, basic stellar structure (hydrostatic equilibrium, equation of state), basics of solar magneto-hydro dynamics, helio-seismology.

Unit V: **5 Hrs.**

Solar system: planets, satellites, asteroids & comets, Titus-Bode law. Extra-solar planets. Are we alone ?
Milkyway: size & shape of our galaxy, star count analysis, star clusters (open, globular), Shapley's model, structure, nature of rotation, missing mass problem.

BOOKS RECOMMENDED:

- Astronomy: Principles and practice, AE Roy and D Clarke
- Astrophysics for Physicists, Arnab Rai Choudhary
- An introduction to Astrophysics, Baidyanath Basu

M.Sc. PHYSICS (2020-2021)

COURSE OUTCOMES - Semester II

PAPER CODE-PHY 221
Classical Electrodynamics- I
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To evaluate fields and forces in Electrodynamics and Magneto dynamics using basic scientific method.
2. To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.
3. To make students able to apply knowledge acquired through this paper to various types of problems of electromagnetics.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 221	**Classical Electrodynamics-I(Theory)**	**The students will be able to –** **CO39:** Basic knowledge of charge, electric field, potential and potential energy, boundary value problems in electrostatics, method of images **CO40:** Define orthonormal functions, Fourier series and Fourier integration **CO41:** Develop a knowledge and understanding of magneto statics, electromagnets, solenoid and toroid **CO42:** Develop a firm basis to understand multipoles, dipole moment, polarization, boundary value problems with dielectrics **CO43:** Develop a knowledge and understanding of electromagnetic fields, maxwell's equations, conservations laws, scalar and vector potentials	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Power point presentation, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals,Additional learning through online videos and MOOC course.	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I: **11 Hrs.**

Electrostatics: Electric field; Gauss Law; Differential form of Gauss' law; Equation of electrostatics and the scalar potential; surface distribution of charges and dipoles and discontinuities in the electric field and potential; Poisson and Laplace equations; Uniqueness Theorem; Green's Reciprocity Theorem; Formal solutions of potential by Green's function; Electrostatic potential energy and energy density.

Unit II: **13 Hrs.**

Boundary Value Problems in Electrostatics: Methods of Images; A point charge near an infinite conducting plane; Point charge in the presence of a conducting sphere: Case (a) When the conducting sphere is grounded; Case (b) When the conducting sphere is insulated; Case (c) When the conducting sphere is charged and insulated; Conducting sphere in a uniform electric field by method of images; Green function for the grounded conducting sphere in the field of a charge q; Green function for the sphere: General solution for the potential; Conducting sphere with hemispheres at different potentials; Orthogonal functions: Expansion of arbitrary functions in terms of a complete set of functions; Examples of systems of orthonormal functions: Fourier series, Fourier Integrals.

Unit III: **12 Hrs.**

Multipoles, Electrostatics of Macroscopic Media, Dielectrics: Spherical Harmonics; Multipole expansions; Monopole moment; Dipole moment; Quadruple moment; Multipole expansions in Cartesian coordinates; multipole expansion of the energy of a charge distribution in an external field; Elementary treatment of electrostatics with permeable media; Boundary value problems with dielectrics; Molecular polarizability and electric susceptibility; A molecular model of the polarizability; Models for molecular polarizability: Displacement polarization, Orientation Polarization; Electrostatic energy in dielectric media.

Unit IV: 12 Hrs.

Magnetostatics: Introduction and definition; Biot-Savart Law; the differential equation of Magnetostatics and Ampere's law; Vector potential and magnetic induction for a circular current loop; magnetic fields of a localized current distribution, magnetic moment; force and torque on and energy of a localized current distribution in an external magnetic induction; macroscopic equations, boundary conditions on **B** and **H**; methods of solving Boundary value Problems in Magnetostatics; uniformly magnetized sphere; magnetized sphere in an external field, permanent magnets; magnetic shielding, spherical shell of permeable material in a uniform field.

Unit V: 12 Hrs.

Maxwell's equations ,conservation laws: energy in a magnetic field, vector and scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Green function for the wave equation, derivation of the equations of macroscopic electromagnetism, Poynting's theorem and conservation of energy and momentum for a system of charged particles and EM fields, conservation laws for macroscopic media, electromagnetic field tensor, transformation of four potentials and four currents, tensor description of Maxwell's equations

BOOKS RECOMMENDED:

- "Classical Electrodynamics", J.D. Jackson
- "Classical electrodynamics and magnetism ",Panofsky & Phillip
- "Introduction to Electrodynamics ",Griffith
- "Classical Theory of Fields" ,Landau & Lifshitz
- " Electrodynamics of continuous media "Landau & Lifshitz,
- "Classical Electrodynamics", Walter Grenier

PAPER CODE-PHY 222
Programming With C++ and Applications of Matlab
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To impart the basic knowledge of computers and C++ Programming
2. To make the students learn essential aspects of a programming language, numerical techniques and their applications in a variety of Physics problems

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>PAPER CODE</th><th>Paper Title</th></tr>
<tr><td>PHY 222</td><td>Programming With C++ and Applications of Matlab (Theory)</td><td>The students will be able to –
CO44: To gain Knowledge about the difference between the top-down and bottom-up approach.
CO45: Describe the object-oriented programming approach in connection with C++.
CO46: Apply the concepts of object-oriented programming.
CO47: Choose appropriate data structures to represent data items in real world problems.
CO48: Analyze the time and space complexities of algorithms
CO49: Design programs using a variety of data structures such as stacks and queues.
CO50: Analyze and implement various kinds of searching and sorting techniques.
CO51: To learn Curve fitting using Matlab and spline function.
CO52: Learn about various interpolating and extrapolating methods.
CO53: Find numerical solutions of system of linear equations and check the accuracy of the solutions using Matlab.
CO54: The student will learn C++ language and MATLAB to the extent, she can apply these techniques to problem solving in Physics, pertaining to P.G. Programme and research.</td><td>Approach in teaching: Additional learning through online videos
Learning activities for the students: Practical assignments, Simulation,</td><td>Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations</td></tr>
</table>

CONTENTS

Unit I: **12 Hrs.**

Introduction to OO Paradigm, Structured Versus object oriented programming, Objects and Class, features of object oriented language (encapsulation, data abstraction ,inheritance, Object composition, Polymorphism)Merits & demerits of OO methodology, Hello World Program and C++ program structure. Data Types, Operators: Tokens ,identifiers and keywords, data types and size, Variables , Variable definition and initialization, constants, Operators (Arithmetic, Relational ,logical , Compound assignment, Increment ,decrement and conditional operator), operator precedence and associativity, Integer overflow and underflow, simple programs, Conditional Statements and Integer Types, Enumeration types.

Unit II : 12 Hrs.

Expression and Precedence : Arithmetic, Relational, logical Expression, Operator Precedence and associatively, promotion and type casting, Different types of comments Control Flow: Statement and blocks, if statement, if–else statement, Nested if–else statement, Switch statement, Break, continue statement, While, for and do-while loops, Scope and Visibility control Modifier. Arrays and Functions: Arrays, operations on Arrays, Multi-Dimensional Arrays, Strings, Strings manipulations and Arrays of strings, Function declaration & definitions, local variables & functions, void functions, Parameter passing, Return by reference, inline functions, overloading , Arrays and functions. main ( ), exist ( ) functions, Array declaration and initializing, processing Arrays, passing an Array to a function, the Linear search and Bubble sort algorithm, binary search algorithm, using arrays with enumeration types, Multidimensional Arrays, Library functions.

Unit III: 11 Hrs.

Pointers & References: Pointers declaration, pointer operator, address operator, pointer arithmetic's References, Derived types, Arrays & pointers, the new operator, the delete operator, dynamic arrays, Arrays of pointers and pointers to Arrays, Pointers to Pointers. Pointers functions, call by value, call by References. Classes and Objects: Introduction, class declaration, Class Objects, Accessing Class Members, Constructors, constructor initialization, Private member function, class constructor, parameterized constructors, constructor overloading, copy constructor, Order of Constructor and destructor, Static data members.Pointers to object.Stream I/O:-Stream classes, the ios class, ios format flags, ios state variables, the istream & ostream classes, unformatted input functions.

Unit IV: 12 Hrs.

Curve fitting using MATLAB: Least square line, Methods of curve fitting, Interpolation by Spline functions, Fourier series and trigonometric polynomials, Bezier curve

Unit V: 12 Hrs.

Numerical Integration using MATLAB: Introduction to Quadrature, Composite trapezoidal and Simpson's Rule, Recursive rules, Adaptive Quadrature, Gauss-Legendre Integration

BOOKS RECOMMENDED:

- A.R.Venugopal, Rajkumar, T. Ravishanker, "Mastering C++", TMH, 2012(Reprint)
- Yashwant Kanetkar , "Let us C++", BPB Publications
- R. Lafore, "Object Oriented Programming using C++", Galgotia Publications, 2004.
- D . Parasons, "Object Oriented Programming with C++", BPB Publication.
- Schildt Herbert, "C++: The Complete Reference", 4th Ed., Tata McGraw Hill, 1999.

- S. B. Lippman & J. Lajoie, "C++ Primer", 3rd Edition, Addison Wesley, 2000.
- "Numerical Methods using MATLAB.", John H. Mathews and Kurtis D. Fink, PHI

PAPER CODE-PHY 223
Atomic and Molecular Physics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To develop an understanding of the atomic and molecular structure.
2. To develop an understanding of the interaction of atomic and molecular systems with external homogeneous static electric and magnetic fields .
3. To enable the students to apply the knowledge acquired from study of this paper to analyze atomic and molecular spectra or to solve problems related to Atomic and Molecular Physics, Molecular Spectra of diatomic molecules, Vibrational and Rotational energy levels and Raman spectra.

Course outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 223	**Atomic and Molecular Physics (Theory)**	**The students will be able to –** **CO55:** Explain the hydrogen fine and hyperfine spectrum **CO56:** Describe Lamb shift **CO57:** Apply the perturbation theory to non –degenerate systems **CO58:** Distinguish Zeeman effect and Stark effect. **CO59:** Understand the system with identical particles and derive Pauli's Exclusion Principle. **CO60:** Apply WKB method for 1-D problems and understand Heitler-London Method. **CO61:** Discuss the general features of various spectra like: Alkali, alkaline earth, Raman, IR Electronic etc. **CO62:** Explain Franck and Condon Principle.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical.Additional learning through online videos	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: **12 Hrs.**

Hydrogen Atom : Gross structure energy spectrum, probability distribution of radial and angular (l=1,2) wave functions (no derivation), effect of spin, relativistic correction to energy levels and fine structure, magnetic dipole interaction and hyperfine structure, the Lamb shift (only qualitative description).

Unit II : **14 Hrs.**

Interaction with External Fields : Non degenerate first order stationary perturbation method, perturbed harmonic oscillator, Zeeman effect(Normal, Anomalous) and calculation of interaction energy, degenerate stationary perturbation theory, atom in a weak uniform external electric field and first and second order Stark effect, Linear Stark effect for H-atom levels

Unit III: **10 Hrs.**

Systems with Identical Particles: Indistinguishability and exchange symmetry, many particle wave functions and Pauli's exclusion principle, spectroscopic terms for atoms.

The Helium atom,Variational method and its use in the calculation of ground state and excited state energy.

Unit IV: **11 Hrs.**

The Hydrogen molecule: Hitler-London method for H_2 molecule, WKB method for one dimensional problem, application to bound states (Bohr Sommerfield quantization) and the barrier penetration (alpha decay problems).

Unit V: **13 Hrs.**

Spectroscopy (Qualitative) : General features of the spectra of one and two electron systems, singlet, doublet and triplet characters of emission spectra, general features of alkali spectra, Raman spectra for rotational and vibrational transitions, comparison with infra red spectra, general features of electronic spectra, Frank and Condon's principle.

BOOKS RECOMMENDED:

- "Elementary Atomic Structure", G.K. Woodgate, Second Edition Clarendon Press, Oxford.
- "Atomic and Molecular Physics", T.A. Littlefield.
- "Quantum Physics of Atoms, Molecules, Solids and Nuclear Particles", Eistaberg and Rasmic.
- "Quantum Mechanics : A Modem Approach", Ashok Das and A.C. Melfessions, Gordon and Breach Science Publishers.
- "Atomic Spectra", White.
- "Molecular spectra", Herzberg.

PAPER CODE-PHY 224
Statistical and Solid State Physics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To provide knowledge of Partition functions, Statistics, Band Theory of solids to solve to various types of applications and problems
2. To make students able to apply knowledge acquired from this paper to realistic problems of Condensed Matter and Solid State Physics.

Course outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>PAPER CODE</th><th>Paper Title</th></tr>
<tr><td>PHY 224</td><td>Statistical and Solid State Physics (Theory)</td><td>The students will be able to –
CO63: Have a brief idea about basic principles and applications of Canonical and Grand Canonical ensembles.

CO64: Have a knowledge of Partition functions, Statistics, partition function for an ideal gas and calculation of thermodynamic quantities, partition function and Specific heat of an ideal diatomic gas.

CO65: Understand the difficulties with Maxwell-Boltzmann statistics.

CO66: Discuss quantum distribution functions like Bose Einstein and Fermi-Dirac statistics and apply them to derive Planck's formula, Bose Einstein condensation.

CO67: Know about quantization of harmonic oscillator and Fermion operators, creation and annihilation of phonon operators.

CO68: Understand the basic idea about Theory of Metals, use of Fermi-Dirac statistics in the calculation of thermal conductivity and electrical conductivity, Drude theory of light, absorption in metals.</td><td>Approach in teaching:
Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials

Learning activities for the students:
Self learning assignments, Effective questions, Seminar presentation, Solving numericals.Additional learning through online videos and MOOC courses.</td><td>Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations</td></tr>
</table>

		CO69: Have basic knowledge of band theory ,Bloch theorem, K.P. model, NFE model, tight binding method ,application to simple cubic lattice and pseudo-potential method.		

CONTENTS

Unit I: **13 Hrs.**

Basic Principles, Canonical and Grand Canonical ensembles : Concept of statistical distribution, phase space, density of states ,Liouville's theorem, systems and ensemble, entropy in statistical mechanics, Connection between thermodynamic and statistical quantities, micro canonical ensemble, equation of state, specific heat and entropy of a perfect gas using microcanonical ensemble.

Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of mean value, energy fluctuation in a gas, grand canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuations.

Unit II : **11 Hrs.**

Partition functions and Statistics : Partition functions and properties, partition function for an ideal gas and calculation of thermodynamic quantities, Gibbs Paradox, validity of classical approximation, determination of translational, rotational and vibration contributions to the partition function of an ideal diatomic gas. Specific heat of a diatomic gas, ortho and para hydrogen.

Unit III: **13 Hrs.**

Identical particles and symmetry requirement, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Bose Einstein and Fermi-Dirac statistics and Planck's formula, Bose Einstein condensation, liquid He4 as a Boson system, quantization of harmonic oscillator and creation and annihilation of phonon operators, quantization of fermion operators.

Unit IV: **11 Hrs.**

Theory of Metals : Fermi-Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi-Dirac statistics in the calculation of thermal conductivity and electrical conductivity, Drude theory of light, absorption in metals.

Unit V: **12 Hrs.**

Band Theory: Bloch theorem, Kroning Penny model, effective mass of electrons, Wigner-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

BOOKS RECOMMENDED:

- "Statistical Mechanics ",Huag
- " Fundamentals of Statistical and Thermodynamical Physics", Reif.
- "Statistical mechanics and Thermal Physics", Rice
- "Elementray statistical mechanics", Kittle.
- "Introduction to solid state physics". Kittle
- "Solid State Physics". Palteros
- "Solid State Physics." Levy

PAPER CODE-PHY 225
Practical
(Practical)

Credits: 8
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 240

Course Objectives:

This course will enable the students to –

1. To enable students to do experiments on the fundamental laws and principles, and gain experience of using a variety of measuring instruments.
2. To enhance basic learning skills of the students.
3. To give students opportunity of learning by doing and develop a correlation between theory and practical.

Course outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 225	**Physics practical (Practical)**	**The students will be able to –** **CO70:** Assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). **CO71:** Be able to understand and demonstrate MATLAB concepts and its experiments. **CO72:** Be able to handle useful equipment's related to solid-state physics like solar sell, hall effect, hysteresis loss of transformer, four probe method.	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments, Asking viva voce questions. **Learning activities for the students:** Performing Experiments, Analysis and interpretation of observations,	Class test, Semester end examinations, Viva voce, Practical record file

CONTENTS

The students will be required to perform 8 experiments in each semester from the following list of experiments

1. Curve fitting using MATLAB.
2. Numerical integration (Simpson's rule/ Trapezoidal rule) using MATLAB.
3. Numerical double integration using MATLAB.
4. Study of a Heat Capacity of Solids.
5. To study temperature variation of resistivity or a semi-conductor and to obtain band gap using four probe method.
6. To study Hall Effect and to determine hall coefficient.
7. To verify Malus law & to determine brewster's angle for glass.
8. Determination of Hysterisis loss of a transformer by CRO.

9. To study the characteristics of a solar cell:

   (i) Illumination characteristics
   (ii) Voltage current characteristic
   (iii) Power load characteristic
   (iv) Areal characteristic

10. To find out dissociation energy of I_2.

PAPER CODE-PHY 226
Seminar

Credits: 2
Maximum marks: 100

Course Objectives:

This course will enable the students to –

1. This course will enhance the writing, presentation, discussion and listening skills of the students.
2. It will also create curiosity to know about other fields of Physics which are not covered in the syllabi.
3. It will provide students an opportunity of self study and work independently.

Course outcomes (COs):

Course	Learning outcomes		Assessment

PAPER CODE	Paper Title	(at course level)	Learning and teaching strategies	Strategies
PHY 226	Seminar	**The students will be able to –** **CO73:** In terms of **content**, students will be able to show competence in identifying relevant information, defining and explaining topics under discussion.In terms of **organization**, students will be able to show competence in working with a methodology, structuring their oral work, and synthesizing information. In terms of **delivery**, students will use appropriate registers and vocabulary, and will demonstrate command of voice modulation, voice projection, and pacing. They will be able to make use of visual, audio and audio-visual material to support their presentation, and will be able to speak cogently with or without notes. **CO74:** Students will be able to judge when to speak and how much to say, speak clearly and audibly in a manner appropriate to the subject, ask appropriate questions, use evidence to support claims, respond to a range of questions **CO75:** Students will demonstrate that they have paid COse attention to what others say and can respond constructively. Through listening attentively, they will be able to build on discussion fruitfully, supporting and connecting with other discussants. **CO76:** Through asking appropriate questions, students will demonstrate their understanding of discussions and spark further discussion	**Approach in teaching:** Interaction, Discussion, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Continuous Assessment , Semester end examinations, Power point Presentation, Report , Viva Voce

PAPER CODE-PHY 227
Medical Physics
(Theory)

Credits: 2
Maximum marks: 100
Contact Hrs/Week: 2
Total Hrs: 30

Course Objectives:

This course will enable the students to –

1. To provide knowledge of the operation and principles used in the systems and procedures associated with the clinical track.
2. To acquaint the students with nuclear radiation and radioactivity, its properties, units of measure, dosimetry measurement concepts and methods .
3. To develop an understanding of the biological effects of radiation and its application for radiation safety and for radiation treatment.
4. To prepare students to take further studies in Bio-Physics or take up interdisciplinary research and make them suitable for handling various medical diagnostic instruments based on principles of Physics.

Course outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 227	**Medical Physics (Theory)**	**The students will be able to –** **CO77:** Gain a broad knowledge of therapeutic applications like the ultrasound, color Doppler, computed tomography, conventional radiography, digital radiography, mammography and magnetic resonance imaging. **CO78:** Gain a fundamental understanding of X-ray technology while developing particular expertise in medical applications. **CO79:** Imparts functional knowledge of radiation dosimeter, regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes. **CO80:** Learn about the human body, its anatomy and biological effects of radiations on human body. **CO81:** Gain knowledge with reference to radiation safety and how it is used as a therapeutic technique and radiation safety practices	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solvingin tutorials, Visit to a medical college/ university **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical, Additional learning through online videos	Class test, Semester end examinations, Quiz, Solving problems s, Assignments, Presentations

CONTENTS

Unit I: **6 Hrs.**

Recent advances in imaging technology: Basic principle of Ultrasound, colour Doppler, Computed tomography, Magnetic Resonance Imaging (MRI)-: Principle, application, its advantage over computed tomography or ultra sonography . Conventional radiography, Digital Radiography, Mammography.

Unit II : 6 Hrs.

X-Rays : Production of X-rays: X-ray tube, anode, cathode construction and working principles of transformers and autotransformers used in x-ray circuits, voltage rectification and measurements in x-ray circuits. Physics of x-ray production (Bremsstrahlung and Characteristic x-rays).

Unit III: 6 Hrs.

Radiation Dosimetry: Characteristic curve of gas filled detectors. Regions of the characteristic curve. Construction of gas filled detectors and their working. Scintillation counter, semiconductor detector, alpha particle monitoring, Gamma and x-ray monitoring, neutron monitoring devices. Measurement of absorbed dose using calorimetry, chemical dosimetry solid state methods, TLD & film dosimetry.

Unit IV: 5 Hrs.

Biological effects of radiation: Direct and indirect action of radiation, cell cycle effect, somatic and genetic effects . Effects on tissues and organs: Stochastic and non-stochastic (deterministic) effects, acute effects, late effects, effects of radiation on Embryo & fetus: lethal effects, organ malformation, growth impairment, mental retardation, cancer induction, genetic effects, Late (delayed) effects: cataract formation, organ function, cancer induction.

Unit V: 7 Hrs.

Radiation Safety: Radiation protection quantities and units: exposure, absorbed dose, KERMA, dose equivalent (H). Committed dose equivalent (HT), effective dose equivalent (HE), Equivalent dose ((HTR), effective dose (E).Sources of radiation exposure: Natural sources and human made sources. Standards and regulations, philosophies of exposure limit , occupational limits, non-occupational limits. Radiation protection procedures for patients and personnel. Advisory groups & regulatory agencies - ICRP, NCRP,UNSCEAR, AERB.

BOOKS RECOMMENDED:

- Medical Physics – J. R. Cameron & J. G. Skofronick.
- Basis Radiological Physics – Dr. K. Thayalam.
- Christenson’s Physics of Diagnostic Radiology : Curry, Dowday & Murry.
- Physics of Human body – Irering P. Herman
- Pysics of Radiation Therapy – F M Kahn
- Essential Physics of Medical Imaging

M.Sc. PHYSICS (2020-2021)

COURSE OUTCOMES - Semester III

PAPER CODE-PHY 321
Classical Electrodynamics – II

(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To enable the students to apply tools of electrodynamics and relativity to various physical problems related to moving charges, Plasma formation and its impact on behavior of particle.
2. To make the students learn Covariant Form of Electrodynamic Equation, Radiation by moving charges, Radiation damping etc.

Course outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 321	**Classical Electrodynamics – II (Theory)**	After the completion of this course the student will be able to: **CO82:** Apply Maxwell's equations to a variety of problems. **CO83:** Solve problems involving the propagation and scattering of electromagnetic waves in a variety of media. **CO84:** Acquire a good understanding of Special Relativity, especially as applied to electrodynamics. **CO85:** Demonstrate an understanding of the characteristics of electromagnetic radiation by moving charges. **CO86:** Develop understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems , Assignments, Presentations

CONTENTS

Unit I: **12 Hrs.**

Plane Electromagnetic Waves and Wave Equation: Plane wave in a non-conducting medium. Frequency dispersion characteristics of dielectrics, conductors and plasma, waves in a conducting or dissipative medium, superposition of waves in one dimension, group velocity, causalty, connection between D and E, Kramers-Kroning relation.

Unit II : **11 Hrs.**

Magneto hydrodynamics and Plasma Physics : Introduction and definitions, MHD equations, Magnetic diffusion, viscosity and pressure, Pinch effect, instabilities in pinched plasma column, Magneto hydrodynamics wave, Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance.

Unit III: **12 Hrs.**

(a)Covariant Form of Electrodynamic Equations: Mathematical properties of the space-time special relativity, Invariance of electric charge, covariance of electrodynamics, Transformation of electromagnetic field.

(b) Thomson scattering and radiation, Scattering by quasi-free charges, coherent and incoherent scattering, Cherenkov radiation.

Unit IV: **13 Hrs.**

Radiation by moving charges: Solution of inhomogeneous wave equation by Fourier analysis; Lienard-Wiechert Potential for a point charge, Total power radiated by an accelerated charge, Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion.

Unit V: **12 Hrs.**

Radiation damping: Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraham Lorentz model, Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator, Scattering and absorption of radiation by an oscillator.

BOOKS RECOMMENDED:

- Classical Electrodynamics : Jackson
- Classical Electricity and Magnetism : Panofsky and Philips.
- Introduction to Electrodynamics : Griffiths.
- Classical Theory of Field : Landau and Lifshitz.
- Electrodynamics of Continuous Media : Landau and Lifshitz.

PAPER CODE-PHY 322
Nuclear Physics-I
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. The students will learn about two nucleon system, nuclear forces and scattering.
2. The student will be understand the working of nuclear counters and nuclear detectors.
3. The course will equip students with the basic background knowledge required for a Nuclear Scientist.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			
PHY 322	**Nuclear Physics-I (Theory)**	**The students will be able to –** **CO87:** have knowledge of Two Nucleon system, Nuclear forces and discussion of (3S1) deuteron. Using to calculate square well potential, range-depth relationship, excited states, ground state and applications. **CO88:** have a brief idea about Nucleon-Nucleon Scattering and Potentials, used in neutron-proton scattering, concept of scattering length, hydrogen molecule, scattering lengths, range and depth of the potential. **CO89:**Know about proton-proton scattering, two-body scattering, apply in low energy effect and high energy effect of exchange forces. **CO90:** Learn about the Hamada-Johnston hard core potential and Reid hard core and soft core potentials, Main features of the One Boson Exchange Potentials (OBEP) (no derivation). **CO91:**Understand about Interaction of radiation and charged particle with matter and their effects to solve the scattering, absorption and pair production problems. **CO92:**Learn about the Experimental Techniques for counters, detectors, accelerators and Electronic circuits of typical nuclear detector.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numericals	Class test, Semester end examinations, Quiz, Solving problems Assignments, Presentations

CONTENTS

Unit I: **12 Hrs.**

Two Nucleon system and Nuclear forces : General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, Central, non-central and velocity dependent potential, Analysis of the ground state ($^3S_1$) of deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of deuteron under non-central force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

Unit II : 12 Hrs.

Nucleon-Nucleon Scattering and Potentials : Partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of scattering length, coherent scattering of neutrons by protons in (ortho and para), hydrogen molecule, conclusions of these analysis regarding scattering lengths, range and depth of the potential, the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential.

Unit III: 11 Hrs.

A qualitative discussion of proton-proton scattering at low energy, General features of two-body scattering at high energy effect of exchange forces. Phenomenological Hamada-Johnston hard core potential and Reid hard core and soft core potentials, Main features of the One Boson Exchange Potentials (OBEP) (no derivation).

Unit IV: 13 Hrs.

Interaction of radiation and charged particle with matter (No derivation) : Law of absorption and attenuation coefficient, photoelectric effect, Compton scattering, pair production; Klein-Nishijima cross-sections for polarized and unpolarized radiation, angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremstrahlung energy target and projectile dependence of all three processes, Range-energy curves, Straggling.

Unit V: 12 Hrs.

Experimental Techniques : Gas filled counters, Scintillation counter, Cerenkov counters, Solid state detectors, Surface barrier detectors, Electronic circuits used with typical nuclear detector, Multiwire proportion chambers, Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron, Linear accelerators, Acceleration of heavy ions.

BOOKS RECOMMENDED:

- J.M. Bhatt and V.E. Weisskipf : Theoretical Nuclear Physics.
- L.R.B. Elton : Introductory Nuclear Theory (ELBS Publication, London, 1959).
- B.K. Agarwal : Nuclear Physics (Lokbharti Publication Allahabad. 1989).
- R.R. Roy and B.P. Nigam: Nuclear Physics (Willey -Easter, 1979).
- M.A. Preston & R.K. Bhaduri: Structure of the Nucleus (Addition-Wesley, 1975).
- R.M. Singru : Introductory Experimental Nuclear Physics.
- England- Techniques on Nuclear Structure (Vol I).
- R.D. Evans : The Atomic Nucleus (Mc Graw Hills, 1955)

- H. Enge. Introduction Nuclear Physics (Addison-Wesley, 1970).
- W.E. Burcham : Elements of Nuclear Physics (ELBS. Longman. 1988)
- B.L. Cohen : Concept of Nuclear Physics (Tata McGraw Hills, 1988).
- E. Segre : Nuclei and Particles (Benjamin, 1977).
- I. Kaplan : Nuclear Physics (Addison Wesley, 1963).
- D. Hallidy : Introductory Nuclear Physics (Wiley, 1955).
- Harvey : Introduction of Nuclear Physics and Chemistry.

PAPER CODE-PHY 323
Numerical Methods and Computational Physics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

will enable the students to –

1. This course To understand the basic Numerical methods and programming.
2. To learn techniques to apply numerical methods into research areas
3. To acquire working knowledge and practice for electronic structure studies of materials by using WIEN2K and Quantum Espresso softwares based on DFT.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 323	**Numerical Methods and Computational Physics** **(Theory)**	**The students will be able to –** **CO93:** Find numerical solutions of system of linear equations and check the accuracy of the solutions.Obtain numerical solutions of algebraic and transcendental equations. **CO94:** Find numerical solutions of system of linear equations and check the accuracy of the solutions. **CO95:** Learn about various interpolating and extrapolating methods. **CO96:** Solve initial and boundary value problems in differential equations using numerical methods. **CO97:** Apply various numerical methods in real life problems. **CO98:** A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice,	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical, Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		concept of Brillouin zones and diffraction of X-rays by crystalline materials. **CO99:** Gain knowledge of WIEN2k software and PSOt DOS, electron structure and band structure.		

CONTENTS

Unit I: **11 Hrs.**

Errors in Numerical Analysis: Source of Errors, Round off error, Arithmetic error, error analysis, Condition and stability, method of undetermined coefficients, use of interpolation formula, iterated interpolation, inverse interpolation, Hermite interpolation and Spline interpolation (linear method).

Unit II : **12 Hrs.**

Solution of Linear equations : Direct and Iterative methods, Jacobi and Gauss Seidal method

Solution of Nonlinear equation: Bisection method, Newton-Raphson method, Generalized Newton Raphson method, method of iteration, Newton Raphson method for the case of nearly equal roots, double root and multiple roots.

Unit III: **13 Hrs.**

Integration of a function: Trapezoidal and Simpson's rules. Gaussian quadrature formula, Singular integrals, Double integration.

Integration of Ordinary differential equation: Predictor-corrector methods, Runga-Kutta method. Simultaneous and Higher order equations.

Numerical differentiation of Data, Least-Squares Approximations, Fast Fourier Transformation.

Unit IV: **12 Hrs.**

Theoretical methods for study of Electric Structure of Materials:

a) **Basic concepts only of**: Periodic boundary conditions, Brillouin zone, Symmetry points in Brillouin zone of common types of lattices, Fermi Energy, Energy Band Diagram, effective mass of electron, Density of States, Fermi surface, Nature of Wave-function of the system, its plane wave expansion, pseudo potentials, Form factor, Structure factor, Dielectric screening, Exchange and Correlation, Various contributions to total energy of a system, Density Functional Theory, The LAPW Method, The APW+lo method.

b) **WIEN2k Software**: its structure, W2web server, Brief description of using W2web for:
Creating a new session and directory, Creating the input and its setting of RMT values, sample structure file (Case. struct) file, Viewing the structure, Initialization of the

calculation. Setting up of RMT*Kmax and k-points. The SCF calculation and convergence limits, flow of WIENk2k program, Saving the calculation, spin polarized calculation, spin- orbit interaction. Calculation and PSOtting of Electron Density distribution, Density of States, X-ray spectra, Band Structure, Fermi Surface. Volume Optimization, Super cell creation and addition of impurity atoms to the system. Serial and Parallel execution of WIEN2k, Working on a cluster, Working on a remote computing system.

Unit V: **12 Hrs.**

Quantum Espresso: Essential Linux Commands. Pseudopotentials in Quantum Espresso. Structure of a program in Quantum Espresso: Symbolizing lattice types, Cell parameters, Atomic Species, Atomic positions, Irreducible Brillouin zone sampling, k-point sampling and other parameters. A sample PW scf code. Self consistent solution of Schrödinger equation. Total energy, Various contributions to total energy, convergence tests for ecut-wfc, ecut-rho and k-points. Structure-stability considerations. Energy lattice constant Diagram and Equation of state.

Structure of files for calculation of electron density, density of states and band structure. PSOtting of diagrams with gnuPSOt. Calculation and PSOtting of Fermi surface. Super cell construction, introduction of impurity in the cell. Sample code for a system with impurity. Running of Quantum Espresso programs in serial and parallel mode and on a cluster of computers.

BOOKS RECOMMENDED:

- A Ralston and P. Rabinowitz, "A First Course in Numerical Analysis", McGraw Hill (1985).
- S.S. Sastry, " Introductory Methods of Numerical Analysis", Prentice-Hall of India (1979).
- P. Blaha, K. Schwarz, G. Madsen, D. Kvasnicka, and J. Luitz, "WIEN2k- An augmented Plan Wave Plus Local Orbitals Program for Calculating Crystal Properties", User's Guide, Vienna University of Technology, Vienna (Austria)
- D. Singh, Plane Waves, Pseudopotentials and the LAPW method, Kluwer Academic (1994).
- Users' Guide for Quantum Espresso (V.6.2).
- Cottenier, "Density Functional Theory and the family of (L) APW-methods: a step by step introduction", WIEN2k website (2013).

PAPER CODE-PHY 324(A)
Condensed Matter Physics – I
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. The student will be equipped with background knowledge to understand different types of materials and to take up research in Condensed Matter Physics.
2. The student will be able to understand Fundamentals of many-electron System, Quasi electrons and Plasmons, spin- orbit and Spin-spin interaction, Density Functional Theory & Experimental techniques in nanotechnology.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 324(A)	**Condensed Matter Physics – I (Theory)**	**The students will be able to –** **CO100:** To understand the role of quantum effects in micro- and meso-scopic systems and acquire a fundamental understanding of a range of physical phenomena in condensed matter systems. **CO101:** To learn about the theory and procedures of Hartree Fock theory and Density functional theory **CO102:** Learn about the difference between Schrodinger's picture and Heisenberg's picture of interactions for a Many body problem **CO103:** Understand the formalism of spin- spin interaction and magnons **CO104:** Knowledge of some useful experimental techniques of material characterization	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical. Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: **12 Hrs.**

Fundamentals of many-electron System: Hartree-Fock Theory: The basic Hamiltonian in a solid: electronic and ionic parts, the adiabatic approximation;

Single-particle approximation of the many-electron system; single product and determinantal wave functions, Occupation number representation; matrix elements of one and two-particle operators; The Hartree-Fock (H-F) method; the one electron H-F equation; exchange interaction and Fermi hole; Coulomb correlation; the H-F ground state energy.

Unit II : 12 Hrs.

The interacting free-electron gas: Quasi electrons and Plasmons: The interacting electron gas; The coulomb interaction; The Hartree-Fock approximation for the electron gas; Exchange Hole; Screeming, Plasmons; Quasi-electrons; The dielectric constant of the electron gas.

Unit III: 12 Hrs.

Spin-spin interaction: Magnons

Absence of magnetism in classical statistics; Origin of the exchange interaction; Direct exchange, super exchange, indirect exchange and itinerant exchange; Spin-waves in ferromagnets-magnons, spontaneous magnetization, thermodynamics of magnons; Spinwaves in lattices with a basis-ferri- and antiferromagnetism; Measurement of magnon spectrum; Ordered magnetism of valence and conduction electrons, Stoner's criterion for metallic ferromagnet

Unit IV: 12 Hrs.

Density Functional Theory: Basics of DFT, Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond: LDA and GGA; Application of DFT in a many body calculation and its reliability.

Unit V: 12 Hrs.

Experimental techniques : Basic ideas of the techniques of field emission, scanning tunneling and atomic force microscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction line broadening, small angle X-ray scattering and small angle neutron scattering; Ultraviolet–visible spectroscopy

BOOKS RECOMMENDED:

- Stanly Raimes: Many Electron Theory; North Holland Publishing company Amsterdam-London
- O. Madelung: Introduction to Solid State Theory; Springer
- D.Pines and P. Nozier: The Theory of Quantum Liquids; Perseus Books Publishing LLC
- W.A. Harison : Pseudopotentials in the Theory of Metals, Benjamin
- Norman Henry March, W. H. Young, S. Sampanthar- Many Body Problem; cambridge university press
- P.I. Taylor, A Quantum Approach to the Solid State, Prentice Hall.
- Ech. Steinhardt and Ostulond: Physics of quasi crystals.
- Neil W. Aschoft & N. David Mermin : Solid State Physics, Harcourt Publishers (1976)
- Gerald Burns: Solid State Physics, Academic Press (1985).
- Wlater A. Harrison: Solid State Physics, Dover Publication (1980).
- Harald Ibach and Hans Luth: Solid State Physics: An introduction to Principles of
- Materials Science, Springer (2003).
- F. Seitz and D.Tumbull (Eds.): Solid State Physics, Advances in research and
- applications, supplement 3: A.A. Maraduddin, E.W. Montrol and G.H. Weiss: Theory of

- lattice dynamics in harmonic approximation : Academic Press (1963).
- 13. Callaway: Quantum Theory of Solids Part A & B, Academic Press (1974).
- 14. M.P. Marder: Condensed Matter Physics, Wiley-Interscience (2000).
- H.Ibach and H.Luth: An Introduction of Theory and Experiments- Solid State Physics, Narosa (1991).
- Edo M. Yussouf: Lecture Notes in Physics, No. 283, Electronic band structure and its Applications, Springer – Vertag (1987).
- D.Pines: Elementary Excitations in Solids; Perseus (1999)
- N.H. March and M. Passinello: Collective Effects in Solids and Liquids.
- J.M. Ziman: Principles of the Theory of Solids; Cambridge
- C. Kittel : Quantum Theory of Solids
- Richard M. Martin: Electronic Structure- Basic Theory and Practical Methods:
- Cambridge (2004).
- Jorge Kohanoff: Electronic Structure Calculations for Solids and Molecules, Cambridge (2006).
- D.J. Singh & Lars Nordstrom: Plane waves, Psedopotentials and the LAPW method 2nd Ed. (2006).
- User guide/manual of softwares: WIEN2K,VASP, Quantum Expresso, Abinit
- J.H.Fendler; Nanoparticles and Nanostructured Films: Preparation, Characterization and Application

PAPER CODE-PHY 324(B)
Microwave Electronics-I
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students learn about basics of microwaves, wave guides and field equations.
2. To familiarize the students with techniques of generation and propagation of microwaves.
3. To acquaint the students with microwave measurement techniques.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			

PHY 324(B)	**Microwave Electronics-I (Theory)**	**The students will be able to –** **CO105:** Have knowledge of rectangular and circular waveguides and derive the field equations for electric and magnetic fields in them. **CO106:** Learn about waveguide resonators and calculate its Q factor. **CO107:** Have an introduction to ferrites and its applications **CO108:** Explain and analyse Klystron and its types , magnetrons and travelling wave tubes. **CO109:** Know about the concept and procedure to measure different parameters like VSWR, Impedance , frequency & attenuation ,etc. **CO110:** Have a concept of Complex permittivity of material and its measurement	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical. Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: **12 Hrs.**

Introduction to microwaves and its frequency spectrum, Application of microwaves.
(a) **Rectangular wave guide** : Wave equation & its solutions, TE & TM modes. Dominant mode and choice of wave guide dimensions, methods of excitation of waveguides.(b**)** **Circular wave guide** : wave equation & it solutions, TE, TM & TEM modes. (c) Attenuation - Cause of attenuation in wave guides, wall current. & derivation of attenuation constant, Q of the wave guide.

Unit II : **13 Hrs.**

(a) **Resonators**: Resonant Modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Excitation techniques, Introduction to Mircostrip and Dielectric resonators, Frequency meter.
(b) **Ferrites:** Microwave propagation in ferrites, Faraday rotation, Devices emPSOying Faraday rotation (isolator, Gyrator, Circulator). Introduction to single crystal ferromagnetic resonators, YIG tuned solid state resonators.

Unit III: **11 Hrs.**

Microwave tubes: Space charge spreading of an electron beam, Beam focusing. Klystrons: Velocity Modulation, Two Cavity Klystron, Reflex Klystron, Efficiency of Klystrons.

Unit IV: **12 Hrs.**

Magnetrons: Types & description, theoretical relations between Electric & Magnetic field of oscillations, Modes of oscillations & operating characteristics,
Traveling wave tubes: O & M type traveling wave tubes. Gyrotrons: Constructions of different Gyrotrons, Field - Particle Interaction in Gyrotron.

Unit V: **12 Hrs.**

Microwave Measurement : Microwave Detectors , Power, Frequency, Attenuation, Impedance using smith chart, VSWR, Reflectometer, Directivity Coupling using direction coupler.
(b) Complex permittivity of material & its measurement: definition of complex permittivity, determination of permittivity of solids, liquids and powders using shift in minima method.

BOOKS RECOMMENDED:

- Electromagnetic Waves & Radiating System-Jorden & Balmain.
- Theory and Applications of Microwaves A.B. Brownwell & R.E. Beam (Mc Graw Hill).
- Introduction to Microwave Theory by Atwater (McGraw Hill).
- Principles of Microwave circuits by G.C. Montogmetry (McGraw Hill).
- Microwave Circuits & Passive Devices by M.L. Sisodia adn G.S. Raghuvanshi (Willey Eastern, New Delhi).
- Foundations of Microwave Engineering by R.E. Collin (McGraw Hill).
- Microwave Semiconductor Devices and their Circuit applications by H.A. Watson.
- Microwaves by M.L. Sisodia & Vijay Laxmi Gupta.
- Antenna Theory, Part-I by R.E. Collin & F.J. Zucker (McGraw Hill, New York).
- Microstrip Antennas by Bahl & Bhartiya (Artech House, Messachausetts).
- Antenna Theory Analysis by E.A. Wolff (J.Willey & sons).
- Antenna Theory Analysis by C.A. Balanis Harper & Row, Publ. & Inc. New York.
- Antenna Theory & Design by R.C. Elliott (LPHI Ltd. New Delhi.).

PAPER CODE-PHY 324(C)
Nanotechnology –I
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students learn about the background of Nanotechnology
2. To develop an understanding of the synthesis and analysis of nanomaterials and their applications.
3. To study the impact of nanomaterials on environment.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 324(C)	**Nanotechnology –I (Theory)**	**The students will be able to –** **CO111:** Learn about wave behavior of particles, duality, Schrodinger equation, band formation and energy band gaps. **CO112:**Know about quantum tunneling and quantum confinement effect. **CO113:**Understand atomic arrangements in solids, crystals,Miller indices, symmetries in crystals. **CO114:** Learn about physical and chemical methods to deposit nanomaterials. **CO115:** Learn various techniques such as X ray diffraction to understand crystal structure.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical. Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: 12 Hrs.

Introduction to Quantum Mechanics: Matter waves, Schrodinger equation, Electron Confinement, Particle in a box, Density of States and Band Gap, Particle in a Coulomb Potential, Tunneling of a particle through Potential Barrier, Excitons, Idea of quantum well structure, quantum dots, quantum wires, Introduction to Density Functional Theory.

Unit II : 12 Hrs.

Structure and Bonding: Arrangement of atoms, Two and three dimensional crystal structure, Reciprocal lattice, Quasi Crystals, Liquid Crystals, Planes in Crystal, Surface Crystallography, Surface Symmetry, Surface energy, Surface reconfiguration, Surface reconstruction and relaxation.

Unit III: 12 Hrs.

Synthesis of Nanomaterials -I: Physical Methods- High Energy Ball Milling, Melt Mixing, Physical Vapour Deposition, Ionized Cluster Beam Deposition, Laser Ablation, DC and RF Sputtering, Magnetron Sputtering, ECR Plasma Deposition, Ion Beam Techniques, Molecular Beam Epitaxy.

Unit IV: 13 Hrs.

Synthesis of Nanomaterials-II: Chemical Method- Colloids and colloids in solution, Nucleation and growth of Nanoparticles, Synthesis of metal and semiconductor nanoparticles by colloidal route,Langmuir-Blodgett method, Microemulsions, Sol-Gel method.

Nano Lithography- Lithography using Photon, Lithography using Particle beam, Soft Lithography

Unit V: 11 Hrs.

Analysis Techniques: Diffraction Techniques- X-Ray Diffraction (XRD), Atomic Scattering Factor, Bragg's Law of Diffraction, Crystal Structure Factor, Diffraction from Nanoparticles, Dynamic Light Scattering, X-Ray Diffractometer.

BOOKS RECOMMENDED:

- Nanotechnology: Principle and Practices, S.K. KulKarni, Capital Publishing Company (2015).
- Introduction to Solid State Physics, Charles Kittle, Wiley-India Edition (2008).
- Physics of Semiconductor Nanostructures, K. P. Jain, Narosa Publishers (1997).
- Quantum Dot Hetrostructures, D.M. Garundmann and N.N.Ledentsov, John-Wiley (1998) .
- Introduction to Nanotechnology, C. P. Poole, F. J. Owens, Wiley-Interscience (2003).
- Nanotechnology: Basic Science & Emerging Technologies, M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Chapman & Hall/CRC Press (2002).
- Nanostructure and Nanomaterials:Synthesis, Properties and Applications, G. Cao and Ying Wang, World Scientific Publishing (2011)
- Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications, Janos H. Fendler, Wiley (1998).

PAPER CODE-PHY 325
Practical
(Practical)

Credits: 8
Maximum marks: 100
Contact Hrs/Week: 16
Total Hrs: 240

Course Objectives:

This course will enable the students to –

- To engage students in significant experiences with experimental processes.
- To develop basic skills and tools of experimental physics and data analysis

- To understand the role of direct observation in Physics and to distinguish between inference based on theory and outcome of experiments.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 325	**Practical (Practical)**	**The students will be able to –** **CO116:** Apply the various procedures and techniques for the experiments. **CO117:** Use the different measuring devices and meters to record the data with precision. **CO118:** Apply the mathematical concepts/equations to obtain quantitative results. **CO119**:Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.	**Approach in teaching:** Demonstration, Group activity, Discussion ,Conduction of Experiments, Asking viva voce questions. **Learning activities for the students:** Performing Experiments, Analysis and interpretation of observations, Record preparation.	Class test, Semester end examinations, Viva-voce, Practical record File.

CONTENTS

The students will be required to perform 8 experiments in each semester from the following list of experiments

1. To study characteristics of a GM counter and to verify inverse law.
2. To determine linear and mass attenuation coefficient (u) for γ rays for a given source.(Al,Cu,Pb)
3. Study the characteristics of a given Klystron and calculate the mode number, E.T.S. and transit time.
4. Study the radiation pattern of a given Pyramidal horn by PSOtting it variation with angle and variation with distance.
5. To study electronic structure of T_i C/TiN/MgB_2 using WEIN 2K.calculate:

   (i) Electronic density (ii) density of states (iii) band structure

   (iv)Fermi surface (v) volume optimization

6. To study Gunn oscillator as a source of microwave power and study I V characteristic, power and frequency vs bias characteristics and power frequency characteristic.
7. To determine ultrasonic velocity and compressibility of a given liquid sample using ultra sonic interferometer.
8. To study absorption of particles and determine range using at least two sources.
9. To study electronic structure of Si/Al/Na using Quantum Espresso/Abinit.
10. Use P spice to study

(i) Inverting amplifier

(ii) Non inverting amplifier

PAPER CODE-PHY 326
Synopsis for Dissertation/Project
(Dissertation)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

This has been incorporated, with the aim that a candidate does extensive literature survey on a topic of choice and prepare a Synopsis or research plan for taking up a project/ dissertation under the supervision of a faculty. The project or dissertation will be taken up in the subsequent semester,on the lines / methodology approved in the synopsis.

Course outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
PAPER CODE	**Paper Title**			
PHY 326	**Dissertation**	**The students will be able to –** **CO120:** Give a clear picture of proposed project and eliminate the gaps perceived from review of literature **CO121:** Have a scientific background about how will the proposed research contribute to the existing body of knowledge. The rationale, problrm formulation and overall and specific objectives is decided. **CO122:** Decide the Method outline and time plan .	**Approach in teaching:** Interaction, Discussion, **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation	Continuous Assessment, Semester end examinations, Power point Presentation, Report , Viva Voce

M.Sc. PHYSICS (2020-2021)

COURSE OUTCOMES - Semester IV

PAPER CODE-PHY 421
Solid State Physics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To provide an information about dynamic (lattice vibrations) arrangements of atoms, Semiconductors, Defects in materials, Magnetism & Superconductivity.
2. To develop an understanding of the phenomena related to Characteristics of solids ,which will help him/her to take advanced studies or research in this area.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 421	**Solid State Physics (Theory)**	**The students will be able to –** **CO123:** Learn about the Lattice Dynamics and Optical Properties of Solids. **CO124:** Understand the physics of insulators, semiconductor and conductors. **CO125:** Knowledge of different kind of defects in crystals. **CO126:** Knowledge of different types of magnetism from diamagnetism to ferromagnetism. **CO127:** Understand the basic idea of the theory of superconductors and their properties in the frame of BCS theory.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, Solving numerical	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: **13 Hrs.**

Lattice Dynamics and Optical Properties of Solids: Interatomic forces and lattice dynamics, simple metals, ionic and covalent crystals, optical phonons and dielectric constants, inelastic neutron scattering, Mossbauer effect. Debye-Waller factor, Anharmonicity, thermal expansion and thermal conductivity, Interaction of electrons and phonons with photons, Direct and indirect transitions, Absorption in insulators, Polarities, one-phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

Unit II : 13 Hrs.

Semiconductors: Law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall Effect, recombination mechanism, optical transitions and Schockely-Read theory, excitations, photoconductivity, photo-luminescence. Point's line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides.

Unit III: 13 Hrs.

Magnetism: Larmor diamagnetism. Paramagnetism, Curie-Langevin and Quantum theories, Susceptibility of rare earth and transition metals, Ferromagnetism: Domain theory, Weiss molecular field and exchange, spin waves: dispersion relation and its experimental determination by inelastic neutrons scattering, heat capacity. Nuclear Magnetic resonance: Conditions of resonance, Bloch equations, NMR- experiment and characteristics of an absorption line.

Unit IV: 11 Hrs.

Superconductivity : Experimental Results : Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giaver and AC and DC Josephson tunnelings.

Unit V: 10 Hrs.

Cooper pairs and derivation of BCS Hamiltonian, results of BCS Theory (no derivation), High T_c superconductivity, introduction to theories of High T_c superconductors.

BOOKS RECOMMENDED:

- Kittel - Introduction to Solid State Physics, 5th Edition (John Wiley).
- Levy-Solid State Physics.
- Patterson - Solid State Physics.
- Mckelvy - Solid State and Semi-conductor Physics.

PAPER CODE-PHY 422
Nuclear physics II
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

- To provide an understanding of static properties of nuclei, nuclear decay modes, nuclear force and nuclear models

- To provide broad understanding of basic experimental nuclear detection techniques
- To motivate the students to take up research in Nuclear Science.

Course outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>PAPER CODE</th><th>Paper Title</th></tr>
<tr><td>PHY 422</td><td>Nuclear physics II (Theory)</td><td>The students will be able to –
CO128: Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.

CO129: Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.

CO130: Learn collective description of nuclear behavior.

CO131: Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays, the properties of the constituents of these rays and the mechanisms of the emissions of these rays, outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series.

CO132: Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.</td><td>Approach in teaching: Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving.

Learning activities for the students:
Self learning assignments, Effective questions, Seminar presentation, Solving numerical

Additional learning through online videos and MOOC courses</td><td>Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations</td></tr>
</table>

		CO133: Know about the general characteristics of weak interaction. **CO134:**Learn theories of Nuclear Reactions and nuclear structure studies with deuteron strapping.		

CONTENTS

Unit I: **13 Hrs.**

Nuclear Shell Model : Single particle and collective motions in nuclei, Assumptions and justification of the shell model, average shell potential, spin orbit coupling, single particle wave functions and level sequence, magic numbers, shell model predictions for ground state parity, angular momentum, magnetic dipole and electric quadruple moments, and their comparisons with experimental data, configuration mixing, single particle transition probability according to the shell model, selection rules, approximate estimates for the transition probability and Weiss Kopf units, Nuclear isomerism.

Unit II : **10 Hrs.**

Collective Nuclear Models : Collective variable to describe the cooperative modes of nuclear motion, Parameterization of nuclear surface, A brief description of the collective model Hamiltonian (in the quadratic approximation), Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of inertia, Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data, Nilsson model for the single particle states in deformed nuclei.

Unit III: **10 Hrs.**

Nuclear Gamma and Beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear systems (no derivations), Reduced transition probability, Selection rules, Internal conversion and zero-zero transition.

Unit IV: **13 Hrs.**

General characteristics of weak interaction: nuclear beta decay and lepton capture, electron energy spectrum and Fermi-Curie PSOt, Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow-Teller) for allowed transitions, ft-values, General interaction Hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions, Experimental verification of parity violation, The V-A interaction and experimental verification.

Unit V: **14 Hrs.**

Nuclear Reactions: Theories of Nuclear Reactions, Partial wave analysis of reaction Cross section, Compound nucleus formation and breakup, Resonance scattering and reaction-Breit-Wigner dispersion formula for s-waves (1 = 0), continuum cross section, Statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions, The optical model, Strapping and pick-up reactions and their simple theoretical description

(Butler theory) using plane wave Born approximation (PWBA), Shortcomings of PWBA, Nuclear structure studies with deuteron strapping (d, p) reactions.

BOOKS RECOMMENDED:

- M.A. Preston and R.K. Bhaduri : Structure of Nucleus, Addision Wesley, 1975.
- R.R. Roy and B.P. It Nigam, Nuclear Physics, Wiley-Eastern. 1979.
- L.R.B. Elton: Introductory Nuclear Theory, ELeBS Pub. London, 1959.
- B.K. Agrawal : Nuclear Physics. Lokbharati Publt., Allahabad 1989.
- M.K. Pal-Nuclear Structure, Affiliated East-West Press, 1982.
- J.B. Blatt and V.F. Weisskopf-Theoretical. Nuclear Physics.
- H. Enge. : Introduction to Nuclear Physics, Addison - Wesley, 1970.
- B.L. Cohen-concept of Nuclear Physics, Tata McGraw Hill, 1988.
- W.E. Burchema - element of Nuclear Physics, ELBS, Longman, 1988.
- R.D. Evans : The Atomic Nucleus, Mc Graw Hill, 1955.
- E. Segre Nuclei and Particles, Benjamin, 1977.
- I. Kaplan-Nuclear Physics, Addison Wesley, 1963.
- W.M. Gibson : The physics of Nuclear Reactions, pergamon Press, 1980.
- G. de Beneditti, Nuclear Interactions. Wiley, 1955.

PAPER CODE-PHY 423
Advanced Quantum Mechanics
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students understand the concepts of relativistic formulation and Dirac equations
2. To develop an understanding about the basics of scattering theory.
3. To enable the students to apply quantum mechanical tools to various types of applications and research.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 423	**Advanced Quantum Mechanics (Theory)**	**The students will be able to –** **CO135:** Describe the basic Hilbert space structures describing all quantum field theories. **CO136:** explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, , Demonstration, Problem Solving in tutorials	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		CO137: Knowledge of interaction of Bosons and Fermions particles . **CO138:** describe second quantization and related concepts. **CO139:** Explain the formalism of relativistic quantum field theory. **CO140:** draw and explain Feynman graphs for different interactions. **CO141:** Model physical systems using common approximation techniques for making dynamical calculations. **CO142:** Critically analyse probability current density for a fully defined quantum theory.	**Learning activities for the students:** Learning activities for the students: Self learning assignments, Effective questions, Seminar presentation, Solving numerical. Additional learning through online videos and MOOC courses	

CONTENTS

Unit I: **13 Hrs.**

Scattering (non-relativistic): Differential and total scattering cross section, transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications: scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependence and resonance scattering, Breit-Wigner formula, quasi stationary states, Lippman-Schwinger equation and the Green's functions approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

Unit II : **9 Hrs.**

Relativistic Formulation and Dirac Equation: Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution of free particle KG equation in momentum representation, interpretation of negative probability density and negative energy solutions.

Unit III: **11 Hrs.**

Dirac equation and Symmetry considerations: Properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction), Solution of free particle Dirac equation, orthogonality and completeness, relations for Dirac spinors, interpretation of negative energy solution, Lorentz covariance of Dirac equation, charge conjugation (C), Parity(P), time reversal (T) , CPT theorem, Zitterbewegung.

Unit IV: **14 Hrs.**

Quantum Theory of Radiation : Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators, photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the dipole approximation, Rayleigh scattering. Thomson scattering and the Raman effect, Radiation damping and Resonance fluorescence.

Unit V: **13 Hrs.**

S-matrix, S-matrix expansion, Wick's theorem, Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes. Applications of S-matrix formalism: The Coulomb scattering, Bhabha scattering, Compton scattering and Pair production.

BOOKS RECOMMENDED:

- Ashok Das and A.C. Milissiones : Quantum mechanics - A Modern Approach (Garden and Breach Science Publishers).
- E. Merzbaker : Quantum Mechanics, Second Edition (John Wiley and Sons).
- Bjorken and Drell : Relativistic Quantum Mechanics (McGraw Hill).
- J.J. Sakurai : Advanced Quantum Mechanics (John Wiley)
- Quantum Field Theory by F. Mandal & G. Shaw (Honh-Wiley).
- Element of Advanced Quantum Theory by J.M. Ziman. (Cambridge University Press).

PAPER CODE-PHY 424(A)
Condensed Matter Physics - II
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To equips the students with the theoretical and experimental knowledge about solids, solid solutions, liquids, alloys, disordered materials, introduction & synthesis of nanomaterials.
2. To prepares the students to take up research in Condensed Matter Physics.

Course outcomes (COs):

Course	Learning outcomes		Assessment

PAPER CODE	Paper Title	(at course level)	Learning and teaching strategies	Strategies
PHY 424(A)	**Condensed Matter Physics - II (Theory)**	**The students will be able to –** After the completion of this course the student will be able to: **CO143:**Understand the quantum mechanical behavior of metals, metallic interactions, pseudo potential, exchange and correlation interactions **CO144:** Knowledge of liquid metals-structure factor and radial distribution functions, its resistivity **CO145:** Define solid solution, its properties, phase transformations, binary metal alloy **CO146:** Understanding of Disordered condense matter, its specifications, defects **CO147:** Knowledge of nano materials, potential barriers, quantum tunneling effect **CO148:** Knowledge of some useful experimental techniques of material deposition	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, problem solving in tutorials **Learning activities for the students:** Self learning assignments, Effective questions, Seminar presentation, solving numerical. Additional learning through online videos and MOOC courses	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

CONTENTS

Unit I: **14 Hrs.**

Theory of Metals

Metallic interactions; Kinetic energy; electrostatic; exchange and correlation; Pseudopotential formulation; local and non-local Pseudopotentials; The diffraction model; Factorization of matrix elements; structure factor; Form Factor; Total Energy of the metals; Free electron energy, Band Structure energy; Self consistent screening of a local pseudopotential; Dielectric screening function, Energy wave number Characteristic

Unit II : **14 Hrs.**

(a)Liquid Metal and Alloys
Liquid structure factor s(q); radial distribution function g(r); Relationship between s(q) and g(r); Ziman's resistivity formula, the role of effective mass on resistivity, Binary liquid metal alloys; Atom-atom partial structure factors; Thermodynamical relations.

(b)Phase Transformation in Alloys
Equilibrium transformation of first and second order, Phase rule, Equilibrium phase diagrams, Interpretation of Phase Diagrams; Substitutional solid solutions, Vegard's law, Interstial Solid Solutions, Hume-Rothery rules, Phase diagrams for binary alloys; Martensitic transitions

Unit III: **12 Hrs.**

Disordered Systems
Disorder in condensed matter- substitutional, positional and topographical disorder; Short and long-range order; Atomic correlation function and structural descriptions of glasses and liquids; Anderson model; mobility edge; Minimum Metallic Conductivity, Qualitative application of the idea to amorphous semiconductors and hopping conduction

Unit IV: **10 Hrs.**

Nanomaterials
Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in infinitely deep square well, confinement of two and one dimensional well, idea of quantum well structure, tunneling through potential barrier, quantum dots, quantum wires, introduction to fullerenes and graphenes

Unit V: **10 Hrs.**

Experimental techniques for Nanomaterials
Different methods of preparation of nanomaterial, Sol-gel and chemical bath deposition method, effect of temperature on the size of the particles. Bottom up: cluster beam evaporation, ion beam deposition, top down: ball milling. DC and RF sputtering.

BOOKS RECOMMENDED:

- W.A. Harison : Pseudo potentials in the theory of metals; W.A. Benjamin Inc. 1966, New York, Amsterdam
- N.H. March: Liquid Metals: Concepts and Theory; Cambridge University Press
- T. E. Faber: An introduction to the Theory of liquid metals; Cambridge University Press
- Egelstaff: An introduction to the liquid state; Academic Press INC. (London)
- Hansel and Mc Donald: Theory of Simple liquids; Academic Press INC. (London)
- March, Young and Saupenthe : Many Body Problems.
- March and Tosi : Atomic Motions in Liquids; Dover Publications
- March, Tosi and Street: Amorphous solids and the Liquids State, Plenum, 1985.
- Dugdale : Electrical Properties of Metals and Alloys; Edward Arnold (June 1977)
- M. Shimoji : Liquid Metals; Academic Press Inc (December 1977)
- P.I. Taylor: A. Quantum Approach to the Solid State, Prentice Hall

- L. Azaroff: Introduction to Solids; McGraw-Hill Companies; New edition edition (1984)
- Srinivasan: Science of Engineering Materials; John Wiley & Sons
- Hand Book of nano-structured Materials & Nanotechnology- Ed. Hari Singh Nalwa (Vol.1 to 4);
- C. Kittal, Quantum theory of Solids
- Pride- An introduction to Condensed Matter Physics
- K.K. Chattopadhyay and A.N. Banerjee; Introduction to Nanoscience and Nanotechnology; PHI
- Sulabha K. Kulkarni; Nanotechnology Principles and Practice; Springer
- David K. Ferry, Stephen M. Goodnick and Jonathan Bird; Transport in Nanostructures;Cambridge University Press (2009)
- J.H. Fendler; Nanoparticles and Nanostructured Films: Preparation, Characterization and Application; Wiley-VCH(1998)

PAPER CODE-PHY 424(B)
Microwave Electronics- II
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To make students learn construction and working of microwave solid state devices.
2. To acquaint the students about microwave experimentation needed for research and industry.
3. To equip students with the practical knowledge of microwaves, so that they prove to be useful manpower to the microwave industry.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 424(B)	**Microwave Electronics- II (Theory)**	**The students will be able to –** **CO149:** Have knowledge of Avalanche Transit Time Device and Transferred Electron Device and differentiate between them. **CO150:** Explain and analyse various microwave devices. **CO151:** Have knowledge of antennas in communication systems., Analyze the radiation mechanisms of antennas and develop an ability to discriminate between antennas on the basis of their electrical performance.	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, Power Point Presentation.problem solving in tutorials **Learning activities for the students:**	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		CO152: Understand the significance of microwave communication. **CO153:** Explain the basics of satellite communication	Self learning assignments, Effective questions, Seminar presentation. Additional learning through online videos and MOOC courses	

CONTENTS

Unit I: **12 Hrs.**

(a) **Avalanche Transit Time Device**: Read Diode, Negative resistance of an avalanching p-n junction diode ,IMPATT and TRAPATT Oscillator.

(b) Transferred Electron Device: Gunn Effect, two valley model, High field domains, Different modes for Microwave generation.

Unit II : **13 Hrs.**

Microwave Devices : Termination (Short circuit and mathced terminations) Attenuator, Phase changers, E & H plane Tees, Hybrid Junctions. Directional coupler. Parametric Amplifier: Varactor, Equation of Capacitance in Linearly graded & Abrupt p-n Junction, Manely Rowe relations, parametric upconvertor and Negative resistance parametric amplifier, use of circulator, Noise in parametric amplifiers.

Unit III: **13 Hrs.**

Microwave Antennas: Introduction to antenna parameters, Magnetic Currents, Electric and magnetic current sheet, Field of Huygen's source, Radiation from a slot antenna, open end of a wave guide and Electromagnetic Horns. Parabolic reflectors, Lens antennas. Radiation fields of Microstrip wave guide, Microstrip antenna calculations, Mircrostrip design formulas.

Unit IV: **11 Hrs.**

Microwave Communications: Modes of Microwave Communication: LOS, Diffraction, Troposphere, Line of sight microwave system, Derivation of LOS communication range, Over the Horizon microwave systems, Derivation of fields strength of tropospheric waves, Transmission, interference and signal damping, Duct propagation.

Unit V: **11 Hrs.**

Satellite Communication : Satellite orbits, Satellite location with Synchronous satellites, Satellite location with respect to earth and looks angle, earth coverage and slant range, Eclipse effect, Link calculation, Noise consideration, Factors Affecting satellite communication.

BOOKS RECOMMENDED:

1. Electromagnetic & Radiating Systems : Jordan & Balamin.
2. Theory and application of microwaves by A.B. Brownwell & R.E. Beam (Mc Graw Hill.)
3. Introduction to microwave theory by Atwater (Mc Graw Hill).
4. Microwave by M.L. Sisodia & Vijay laxmi Gupta.
5. Microwave Electronics by R.F. Soohoo (Addisen Welsey Publ. Comp.).
6. Foundations of microwave engineering by R.E. Collin. (Mc Graw Hill).
7. Solid State physical electronics by a. Vanderziel, (PHI India).
8. Semiconductors & Electronic devices by A. Barlevc (CPHI, India.)
9. Hand book of microwave measurement Vol-II by M. Sucher & J. Fox (Polytechnic Press, New York).
10. Microwave device & circuits by S.Y. Liao (HPI, India).
11. Solid State physical electronics by B G Steelman (PHI, India).
12. Microwave Principles by H.J. Reich (CBS).
13. Simple microwave technique for measuring the dielectric parameters of solids & their powder by J.M. Gandhi, J.S. Yadav, J. of pure & applied physics Vol 30, pp-427-431, 1992.

PAPER CODE-PHY 424(C)
Nanotechnology – II
(Theory)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 60

Course Objectives:

This course will enable the students to –

1. To introduce the types and Properties of Nanomaterials, Carbon Nanotubes, Nanoelectronics & analysis techniques.
2. To provide a basic understanding of the physical laws and effects that are active in the nano-world.
3. To outline the relationship between the physical laws and the extraordinary properties of nanodevices.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	**Paper Title**			
PHY 424(C)	**Nanotechnology – II (Theory)**	**The students will be able to –** **CO154:** Learn about various types of nanomaterials, structural ,electrical , optical and magnetic properties of nanomaterials. **CO155:** Understand synthesis and properties of Carbon nanotubes and porous Silicon. **CO156:** Learn electronic and magnetic behavior of nanoparticles, spin	**Approach in teaching:** Interactive Lectures, Discussion, Tutorials, Demonstration, problem solving in tutorials. **Learning activities for the students:** Self learning assignments, Effective questions, Simulation,	Class test, Semester end examinations, Quiz, Solving problems, Assignments, Presentations

		tunneling through magnetic junctions and magnetoresistance. **CO157:** Understand the practical application and advantages of nanomaterials in various fields for example energy generation and storage memory devices.	Seminar presentation, Giving tasks Additional learning through online videos and MOOC courses	

CONTENTS

Unit I: **12 Hrs.**

Types and Properties of Nanomaterials: Clusters and their types, Semiconductor Nanoparticles-Effective Mass Approximation, Optical Properties of Semiconductor nanoparticles, Plasmonic Material-localized surface Plasmon resonance, Surface plasmon Polariton, Nanomagnetism and Types of magnetic material, Mechanical and Structural Properties of Nanomaterials.

Unit II : **12 Hrs.**

(a) Nanomaterials: Carbon Nanotubes- types of Carbon Nanotubes (CNT's), Synthesis and Properties and Structure of CNT's, Synthesis, Properties & Structure of Porus Silicon, Aerogels and Zeolites.

(b) Nanoelectronics: Coulomb Blockade, Single Electron Transistor (SET), Sprintonics-Gaint magneto Resistance, Spin Valve, Magnetic Tunnel Junction (MTJ), Spin Field Effect Transistor (SFET).

Unit III: **12 Hrs.**

Analysis Techniques- I: Microscopy-Optical and Confocal Microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Atomic Force Microscope (AFM), Scanning Near-Field Optical Microscope (SNOM)

Unit IV: **12 Hrs.**

Analysis Technique -II: Spectroscopy- Optical Absorption Spectrometer, Infrared Spectrometer, Dispersive Infrared Spectrometer, Fourier Transform Infrared Spectrometer (FTIR), Raman Spectroscopy, Photoluminescence Spectrometer, X-Ray Photoelectron Spectrometer (XPS), Auger Electron Spectroscopy.

Unit V: **12 Hrs.**

Applications of nanomaterials: Molecular and Nanoelectronics, Nanobots, Quantum well and Quantum dot devices, Photovoltaics, Fuel Cell, Hydrogen Strorage, Hybrid Energy Cells, Automobiles, Textiles, Medical Field, Space, defence and Engneering, Polymer LED, Organic LED, Spin based data storage.

BOOKS RECOMMENDED:

- Nanotechnology: Principle and Practices, S.K. KulKarni, Capital Publishing Company (2015).
- Physics of Semiconductor Nanostructures, K. P. Jain, Narosa Publishers (1997).
- Nanostructures: theory and modeling, C. Delerue and M. Lannoo, Springer Verlag (2006).
- Nanotechnology: An Introduction to Nanostructring techniques, M. Kohler, W. Fritzche, Wiley-VCH (2007).
- Carbon Nanotubes: Synthesis,Structure, Properties and Applications, M.S. Dresselhaus, G. Dresselhaus, Ph.Avouris, Springer (2001).
- Carbon Nanotubes; Properties and Applications, Michael J.O. Connell, CRC Press (2006).
- Nanostructure and Nanomaterials:Synthesis, Properties and Applications, G. Cao and Ying Wang, World Scientific Publishing (2011)
- Characterization of Nanophase material, Zhong lin Wang, Wiley-VCH Verlag (2001).
- Introduction to Magnetic Materials, B.D. Cullity and C.D. Graham; Wiley, A John (2011).
- Nanotechnology: Basic Science & Emerging Technologies, M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Chapman & Hall/CRC Press (2002).

PAPER CODE-PHY 425
Dissertation/ Project
(Dissertation)

Credits: 12
Maximum marks: 100
Contact Hrs/Week: 12
Total Hrs: 180

Course Objectives:

This course will enable the students to –

To give an exposure of research to students, dissertation has been introduced in semester IV. Candidate is required to carry out a minor research project on any topic of choice (based on synopsis prepared in Semester III) under the supervision of an allotted research supervisor. The students will conceptualize the project/ dissertation, performs its execution, presents the outcome in the form of a report and power point presentation and defends it while questioned in the viva voce.

Course outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
PAPER CODE	Paper Title			

PHY 425	**Dissertation / Project (Dissertation) (Theory)**	**The students will be able to –** **CO158:** performing a literature review & writing a theoretical/conceptual framework; **CO159:** researching the design or approach to the problem; **CO160:** collecting and analysing the data and/or designing and validating the design; **CO161:** drawing conclusions and giving recommendations.	**Approach in teaching:** Interaction, Discussion, Demonstration, Experiment conduction **Learning activities for the students:** Self learning assignments, Effective questions, conduction of experiment, observation, analysis and interpretation of result.	Continuous Assessment, Presentation, Report , Viva Voce, Semester end examinations

(deemed to be UNIVERSITY)
JAIPUR

Programme- M.Sc. Statistics

OUTCOMES - Academic Year- 2020-21

PROGRAMME OUTCOMES

PO1	Analyse the given scientific data critically and systematically and will have the ability to draw the objective conclusions. Know basics of cognitive biases, mental models, logical thinking, scientific methodology and constructing cogent scientific arguments. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of this course. Students will become critical thinker and acquire problem solving capabilities.
PO2	Keenly observe about what is going on in the natural surroundings to awake their curiosity and design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
PO3	Apart from the research jobs, students can also work or get jobs in Marketing, Business & Other technical fields. Science graduates also recruited in the bank sector to work as customer service executives. Students can also find employment in government sectors. Often, in some reputed universities or colleges in India and abroad the students are recruited directly by big MNC's after their completion of the course.
PO4	Acquire the ability to engage in independent and self learning as well as to successfully pursue their career objectives in advanced education and in professional courses, in a 22 scientific career in government or industry, in a teaching career in the school systems, or in a related career following graduation. Understand the importance of modern branches of science like genetic engineering for the improvement of human race.

PO5	Students are trained to be an individual with concern for the society they live and to contribute at maximum, their skills and knowledge in the broadest context, for the development of the nation.
PO6	Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses. Students are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
PO7	Develop scientific outlook not only with respect to science subjects but also in all aspects related to life. It will also enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination. Students will gain knowledge and skills for further higher studies, competitive examinations and employment.
PO8	Digitally literate to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
PO9	Students will learn team workmanship with productive cooperation's involving members from diverse socio-cultural backgrounds in order to serve efficiently institutions, industry and society.
PO10	Develop various skills like Use of IT (word-processing, use of internet, statistical packages and databases), Communication of scientific ideas in writing and orally,. Ability to work as part of a team, Ability to use library resources, Time management and Career planning.
PO11	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and development of the information to provide valid conclusions.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Gives a platform to students for pursuing higher degree and research.
PSO 2	Students become more computer friendly as they learn various functions of statistical software like Excel, R, SPSS and Python to analyse the statistical data during the programme duration.
PSO 3	Ability to use skills in Statistics and different practicing areas for formulating and tackling data related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics
PSO 4	Improving problem solving skills that are required to solve different types of Statistics related problems with well-defined solutions, and tackle open-ended problems that belong to the other disciplinary-area boundaries.
PSO 5	Enhances theoretical rigor with technical skills which prepare students to become globally competitive to enter into a promising professional life.
PSO 6	This program offers opportunities in academics, Govt. Service, IAS, Indian Statistical Services, Industries, Banking and Insurance Sectors, CSO and NSSO, Research Personnel/Investigator in Govt. organizations such as NCAER, IAMR, ICMR, Statistical and Economic Bureau & various PSUs, MNC as data analyst, actuarial science.
PSO 7	Ready to deal with the problems related to quality control of product during process and also after the completion of product in industry, removal of outliers, market demand and supply, income and expenditure, comparing the price, quantity and value indices.
PSO 8	Ability to analyse the cost of transportation of material and product, stocking of material at minimum cost, minimize waiting time and select the priority among different goals to obtain maximum profit in market.
PSO 9	Analyse the behaviour of the population and sample data and also obtain the appropriate Univariate, bivariate and multivariate distributions and to compare two or more population parameters using parametric and non-parametric test.
PSO 10	Students gain a deeper knowledge to generate the model based on time from the raw data and perform forecasting based on them.

PSO 11	Ability to generate and compare various national and international life tables and vital events of different groups or places so that they are able to generate new policies for individuals and groups.
PSO 12	Get knowledge about the population characteristics and be able to compare by applying an appropriate method of probability and non-probability sampling. If the students opt for the advance paper of sampling then they will be eligible for research, government and non-government projects regarding the conduction of surveys.
PSO 13	Able to analyse the data properly when the population is not known using various designs. If the students opt the advance paper of design they will be eligible for jobs in agricultural departments, and also for higher research.
PSO 14	Ability to generate and infer confidence intervals, obtain sample statistic to estimate the population parameters, also check the accuracy of parameters.
PSO 15	Ability to develop a new model on already existing economic theories and also check and remove the discrepancies of the model.
PSO 16	Ability to analyse the market policies for different group of population and also develop new policies model based on given vital information.
PSO 17	Analyse the reliability of a model, develop new models and connect it with biological behaviour of data. If students opt clinical and survival analysis and reliability analysis then they are eligible for jobs in medical field as scientist.

COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

Course	**COS**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**	**PSO11**	**PSO12**	**PSO13**	**PSO14**	**PSO15**	**PSO16**	**PSO17**
STT 121	**CO1**	x		x	x	x	x											
	CO2	x		x	x	x	x											

	CO3	x		x	x	x	x											
	CO4	x		x	x	x	x											
	CO5	x		x	x	x	x											
STT 122	**CO6**	x		x	x	x	x			x								
	CO7	x		x	x	x	x			x								
	CO6	x		x	x	x	x			x								
	CO8	x		x	x	x	x			x								
	CO9	x		x	x	x	x											
	CO10	x		x	x	x	x											
STT 123	**CO11**	x		x	x	x	x			x								
	CO12	x		X	x	x	x			x								
	CO13									x								
	CO14									x								
STT 124	**CO15**	x		x	x	x	x			x					x			
	CO16	x		x	x	x	x			x					x			
	CO17	x		x	x	x	x			x					x			
	CO18	x		x	x	x	x			x					x			
	CO19	x		x	x	x	x								x			
STT 125	**CO20**	x	x	x	x	x	x											

	CO21	x	x	x	x	x	x											
	CO22	x	x	x	x	x	x											
	CO23	x	x	x	x	x	x											
	CO24	x	x	x	x	x	x											
	CO25	x	x	x	x	x	x											
	CO26	x	x	x	x	x	x											
STT 126	**CO27**	x	x	x	x	x	x			x								
	CO28	x	x	x	x	x	x			x					x			
STT 221	**CO29**	x		x	x	x	x											
	CO30	x		x	x	x	x											
	CO31	x		x	x	x	x											
STT 222	**CO32**	x		x	x	x	x			x								
	CO33	x		x	x	x	x								x			
	CO34	x		x	x	x	x								x			
	CO35	x		x	x	x	x											
	CO36	x		x	x	x	x											
STT	**CO3**	x		x	x	x	x						x					

223	**7**																	
	CO38	x		x	x	x	x						x					
	CO39	x		x	x	x	x						x					
	CO40	x		x	x	x	x						x					
STT 224	**CO41**	x		x	x	x	x							x				
	CO42	x		x	x	x	x							x				
	CO43	x		x	x	x	x							x				
	CO44	x		x	x	x	x							x				
STT 225	**CO45**	x	x	x	x	x	x											
	CO46	x	x	x	x	x	x											
	CO47	x	x	x	x	x	x											
STT 226	**CO48**	x	x	x	x	x	x											
	CO49	x	x	x	x	x	x											
STT 321	**CO50**	x		x	x	x	x			x					x			
	CO51	x		x	x	x	x			x					x			
	CO52	x		x	x	x	x								x			
	CO53	x		x	x	x	x								x			

	CO54	x		x	x	x	x								x			
STT 322	**CO55**	x		x	x	x	x			x								
	CO56	x		x	x	x	x											
	CO57	x		x	x	x	x											
STT 323	**CO58**	x		x	x	x	x		x									
	CO59	x		x	x	x	x		x									
	CO60	x		x	x	x	x		x									
	CO61	x		x	x	x	x		x									
	CO62	x		x	x	x	x		x									
STT 324 (A)	**CO63**	x		x	x	x	x					x				x		
	CO64	x		x	x	x	x					x				x		
	CO65	x		x	x	x	x					x				x		
STT 324 (B)	**CO66**	x		x	x	x	x					x				x		
	CO67	x		x	x	x	x					x				x		
	CO68	x		x	x	x	x					x				x		
	CO69	x		x	x	x	x					x				x		
	CO7	x		x	x	x	x					x				x		

	0																	
STT 324 (C)	**CO71**	x		x	x	x	x					x					x	
	CO72	x		x	x	x	x					x					x	
	CO73	x		x	x	x	x					x					x	
	CO74	x		x	x	x	x					x					x	
STT 325	**CO75**	x	x	x	x	x	x											
	CO76	x	x	x	x	x	x			x								
	CO77	x	x	x	x	x	x		x									
	CO78	x	x	x	x	x	x		x									
	CO79	x	x	x	x	x	x		x									
STT 326	**CO80**	x		x	x	x	x											
	CO81	x		x	x	x	x											
STT 421	**CO82**	x		x	x	x	x									x		
	CO83	x		x	x	x	x									x		
	CO84	x		x	x	x	x									x		
	CO85	x		x	x	x	x									x		
	CO86	x		x	x	x	x									x		

	CO87	x		x	x	x	x									x		
	CO88	x		x	x	x	x									x		
STT 422 (A)	**CO89**	x		x	x	x	x	x										
	CO90	x		x	x	x	x	x										
	CO91	x		x	x	x	x	x										
	CO92	x		x	x	x	x	x										
STT 422 (B)	**CO93**	x		x	x	x	x											
	CO94	x		x	x	x	x											
	CO95	x		x	x	x	x											
	CO96	x		x	x	x	x											
STT 422 (C)	**CO97**	x		x	x	x	x	x		x								
	CO98	x		x	x	x	x	x		x								
	CO99	x		x	x	x	x	x		x								
STT 423 (A)	**CO100**	x		x	x	x	x							x				x
	CO101	x		x	x	x	x							x				x
	CO102	x		x	x	x	x							x				x
	CO1	x		x	x	x	x							x				x

	03																	
	CO1 04	x		x	x	x	x							x				x
STT 423 (B)	**CO1 05**	x		x	x	x	x						x					
	CO1 06	x		x	x	x	x						x					
	CO1 07	x		x	x	x	x						x					
	CO1 08	x		x	x	x	x						x					
STT 423 (C)	**CO1 09**	x		x	x	x	x											
	CO1 10	x		x	x	x	x											
	CO1 11	x		x	x	x	x											
	CO1 12	x		x	x	x	x											
STT 423 (D)	**CO1 13**	x		x	x	x	x											
	CO1 14	x		x	x	x	x											
	CO1 15	x		x	x	x	x											
	CO1 16	x		x	x	x	x											
	CO1 17	x		x	x	x	x											
STT 424	**CO1 18**	x	x	x	x	x	x											
	CO1 19	x	x	x	x	x	x											

	CO1 20	x	x	x	x	x	x											
	CO1 21	x	x	x	x	x	x											
	CO1 22	x	x	x	x	x	x											
	CO1 23	x	x	x	x	x	x											
	CO1 24	x	x	x	x	x	x											
	CO1 25	x	x	x	x	x	x				x							
	CO1 26	x	x	x	x	x	x				x							
	CO1 27	x	x	x	x	x	x				x							
STT 425	**CO1 28**	x	x	x	x	x	x											
	CO1 29	x	x	x	x	x	x											
	CO1 30	x	x	x	x	x	x											

M.Sc. STATISTICS (2020-2021)

COURSE OUTCOMES - Semester I

PAPER CODE - STT121
Statistical Mathematics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT121	**Statistical Mathematics (Theory)**	**The students will be able to –** **CO1:** Understand the concept of a vector space, base and dimension of vector space and linear transformation of vectors. **CO2:** Use the concept of matrices, rank, characteristic roots, Cayley Hamilton theorem and applications. **CO3:** Define special matrices and solve problems related to Quadratic forms. **CO 4:** Understand the concept of sequence, series, continuity and differentiability of real numbers and maxima-minima of functions. **CO 5:** Understand numerical methods related to differentiation, integration and finding numerical solution of nonlinear equations and ordinary differential equations.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Vector space, sub space, linear combination of vectors, linearly dependent and independent vectors, basis and dimension, linear transformations of vectors, nullity and rank of linear transformation (Sylvester Theorem), Algebra of linear transformations(elementary properties).

Unit –II **15 Hrs.**

Matrix: Basic terminology, row and column space, Echleon form, determinants, rank and inverse of matrix, characteristics roots and vectors, Caley- Hamilton Theorem and applications.

Unit-III **12 Hrs.**

Special matrices: idempotent, orthogonal and symmetrical, reduction of a real symmetric matrix to a diagonal form. Quadratic forms: definition, reduction and classification, simultaneously reduction of two quadratic forms, maxima- minima of ratio of quadratic form.

Unit-IV **15 Hrs.**

Real analysis: sequence and their convergence, real valued function, continuous function, discontinuity: Borel covering theorem, Boundness theorem and moistest theorem, differentiation, maxima and minima of one variable function.

Unit-V **18 Hrs.**

Numerical integration, trapezoidal, Simpsons 1/3 and 3/8 rule, solution of system of linear equations: Gauss estimation, Jacobi, Gauss-Seidel method. Numerical solution of nonlinear equations: Bisection method, Regula-Falsi method, Method of Iteration, Newton Rapson method. Numerical solution of ordinary differential equation: Runge-Kutta method.

BOOKS RECOMMENDED

- Apostol, T.M. (1985): Mathematical Analysis, Narosa Publishing House.
- Burkill,J.C.(1980):A first Course in Mathematical Analysis, Vikas Publishing House.
- Cournat, R.and John, F. (1965): Introduction to Calculus and Analysis, John Wiley.
- Khuri,A.l(1983): Advanced Calculus with Applications in Statistics, John Wiley.
- Miller,K.S.(1957): Advanced Real Calculus, Harper, New York.
- Sastry S.S. (1987): Introductory Methods of Numerical Analysis, Prentice Hall.
- Saxena,H.C (1980).: Calculus of Finite Difference, S. Chand & Co.
- Searle, S.R.(1982): Matrix Algebra Useful for Statistics, John Wiley
- Shanti Narayan,(1998):A Textbook of Matrices , S. Chand & Co, 12th revised edition.
- Harville, DA. (1997): Matrix Algebra from a Statistician's Perspective, Springer.
- Searle, SR. (1982). Matrix Algebra Useful for Statistics, John Wiley.
- Rao, A.R. and Bhimasankaram, P(1992) : Linear algebra, Tata –McGraw-Hill Publishing Co. Ltd.
- Rao,C.R., Mithra,S.K. (1971) : Generalized inverse of matrices and its applications, John Wiley & Sons Inc.

PAPER CODE - STT122
Probability Theory
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes
(at course level)</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>STT122</td><td>Probability Theory (Theory)</td><td>The students will be able to –

CO6: Able to apply discrete and continuous probability distribution to various practical problems.
CO7: Deep knowledge about Weak laws and strong laws of large numbers.
CO8: Able to deal with the applications of law of large numbers.
CO9: Understanding the use of probability theory to solve industry related problems.
CO10: Compute the characteristic functions of some distributions.</td><td>Approach in teaching:

Interactive Lectures, Discussion, Power Point Presentations, Informative videos

Learning activities for the students:
Self learning assignments, Effective questions, presentations, Field trips</td><td>Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination</td></tr>
</table>

CONTENTS

Unit-I **15 Hrs.**

General probability space, various definition of probability, combinations of events, additive and multiplicative law of probability, conditional probability, Bayes' theorem and its application.

Unit –II **15 Hrs.**

Concept of random variable, cumulative distribution function, probability distribution function, joint probability distribution function, marginal distribution function and their application, conditional distribution function and conditional probability distribution function of random variables and their distributions using: jacobian transformation, cumulative distribution function, moment generating function.

Unit-III **15 Hrs.**

Mathematical Expectation, moments, Sheppard's correction, conditional expectation, moment generating function and their applications, cumulant generating function and their applications, characteristic function and its applications. Inversion Theorem, Continuity Theorem, Uniqueness Theorem.

Unit-IV **15 Hrs.**

Levy's continuity theorem (statement only), probabilities inequalities and their applications, Chebychev inequality, Markov and Jenson inequality. Convergence in probability and convergence in distribution, weak law of large numbers,

Unit-V **15 Hrs.**

Central limit theorem: De-Moivre's Laplace, Liaponouff, Lindeberg-Levy and their simple problems, Zero-One law of Borel and Kolmogorov almost sure convergence in mean square, strong law of large numbers.

BOOKS RECOMMENDED

- Kingman, J.F. & Taylor, S.J. (1996): Introduction to Measure and Probability, Cambridge Univ. Press.
- Loeve (1996): Probability Theory, Affiliated East –West Press Pvt. Ltd. New Delhi.
- Bhatt, B.R. (2000): Probability, New Age International India.
- Feller,W.(1971): Introduction to Probability Theory and its Applications, Vol. I and II. Wiley, Eastern-Ltd.
- Rohatgi, V.K (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, third edition.
- Billingsley, P. (1986): Probability and Measure, John Wiley Publications, forth edition.
- Dudley, R.M. (1989): Real Analysis and Probability, Worlds Worth & Books.
- Tucket H.G. (1967): A Graduate Course in Probability, Academic Press.
- Basu, A.K. (1999): Measure Theory and Probability, PHI.

PAPER CODE - STT123
Probability Distributions
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course lays the foundation of probability distributions and sampling distributions, their application which forms the basis of Statistical Inference.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT123	**Probability Distributions (Theory)**	**The students will be able to –** **CO11:** Identify the behavior of the population and sample and their distribution. **CO12:** Able to derive the probability distributions function of random variables and use these techniques to generate data from various distributions. **CO13:** Analyse the behaviour of the data by Fitting the discrete and continuous distributions. **CO14:** Able to translate real-world problems into probability distributions.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Bernoulli distribution, Binomial distribution (compound and truncated also), Poisson distribution (compound and truncated also)- moments, moment generating function, Cumulant generating function, characteristic functions, recurrence relations, properties, fitting of distributions

Unit –II **15 Hrs.**

Geometric distribution, Negative Binomial distribution, Hyper-geometric distributions, Power Series distribution- moments, moment generating function, cummulant generating function, characteristic functions, recurrence relations, properties, fitting of distributions

Unit-III **15 Hrs.**

Rectangular distribution, Normal distribution (truncated also), Exponential distribution, Lognormal distribution, Multinomial of binomial and Poisson- moments, moment generating function, cummulant generating function, characteristic functions, recurrence relations, properties, fitting of distributions

Unit-IV **15 Hrs.**

Triangular distribution, Gamma distribution (one and two parameter) , Beta distribution(I kind and II kind) Cauchy distribution (truncated also), Laplace distributions, Pearson's distribution (Type I, IV and VI)

Unit-V **15 Hrs.**

Chi-Square, t and F distributions (central and non-central) and their applications. Large sample test. Fisher's Z distributions and their applications. Order statistics: their distributions and properties; joint and marginal distributions of order statistics, sampling distributions of range and median of univariate population.

BOOKS RECOMMENDED

- Goon, Gupta & Das Gupta. (2003): Outline of Statistical Theory. Vol. I, World Press.
- Hogg, R.V. and Craig, A.T.(2009): Introduction to Mathematical Statistics, McMillan.
- Johnson, S. and Kotz. (1972): Distribution in Statistics, Vol.I, II. And III, Houghton and Muffin.
- Kendall, M.G. and Stuart. (1996): An Advanced Theory of Statistics, Vol. I,II. Charls Griffin.
- Mood, A.M., Graybill, F.A. and Boes, D.C.(2007): Introduction to the Theory of Statistics, McGraw Hill, third edition.
- Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency (P) Ltd.
- Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, third edition.

PAPER CODE - STT124
Statistical Inference-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
STT124	**Statistical Inference-I (Theory)**	**The students will be able to –** **CO15:** Identify the samples following parametric and non-parametric distribution. **CO16:** Obtain the point estimator and interval estimator of the parameters. **CO17:** Apply the significance level as	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for**	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester

		the probability of rejecting a true null hypothesis. **CO18:** Construct and interpret a confidence interval about the population parameters. **CO19:** Apply the application of sequential statistical techniques on various probabilities.	**the students:** Self learning assignments, Effective questions, presentations, Field trips	End Examination

CONTENTS

Unit-I **15 Hrs.**

Point estimation, criteria of a good estimator: unbiasedness, consistency, efficiency and sufficiency. Concept of sufficient statistics, Fisher Neyman factorization theorem, Cramer-Rao inequality, Bhattacharya Bounds, Rao-Blackwell theorem, Completeness and Lehmann-Scheffe theorem, Uniformly minimum variance unbiased estimator, minimal sufficient statistic.

Unit –II **15 Hrs.**

Methods of Estimation: Maximum likelihood method, moments, minimum Chi-square and modified minimum Chi-square methods. Properties of maximum likelihood estimator (without proof). Confidence intervals: Determination of confidence intervals based on large samples, confidence intervals based on small samples.

Unit-III **15 Hrs.**

Statistical Hypothesis: Simple and composite, procedure of testing of hypothesis, critical region, types of errors, level of significance, p-value, power of a test, most powerful test and Neyman-Pearson fundamental lemma.

Unit-IV **15 Hrs.**

Sequential Analysis: Definition and construction of S.P.R.T. Fundamental relation among, A and B. Wald's inequality for testing null hypothesis v/s alternative hypothesis. Determination of A and B Average sample number and operating characteristic curve, and determination of OC and ASN functions through Wald's fundamental identity.

Unit-V **15 Hrs.**

Non-Parametric Tests: Sign tests, signed rank test, Kolmogorov-Smirnov one sample test. General two sample problems: Wolfowitz runs test, Kolmogorov Smirnov two sample test (for sample of equal size), Median test, Wilcoxon-Mann-Whitney U test. Test of randomness using run test based on the total number of runs and the length of a run. Kendall's Tau test for independence of correlation, Kruskal Wallis K sample test and concept of asymptotic relative efficiency(ARE).

BOOKS RECOMMENDED

- Casela G & Berger RL. (2002): Statistical Inference. Duxbury Thompson Learning.
- Conover WJ. (1980): Practical Nonparametric Statistics. John Wiley.
- Kiefer JC. (1987): Introduction to Statistical Inference. Springer.

- Lehmann EL. (1986) Theory of Point Estimation. John Wiley.
- Wald A. (2004) Sequential Analysis. Dover Publ.
- Cramer, H.(1946) : Mathematical methods of Statistics, Princeton University Press.
- Goon and others.(2003): Outline of Statistical theory Vol-I, World Press.
- Rao, C.R. (1973) : Linear Statistical inference and its applications, 2nd Ed, John Wiley & Sons Inc.
- Gibbons, J.D. (1985): Non- Parametric Statistical Inference, McGraw-Hill.
- Kendall, M.G. and Stuart, A. (1971): Advanced Theory of Statistic Vol. I and II, Charles Griffin.
- Mood, Graybill and Boes. (1974): Introduction to the theory of Statistics 3rded, McGraw- Hill.
- Hogg,R.V. and Craig,A.T.(2005): Introduction to Mathematical Statistics, Princeton University Press, sixth edition.
- Rao, C. R. (2002): Linear Statistical Inference and its Applications, Willey- Blackwell
- Gibbons (1971): Non Parametric Inference, Chapman and Hall
- Sidney and Siegal (1956): Non Parametric for Behavioral science, Mcgraw-Hill Book Company

PAPER CODE - STT125
Practical-I
(Practical)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 8
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This paper is designed so that the student get familiar with statistical software for solving the problems based on various mathematical operations and also how to deal and analyse the probability of different data.

Course Outcomes (COs):

Course		**Learning outcomes (at course level)**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT125	**Practical-I (Practical)**	**The students will be able to –** **C CO20:** Able to solve linear systems of equation. **CO21:** Deal with numerical differentiation and integration. **CO22:** Ability to apply numerical methods for differential equation. **CO23:** Evaluate the determinant and inverse of a matrix and also find the solution of matrix equation. **CO24:** Compute various measures of	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations,	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

		central tendencies, dispersion, moments, Skewness, kurtosis and to interpret them. **CO25:** Able to find the probabilities of various events. **CO26:** Understand the concept of conditional probability and independence of events.	Field trips	

CONTENTS

1. Determinants - by row and column operations, by partitioning.
2. Inverses of a matrix - by row and column operations, by partitioning
3. Rank of a matrix
4. Solutions of matrix equations
5. Characteristic roots and vectors of a matrix
6. Interpolation using Lagrange's formula, Newton-Gregory formula
7. Interpolation using Newton's divided difference formula
8. Numerical differentiation using Newton's formula
9. Numerical differentiation using Lagrange's formula
10. Numerical integration using trapezoidal formula
11. Numerical integration using Simpson's one-third formula
12. Numerical integration using Simpson's three-eighth formula
13. Numerical integration using Runge Kutta Method
14. Coefficient of variation.
15. Calculation of raw moments, central moments, β_1, β_2 and γ_1, γ_2 coefficients, Sheppard's correction to moments.
16. Probability, Conditional Probability and Baye's theorem

Note: Practical exercises will be conducted on computer by using MS-Excel/ Matlab/ SPSS/R.

PAPER CODE - STT126
Practical-II
(Practical)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 8
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on fitting of probability distributions, application of parametric and non-parametric test.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT126	**Practical-II (Practical)**	**The students will be able to –** **CO27:** Analyse the various data and ability to fit various distributions on data. **CO28:** Able to identify the problem and apply the test accordingly.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities.	Software based Assignments Individual Presentation Class Test

CONTENTS

1. Plot binomial curve for different values of n and p
2. Fitting of binomial distributions when p is known and when p is unknown.
3. Fitting of Poisson distribution when λ is known and when λ is unknown.
4. Fitting of negative binomial distribution.
5. Fitting of Normal distribution
6. Calculation of areas under normal curve.
7. Small sample tests viz. t, F, Chi- Square.
8. Bartlett's test for homogeneity of variances.
9. Test of significance of sample correlation coefficient.
10. Sign, median and run tests for small and large samples.
11. Kolmogorov- Smirnov one and two sample test.
12. Kruskal Wallis K sample test.
13. Wilcoxon-Mann-Whitney U test.
14. Kendall Tau Test.
15. Sequential probability ratio test and calculation of constants and graphical representation for testing simple null against simple alternative for (i) Binomial (ii) Poisson (iii) Normal (iv) Exponential distributions.
16. Large sample test

Note: Practical exercises will be conducted on computer by using MS-Excel/SPSS/R.

M.Sc. STATISTICS (2020-2021)

COURSE OUTCOMES - Semester II

PAPER CODE – STT221
Official Statistics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper aims at teaching the students to develop their knowledge to make comparisons between countries or understand changes in economic and social development

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT221	**Official Statistics**	**The students will be able to –** **CO29:** More familiar with institutional, legal and organizational bases, and principles of functioning of official statistics. **CO30:** Able to Judge implications of the functioning of official statistics and quality of data in official statistics, especially with regard to limitations that arise from measurement and processes of statistical production. **CO31:** Able to compare official statistics at national and international level.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Indian Official Statistics: Introduction related to the census and population, need, uses, users, relevance, transparency and its visibility. Methods of collecting, compilation, processing, analysis and dissemination of official data, their reliability and limitation. Comparison between Indian and international (UNDP) statistical system.

Unit –II **15 Hrs.**

National statistical organization: Role, functions and activities of central and state statistical organization: NSSO, CSO, Ministry of Statistics and Program implementation and special data dissemination systems.

Unit-III **15 Hrs.**

Economical Statistics: National Income**,** concept, issues and strategy, method of estimate national income, collection of data and release. inter-industry flows and table, Role, functions and acts of National statistical commission about population, industry and finance. Index numbers: different types, need, data collection mechanism, periodicities, agencies involved and uses.

Unit-IV **15 Hrs.**

Agricultural Statistics: Introduction, indicators, agencies and uses, crop forecasting and estimation, productivity, fragmentation of holdings, support price, buffer stock, impact of irrigation projects.

Unit-V **15 Hrs.**

Socio and economic indicators, gender awareness and statistics, important census and survey. Introduction, role, scope, merits and limitations: Trade Statistics, Labour Statistics, Educational Statistics

BOOKS RECOMMENDED

- Goon, A.M., Gupta, M.K. and Dasgupta, B. Das (2008): Fundamentals of Statistics, Volume II, The World Press Pvt Ltd, Calcutta, ninth edition.
- Guide to Current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
- Srivastava, S. S. and Asthana, B. N. (1965): Applied Statistics of India, Chaitnya Publishing House.

PAPER CODE – STT222
Regression Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT222	**Regression Analysis (Theory)**	**The students will be able to –** **CO32:** Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis for forecasting **CO33:** Develop a deeper understanding of the linear regression model and its limitations **CO34:** Determine whether a regression model is significant. **CO35:** Recognize regression analysis applications for purposes of description and prediction. **CO36:** Recognize some potential problems if regression analysis is used incorrectly	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Introduction to correlation and its types, Measures of correlation coefficient, multiple and partial correlation, intra class correlation and correlation ratio. Problem of correlated errors: Autocorrelation , Durbin Watson Statistics, Removal of auto Correlation by transformation. Analysis of collinear data, Detection and correction of multicollinearity, Coefficient of determination.

Unit –II **15 Hrs.**

Linear regression analysis, method of least square for regression curve fitting, regression coefficient and properties. Multiple and partial regression, examine the multiple regression equation, concept of weighted least square, regression equation on grouped data, various methods of selecting the best regression equation.

Unit-III **15 Hrs.**

Linear estimation, Gauss-Markoff's theorem. Estimable functions, error and estimate space, normal equation and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of matrix and solution of normal equations, variance and covariance of least square estimators

Unit-IV **15 Hrs.**

Linear model: fixed, random and mixed effects models. Analysis of variance, multiple comparisons test: Tukey, Scheffe and Student-Newmann-Kuel,Duncan.

Unit-V **15 Hrs.**

Regression diagnostic, normal probability plot, Goldfeld-Quandt test, Park test, Breusch- godfrey, Logistic regression.

BOOKS RECOMMENDED

- Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (1992): A First Course in Order Statistics. John Wiley.
- David, H.A. & Nagaraja, H.N. (2003): Order Statistics. 3rd Ed. John Wiley.
- Goon, Gupta & Das Gupta. (2003): Outline of Statistical Theory. Vol. I, World Press, 14^{th} edition.
- Hogg, R.V. and Craig, A.T. (2009): Introduction to Mathematical Statistics, McMillan.
- Johnson, S. and Kotz. (1972): Distribution in Statistics, Vol.I, II. And III, Houghton and Muffin.
- Kendall, M.G. and Stuart. (1996): An Advanced Theory of Statistics, Vol. I,II. Charls Griffin.
- Mood,A.M., Graybill, F.A. and Boes, D.C.(1974): Introduction to the Theory of Statistics, McGraw Hill, third edition.
- Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency (P) Ltd.
- Draper, N.R. & Smith, H. (1998): Applied Regression Analysis, 3rd Ed. JohnWiley.
- Ezekiel, M. (1963): Methods of Correlation and Regression Analysis, JohnWiley.
- Kutner, M.H., Nachtsheim, C.J. & Neter, J. (2004): Applied Linear Regression Models, 4th Ed. With Student, CD. McGraw Hill.
- Rohatgi, V.K. (2009): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
- C.R. Rao.(2001): Linear Models & Generalization.
- Kailath (2016): Linear Estimation.

PAPER CODE – STT223
Sampling Techniques
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

The students would be exposed to elementary, systematic, stratified and two stage sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes (at course level</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>STT223</td><td>Sampling Techniques (Theory)</td><td>The students will be able to –

CO37: Determine the sample is a simple random sample, a voluntary response sample, a convenience sample, or has other forms of sampling bias.
CO38: Analyse the data from multi-stage surveys.
CO39: Able to recognize typical forms of biases such as potential under coverage, non-response and response bias.
CO40: Identify the type of data and also able to take decision of appropriate sampling scheme.</td><td>Approach in teaching:
Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions

Learning activities for the students:
Assignments Seminar Presentation Subject based Activities</td><td>Classroom Quiz
Assignments
Class Test
Individual Presentation</td></tr>
</table>

CONTENTS

Unit-I **15 Hrs.**

Simple random sampling with and without replacement: Definition, properties, estimation of population mean, its variance and estimates of variance, optimum properties of sample mean, estimation of sample size, estimation of properties, Inverse sampling.

Unit –II **15 Hrs.**

Stratified Sampling: estimation of population, mean under proportional, optimum and Neyman allocation, comparison and estimation of gain in precision, Post stratification. Systematic sampling: estimation of mean, its variance and estimation of variance. Comparison with stratified sampling. Cluster sampling and two stage sampling with unequal number of second stage unit.

Unit-III **15 Hrs.**

Use of Auxiliary Information: Ratio, difference, regression and product methods of estimation and properties. Unbiased ratio type estimates: Hartley& Ross, Quenoullie's Techniques.

Unit-IV **15 Hrs.**

Double sampling and its uses in ratio estimation, Stratified sampling. Population proportion to size with replacement and without replacement (PPSWR or PPSWOR) sampling, cumulative total and Lahiri's method. Ratio estimator under varying probabilities, Midzuno scheme of sampling.

Unit-V **15 Hrs.**

Non Sampling errors: observational error, mathematical model, the sample mean, its variance and estimation of the variance. Non-Response error: Hanson and Horvitz, Politz & Simmon Warness technique.

BOOKS RECOMMENDED

- Cocharan, W.G.(1997): Sampling Techniques III ed, John Wiley Pub. New York.
- Murthy, MN. (1977) Sampling Theory and Methods, 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D., Singh, P. & Kumar P. (1982): Handbook on Sampling Methods, IASRI Publ.
- Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. & Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Chaudhuri, A. and Mukerjee, R. (1988):Randomized Responses .Theory and Techniques, New York : Marcel Dekker Inc.
- Des Raj and Chandok (1999): Sampling Theory, Norsa Pub. New Delhi.
- Sampath, S. (2000): Sampling theory and Methods, Narosa Publishing House.
- Singh, D. and Chaudhary ,F.S. (1986):Theory and Analysis of Sample Survey Designs, New Age International Publishers.
- Mukhopadhya, P.(1996): Inferencial Problems in Survey Sampling, New Age International.
- Singh, R. and Mangat, M.S. (1996): Elements of Sample Survey, Springer
- Singh, Sarjinder (2003): Advanced Sampling Theory with Applications: How Michael 'selected' Amy, Volume 2, Kluwer Academic Publishers

PAPER CODE – STT224
Design of Experiments
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
		The students will be able to –	**Approach in teaching:** Interactive Lectures,	Classroom Quiz Assignments

STT224	**Design of Experiments (Theory)**	**CO41:** Identify the behaviour of the experimental unit and recognize issues of non-independence. **CO42:** Deal with any type of data, check their normality assumptions. **CO43:** Able to construct the design and deal the problems of real world situation. **CO44:** Take decision on the output of the design and also identify the outliers.	Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Principles of design of experiments, uniformity trails, need of design of experiments, complete analysis of completely randomized design, randomized block design

Unit –II **15 Hrs.**

Complete analysis of Least square design. Analysis of covariance. Missing plot technique in RBD and LSD, Efficiency of LSD,RBD and LSD.

Unit-III **15 Hrs.**

Factorial Experiment 2^n and 3^2, Confounding: Total and partial confounding. Construction of confounded factorial experiments belonging to 2^n

Unit-IV **15 Hrs.**

Non orthogonal data: analysis of missing plot and mixed plot data. Split plot and strip plot designs. Balanced incomplete block design (intra - block analysis).

Unit-V **15 Hrs.**

Construction of complete sets of mutually orthogonal latin square.Construction of BIBD using mols. Simple methods of construction of BIB designs. Constructions of symmetrical fractional factorial experiments.

BOOKS RECOMMENDED

- Cochran, W.G. & Cox, G.M. (1959): Experimental Designs, 2nd Ed. John Wiley.
- Dean, A.M. & Voss, D. (1999): Design and Analysis of Experiments, Springer.
- Federer, WT. (1985): Experimental Designs, MacMillan.
- Fisher, R.A. (1966): Design and Analysis of Experiments, Oliver & Boyd, eighth edition.
- Nigam, A.K. & Gupta, V.K. (1979): Handbook on Analysis of Agricultural Experiments, IASRI Publ.
- Alok dey (1988): Theory of Block Design, Violester Willey Eastern

- Alok Dey (1999): Fraction Fractorial Plans, John Wiley & sons
- Das, M. N. and Giri C. (2002): Design and Analysis of Variance, John Wiley & sons Inc.
- John P.W.M. (1999): Statistical Design and Analysis of Variance, society for industrial mathematics.
- Raghava, Rao.(1971): Construction and Combinatorial Problems in Design of Experiments, John Wiley.
- Dey, Alok,(1987):Theory of Block Designs, John Wiley & Sons
- Joshi, D.D. (2003): Linear Estimation and Design of Experiments, John Wiley & sons

PAPER CODE – STT225
Practical
(Practical)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on descriptive statistics and bivariate data.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT225	**Practical (Practical)**	**The students will be able to –** **CO45:** Analyze statistical measures such as Covariance, correlation coefficient, rank correlation for bivariate data. **CO46:** Calculation, Interpretation and application of Correlation and Regression Analysis. **CO47:** Deal with the problems of partial and multiple correlations	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Software based Assignments Individual Presentation Class Test

CONTENTS

1. Correlation and regression(multiple and partial)
1. One-way classified data
2. Two way classification with single and equal observations
3. Two way classification with unequal observations
4. Analysis of BIBD.
5. Yates method for analysis 2^n factorial experiments : n=2,3,4
6. Total confounding in 2^n, n = 3, 4
7. Partial confounding in 2^n, n = 3, 4
8. 3^2factorial experiments
9. Analysis of covariance in one way classified data and two way classified data
10. Analysis of RBD, LSD with one and two missing observations.
11. Drawing of random samples from finite populations.
12. Estimation of population mean and estimation of variance in SRS with and without replacement.
13. Estimation of mean and variance in stratified sampling under proportional and optimum allocations.
14. Gain in precision due to stratification.
15. Estimation of mean and variance in systematic sampling and comparison with S.R.S.
16. Estimation of mean and variance in cluster sampling and comparison with S.R.S.
17. PPSWR Sampling: Cumulative total method, Lahri's method of sample selection/section, estimation of total and its variance.
18. Estimation of mean and variance by (i) ratio and (ii) regression methods of estimation.
19. Two-stage sampling method where f.s.u. being selected with pps with replacement and s.s.u. with equal prob. without replacement, Estimation of optimum number of s.u. and s.s.u.

Note: Practical exercises will be conducted on computer by using MS-Excel/ SPSS/R.

PAPER CODE – STT226
Seminar
(Seminar)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 4
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This has been incorporated, with the aim that a candidate does a review of literature on a topic of choice and prepares a Seminar under the supervision of a faculty.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT226	**Seminar (Seminar)**	**The students will be able to –** **CO48:** Able to review any topic with the help of already published paper. **CO49:** Develop the skill based on presentation, discussion, questioning.	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing

M.Sc. STATISTICS (2020-2021)

COURSE OUTCOMES - Semester III

PAPER CODE – STT321
Statistical Inference-I
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base in basic statistics that would help them in undertake basic and applied research in Statistics.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT321	**Statistical Inference-I (Theory)**	**The students will be able to –** **CO50:** Know the notion of a parametric model and point estimation of the	**Approach in teaching:** Interactive Lectures,	Classroom Quiz Assignments Class Test

		parameters of those models. **CO51:** Demonstrate computational skills to implement various statistical inferential approaches. **CO52:** Explain in detail elements of statistical decision problems and various inference problems viewed as decision problem. **CO53:** Explain in detail approaches to include a measure of accuracy for estimation procedures and our confidence in them by examining the area of interval estimation. **CO54:** Choose appropriate methods of inference to tackle real problems.	Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Location Invariance, scale invariance. Pitmann's estimators for location and scale parameters. Pitman concept of closeness of estimator. Proof of the properties of M.L.E(large samples), Huzur Bazaar theorem

Unit –II **15 Hrs.**

Consistent asymptotic normal (CAN) estimator, invariance property of likelihood estimator. Wilks likelihood ratio criteria and the various test based on it.

Unit-III **15 Hrs.**

Asymptotic distribution of likelihood ratio statistic. Bartlett's test for homogeneity of variances. Randomized tests. Generalized Neyman- Pearson lemma.

Unit-IV **15 Hrs.**

Uniformly most powerful tests for two-sided hypothesis. Unbiased tests. Uniformly most powerful unbiased tests, Generalized likelihood ratio test-mean and variance. Tests with Neyman's Structures and its relation with complete family of distributions.

Unit-V **15 Hrs.**

Basic Elements of Statistical Decision Problem. Various inference problems viewed as decision problem. Randomization optimal decision rules. Bayes and minimax decision rule. ε-bayes & minimax decision rule, Generalized Bayes rule.

BOOKS RECOMMENDED

- Casela G & Berger RL. (2002): Statistical Inference. Duxbury Thompson Learning.
- Conover WJ. (1980): Practical Nonparametric Statistics. John Wiley.
- Kiefer JC. (1987): Introduction to Statistical Inference. Springer.

- Lehmann EL. (1986) Theory of Point Estimation. John Wiley.
- Wald A. (2004) Sequential Analysis. Dover Publ.
- Cramer, H.(1946) : Mathematical methods of Statistics, Princeton University Press.
- Goon and others.(2003): Outline of Statistical theory Vol-I, World Press.
- Rao,C.R. (1973) : Linear Statistical inference and its applications, 2nd Ed, John Wiley & Sons Inc.
- Gibbons,J.D. (2010): Non- Parametric Statistical Inference, McGraw-Hill, fifth edition.
- Kendall, M.G. and Stuart, A. (1971): Advanced Theory of Statistic Vol. I and II,Charles Griffin.
- Mood, Graybill and Boes. (1974): Introduction to the theory of Statistics 3rded, McGraw- Hill.
- Hogg,R.V. and Craig,A.T.((1971): Introduction to Mathematical Statistics, Princeton University Press.
- Rao, C. R. (2002): Linear Statistical Inference and its Applications, Willey- Blackwell.
- Gibbons (1971): Non Parametric Inference, Chapman and Hall.
- Sidney and Siegal (1956): Non Parametric for Behavioral science, Mcgraw-Hill Book Company.

PAPER CODE – STT322
Multivariate Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course lays the foundation of Multivariate data analysis. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT322	**Multivariate Analysis (Theory)**	**The students will be able to –** **CO55:** Able to derive various multivariate sampling distributions and use exterior forms where appropriate, to make the necessary changes of variables. Understand and be able to use Kronecker products in problems related to the multivariate normal distribution. **CO56:** Understand how the Wishart distribution arises in multivariate sampling and how to use it. **CO57:** Understand how to use various multivariate statistical methods (for	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for**	Classroom Quiz Assignments Class Test Individual Presentation

		example: test for significant differences between populations, use principal component analysis and factor analysis, discriminant analysis, cluster analysis and canonical correlation analysis)	**the students:** Assignments Seminar Presentation Subject based Activities	

CONTENTS

Unit-I **15 Hrs.**

Multivariate normal distribution and bivariate normal distribution- marginal and conditional distributions, joint distribution of linear function of correlated normal variates. Characteristic function of multivariate normal distribution. Distribution of quadratic forms.

Unit –II **15 Hrs.**

Maximum likelihood estimator of the mean vector and covariance, their independence and related distributions. Null and non-null distribution of partial and multiple correlation coefficients. Sample regression co-efficient and its applications.

Unit-III **15 Hrs.**

Hotelling-T^2 and its properties and applications, Mahanalobis D^2. Wishart distributions and its properties. Asymptotic distribution of Z-tanh (r).Multivariate central limit theorem.

Unit-IV **15 Hrs.**

Classification and discrimination procedure for discrimination between two multivariate normal populations, sample discriminate function, test associated with discriminate functions probabilities of misclassification and their estimation. Classification into more than two multivariate normal population.

Unit-V **15 Hrs.**

Introduction to principle component analysis, Cannonical variables and canonical correlation, factor analysis, cluster analysis, basic methods and applications of MANOVA (without derivation of the distribution of wilk's)

BOOKS RECOMMENDED

- Giri, N.C. (1977): Multivariate Statistical Inference, Academic Press.
- Anderson, T .W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd edition John Wiley.
- Rao, C.R. (1973): Linear Statistical Inference and its Applications , 2nd edition Wiley.
- Srivastava, M.S. and Khatri, C.G. (1970): An Introduction to Multivariate Statistics, North Holland.
- Morrison, D.F. (1976): Multivariate Statistical Methods, McGraw- Hill.
- Nuirhead, R.J.(1982): Aspects of Multivariate Statistical Theory, John Wiley.
- Kshirsagar, A.M. (1972). Multivariate Analysis, Marshell & Decker.
- Roy, S.N. (1957): Some Aspects of Multivariate Analysis, John Wiley.
- Johnson, Richard A., Wichern, Dean W. (2007): Applied Multivariate Statistical Analysis (6th Edition), Pearson.

PAPER CODE – STT323
Operation Research
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT323	**Operation Research (Theory)**	**The students will be able to –** **CO 58:** Understand about the scope, principles and models of Operation Research, concept of duality and simulation and able to solve linear programming problems **CO59:** Describe the concept of decision theory and sensitivity analysis and Discuss various methods to solve dynamic programming problems. **CO60:** Determine the inventory level of an industry for the smooth functioning and Understand the concept of probability inventory problems. **CO61:** Understand the concept of queuing theory and solve related problems. **CO62:** Explain problems related to sequencing and PERT-CPM to solve network analysis problems.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Operation Research: Definition and scope, phases, principles, models and their solutions. Review of linear programming problem, Duality Problems, Concept of simulation: Monte Carlo Simulation technique and its applications.

Unit –II **15 Hrs.**

Decision theory: decision making under uncertainty and risk, sensitivity analysis. Dynamic programming: Introduction, decision tree, Bellman principle of optimality, solution of problems with finite number stages, concept of dynamic programming, minimum path problem

Unit-III **15 Hrs.**

Inventory control: Introduction, costs, advantages, Static Economic-Order-Quantity (EOQ) models with and without shortage, Deterministic models of price break, probabilistic inventory model, ABC Analysis.

Unit-IV **15 Hrs.**

Queuing System: Definition, Characteristics of queuing system, Markov chain, Markov process, Poisson process: pure birth and pure death process. Kendall's notations, Steady state solution of (M/M/1) and (M/M/s) models with associated distributions of queue length and waiting time. (M/G/1) model–Pollaczek Khintchine formula.

Unit-V **15 Hrs.**

Sequencing Problems: notions, terminology, and assumptions, processing n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines with graphical method, processing n jobs through m machines. PERT and CPM: basic concepts, probability of projection completion, travelling salesman problem, replacement problems- block and age replacement policies.

BOOKS RECOMMENDED

- Taha, H.A.(2007): Operation Research, McMillan Publishing Co. Inc 8^{th}Edition,
- Kanti Swaroop et. Al (2007): Operation Reseach, Sultan chand & Sons, 13^{th} edition.
- Gross, D. & Harris C.M. 1975): Fundamentals of Queueing Theory, John Wiley & Sons.
- Sharma, S.D. (2000): Operation Research, Kedar Nath Pub. Meerut.
- Bronso,.R. et.al.(1983) , Schaum's outlines Operation Research, Tata McGraw Hill Edition
- Klienrock, L. (1975): Queueing System, Vol. 1 Theory, John Wiley.
- Starr, M.K. and Miller, D.W. (1962): Inventory Control-Theory and Practice, Prentice Hall.

PAPER CODE – STT324(A)
Demography and Vital Statistics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper aims at teaching the students to develop their knowledge to make comparisons between countries demography .Vital Statistic deals with laws of human mortality, morbidity and fertility

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT324(A)	**Demography and Vital Statistics (Theory)**	**The students will be able to –** **CO63:** Utilizing information sources and indicators on the population, including censuses, vital statistics and surveys, and understanding how to access and use such data. **CO64:** Analyze the basic concepts used in the description and study of a population with a particular focus on three fundamental demographic processes in the dynamics and composition of a population: mortality, fertility and migration. **CO65:** Analyze the results and research in Demography.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Vital Statistics: Meaning, definition and utility. Sources of demographic data- census, registration, ad-hoc surveys, hospital records. Demographic profile of Indian census. Rates and ratio of vital statistics. Fertility: Measurement of fertility – crude birth rate, general fertility rate, Age- specific fertility rate, total fertility rate. Gross and Net Reproduction Rates.

Unit –II **15 Hrs.**

Mortality: Measurement of mortality, crude death rate, standardization death rates, age specific death rate, infant mortality rate and cause of death rate with their merits and limitations. Decennial population census in india.

Unit-III **15 Hrs.**

Life table and its uses, assumptions, Construction of complete life table from graduated rates of mortality and evaluation of probabilities of survival and death from a life table. Makhemams and Gompertz curves.

Unit-IV **15 Hrs.**

National life tables, UN model life tables, Abridged life table. Stationary and stable population, concept and determination of the rate of increase in a stable population.

Unit-V **15 Hrs.**

Internal migration and its measurement, migration models, concept of international migration. Net migration. International and postcensal estimates. Projection method including logistic curve fitting.

Books Recommended/ Reference Books

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Volume II, The World Press Pvt Ltd, Calcutta, ninth edition.
- Gupta, S.C. and Kapoor, V.K.(2000): Fundamentals of Applied Statistics, S Chand & Company, New Delhi
- Croxton, F.E. and Cowden, D.J. (1973): Applied General Statistics, Prentice Hall of India, third edition.
- Srivastava, O.S.: A Textbook of Demography, Vikas Publishing.
- Gupta, O.P.: Mathematical Statistics, Kedarnath Publication, Meerut.
- Shrinivasan, K. and Srinivasan, K.: Basic Demographic Techniques and Applications.

PAPER CODE – STT324(B)
Actuarial Statistics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper aims at teaching the students to deal with asses risk in insurance and finance using statistical methods.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT324(B)	**Actuarial Statistics (Theory)**	**The students will be able to –** **CO66:** Assess the suitability of actuarial, financial and economic models in solving actuarial problems. **CO67**: Analyze actuarial data using	**Approach in teaching:** Interactive Lectures, Group Discussion,	Classroom Quiz Assignments Class Test Individual Presentation

		advanced statistical techniques. **CO68:** Calculate quantities such as premiums, reserves and superannuation contribution rates using actuarial techniques. **CO69:** Increase management skills for dealing with organizations, teams and policy issues; **CO70:** Expand their applied knowledge in various specialized areas of actuarial studies and statistics.	Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	

CONTENTS

Unit-I **15 Hrs.**

Actuarial Science: Concept, scope, Introduction to insurance business, concept of risk, role of statistics in insurance. Risk models for short term: expected value principle, notation of utility risk model for short term

Unit –II **15 Hrs.**

Survival Distribution: Future life time distribution and life table, future life time random variable, curate future life time, complete life table, assumption of fraction ages, force of mortality

Unit-III **15 Hrs.**

Life Insurance: Actuarial present value benefit in life insurance product, compound interest, discount factor, benefit payable at the moment of death, relation between A and pure endowment. Sickness benefit, disability benefit, widows pension, benefit dependent on marriage

Unit-IV **15 Hrs.**

Annuity: introduction, life annuity: single payment, continuous life annuity, discrete life annuity, life annuity with monthly payments, commutation function, varying annuity recursion, complete annuity: immediate and apportionable annuities- due

Unit-V **15 Hrs.**

Multiple decrement tables, force of decrement, construction of decrement table. Premium: continuous and discrete premium, true monthly payment premium, apportionable premium, commutation functions, accumulation type benefits.

BOOKS RECOMMENDED

- Dickson, C.M.D. (2005): Insurance Risk and Ruin(International Series On Acturial Science), Cambridge University Press

- Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A., Nesbitt, C.J.(1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.
- Atkinson, M.E. & Dickson, D.C.M. (2011). An Introduction to Actuarial Studies, Elgar Publ, second edition.
- Daykin, C.D, Pentikainen, T & Pesonen, M. (1994). Practical Risk Theory for Actuaries, Chapman & Hall.

PAPER CODE – STT324(C)
Reliability Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper aims at teaching the students to deal with reliability and replacement policies of statistical data.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT324(C)	**Reliability Analysis (Theory)**	**The students will be able to –** **CO71:** Deal with the reliability concepts in the real world **CO72:** Analyse the data of various life tables. **CO73:** Find out which policy has to be framed on the given data and also identify the reliability of that policy. **CO74:** Characterize probability models and function of random variables based on single & multiples random variables.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Reliability: Concepts and measures, components and systems, coherent systems, reliability of coherent systems; cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components.

Unit –II **15 Hrs.**

Life distributions, reliability function; hazard rate; common life distributions-exponential, Weibull, Gamma etc. Estimation of parameters and tests in these models.

Unit-III **15 Hrs.**

Notions of ageing, IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss of memory property of the exponential distribution; closures or these classes under formation of coherent systems, convolutions and mixtures

Unit-IV **15 Hrs.**

Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items stress-strength reliability and its estimation.

Unit-V **15 Hrs.**

Maintenance and replacement policies, availability of repairable systems, modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models, probability plotting techniques, Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing.

BOOKS RECOMMENDED

- Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing, Holt, Rinehart and Winston.
- Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data, John Wiley.
- Bain, L.J. and Engelhardt, (1991): Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker, sixth edition.
- Nelson, W (2003): Applied Life Data Analysis, John Wiley.
- Zacks, S. (2004): Reliability Theory, Springer.
- Sinha, S.K.(1986): Reliability & Life Testing,Wiley
- Cox, D.R. and Oakes, D (1984): Analysis of Survival Data, Chapman and hall, New York.
- Kalbfleisch, J.D. & Prentice, R.L. (2002): The Statistical Analysis of Failure Time Data, John Wiley.

PAPER CODE – STT325
Practical
(Practical)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 8
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This paper is designed so that the student get familiar with statistical software for solving the problems based on multivariate data and various mathematical problems.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT325	**Practical (Practical)**	**The students will be able to –** **CO75:** Able to test partial and multiple correlation coefficients. **CO76:** Understand multinomial and multivariate normal distribution. **CO77:** Solve dynamic programming problems using various methods. **CO78:** Determine the inventory level of an industry for the smooth functioning and Understand the concept of probability inventory problems. **CO79:** Solve the problems related to queuing theory and PERT-CPM to solve network.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Software based Assignments Individual Presentation Class Test

CONTENTS

1. Power curve for testing one sided Null Hypothesis hypothesis against one sided and two sided attentive for
   (i) Binomial distribution
   (ii) Poisson distribution
   (iii) Normal distribution
   (iv) Exponential distribution
2. Linear combination of correlated normal variates and evaluation of probabilities.
3. Estimation of mean vector and covariance matrix.
4. Testing of partial and multiple correlation coefficients.
5. Discriminate function.
6. Decision problems under uncertainty and risk.
7. Solving linear Programming Problem using graphical method.
8. Solving linear Programming Problem using simplex method.

9. Deterministic Inventory problems.
10. Queuing models M/M/1 and M/M/c.
11. Sequencing problem
12. Pert- CPM
13. Practical based on the optional paper (STT-324) opted by students.

Note: Practical exercises will be conducted on computer by using MS-Excel/SPSS/R.

PAPER CODE – STT326
Synopsis for dissertation /project
(Synopsis)

Credits: 6
Maximum marks: 100
Contact Hrs/Week: 6
Total Hrs: 90

Course Objectives:

This course will enable the students to –

This has been incorporated, with the aim that candidates does extensive literature survey on a topic of choice and prepare a Synopsis under the supervision of a faculty. This will be further taken up as a project or dissertation in the subsequent semester.

Course Outcomes (COs):

Course		**Learning outcomes (at course level**	**Learning and teaching strategies**	**Assessment Strategies**
Paper Code	**Paper Title**			
STT326	**Synopsis for dissertation /project (Synopsis)**	**The students will be able to –** **CO80:** Analyse and define a complex and open problem, put it into its broader context and make a plan for its solution. **CO81:** Using a background in a specialized discipline, to develop new ideas and solve new problems	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing

M.Sc. STATISTICS (2020-2021)

COURSE OUTCOMES - Semester IV

PAPER CODE – STT421
Econometrics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course is meant for training the students in econometric methods and their applications. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes (at course level</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>STT421</td><td>Econometrics (Theory)</td><td>The students will be able to –

CO82: Construct, test, and analyse econometric models, using variables and relationships commonly found in studies of economic theory;
CO83: Collect, organise, and analyse economic data, and interpret results from statistical analyses.
CO84: Identify key classical assumptions in the field of econometrics, explain their significance, and describe the effects that violations of the classical assumptions can have;
CO85: Use the least squares method in evaluating the relationship of one explanatory variable to the dependent variable and the relationships of multiple explanatory variable to the dependent variable
CO86: Remove the problems of econometrics such as heteroscedasticity, auto correlation, multicollineraity.
CO87: be a qualified user of</td><td>Approach in teaching:
Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions

Learning activities for the students:
Assignments Seminar Presentation Subject based Activities</td><td>Classroom Quiz
Assignments
Class Test
Individual Presentation</td></tr>
</table>

		econometric methods. **CO88:** be able to make use of econometric models in your own academic work		

CONTENTS

Unit-I **15 Hrs.**

Representation of Economic phenomenon, relationship among economic variables, the general linear model and its extensions, basic assumptions, Ordinary least squares estimation and prediction, generalized least square estimation and prediction

Unit –II **15 Hrs.**

Heteroscedasticity, Auto-correlation: its consequences and tests (Durbin Watson test), Multicollinearity: problem, its implications and tools for handling the problem

Unit-III **15 Hrs.**

Linear regression and stochastic regression, instrumental variable estimation, autoregressive linear model, lagged variables, Distributed Lag models: Koyck's Geometric Lag model

Unit-IV **15 Hrs.**

Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods

Unit-V **15 Hrs.**

Three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

BOOKS RECOMMENDED

- Croxton, F.E. & Cowden, DJ. (1979): Applied General Statistics, Prentice Hall of India.
- Johnston, J. (1984): Econometric Methods. McGraw Hill.
- Judge, G.C., Hill, R.C., Griffiths, W.E., Lutkepohl, H. & Lee, T.C. (1988): Introduction to the Theory and Practice of Econometrics, 2nd Ed. John Wiley.
- Kmenta, J. (1986): Elements of Econometrics, 2nd Ed. University of Michigan Press.
- Koop, G. (2007): Introduction to Econometrics, John Wiley.
- Maddala, G.S. (2017): Introduction to Econometrics, 3rd Ed. John Wiley.
- Pindyck, R.S. & Rubinfeld, D.L. (1998): Econometric Models and Economic Forecasts, 4th Ed. McGraw Hill.
- Verbeek, M. (2008): A Guide to Modern Econometrics, 3rd Ed. John Wiley.
- Judge, G.C., Hill, R,C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988): Introduction to the Theory and Practice of Econometrics, Second Edition, John Wiley & Sons.
- Kendall, M.G. and Stuart, A. (1968): The Advanced Theory of Statistics (Vol. III), Second Edition, Charles Griffin.

PAPER CODE – STT422(A)
Applied Statistics
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications, index number, and demand analysis.

Course Outcomes (COs):

Course		Learning outcomes (at course level	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
STT422(A)	**Applied Statistics (Theory)**	**The students will be able to –** **CO89:** In-depth knowledge of theoretical and practical aspects of SQC and understanding of the link between SQC and business analysis. **CO90:** How to interpret and use a range of index numbers commonly used and also to understand other indices used in the business sector. **CO91:** Understand the basic structure of the Consumer Price Index (CPI) and perform calculations involving its use. **CO92:** Students will demonstrate their ability to apply statistics in other fields at an appropriate level and demonstrate their ability to apply knowledge acquired from their major to real world models.	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

CONTENTS

Unit-I **15 Hrs.**

Control-Charts: Concept and construction of control charts for variables and attributes and their OC Curve. Modified control limits. Acceptance Sampling Plans by Attribute: AQL, AOQL, Producer's Risk and Consumer Risk. Rectification and their O.C. function, ASN and ATI .

Unit –II **15 Hrs.**

Single and double sampling plans and their mathematical analysis. Idea of Standard sampling tables: Dodge and Romig tables. Sampling Inspection Plans for Variables: One sided specification standard (Known and Unknown Cases), two sided specifications (for known standards).

Unit-III **15 Hrs.**

Multivariate control chart: CUSUM charts, EWMA chart –Use of these charts for prediction. CUSUM, EWMA for controlling process variability. Comparison of these charts with Shewart charts

Unit-IV **15 Hrs.**

Process Capability analysis: Meaning, Estimation technique for capability of a process – Capability Indices: Process capability ratios Cp; Cpk, Cpm, Cmk, Cpc – Process capability analysis using a control chart – Process capability analysis using design of experiments, Gage and measurement system capability studies

Unit-V **15 Hrs.**

Index Number : Meaning and uses, problem in the construction of index numbers, price relatives, quantity and value relatives. Fixed base and chain base index numbers. Laspeyers, Paasche's, Marshall-Edgeworth and Fisher's ideal index numbers. Test for index numbers. Base shifting, Construction of cost of living index and Whole-sale price index. Theory and analysis of consumer demand, estimations of demand function. Demand and income elasticity. Income Distributions: Pareto's law of income distributions. Engle's curve, curves of concentration.

BOOKS RECOMMENDED

- Cowden, D.J. (1957): Statistical Methods in Quality Control, Prentice Hall of India.
- Duncan, A.J. (1986): Quality Control and Industrial Statistics, 5th Ed. Irwin Book Co.
- Grant E.L. & Leavenworth, R.S. (1996): Statistical Quality Control, 7th Ed. McGraw Hill.
- Montgomery, D.C. (2019): Introduction to Statistical Quality Control, 5th Ed. John Wiley.
- Wetherhil, G.B. (1977): Sampling Inspection and Quality Control, Halsted Press.
- Biswas, S. (2008): Statistics of Quality Control, New Central Book Agency.

PAPER CODE – STT422(B)
Stochastic Process
(Theory)

Credits: 5
Maximum marks: 100

Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This is a course on Stochastic Processes that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			
STT 422(B)	**Stochastic Process (Theory)**	**The students will be able to –** **CO93:** Identify and formulate fundamental probability distribution and density functions, as well as functions of random variables. **CO94:** Explain the concepts of expectation and conditional expectation, and describe their properties. **CO95:** Understand and analyze continuous and discrete-time random processes. **CO96:** Explain the concepts of stationary and wide-sense stationarity, and appreciate their significance.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Introduction to stochastic process - classification according to state space and time domain. Finite and countable state Markov chains; time homogeneity; Chapman-Kolmogorov equations, marginal distribution and finite dimensional distributions. Classification of Markov chain.

Unit-II **15 Hrs.**

Canonicalform of transition probability matrix of a Markov chain. Fundamental matrix; probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time for absorption. Ergodic state and Ergodic chain. Stationary distribution of a Markov chain, existence and evaluation of stationary distribution. Random walk and gamblers ruin problem.

Unit-III **15 Hrs.**

Discrete state continuous time Markov process: Kolmogorov difference – differential equations. Birth and death process, pure birth process (Yule- Fury process). Immigration-Emigration process. Linear growth process, pure death process.

Unit-IV **15 Hrs.**

Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density. Statements of Elementary renewal theorem and Key renewal theorem.

Unit-V **15 Hrs.**

Branching process: Galton-Watson branching process. Mean and variance of size of nth generation, probability of ultimate extinction of a branching process. Fundamental theorem of branching process and applications. Introduction of Wiener process

Books Recommended

- Adke, S.R. & Manju nath S.M. (1984) : An Introduction of Finite Markov Processes, Wiley Eastern.
- Bhatt ,B.R. (2000): Stochastic Models: Analysis and applications, New Age International, India
- Cox, P.R.(1970): Demography, Cambridge University Press
- Harris, T.E. (1963): The Theory of Branching processes, Springer-Verlag.
- Medhi, J (1982): Stochastic Processes, Wiley Eastern.
- Ballingsley, P (1962): Statistical Inference for Markov Chains, Chicago University Press, Chicago.
- Ross, S.M (1983): Stochastic Processes, Wiley.

PAPER CODE – STT422(C)
Time Series Analysis
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper is design to help the students in the field of forecasting and monitoring the data points by applying suitable model to time series data

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

STT 422(C)	**Time Series Analysis (Theory)**	**The students will be able to –** **CO97:** Define time series components and their uses **CO98:** Able to construct stationary time series models, nonlinear stochastic models and their applications **CO99:** Students will demonstrate their ability to apply statistics in other fields at an appropriate level and demonstrate their ability to apply knowledge acquired from their major to real world models.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Time Series Analysis- Definition and its different components, additive and multiplicative models. Different methods of determining trend and seasonal and cyclic fluctuations, their merits and demerits. Time series as discrete parameter stochastic process, auto-covariance and auto-correlation functions and, their properties.

Unit-II **15 Hrs.**

Detailed study of the stationary processes: (i) moving average (MA), (ii) auto-regressive (AR),(iii) ARMA, and, (iv) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (withoutproof) of estimation of mean, auto-covariance and auto-correlation functions under large sample theory.Choice of AR and MA orders. Estimation of ARIMA model parameters

Unit-III **15 Hrs.**

Spectral analysis of weakly stationary process, peridogram and correlogram analyses, computations based on Fourier transform. Forecasting: Exponential and adaptive Smoothing methods`

Unit-IV **15 Hrs.**

Multivariate Liner Time series: Introduction, Cross covariance and correlation matrices, testing of zero cross correlation and model representation. Basic idea of Stationary vector Autoregressive Time Series with orders one: Model Structure, Granger Causality, stationary condition, Estimation, Model checking.

Unit-V **15 Hrs.**

Non-linear time series models, ARCH and GARCH Process, order identification, estimation and diagnostic tests and forecasting. Study of ARCH (1) properties. GARCH (Conception only) process for modelling volatility.

BOOKS RECOMMENDED

- Box, G.E.P. and Jenkins, G.M. (1976): Time series analysis—Forecasting and Control, Holden-day, San Francisco.
- Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
- Montgemory, D.C. and Johnson, L.A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
- Kendall, Sir Maurice and Ord, J.K. (1990): Time Series (Third Edition), Edward Arnold.
- Brockwell, P.J. and Davis, R.A.: Time Series: Theory and Methods (Second Edition), Springer-Verlag.
- Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.
- Granger, C.W.J. and Newbold (1984): Forecasting Econometric Time Series, Third Edition, Academic Press.
- Priestley, M.B. (1981): Spectral Analysis & Time Series, Griffin, London.
- Kendall, M.G. and Stuart A. (1966): The Advanced Theory of Statistics, Volume 3, Charles Griffin, London.
- Bloomfield, P. (1976): Fourier Analysis of Time Series—An Introduction, Wiley.
- Granger, C.W.J. and Hatanka, M. (1964): Spectral Analysis of Economic Time Series, Princeton Univ. Press, N.J.
- Koopmans, L.H. (1974). The spectral Analysis of Time Series, Academic Press.
- Nelson, C.R. (1973): Applied Time Series for Managerial Forecasting, Holden-Day.
- Findley, D.F. (Ed.) (1981): Applied Time Series Analysis II, Academic Press.

PAPER CODE – STT423(A)
Advanced Design of Experiments
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT 423(A)	**Advanced Design of Experiments (Theory)**	**The students will be able to –** **CO100:** Analyze the data and also identify the appropriate design. **CO101:** Construct the design for the provided data and also check their	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects,

		applications. **CO102:** Plan and execute screening experiments to select factors that affect the process **CO103:** Analyze the results and also able to research in Design of experiments. **CO104:** Examine factors at three levels and mixed levels.	**Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Desirable properties of a good design: orthogonality, connectedness and balancing. Various optimality criteria and their interpretations. Relation between blocks of incomplete block designs, duality, resolvability and affine resolvability.

Unit –II **15 Hrs.**

Finite Group and finite field, finite geometry projective and Euclidean., Finite geometry and different method of mols, inter and intra block analysis of BIBD. Constructions of orthogonal Latin squares - (i) for prime power numbers and (ii) by Mann-Mechneish theorem

Unit-III **15 Hrs.**

Group divisible design. Lattice Design, Linked Block Design, Two-associate PBIBD, association scheme and intra block analysis.

Unit-IV **15 Hrs.**

Fractional Factorial Design, Orthogonal and balanced arrays and their connections with confounded and fractional confounded

Unit-V **15 Hrs.**

Response surface design: orthogonality, rotatibility and blocking, construction and analysis, method of steepest ascent.

BOOKS RECOMMENDED

- Dey, A & Mukerjee, R. (1999). Fractional Factorial Plans, John Wiley.
- Atkinson, A.C. and Donev.A.N.(1992): Optimal Experimental Design, Oxford University Press.
- Raghava, Rao. (1971): Construction and Combinatorial Problems in Design of Experiments, John Wiley.
- Chakravarti, M.C. (1962): Mathematics of Design of Experiments, Asia Publishing House.
- John, P.W.N. (1971): Statistical Design and Analysis of Experiments, Mc Millan.
- Khuri, A.N. and Cornell, M.(1991): Response Surface Methodology, Marchell & Decker.
- Shah, K.R. and Sinha, B.K.(1989): Theory of Optimal Design, Springer-Verlog.
- Dey, Alok,(1988):Theory of Block Designs, John Wiley & Sons

PAPER CODE – STT423(B)
Advanced Sample Surveys
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to Statistical System in the country.

Course Outcomes (COs):

<table>
<tr><th colspan="2">Course</th><th rowspan="2">Learning outcomes (at course level</th><th rowspan="2">Learning and teaching strategies</th><th rowspan="2">Assessment Strategies</th></tr>
<tr><th>Paper Code</th><th>Paper Title</th></tr>
<tr><td>STT423(B)</td><td>Advanced Sample Surveys (Theory)</td><td>The students will be able to –

CO105: Understand the principles underlying sampling as a means of making inferences about a population,
CO106: Understand the concepts of bias and sampling variability and strategies for reducing these biases.
CO107: Be able to analyse data from multi-stage surveys,
CO108: Have an appreciation of the practical issues arising in sampling studies.</td><td>Approach in teaching:
Interactive Lectures,
Group Discussion,
Classroom Assignment
Problem Solving Sessions

Learning activities for the students:
Assignments
Seminar Presentation
Subject based Activities</td><td>Classroom Quiz
Assignments
Class Test
Individual Presentation</td></tr>
</table>

CONTENTS

Unit-I **15 Hrs.**

Varying probabilities and without replacement. Des Raj ordered estimates, Murthy's unordered estimates (general cases), estimation of linear classes of estimates, Narain-Horvitz-Thompson's estimator and variance. Inclusion probabilities(n=2).

Unit –II **15 Hrs.**

Estimation of variance of Horvitz-Thompson estimator, Horvitz-Thompson, Yates-Grundy, Sen-Midzuno's results, Midzuno Sampling scheme. Rao-Hartley-Cochran sampling scheme.

Unit-III **15 Hrs.**

Brewer's sampling design, Durbin's grouped and ungrouped procedure, systematic sampling with varying probabilities, multivariate extensions of ratio and regression estimates.

Unit-IV **15 Hrs.**

Sub sampling using varying probabilities with and without replacement: unbiased estimator, its variance and estimates of the variance, Durbin's result.

Unit-V **15 Hrs.**

Double sampling in regression estimation, successive sampling for $h \geq 2$ ocassions. Super population concepts and super population models (introduction). Optimal properties of ratio and regression method of estimation.

BOOKS RECOMMENDED

- Cocharan,W.G.(1997): Sampling Techniques III ed, John Wiley Pub. New Yark.
- Des Raj and Chandok (1999): Sampling Theory , Norsa Pub. New Delhi.
- Murthy, M.N. (1967) : Sampling Theory and Methods, Statistical Pub.Society, Kolkata.
- Chaudhary, A and. Mukherjee R (1988): Randomised Response: Theory & Techniques, Marcel Dekker Inc New Yark.
- Shukhatme, P.V.et al(1984): Sampling Theory of Surveys in the Applications, Iawa State press & Ind.Soc. of Agri. Stat.
- Mukhopadhya, P. (1996): Inferencial Problems in Survey Sampling, New Age Intenational.
- Singh, D. & Choudhary,F.S.(2002): Theory and Analysis of Sample Surveys and its Applications, New Age international Publication.

PAPER CODE – STT423(C)
Survival Analysis and Clinical Trials
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT 423(C)	**Survival Analysis and Clinical Trials (Theory)**	**The students will be able to –** **CO109:** Easily identify the distribution of data. **CO110:** Have much more knowledge of biological data. **CO111:** Analyze the data through appropriate techniques. **CO112:** Cope-up with the data related to medical sciences and life sciences statistically.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit-I **15 Hrs.**

Concepts of Time, Order and Random Censoring. Life distributions - Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference Point estimation, Confidence Intervals, Scores, tests based on LR , MLE

Unit –II **15 Hrs.**

Life tables, Failure rate, mean residual life and their elementary properties. Ageing classes -IFR, IFRA, NBU, NBUE, HNBUE and their duals, Bathtub Failure rate. Estimation of survival function - Actuarial Estimator, Kaplan - Meier Estimator, Estimation under the assumption of IFR/DFR.

Unit-III **15 Hrs.**

Tests of exponentially against non-parametric classes - Total time on test, Deshpande test. Two sample problem - Gehan Test, Log rank test. Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates.

Unit-IV **15 Hrs.**

Clinical trials: introduction, need and ethics , bias and random error, conduct of clinical trials. Overview of phase I-IV trials, multicenter trials. Data management: data definition, case report forms, database design, data collection system

Unit-V **15 Hrs.**

Planning and Design of clinical trials: parallel vs cross over design, cross sectional vs longitudinal designs, Phase I, II, and III trials. Consideration in planning a clinical trial,. Analysis of categorical outcomes o Phase I, II, and III trials, analysis of survival data from clinical trials

BOOKS RECOMMENDED

- Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall, New York.
- Gross, A. J. and Clark, V. A. (1976). Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
- Elandt - Johnson, R.E., Johnson, N.L. (1980). Survival models and Data Analysis, John Wiley and Sons.
- Miller, R.G. (1981). Survival Analysis, Wiley.
- Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
- Ewens, W. J. and Grant, G.R. (2001). Statistical methods in Bio informatics: An Introduction, Springer.
- Friedman, L.M., Furburg, C. and DeMets, D.L. (1998). Fundamentals of Clinical Trials,
- Springer Verlag.
- Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
- Robert F. Woolson (1987). Statistical Methods for the analysis of biomedical data, John
- Wiley & Sons.

PAPER CODE – STT423(D)
Bayesian Inference
(Theory)

Credits: 5
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 75

Course Objectives:

This course will enable the students to –

This paper gives an insight to use decision making process with the help of prior and posterior probabilities in various fields.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	Paper Title			

STT423(D)	**Bayesian Inference (Theory)**	**The students will be able to –** **CO113:** Use relative frequencies to estimate probabilities. **CO114:** Calculate conditional probabilities. **CO115:** Calculate posterior probabilities using Bayes' theorem. **CO116:** Calculate simple likelihood functions. **CO117:** Describe the role of the posterior distribution, the likelihood function and the posterior distribution in Bayesian inference about a parameter.	**Approach in teaching:** Interactive Lectures, Discussion, Power Point Presentations, Informative videos **Learning activities for the students:** Self learning assignments, Effective questions, presentations, Field trips	Quiz, Poster Presentations, Power Point Presentations, Individual and group projects, Open Book Test, Semester End Examination

CONTENTS

Unit –I **15 Hrs.**

Basic elements of Statistical Decision Problem. Expected loss, decision rules (nonrandomized and randomized). Overview of Classical and Bayesian Estimation. Advantage of Bayesian inference, Prior distribution, Posterior distribution, Subjective probability and its uses for determination of prior distribution. Importance of non-informative priors, improper priors, invariant priors.

Unit –II **15 Hrs.**

Point estimation, Concept of Loss functions, Bayes estimation under symmetric loss functions, Bayes credible intervals, highest posterior density intervals, testing of hypotheses. Comparison with classical procedures.

Unit –III **15 Hrs.**

Bayesian approximation techniques: Normal approximation, T-K approximation, Monte-Carlo Integration, Accept-Reject Method, Idea of Markov chain Monte Carlo technique.

Unit –IV **15 Hrs.**

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors

Unit –V **15 Hrs.**

Hierarchical priors and partial exchangeability. Predictive inference, Predictive density function, prediction for regression models, Decisive prediction, point and internal predictors, machine tool problem.

BOOKS RECOMMENDED

- Berger, J. O.: Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
- Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.

- Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.
- Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
- Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.
- Gemerman, D.: Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
- Bansal, A. K. (2007). Bayesian Parametric Inference, Narosa Publishing House, New Delhi.
- Box, G.P. and Tiao, G. C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.
- Aitchison, J. and Dunsmore, I.R. (1975). Statistical Prediction Analysis, Cambridge University Press.
- De. Groot, M.H. (1970). Optimal Statistical Decisions, McGraw Hill.

PAPER CODE – STT424
Practical
(Practical)

Credits: 4
Maximum marks: 100
Contact Hrs/Week: 8
Total Hrs: 120

Course Objectives:

This course will enable the students to –

This paper is designed so that the student get familiar with statistical software for solving the statistical problems based on Statistical quality control, time series data and index number.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT424	**Practical (Practical)**	**The students will be able to –** **CO118:** To understand and calculate variable and attribute control charts and judges the process quality. **CO119:** To understand and calculate probabilities associated to single and double sampling plans, including AQL, LQL, consumer's and producer's risks, OC, ASN. **CO120:** To give judgment of quality issues of process and product and to rectify them using control charts and acceptance sampling plans. **CO121:** To understand the concept, formulation and application of index	**Approach in teaching:** Interactive Lectures, Group Discussion, Classroom Assignment Problem Solving Sessions **Learning activities for the students:** Assignments Seminar Presentation Subject based Activities	Classroom Quiz Assignments Class Test Individual Presentation

		numbers. **CO122:** To construct simple and weighted price, quantity, and value indexes and interpret them to identify trends in a data set. **CO123:** To use the consumer price index to determine the purchasing power of the money **CO124:** To shift the base to make two series comparable and splice an old series with a new series of index numbers. **CO125:** To understand the concept of time series, its components and their estimation. **CO126:** To apply ideas to real time series data and interpret outcomes of analyses. **CO127:** To be able to estimate models for time-series data.		

CONTENTS

1. Practical based on paper STT-421
2. Practical Based on opted paper STT-422
3. Practical Based on opted paper STT-423

Note: Practical exercises will be conducted on computer by using MS-Excel/SPSS/R.

PAPER CODE – STT425
Dissertation/Project
(Dissertation)

Credits: 15
Maximum marks: 100
Contact Hrs/Week: 5
Total Hrs: 255

Course Objectives:

This course will enable the students to –

To give an exposure of research to candidates, dissertation has been introduced in semester IV. Candidate is required to carry out research project on any topic of choice (based on Semester III Literature Survey) under the supervision of an allotted research supervisor.

Course Outcomes (COs):

Course		Learning outcomes (at course level)	Learning and teaching strategies	Assessment Strategies
Paper Code	**Paper Title**			
STT425	**Dissertation /Project (Dissertation)**	**The students will be able to –** **CO128:** Be able to work on secondary and primary data, communicate and report research results in written form. **CO129:** Able to understand the business and societal contexts of the research. **CO130**: Be able to find, analyse and critically evaluate information and use it to identify and relate it to future use.	**Approach in teaching:** Group Discussion, Classroom Problem Solving Sessions **Learning activities for the students:** Field activities Seminar Presentation Subject based Activities	Presentation VIVA report writing