Curriculum Booklet

B.Sc. (3 year)/B.Sc. Hons. (4 year) in Physics

Department of Physics
Pandit Deendayal Energy University
Knowledge Corridor, Raisan Village,
Gandhinagar - 382426 Gujarat (State), INDIA
Tel: +91 79 23275060 | Fax: +91 79 23275030
Website: www.pdpu.ac.in

Department of Physics, SOET, PDEU

Semester	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester I	DSC -I	Core		University Physics – I	3	0	0	3	3
	DSC - I (P)	Core		University Physics – I LAB	0	0	2	2	1
	DSC - II	Core		Waves and Optics/ (T)	3	1	0	4	4
	DSE - I	EM		Mathematics - I (A & B)	3	1	0	4	4
	MDC- I	MDC		Basic Concept of Atmospheric Sciences	**3**	0	2	5	4
	AEC - I	AEC		Communication Skills	2	0	0	2	2
	SEC- I	SEC		Foreign Language I	2	0	0	2	2
	VAC - I	VAC/IKS		Yoga & Meditation	2	0	0	2	2
					18	**2**	**4**	**24**	**22**

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester II	DSC -III	Core		University Physics – II	3	0	0	3	3
	DSC - III (P)	Core		University Physics – II LAB	0	0	2	2	1
	DSC - IV	Core		Mechanics	3	1	0	4	4
	DSE - II	EM		Mathematics - II (A & B)	3	1	0	4	4
	MDC - II	MDC		Numerical Analysis	4	0	0	4	4
	AEC - II	AEC		Leadership & Management	2	0	0	2	2
	SEC- II	SEC		Foreign Language II	2	0	0	2	2
	VAC - II	VAC/IKS		Ethics & Values	2	0	0	2	2
					19	**2**	**2**	**23**	**22**

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester III	DSC- V	Core		Electricity and Magnetism	3	0	0	3	3
	DSC - V (P)	Core		Electricity and Magnetism - Lab	0	0	2	2	1
	DSC - VI	Core		Heat & Thermodynamics	3	1	0	4	4
	DSC - VII	EM		Mathematical Physics - I	3	1	0	4	4
	DSE - III	MDC		Introduction to Plasma Physics	4	0	0	4	4
	AEC - III	AEC		Advance excel	2	0	0	2	2
	SEC- III	SEC		Programming in Python	0	1	2	3	2
	VAC - III	VAC/IKS		Elements of Environmental Studies	2	0	0	2	2
					17	**3**	**4**	**24**	**22**

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester IV	DSC -VIII	Core		Electromagnetic Theory	3	1	0	4	4
	DSC - IX	Core		Quantum Mechanics - I	4	0	0	4	4
	DSC - X	Core		Electronics	3	0	0	3	3
	DSC - X(P)	Core		Electronics - LAB	0	0	2	2	1
	DSE -IV	MDC		Introduction to Astronomy & Astrophysics	4	0	0	4	4
	AEC - IV	AEC		Financial Literacy	2	0	0	2	2
	SEC- IV	SEC		Renewable Energy and Energy Harvesting	2	0	0	2	2
	VAC - IV	VAC/IKS		Cyber Security	2	0	0	2	2
					20	**1**	**2**	**23**	**22**

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester V	DSC - XI	Core		Solid State Physics	3	0	0	3	3
	DSC - XI (P)	Core		Solid State Physics - LAB	0	0	2	2	1
	DSC- XII	Core		Classical Mechanics	3	1	0	4	4
	DSC-XIII	Core		Atomic and Molecular Physics	4	0	0	4	4
	DSE - V	EM		Physics of Semiconductor devices	4	0	0	4	4
	MDC- III	MDC		Experimental Techniques	4	0	0	4	4
	SEC - V	Internship		Microprocessor	0	1	2	3	2
					18	**2**	**4**	**24**	**22**

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester VI	DSC - XIV	Core		Statistical Mechanics	4	0	0	4	4
	DSC - XV	Core		Nuclear and Particle Physics-I	3	0	0	3	3
	DSC- XV (P)	Core		Nuclear and Particle Physics - I -LAB	0	0	2	2	1
	DSC - XVI	Core		Mathematical Physics- II	3	1	0	4	4
	DSE- VI	EM		Laser and Optoelectronics	4	0	0	4	4
	MDC - IV	MDC		Time Series Analysis	4	0	0	4	4
	SEC - VI	Internship		Advanced Python Programming	0	1	2	3	2
					18	**2**	**4**	**24**	**22**

Applicable for B.Sc. (Hons.)

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits	
Semester VII	DSC- XVII	Core		Classical Electrodynamics	4	0	0	4	4	**Option - I Student opt for Specialization and Six onth Project**
	DSE - VII	EM		**Specialization Electives from basket 2*4 = 8**	4	0	0	4	4	
	DSE - VIII	EM			4	0	0	4	4	
	Project Phase - I	Pro		Minor Project	10	0	0	10	10	
					22	**0**	**0**	**22**	**22**	
	Category Code as per NEP	**Category Code**	**Course Code**	**Course Name**	**Theory**	**Tutorial**	**Practical**	**Hrs**	**Credits**	
Semester VIII	DSC- XVIII	Core		Quantum Mechanics - II	4	0	0	4	4	
	DSE - IX	EM		**Specialization Electives from basket 2*4 = 8**	4	0	0	4	4	
	DSE - X	EM			4	0	0	4	4	
	Project Phase - II	Pro		Minor Project	10	0	0	10	10	
					22	0	0	22	22	

Applicable for B.Sc. (Hons.) with Research

	Category Code as per NEP	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits	
Semester VII	DSC- XVII	Core		Classical Electrodynamics	4	0	0	4	4	**Option - II Student opt for Complete One year Project.**
	Project Phase -I	Pro		Major Project	18	0	0	18	18	
					22	**0**	**0**	**22**	**22**	
	Category Code as per NEP	**Category Code**	**Course Code**	**Course Name**	**Theory**	**Tutorial**	**Practical**	**Hrs**	**Credits**	
Semester VIII	DSC- XVIII	Core		Quantum Mechanics - II	4	0	0	4	4	
	Project Phase -II	Pro		Major Project	18	0	0	18	18	
					22	**0**	**0**	**22**	**22**	

Category code	3 year B.Sc.	4 year B.Sc.(H)	4 year B.Sc.(H)
	Credit	Credit	Credit
DSC	64	72	72
DSE	24	40	24
MDC	16	16	16
AEC	8	8	8
SEC	12	12	12
VAC	8	8	8
Project	0	20	36
Total Credit	**132**	**176**	**176**

Total Credit **176**

Specialization Basket	**Astrophysics & Cosmology**	**Radiation Physics**
Semester VII	Quantum Field Theory and Astroparticle Physics	Fundamentals of Radiation Physics,
	Introduction to Relativity	Radiation Detection and Measurement
Semester VIII	Introduction to Cosmology and Early Universe	Radiation Detection Instrumentation
	Experimental Astrophysics	Radiation Physics Applications

Semester - 1

<Course Code>					University Physics-I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To acquire the basic knowledge of inadequacies of classical physics & other concepts of modern physics
2. To understand and analyze the motion of the particle under central forces.
3. To demonstrate the basic understanding of kinematics and dynamics.
4. To explain the basic concepts of waves and heat.

UNIT I: INTRODUCTION TO PHYSICAL SCIENCE **12 Hrs.**

Introduction to various branches of Physics, Fundamental laws of classical and quantum physics, Failures of classical Physics: Ultraviolet catastrophe, Photoelectric effect, Compton effect, atomic spectra, general rules for scalars and vectors, vector algebra.

UNIT II: INTRODUCTION TO LASER AND SEMICONDUCTOR PHYSICS **12 Hrs.**

Introduction to LASER, constraints for normal light, spontaneous emission, metastable state, population inversion, stimulated emission, three and four level pumping schemes, conditions for light amplification, optical resonator, applications of LASER.

Energy Band, classification of solids, Electron distribution function, Fermi Dirac distribution function, Fermi level in N type and P type semiconductor, Effect of temperature on energy band, P-N Junction diode, forward and reverse biased connection.

UNIT III: MOTION UNDER FORCES **08 Hrs.**

Applications of Newton's laws, Work, friction, energy, power, momentum, examples and applications, conservation law: force and energy, non-conservative forces and energy dissipation, Rotational Kinematics, dynamics and statics, torque, angular momentum, moments.

UNIT IV: BASIC CONCEPTS OF WAVES AND HEAT **10 Hrs.**

Introduction to waves, Description of Wave motion, types of waves: mechanical, electromagnetic, matter and standing, wave propagation in a medium, Concept of heat and temperature, Kinetic theory of gases, specific heat, thermodynamic processes; concept of entropy. .

MAX HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the experimental results incompatible with classical physics and concepts of quantum theory.
CO2 : Understand the important concepts of modern physics.
CO3 : Apply basic concepts of LASER and semiconductor physics in real time applications.
CO4 : Illustrate an ability to apply the concepts of kinematics.
CO5 : Validate underlying principles of physics for waves and heat.
CO6 : Solve the numerical based on the various concepts of physics.

TEXT/REFERENCE BOOKS

1. Resnick, Halliday and Krane, Physics part I and II, 5th Edition John Wiely (2002).
2. Heat and Thermodynamics by Brij lal and N Subramaniyam, (S Chand & Co. Ltd, New Delhi).
3. Concepts of Physics by H.C Verma Vol-I and II, Bharati Bhawan Publishers.

<table>
<tr><th colspan="5"><Course Code></th><th colspan="6">University Physics-I Laboratory</th></tr>
<tr><th colspan="5">Teaching Scheme</th><th colspan="6">Examination Scheme</th></tr>
<tr><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">C</th><th rowspan="2">Hrs/Week</th><th colspan="3">Theory</th><th colspan="2">Practical</th><th>Total Marks</th></tr>
<tr><th>MS</th><th>ES</th><th>IA</th><th>LW</th><th>LE/Viva</th><th></th></tr>
<tr><td>0</td><td>0</td><td>2</td><td>1</td><td>2</td><td>--</td><td>--</td><td>--</td><td>50</td><td>50</td><td>100</td></tr>
</table>

COURSE OBJECTIVES

1. To understand the working of various electrical, mechanical and optical instruments in the laboratory.
2. To gain practical knowledge in Physics through experiments.
3. To understand basics concepts of Physics and be able to apply in performing the experiments.

LIST OF EXPERIMENTS

1 To study the principle of hall effect and to determine (a) Hall voltage and (b) Hall coefficient.
2 To demonstrate/investigate phenomenon of resonance using forced oscillations.
3 To determine the angle of reflection and prove angle of incidence is equal to angle of reflection using ultrasonic waves.
4 To find the slit width of single slit, blade slit and aperture width of the double slit.
5 To measure the linear thermal expansion coefficient for Copper and Brass rod.
6 To understand the principle of Heat pump and its applications.
7 To observe the waveform produced by output of half and full wave rectifier.
8 To plot V-I characteristics of P-N junction diode and calculate various associate parameters.
9 To find the energy band gap of the Germanium semiconductor chip using Four Probe Method.
10 To demonstrate the use of cathode ray oscilloscope and its various functions.
11 To determine the electrical conductivity of the Copper and Aluminium rods.
12 To determine the wavelength of monochromatic light source using Newton’s rings apparatus.
13 To demonstrate/investigate the working principle of solar cell.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Apply and analyse the concepts of electricity and magnetism.
CO2 : Understand the various concepts of kinematics.
CO3 : Demonstrate and implement the phenomenon related to waves.
CO4 : Investigate the electrical properties of a given semiconductor device.
CO5 : Examine the heat transfer mechanism in heat pump based devices.
CO6 : Design and analyse the circuits applications based on semiconductor diode.

TEXT/REFERENCE BOOKS

1. Kittel, Knight and Ruderman, Mechanics - Berkeley Physics Course, Vol. 1, Tata McGraw-Hill.
2. Avadhanulu, A text book of engineering Physics, S. Chand & Company, Ltd.
3. Brij Lal, N. Subrahmanyam, Heat and Thermodynamics, S. Chand & Company, Ltd
4. Halliday, Resnick, Walker, Fundamentals of Physics (Wiley)

<Course Code>					<Waves and Optics>					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the connection between waves and optics.
2. To apply the concepts of waves and optics to solve problems related to interferometry.
3. To critically analyse optical systems using diffraction, interference and polarization concepts.
4. To identify and apply formulas of optics and wave physics.
5. To evaluate the resolving power of optical instruments.

UNIT I: CONTINUA **14 Hrs.**

Characteristic of progressive wave, Mathematical representation of a plane progressive wave, Simple Harmonic Motion, Real Oscillators, Superposition, Damped SHM; Driven SHM, Coupled SHM, Continua, Fourier Analysis, Wave Motion.

UNIT II: SOUND AND WATER WAVES **14 Hrs.**

Sound waves (adiabatic versus isothermic), Sound waves in solids, transverse and longitudinal waves, seismic waves, Pulse propagation, group velocity, wavepackets and dispersion, Doppler effect (classical and relativistic) in one dimension, Surface water waves – Airy theory, Tsunamis.

UNIT III: INTERFERENCE AND DIFFRACTION **14 Hrs.**

Condition for sustained interference, classification of interference, Division of wave front: Biprism, Division of amplitude: Newton's rings. Interference in Thin Films : Interference due to reflected light and transmitted light, Variable thickness of film, Michelson's interferometer, Fabry-Perot interferometer (etalon), Applications of interferometers.

Diffraction : Fresnel's assumption, rectilinear propagation of light, zone plate, Fresnel and Fraunhofer diffraction, Diffraction due to a straight edge, Fraunhofer diffraction due to a single slit, Fraunhofer diffraction at N slits, Diffraction Grating: plane diffraction grating, Dispersive power of a grating

UNIT IV: POLARIZATION AND OPTICAL INSTRUMENTS **14 Hrs.**

Resolving Power: Rayleigh's criterion, Resolving power of optical instrument: Telescope and Microscope, Resolving power of a plane diffraction grating, Huygen's and Ramsden's eye-piece.

Polarization: Polarization by scattering and by selective Absorption Double refraction, Huygen's theory of double refraction, Nicol's prism, Production and detection of plane, elliptically and circularly polarized lights, Analysis of Polarized lights (experimental aspects only), Identification of Polarization, Quarter wave plate, Babinet compensator.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Understand wave characteristics, their types and applications of wave theory to explain effects in sound, water and light.

CO2 : Identify and illustrate physical concepts and terminology used in waves and optics and to be able to explain them in appropriate detail.

CO3 : Critically analyze waves and optical systems using SHM, damped & forced harmonic motion, Fourier analysis, diffraction, interference and polarization concepts.

CO4 : Apply the concepts of waves and optics to solve problems related to wave motion and interferometry.

CO5 : Evaluate the resolving power of optical instruments.

CO6 : Analyse components creating polarization and polarized light.

TEXT/REFERENCE BOOKS

1. Brijlal and N Subramaniyam, **"A Textbook of Optics"**, S. Chand & Company Ltd, New Delhi.
2. Arthur Beiser, **"Concepts of Modern Physics"**, Tata McGraw-Hill.
3. A.P. French, **"Vibrations and Waves"**, W.W. Norton & Company.
4. Richard Feynman, **"Lectures on Physics"**, Pearson Education.
5. Berkley Physics Course, **"Waves (Vol. III)"**, McGraw-Hill.
6. C.A. Coulson, **"Waves"**, Oxford University Press.
7. W.C. Elmore and M.A. Heald, **"Physics of Waves"**, Dover Publications.
8. H.J. Pain, **"Physics of Vibrations and Waves",** John Wiley & Sons.
9. Eugene Hecht, **"Optics"**, Addison-Wesley.
10. Born and Wolf, **"Principles of Optics"**, Cambridge University Press.
11. Ajay Ghatak, **"Introduction to Optics",** Cambridge University Press.

BSM101					Calculus-I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVE

- To make familiar the students to basic elements of calculus in sufficiently rigorous manner.

UNIT 1 DERIVATIVES OF A FUNCTION **10 Hrs.**

Hyperbolic functions, Higher order derivatives, Applications of Leibnitz rule. The first derivative test, concavity and inflection points, Second derivative test, Curve sketching using first and second derivative test, limits at infinity, and graphs with asymptotes. Graphs with asymptotes, L'Hopital's rule, applications in business, economics and life sciences.

UNIT 2 PARAMETRIC REPRESENTATION OF CURVE **10 Hrs.**

Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates. Reduction formulae, derivations and illustrations of reduction formulae of the type.

UNIT 3 APPLICATIONS OF CALCULUS **10 Hrs.**

Volumes by slicing; disks and washers methods, Volumes by cylindrical shells. Arc length, arc length of parametric curves, Area of the surface of revolution. Rotation of axes and second degree equations, classification into conics using the discriminant.

UNIT 4 VECTOR FUNCTION **10 Hrs.**

Introduction to vector functions and their graphs, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. Modeling ballistics and planetary motion, Kepler's second law, Curvature.

40 Hrs.

COURSE OUTCOME

On completion of the course, student will be able to
CO1– Evaluate the derivative of a function.
CO2– Apply calculus to calculate the volume, area etc. of one dimensional object.
CO3– Analyze the applied problems using concept of derivative.
CO4– Analyze vector functions to find derivatives, tangent lines, integrals, arc length and curvature.
CO5– Determine the properties of a graph of a function using derivative.
CO6– Solve wide range of problems of mathematical applications using derivative or integral of vector function.

TEXT/REFERENCE BOOKS

1. J. Stewart, Essential Calculus-Early Transcendentals-Second Edition, Cengage Learning.
2. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and sons (Asia), Pvt Ltd., Singapore, 2002.
3. F. Ayres and E. Mendelson, Schaum's outline of Calculus, 6th edition, McGraw-Hill Education.
4. Tom M. Apostol, Calculus, volume I, 2nd edition, John Wiley & sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 6 questions of 5 marks each 30 Marks (50 mins.)

Part B: 4 questions 10 marks each 40 Marks (80 mins.)

Part C: 2 questions 15 marks each 30 Marks (50 mins.)

20BSM102					Basic Mathematics-I (Group B)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To make students acquainted with basic of sets, relation and functions.
- To familiarize the students with concept complex variable.
- To introduce concept of matrix, determinants and their use to solve system of equation
- Learn fundamental of differential and integral calculus.
- Demonstrate concepts and visualization of analytical geometry.

UNIT 1 SETS, RELATIONS, FUNCTIONS AND COMPLEX NUMBERS 10Hrs.

Sets and their representation. Union, intersection and compliment. Mapping or function. One-one, onto mappings. Inverse and composite mappings. Definition and geometrical representation. Algebra. Complex conjugate. Modulus and amplitude. Polar form. DeMoivre's theorem. Roots of complex numbers. Simple functions.

UNIT 2 MATRICES AND DETERMINANTS 10Hrs.

Algebra of matrices. Determinant of a square matrix. Properties of determinants. Some simple type of matrices. Inverse of a matrix. Solution of equations. Intersections. Distance between two points. Shortest distance between lines.

UNIT 3 DIFFERENTIAL AND INTEGRAL CALCULUS 10Hrs.

Basic concept of limit and continuity. Derivative. Rules of differentiation. Tangent to a curve. Taylor's series. Maxima and minima. Antiderivative, Fundamental theorem of calculus (statement only). Integrals of elementary functions. Substitution and partial fractions. Definite integral as a limit of sum. Properties of definite integrals. Application to areas and lengths.

UNIT 4 TWO DIMENSIONAL COORDINATE GEOMETRY 10Hrs.

Cartesian coordinate system. Distance between two points. Equation of line in different forms. Equations of circle, ellipse and parabola. Equation of a tangent to a curve. Area of a triangle.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1– Perform set operations.
CO2– Understand functions and its composition.
CO3– Perform operations on complex variables.
CO4– Perform basic matrix operations.
CO5– Solve linear system of equations.
CO6– Find rate of change of any function and further maxima and minima.

TEXT/REFERENCE BOOKS

1. Thomas, G. B. and Finney, R. L., Calculus and analytical geometry, 9th Ed., Pearson Education Asia (Adisson Wesley), New Delhi, 2000
2. NCERT, Mathematics Textbook for class XI and XII, 2009.
3. Sharma, R.D., Mathematics, Dhanpat Rai Publications, New Delhi, 2011.
4. Raisinghania, M.D., Ordinary and Partial Differential Equations by, 8th edition, S. Chand Publication (2010).

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 10 questions of 2 marks each 20 Marks (40 mins)
Part B: 5 questions 6 marks each 30 Marks (50 mins)
Part C: 5 questions 10 marks each 50 Marks (90 mins)

24XXXXXX					Basic Concepts of Atmospheric Sciences					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To know about the formation of the universe and evolution of the earth's atmosphere
2. To learn basic concepts of atmosphere such as weather, climate, hydrological cycle global warming.
3. To make students aware about various systems comprising the Earth's atmosphere including assessment of relevant parameters.
4. To develop analytic skills to interpret/predict weather systems with the help of utilized parameters.

UNIT I: Evolution of earth and its atmosphere **12 Hrs.**

Various theories for formation of the Universe, formation of stars and our solar system, evolution of earth and its atmosphere, changes in the atmosphere during evolution of earth evolution of life on earth, earth-sun radiation equilibrium, and green-house effect.

UNIT II: Composition of the Atmosphere **10 Hrs.**

Atmospheric constituents and their vertical distribution, vertical and horizontal structure of atmosphere: temperature and pressure profiles, troposphere, stratosphere, mesosphere, ionosphere, scale height, Atmospheric radiation budget, Coriolis effect, Ozone hole, Introduction of aerosols, role of aerosols in global climate change: primary and secondary effects, behaviour of atmosphere under different climatic scenarios.

UNIT III: Hydrological Cycle **10 Hrs.**

Hydrological cycle, cloud types, their formation processes, wet and dry adiabatic lapse rate, atmospheric stability, various types of precipitates, rain formation process, basic instruments to understand rain formation, monsoon dynamics and its importance, seasons, south-west and north-east monsoon, cyclones: their formation and death.

UNIT IV: Global warming and climate change **10 Hrs.**

Global warming, natural and anthropogenic sources for warming, long and short term effects of global warming, components of the climate change process, comparison of various IPCC reports, Climate Change: Regional and Global challenges, Important findings of IPCC report, sustainability and our role.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify various constituents of the earth's atmosphere along with their contribution.
CO2 : Understand evolution of the Universe and the earth's atmosphere to form life.
CO3 : Apply basic concepts of the atmospheric science to study components and dynamics of the hydrological cycle.
CO4 : Analise human contributions to the global warming and its regional and global impacts.
CO5 : Evaluate present understanding to solve real time atmospheric problems.
CO6 : Justify importance of understanding climate change and necessity of adaptation and mitigation.

TEXT/REFERENCE BOOKS

1. R. Freedman, and William J. Kaufmann, **"Universe"**, W. H. Freedman publishers.
2. Paul Fleisher, **"The Big Bang (Great Ideas of Science)"**, Lerner Publishing Group.
3. David G. Andrews, **"An introduction to atmospheric physics"**, Cambridge University press.
4. John Houghton, **"Physics of Atmospheres"**, Cambridge University press.
5. Charles H. Langmuir, and Wallace S. Broecker, **"How to Build a Habitable Planet"**, Princeton University Press.
6. Stanley Q Kidder and Thomas H. Vonder Haar, **"Satellite Meteorology: An Introduction"**, Academic Press.
7. J. T. Houghton, F. W. Taylor and C. D. Rodgers, **"Remote Sensing of Atmosphere"**, Cambridge Univ. Press.

24XXXXXX					Atmospheric Science and Remote Sensing Lab					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. To gain practical knowledge of atmospheric science using remote sensing data as well as in-situ measurements.
2. To interpret and analyse atmospheric data for better understanding of short and long term weather patterns.
3. To give hands on experience of various instruments to measure atmospheric parameters along with their uncertainty, this would be useful to weather climate models.

LIST OF EXPERIMENTS

1 Introduction to basic operating procedure and programming of Arduino UNO mini weather station using breadboard.
2 To measure various water levels by employing a water sensor interfaced with an Arduino UNO.
3 To detect various noise levels with the help of a noise sensor and an Arduino UNO.
4 Introduction to GRADS (a) Basic Introduction and installation procedure (b) To understand the applications of GRADS along with the arithmetic operations.
5 To get familiar with the atmospheric data channelling from various sources such as satellites, in-situ and models and visualize it effectively using the GRADS.
6 Examine seasonal/regional variations through the analysis of various parameters from satellite data using GRADS.
7 Identify the real-time atmospheric problems and analyze outcomes through the utilization of satellite data
8 To generate a noise pollution map within the chosen region of interest using a noise sensor.
9 To investigate the difference in concentration of Particulate Matter (PM10 and PM2.5) in the selected region of interest.
10 To analyze the variations in CO & CO_2 concentrations in the selected region of interest.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Understand the various concepts of atmospheric science and remote sensing.
CO2 : Knowledge of basic concepts of atmospheric science to understand real time meteorological problem.
CO3 : Apply variations of basic atmospheric parameters to study its effect.
CO4 : Analyze in-situ and remote sensing data to study nature and pattern of parameters.
CO5 : Examine capability to extract meaningful information from the in-situ measurements of various atmospheric parameters.
CO6 : Design circuits using various components of Arduino kit to study various parameters.

TEXT/REFERENCE BOOKS

1. Stefan Emeis, **"Measurement Methods in Atmospheric Sciences: In Situ and Remote"**, Borntraeger Science Publishers.
2. Frederick K. Lutgens, Edward J. Tarbuck, **"The Atmosphere: An introduction to Meterology"**, Pearson.
3. William Emery, Adriano Camps, "**Introduction to Satellite Remote Sensing"**, Elsevier.
4. Jian Guo Liu, Philippa J. Mason, **"Image Processing and GIS for Remote Sensing: Techniques and Applications"**, Wiley Blackwell.
5. Banzi Massimo, Michael Shiloh, **"Getting started with Arduino"**. Maker Media, Inc.
6. McRoberts Michael, **"Beginning Arduino"**, Apress.
7. Tiwary Abhishek, Ian Williams, **"Air pollution: measurement, modelling and mitigation"**, CRC Press.

Semester - 2

<Course Code>					< University Physics-II >					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To foster a foundational comprehension of electricity and magnetism.
2. To offer essential insights into the principles of basic thermodynamics.
3. To explore the concepts of elementary optics and their practical implications.
4. To provide insight into the inception of modern physics.

UNIT I: CONCEPTS OF ELECTRICITY AND MAGNETISM **12 Hrs.**

Coulomb's law, Electric field, Gauss's law, Electric Potential; Capacitors, Dielectrics, DC and AC circuits, RC-RL-LC circuits, Electric fields in matter, Polarization.

Sources of magnetism, magnetic force on a moving charge, Biot-Savart law, Ampere's law, Induced emf, Torque on a current loop in B field, Magnetic dipoles in atoms and molecules, Gyro magnetic ratio.

UNIT II: BASIC THERMODYNAMICS **10 Hrs.**

Continuum and macroscopic approach, Thermodynamic systems (closed and open), Thermodynamic properties and equilibrium, State of a system, Concepts of heat and work, Different modes of work, Concept of energy and various forms of energy, Internal energy, Enthalpy, Zeroth law of thermodynamics, First Law of Thermodynamics, Second Law of Thermodynamics, Concept of entropy, Applications of the Laws of thermodynamics.

UNIT III: ELEMENTARY OPTICS **10 Hrs.**

Reflection, Refraction, Image formation by mirrors & thin lenses, Optical instruments: Digital camera, Microscope, Telescope, Magnification, Interference, Thin film interference, Newton’s Rings, Diffraction, Advancement and role of optics in modern applications.

UNIT IV: ELEMENTS OF MODERN PHYSICS **10 Hrs.**

Introduction to Quantum Mechanics, Plank’s Hypothesis, De Broglie’s Dual Nature Principle, Introduction to special theory of relativity, Basic idea of twin paradox, time dilation and length contraction.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Gain familiarity with fundamental principles of electricity and magnetism.
CO2 : Comprehend and utilize the principles of basic thermodynamics.
CO3 : Grasp the principles of elementary optics and their application in diverse optical instruments.
CO4 : Apply the principles of electromagnetism, thermodynamics, and optics to solve numerical problems.
CO5 : Distinguish between classical and quantum physics.
CO6 : Cultivate the comprehension necessary to engage with more advanced courses in physics.

TEXT/REFERENCE BOOKS

1. B B Laud, “**Electromagnetism”**, Wiley eastern limited.
2. K. K. Tiwari, “**Electricity and Magenetism with Electronics”,** S. Chand & Company Ltd.
3. Brij lal and N Subramaniyam, “**Heat and Thermodynamics”**, S. Chand & Company Ltd.
4. Brij lal and N Subramaniyam, **“Optics”**, S. Chand & Company Ltd.
5. Arthur Beiser, **“Concepts of modern Physics”,** Tata McGraw Hill.

<Course Code>					< University Physics-II Laboratory >					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To develop proficiency in using precision measuring determine their least count accurately.
2. To understand the principles and characteristics of instruments related to electricity and magnetism, heat and optics.
3. To understand phenomenon of photoconductivity, charging and discharging of capacitors, and working of power supplies.

LIST OF EXPERIMENTS

1. To determine the Least count of Vernier callipers, Screw gauge and Spectrometer and measure the dimensions of given objects.
2. To study the optical fiber characteristics.
3. To study the phenomenon of photoconductivity.
4. To determine the wavelength of light using Newton's ring experiment
5. To study the charging and discharging of capacitors.
6. To study filters in power supply.
7. To determine the value of "g" using simple pendulum.
8. To study LCR circuits in series and parallel.
9. To study thermal expansion in solids
10. To determine the value of "g" using compound pendulum
11. To verify the Biot Savart's law.
12. To determine the Cauchy's constant.

** Any 10 experiments will be conducted relevant to theory course.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Interpret experimental data from Vernier callipers, spectrometers, etc., to determine least count.
CO2 : Understand principles of precision measuring instruments and optical fibers, including their applications and limitations.
CO3 : Explain theory behind Newton's ring experiment, photoconductivity, capacitor behavior, and filter operation.
CO4 : Critically evaluate experimental data, identify errors, and propose improvements.
CO5 : Determine the acceleration due to gravity ('g') using experimental data and mathematical analysis.
CO6 : Develop skills in experimental design, data collection, analysis, and interpretation.

TEXT/REFERENCE BOOKS

1. B B Laud, "**Electromagnetism**", Wiley eastern limited.
2. K. K. Tiwari, "**Electricity and Magenetism with Electronics",** S. Chand & Company Ltd.
3. Brij lal and N Subramaniyam, "**Heat and Thermodynamics**", S. Chand & Company Ltd.
4. Brij lal and N Subramaniyam, **"Optics"**, S. Chand & Company Ltd.
5. Arthur Beiser, **"Concepts of modern Physics",** Tata McGraw Hill.
6. Walter Fox Smith, **"Experimental Physics Principles and Practice for the Laboratory",** CRC Press.

24XXXXXX					Mechanics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Understand and apply vector operations, differentiation, and theorems in multiple coordinate systems.
2. Get Proficiency in using Newton's laws, conservation laws, and potential energy graphs to analyze motion dynamics and collisions
3. Investigate angular momentum conservation, dynamics under central forces and rigid body dynamics
4. Understand the fundamental principles of special relativity.

UNIT I: VECTOR CALCULUS **16 Hrs.**

Vectors and their properties: vector operations (Addition, Subtraction, dot product, cross product, triple product); scalar and vector field, Vector Differentiation: divergence, gradient and curl of the vector field, Examples of electric and magnetic field, Divergence and Stoke's theorem, Cartesian, cylindrical and spherical co-ordinate system.

UNIT II: KINETICS **16 Hrs.**

Forces, Newton's laws of motion, Frames of reference, Concept of inertial and non-inertial reference frames, Momentum, Momentum of system of particles, Conservation laws, Center of mass, Work energy theorem, Potential Energy, Use of potential energy graphs to understand motion, Conservation laws and Particle collisions, scattering, Simple harmonic oscillator and damped oscillator

UNIT III: RIGID BODY AND CENTRAL FORCE MOTION **16 Hrs.**

Angular Momentum, Conservation of angular momentum for a point particle, Projectile motion, Motion under central force, Kepler laws of motion, Rigid bodies: Rotational inertia, Momentum and Energy, Conservation laws, Moment of Inertia-Examples with simple symmetric bodies, Torque and work energy theorem, Non-Inertial and rotating frame of reference, Fictitious force,

UNIT IV: SPECIAL THEORY OF RELATIVITY **08 Hrs.**

Special Theory of Relativity: Measuring space-time in Galilean relativity; Michelson Morley experiment, Postulates of special relativity, Lorentz transformation-Relativity of Simultaneity, Length contraction, Time dilation; Minkowski space-time diagram, Examples: Twin paradox, Doppler Effect.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Learn fundamental vector operations and coordinate systems.
CO2 : Explain divergence, gradient, and curl of vector fields and their applications.
CO3 : Utilize Newton's laws and conservation principles to analyze motion and collisions.
CO4 : Differentiate inertial and non-inertial frames and analyze dynamics of angular momentum and rigid bodies.
CO5 : Assess implications of special relativity principles on phenomena like the Twin paradox and Doppler Effect.
CO6 : Construct solutions to complex problems integrating vectors, forces, and relativity principles.

TEXT/REFERENCE BOOKS

1. D. Kleppner and R. Kolenkow, **"An Introduction to Mechanics",** McGraw Hill Education (2017).
2. R.G. Takwale and P.S. Puranik, "Introduction to Classcial Mechanics", McGraw Hill Education (2017).
3. R. P. Feynman, R. B. Leighton and M. Sands**, "The Feynman Lecture of Physics Vol 1"**, Pearson Publications (2012).
4. C. Kittel, W. D. Knight, M. A. Ruderman, and A. C. Helmholz, **"Mechanics (In SI Units): Berkeley Physics Course Vol 1",** McGraw Hill Education (2017).
5. D. Resnick, R. Halliday and K. S. Krane, **"Physics, Vol 1, 5th Ed",** Wiley publications (2022).
6. M. K. Verma, **"Introduction to Mechanics"**, CRC Press (2009).
7. D. S. Mathur, **"Mechanics"**, S Chand & Co. Ltd., N Delhi (2006).

16BSM201T					Calculus-II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	0	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide basic understanding of calculus of several variables.
- To be able to obtain extreme values of multivariate function.
- To study the multiple integration, understand it geometrically and explore its applications.
- To use this basic course in upcoming courses in respective specializations in higher classes.

UNIT 1 **11 Hrs.**

Functions of several variables, limit and continuity of functions of two variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.

UNIT 2 **07 Hrs.**

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl

UNIT 3 **11 Hrs.**

Double integration over rectangular region, double integration over nonrectangular region. Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.Change of variables in double integrals and triple integrals

UNIT 4 **11 Hrs.**

Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem, The Divergence theorem.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 –Define Function of several variables along with the concept of its limit, continuity and derivative.
CO2 – Evaluate the extreme value of multivariate function.
CO3 – Understand the technique of finding multiple integral and their applications
CO4 – Analyze the applications of line integrals.
CO5 – Understand the basics of vector calculus.
CO6 – Apply calculus of several variables and vector calculus to various problems of science and engineering.

TEXT/REFERENCE BOOKS

1. E. Marsden, A. J. Tromba and A. Weinstein, Basic multivariable calculus, Springer (SIE), Indian reprint, 2005.
2. G. B. Thomas, R. L. Finney, Calculus and Analytic Geometry-Ninth Edition, Addison-Wesley Publishing Company.
3. J. Stewart, Essential Calculus-Early Transcendentals- Second Edition, Cengage Learning.
4. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and sons (Asia), Pt Ltd., Singapore, 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 6 questions of 4 marks each 24Marks

Part B: 6 questions 8 marks each 48 Marks

Part C: 2 questions 14 marks each 28 Marks

16BSM202T					Basic Mathematics – II (Group B)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To be able to understand the applications of vectors in real world.
- To be able to solve differential equations.
- To be able to classify the data and can measure the central tendency and other
- To study the finite differences and effect of errors in real life situations.

UNIT 1 VECTORS AND COORDINATE GEOMETRY (3D) **10 Hrs.**

Vectors and their algebra. Simple applications to geometry and mechanics. Unit vectors, vectors i, j and k . Components of a vector. Position vector. Direction cosines and direction ratios. Dot and cross products. Projection of a vector on another. Distance between two points. Equations of a line, plane and sphere. Intersections. Distance between two points. Shortest distance between lines.

UNIT 2 ELEMENTARY DIFFERENTIAL EQUATIONS **10 Hrs.**

Definitions of order, degree, linear, nonlinear, homogeneous and non-homogeneous. Solution of first order equations. Complementary function and particular integral. Initial and boundary value problems. Linear differential equations with constant coefficients. Cauchy-Euler equation.

UNIT 3 BASIC STATISTICS **10 Hrs.**

Classification of data. Mean mode, median and standard deviation. Frequency distributions and Measures of Central Tendency, Measures of Dispersion, Skewness and Kurtosis.

UNIT 4 BASICS OF NUMERICAL METHODS **10 Hrs.**

Calculus of finite differences, Difference formula, difference table, Effects of an error in a tabular value, The operator E, Properties of two operators E and Δ, Factorial Notations, Methods of any given polynomial in factorial notation, Leibnitz rule.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Identify the use of 2D and 3D vectors in daily life.
CO2 – Understand the concept of basic distance formulas in 1D, 2D and 3D and their applications.
CO3 – Develop the ability to classify differential equations and solve according to various categories and shortcut methods.
CO4 – Analyze the supplied data statistically and measure the results according to the requirement.
CO5 – Appraise the significance of finite differences in all simple calculations and also able to get the idea of errors occurring therein.
CO6 – Evaluate problems on the basis of operators and develop a polynomial in factorials.

TEXT/REFERENCE BOOKS

1. Thomas, G. B. and Finney, R. L., Calculus and analytical geometry, 9th Ed., Pearson Education Asia, (2000)
2. NCERT, Mathematics Textbook for class XI and XII (2009).
3. Sharma, R.D., Mathematics, Dhanpat Rai Publications, New Delhi (2011).

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A: 10 questions of 3 marks each 30 Marks (40 mins.)

Part B: 5 questions 6 marks each 30 Marks (50 mins.)

Part C: 5 questions 8 marks each 40 Marks (90 mins.)

24XXXXXX					Numerical Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide a basic understanding of finding roots of equations and solving system of linear equations.
2. To introduce the basics of numerical interpolation and curve fitting.
3. To introduce numerical methods differentiation, integration and solving differential equations.
4. To intriduce the Monte Carlo technique and its applications.

UNIT I ROOTS OF EQUATIONS AND SYSTEMS OF EQUATIONS **7 Hrs.**
Root Finding: Bisection method, Newton-Raphson method, Secant method, Fixed-point iteration, False position method; Linear equations: Gauss-elimination method, Gauss-Jordan method, LU decomposition, Singular Value Decomposition Matrix inversion by Gauss-Jordan method, Iterative methods: Gauss-Jacobin method and Gauss-Seidel method, Methods for solution of Eigen value problems.

UNIT II INTERPOLATION AND LEAST SQUARES **6 Hrs.**
Interpolation: Newton's forward and backward interpolation formulae, Lagrange's interpolation formula, Newton's divided difference formula, Inverse interpolation, Spline interpolation, Chebyshev Interpolation; Least Squares Approximation: Linear regression, Polynomial regression, Multiple linear regression, Exponential regression.

UNIT III NUMERICAL DIFFERENTIATION AND INTEGRATION **7 Hrs.**
Numerical differentiation: Forward, backward and centred difference formulae, Richardson extrapolation; Numerical integration: Midpoint rule, Trapezoidal rule, Simpson's rule, Romberg formula, Gauss-Legendre integration, Gaussian quadrature formulae (2-point, 3-point and 4-point).

UNIT IV ORDINARY DIFFERENTIAL EQUATIONS, BOUNDARY VALUE AND RANDOM NUMBERS **8 Hrs.**
Numerical solution of ordinary differential equation: Initial value problems, Euler's method, Modification of Euler's method, Picard's method, Taylor Series method, Second and fourth order Runge-Kutta methods; Boundary value problems: finite difference method, Shooting Method; Stochastic methods: Random Numbers and Generators, Monte Carlo technique of numerical integration, Adaptive and Recursive Monte Carlo Methods.

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Derive the solution of roots of polynomial equations and linear algebraic equations by using numerical methods.
CO2 : Demonstrate the understanding of numerical interpolation and least squares approximations.
CO3 : Understand and perform numerical integration and differentiation.
CO4 : Develop and implement stable numerical methods to solve ordinary differential equations
CO5 : Identify and apply the appropriate numerical techniques for solving boundary value problems.
CO6 : Acquire the knowledge about the random numbers generators and Monte Carlo technique.

TEXT/REFERENCE BOOKS

1. Jaan Kiusalaas, "**Numerical Methods in Engineering with Python**", Cambridge University Press, 2010 (Second Edition).
2. Timothy Sauer, "**Numerical Analysis**", Pearson, 2018 (Third Edition).
3. Steven C. Chapra and Raymond P. Canale, "**Numerical Methods for Engineers**", McGraw-Hill Edution, 2015 (Seventh Edition).
4. B. S. Grewal, "**Numerical Methods in Engineering & Science**", Khanna Publishers, 2013 (Eleventh Edition)
5. Rajesh Kumar Gupta, "**Numerical Methods: Fundamentals and Applications**", Cambridge University Press, 2019.
6. William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, "**Numerical Recipes : The art of Scientific Computing**", Cambridge University Press.

Semester - 3

<Course Code>					< Electricity and magnetism >					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To foster a foundational comprehension of electricity and magnetism.
2. To offer essential insights into the principles of basic thermodynamics.
3. To explore the concepts of elementary optics and their practical implications.
4. To provide insight into the inception of modern physics.

UNIT I: REVIEW OF VECTOR CALCULUS **8 Hrs.**

Properties of vectors, Introduction to Gradient, Divergence, Curl, Laplacian, Introduction to spherical polar and cylindrical coordinates, Stokes' theorem and Gauss divergence theorem, Problem solving.

UNIT II: ELECTRICITY **10 Hrs.**

Coulomb's law and principle of superposition. Gauss's law and its applications. Electric potential and electrostatic energy Poisson's and Laplace's equations with simple examples, uniqueness theorem, boundary value problems, Method of images (in brief), Dielectrics- Polarization and bound charges.

UNIT III: MAGNETISM **12 Hrs.**

Magnetostatics- Biot & Savart's law, Amperes law. Divergence and curl of magnetic field, Vector potential and concept of gauge, Calculation of vector potential for a finite straight conductor, infinite wire and for a uniform magnetic field, Magnetism in matter, volume and surface currents, Auxiliary Field H, classification of magnetic materials.

UNIT IV: ELECTROMAGNETIC INDUCTION AND MAXWELL'S EQUATIONS **12 Hrs.**

Faraday's law in integral and differential form; Laws of electromagnetic induction, Lenz's law; Self-inductance, Mutual inductance, Neumann's formula, Relation between self and mutual inductances, Idea of displacement current and Maxwell's modification of Ampere's law, Maxwell's equations and their significance, Propagation of electromagnetic waves in free space and isotropic non-conducting dielectric medium, Poynting vector and Poynting's theorem.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Acquire basic knowledge about vectors and apply it to solve problems.
CO2 : Understand the basic laws of electricity and magnetism.
CO3 : Understand and explain the physical significance of various concepts in electricity and magnetism.
CO4 : Describe the electromagnetic induction and related concepts, and make calculations using Faraday and Lenz's laws.
CO5 : Correlate the concepts learned so far with the Maxwell's equations.
CO6 : Develop the skills in solving various real world problems in electricity and magnetism.

TEXT/REFERENCE BOOKS

1. Halliday, Resnick, Walker, "**Fundamentals of Physics"**, Wiley eastern limited.
2. David J. Griffiths, "**Introduction to Electrodynamics"**, Prentice Hall.
3. Purcell, Edward M., **"Electricity and Magnetism"**, McGraw-Hill.
4. Feynman, Richard P., Robert B. Leighton, and Matthew Sands, **"The Feynman Lectures on Physics",** Addison-Wesley.

<Course Code>					< Electricity & Magnetism Laboratory >					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. To understand the working of various instruments used in electricity and magnetism.
2. To gain practical knowledge in electricity and magnetisms through experiments.
3. To understand basics concepts of electromagnetism be able to apply in practise.

LIST OF EXPERIMENTS

A. List of experiments (Any 8)

1. To verify Faraday and Lenz's law
2. To demonstrate and investigate diamagnetism, paramagnetism and ferromagnetism in given samples
3. To determinate e/m by Thomson's method.
4. To measure high resistance using leakage method
5. To study the Post office box and determine the value of unknown resistance
6. To study the behaviour of high-pass and low-pass filters
7. To study the Balmer series of Hydrogen using spectrometer
8. To study the phenomenon of Ferromagnetic hysteresis
9. To measure the electrical conductivity of metals
10. To study and measure the magnetic field along the axis of a coil
11. To measure the ballistic constant of a Ballistic galvanometer.

B. Project/Model based on the principles of Electricity & Magnetism

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Utilize and assess the principles of electricity and magnetism
CO2 : Comprehend the process of electromagnetic induction.
CO3 : Display and implement the phenomenon of hysteresis.
CO4 : Explore the electrical and magnetic characteristics of a material.
CO5 : Evaluate different electrical and magnetic components utilized in relevant experiments.
CO6 : Employ electrical principles in designing a functional model.

TEXT/REFERENCE BOOKS

1. D. J. Griffiths, "**Introduction to Electrodynamics"**, Prentice Hall.
2. E. M. Purcell, "**Electricity and Magnetism, Berkeley Physics Course"**, NY: McGraw-Hill.
3. Resnick, Halliday and Krane, **"Physics part I and II"**, John Wiely.
4. C.S. Robinson, R, Das, **"Textbook of Engineering Physics Practical",** University Science Press.
5. A. Ghatak, **"Optics",** Tata McGraw Hill.

24XXXXXX					Heat and Thermodynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Define the basic concepts of thermodynamics through laws of thermodynamics and understand the process of heat transfer.
2. To analyze the working principle of heat engines and refrigerators based on laws of thermodynamics.
3. To assess the nature of various substances during phase transition by using the concept of new thermodynamic potential.
4. To apply the kinetic theory of gases to solve problems related to behavior of gases.

UNIT I: BASICS OF THERMODYNAMICS AND HEAT TRANSFER PROCESSES 15 Hrs.

Laws of Thermodynamics, Types of thermometer and concept of temprature, Various types of thermometers, Simple thermodynamic systems and thermodynamic equilibirium, concept of heat and work, Internal Energy, Mathematical formulation of first law of thermodynamics, Heat capacity and measurements, Heat conduction and convection, Thermal radiation: Black body, Kirchoff's law, radiated heat, Stefan-Boltzmann law, Wien's displacement law, Rayleigh-Jean's law, Equation of state of Ideal gas

UNIT II: HEAT ENGINES AND ENTROPY 15 Hrs.

Conversion of heat into work, Various types of heat engines, Kelvin-Planck and Clausius Statements and their Equivalence, Reversibiility and Irreversibility, Carnot cycle and Carnot refrigerator, Carnot's theorem, The thermodynamic temprature scale, Absolute zero and carnot efficiency, Concept of Entropy, Reversible and Irresversible part of second law and entropy, Entropy of a Perfect Gas. Entropy of the Universe. Principle of Increase of Entropy, Impossibility of Attainability of Absolute Zero: Third Law of Thermodynamics.

UNIT III: PHASE TRANSITION AND THERMODYNAMIC POTENTIALS 13 Hrs.

First and second order Phase Transitions, Examples of phase diagrams, Triple point of water, Enthalpy, Hemholtz and Gibbs functions, Derivations of Maxwell's Relations, Clausius Clapeyron equation, Temperature-Entropy Diagrams, Joule Thomson Expansion, Liquefaction of gases, Properties of liquid helium.

UNIT IV: KINETIC THEORY OF GASES 13 Hrs.

Maxwell-Boltzmann Law of Distribution of Velocities, Mean, RMS and Most Probable Speeds, Degrees of Freedom, Law of Equipartition of Energy, Mean Free Path, Collision Probability, Behavior of Real Gases: from the Ideal Gas Equation, Van der Waal's Equation of State for Real Gases, Thermodynamic equations for a Van der Waals gas, Introduction to superfluidity and superconductivity.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Learn the basic concepts of thermodynamics and investigate the effect of heat through the flow of radiation.
CO2 : Understand and assess the implications of conversion of heat into work.
CO3 : Apply laws of thermodynamics to understand the working principle of heat engines and refrigerators.
CO4 : Analyze laws of thermodynamics to develop the understanding about using new thermodynamic potentials.
CO5 : Evaluate phase transition of various substances by using the knowledge of thermodynamic potential.
CO6 : Demonstrate comprehensive understanding about behavior of gases by using kinetic theory of gases.

TEXT/REFERENCE BOOKS

1. Mark Waldo Zemansky & Richard Dittman, **"Heat and Thermodynamics: An Intermediate Textbook"**, McGraw-Hill (1981).
2. D. V. Schroeder, **"An Introduction to thermal physics"**, Pearson Publications (2007).
3. Enrico Fermi, **"Thermodynamics",** Courier Dover Publications (1956).
4. Yunus A Cengel and Michael A Boles, **"Thermodynamics: An engineering approach**", McGraw Hill Education, 8th edition (2017).

24XXXXXX					Mathematical Physics - I					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Understand abstract systems, binary operations, and group theory.
2. Apply matrix operations and solve eigenvalue problems effectively.
3. Analyze differential equations using power series and Frobenius methods.
4. Synthesize special functions to address diverse mathematical challenges.

UNIT I Linear Vector Spaces **14 Hrs.**

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Rank – Nullity Theorem.

UNIT II Matrices **14 Hrs.**

Properties of Matrices, Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Adjoint of a Matrix. Inverse of a Matrix by Adjoint Method. Similarity Transformations. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product. Eigen-values and Eigenvectors. Cayley- Hamilton Theorem. Diagonalisation of Matrices.

UNIT III Partial and Ordinary Differential Equations **14 Hrs.**

General Solution of Wave Equation in 1 Dimension, Separation of variables, Helmholtz and Laplace's equations in various coordinate systems, Power series methods for second order differential equation, Frobenius method, Wronskian, Bessel's Equation and its Solution, Oscillations of Hanging Chain

UNIT IV Special Functions **14 Hrs.**

Bessel functions, Bessel functions of the second kind, Henkel functions, Spherical Bessel functions, Legendre polynomials, Associated Legendre polynomials, Hermite polynomials, Laguerre polynomials, The Dirac delta function, examples.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recognize fundamental concepts in linear algebra and differential equations.
CO2 : Apply matrix operations and methods to solve mathematical problems.
CO3 : Analyse differential equations using various solving techniques.
CO4 : Evaluate solutions to differential equations in physical contexts.
CO5 : Construct solutions to mathematical problems integrating special functions.
CO6 : Assess methods' appropriateness in solving mathematical challenges effectively.

TEXT/REFERENCE BOOKS

1. Erwin Kreyszig, **"Advanced Engineering Mathematics"**, Wiley Eastern Limited
2. Dan Margalit and Joseph Rabinoff, **"Interactive Linear Algebra**", Georgia Institute of Technology
3. P K Chattopadhyay, **"Mathematical Physics",** New Age International Publishers
4. H K Das, **"Advanced Engineering Mathematics"**, S. Chand & company LTD.

<table>
<tr><td colspan="5">24XXXXXX</td><td colspan="6">Introduction to Plasma Physics</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td colspan="6">Examination Scheme</td></tr>
<tr><td rowspan="2">L</td><td rowspan="2">T</td><td rowspan="2">P</td><td rowspan="2">C</td><td rowspan="2">Hrs./Week</td><td colspan="3">Theory</td><td colspan="2">Practical</td><td rowspan="2">Total Marks</td></tr>
<tr><td>MS</td><td>ES</td><td>IA</td><td>LW</td><td>LE/Viva</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td><td>25</td><td>50</td><td>25</td><td>--</td><td>--</td><td>100</td></tr>
</table>

COURSE OBJECTIVES

1. To understand the general properties of Plasma, the fourth state of matter.
2. To understand the dynamics of a single particle of Plasma in static fields and time varying fields.
3. To introduce the basic concepts of Plaxma Kinetics and magnetohydrodynamics (MHD).
4. To introduce the techniques of Plasma production and applications.

UNIT I General Properties of Plasmas **7 Hrs.**

Criteria for the Definition of a Plasma, Macroscopic Neutrality, Debye Shielding, The Plasma Frequency, The Occurrence of Plasmas in Nature, Applications of Plasma Physics, Theoretical Description of Plasma Phenomena.

13 Hrs.

UNIT II Charged particle dynamics

Charged particle dynamics in uniform electrostatic and magnetostatic fields, Charged particle dynamics in non-uniform magnetostatic fields, Charged particle dynamics in time varying electromagnetic fields.

UNIT III Introduction Plasma Kinetics and MHD **10 Hrs.**

The Boltzmann Equation, Relaxation Model for the Collision Term, The Vlasov Equation, Plasma as a Conducting Fluid, The Langevin Equation, Fundamental Equations of Magnetohydrodynamics.

UNIT IV Plasma production and applications **10 Hrs.**

dc discharge, rf discharge, photo-ionization, tunnel ionization, avalanche breakdown, laser produced plasmas, Langmuir probe. Medium and short wave communication, plasma processing of materials, laser ablation, laser driven fusion, magnetic fusion.

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Understand the general properties of Plasma, the fourth state of matter.
CO2 : Understand the dynamics of a single particle of Plasma in static fields.
CO3 : Understand the dynamics of a single particle of Plasma in time varying fields.
CO4 : Have the knowledge Plasma dynamics in terms of Boltzman equation and as a fluid.
CO5 : Have the knowledge of the basic concepts of magnetohydrodynamics.
CO6 : Have the knowledge of the techniques of Plasma production and applications.

TEXT/REFERENCE BOOKS

1. Goldston, R. J., and P. H. Rutherford. “**Introduction to Plasma Physics”**. Philadelphia, PA: IOP Publishing, 1995.
2. J.A. Bittencourt, **“Fundamentals of Plasma Physics”**, Springer, 2004
3. Krall, N. A., and A. W. Trivelpiece. “**Principles of Plasma Physics”**. Berkeley, CA: San Francisco Press,
4. Wesson, J. “T**okamaks”**. 3rd ed. Oxford, UK: Oxford University Press, 2004
5. Stix, T. H. “**Waves in Plasmas**”. New York, NY: Springer, 1992.
6. Miyamoto, K. “**Plasma Physics for Nuclear Fusion”**. Cambridge, MA: MIT Press, 1989.

24???T					Advanced Excel					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs. / Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
2	**0**	**0**	**2**	**2**	**25**	**50**	**25**	**-**	**-**	**100**

COURSE OBJECTIVES

- Understand Master advanced functions and formulas for complex calculations
- Explore data analysis techniques such as pivot tables, data validation, and conditional formatting
- Learn the optimization of spreadsheet performance and efficiency
- Utilize external data sources and connections for real-time data analysis

UNIT 1 Fundamental Functions and Data Analysis Techniques	**7 Hrs.**
Nested functions, Array formulas, Lookup and reference functions, Text functions for data manipulation, Pivot tables and pivot charts, Data validation and validation rules	
UNIT 2 Data Visualization	**6 Hrs.**
Creating interactive dashboards, Using sparklines and data bars, Advanced chart types and customization	
UNIT 3 Spreadsheet Optimization	**7 Hrs.**
Managing large datasets efficiently, Workbook organization and structure, Performance optimization techniques, namely, Caching, Reduce volatile functions, Compression, and data partitioning.	
UNIT 4 External Data Sources	**8 Hrs.**
Importing data from external sources (e.g., databases, web), Using data connections for real-time analysis, Refreshing data and updating connections, ChatGPT 4.0	
	28 Hrs.

COURSE OUTCOMES

Upon completion of the course, students will be able to:

CO1	:	Use nested functions and array formulas for complex calculations.
CO2	:	Utilizing lookup and reference functions for data retrieval and manipulation.
CO3	:	Implement data validation and conditional formatting techniques to ensure data integrity and enhance visual analysis.
CO4	:	Create dynamic and interactive dashboards to present insights effectively.
CO5	:	Understand techniques for managing large datasets efficiently and organizing workbooks effectively.
CO6	:	Import the data from external sources and establish connections for real-time data analysis.

TEXTS/REFERENCE BOOKS

1. Jordan Goldmeier and John Michaloudis, “**Advanced Excel Essentials**," Apress Publishing
2. Nathan George, “**Excel Charts and Graphs: Master Data Visualization in Excel,**” Que Publishing

24xxxXXXX					Foundations of Python Programming					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**1**	**2**	**2**	**3**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. Apply Python for physics problem-solving and data analysis.
2. Understand Python control structures and module functionalities.
3. Develop Python proficiency for computational tasks in physics.

LIST OF EXPERIMENTS

1 Implementation of python data types, operators and user inputs.
2 Using conditional statements for controlling flow of program.
3 Using various types of loops in the algorithm.
4 Introduction to python modules math, cmath and matplotlib.
5 Functions in Python.
6 Complex Analysis using cmath library.
7 Program to convert one co-ordinate system to another.
8 Performing differentiation and integration.
9 Discrete and Continuous Probability Distribution.
10 Finding roots for algebraic and transcendental equations.
11 File I/O operations for ASCII, Binary and HDF5 format.
12 Random numbers and simulation.
13 Random Data generation

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall Python syntax and basic programming concepts.
CO2 : Explain Python control structures, functions, and module functionalities.
CO3 : Apply Python modules to solve computational problems effectively.
CO4 : Analyze data and perform complex tasks using Python libraries.
CO5 : Evaluate Python approaches to mathematical problems.
CO6 : Design and implement Python programs to address specific challenges.

TEXT/REFERENCE BOOKS

1. Mark Lutz, **"Learning Python"**, O'Reilly Media.
2. Wes McKinney, **"Python for Data Analysis"**, O'Reilly Media.
3. Eric Matthes, **"Python Crash Course"**, No Starch Press.
4. Jake VanderPlas, "**Python Data Science Handbook"**, O'Reilly Media.

24XXXXXX					Elements of Environmental Studies					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand basic concepts of environment such as ecology, biodiversity, natural resources and global warming.
2. To make students aware about the environmental systems and environmental issues in scientific, cultural, and social realms.
3. To develop ability to work effectively on complex problems involving multiple competing stakeholders and agendas.
4. To think across and beyond existing disciplinary boundaries, mindful of the diverse forms of knowledge and experience that arise from human interactions with the world around them.

UNIT I: INTRODUCTION TO ENVIRONMENTAL STUDIES **07 Hrs.**

Major environmental challenges, Importance of environmental Studies, multidisciplinary nature, Ecology and Ecosystem, types of ecosystems, functioning of an ecosystem; Biodiversity – its importance, threats and conservation; Natural Resources – Forest, Water, Mineral, Energy, Minerals.

UNIT II: ENVIRONMENTAL POLLUTION **07 Hrs.**

Causes, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, Pollution from micro-plastic, Solid waste Management: Causes, effects and control measures of urban and industrial wastes.

UNIT III: ENVIRONMENTAL LEGISLATION AND PUBLIC AWARENESS **06 Hrs.**

Environment Protection Act, Wildlife Protection Act, Issues involved in enforcement of environmental legislation, Public awareness, Environmental impact assessment, practical challenges for implementation.

UNIT IV: SOCIAL ISSUES AND THE ENVIRONMENT **08 Hrs.**

Global warming and Climate change, Global and Regional climate challenges, ozone layer depletion, Water conservation, rain water harvesting, Green technology solutions, Sustainable development, Case Studies, Environmental ethics: Issues and possible solutions.

TOTAL HOURS: 28 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify major environmental challenges and probable solution.
CO2 : Understand core concepts the environmental studies.
CO3 : Apply concepts and methodologies to analyse and understand interactions between social and environmental processes.
CO4 : Analyse role of human beings in shaping the environment.
CO5 : Critically examine the interlink between development and the environment.
CO6 : Develop the skills in solving various real world problems in environmental studies.

TEXT/REFERENCE BOOKS

1. Dave, D. & Katewa, S. S., **“Textbook of Environmental Studies”**, Cengage Learning.
2. Daniel B. Botkin & Edwards A. Keller, **“Environmental Science”**, Wiley INDIA.
3. Odum E. P., **“Fundamentals of Ecology”**, Cengage India Private Limited.
4. Rao, M. N. & Rao H. V. N., **“Air Pollution”**, Mc Graw Hill.
5. Trivedi R. K., **“Handbook of Environmental Laws, Rules and Guidelines, Compliances and Standards”**, B.S. Publications.
6. Rajagopalan, R., **“Environmental Studies”**, Oxford University Press.

Semester - 4

<Course Code>					Electromagnetic Theory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Apply electromagnetic principles to solve real-world engineering problems.
2. Analyze electromagnetic phenomena using advanced mathematical and computational techniques.
3. Design experiments to validate theoretical concepts in electromagnetism.
4. Acquire hands-on experience in utilizing electromagnetism principles.

UNIT I: VECTOR CALCULUS & SPECIAL TECHNIQUES **12 Hrs.**

Fundamental Theorems of Gradient, Curl and Divergences, Line Surface and Volume Integrals, Curvilinear Co-ordinate systems, Laplace's equation, Boundary Conditions and Uniqueness Theorems, Method of Images, Separation of Variables, Multipole Expansion, Approximate Potentials at Large Distances, Monopole and Dipole terms, Electric field of a dipole.

UNIT II: ELECTRIC FIELDS IN MATTER **18 Hrs.**

Dielectrics, Induced Dipole, Polarization, Field of Polarized object, Bound Charges, Field Inside a Dielectric, Electric Displacement, Gauss's Law in the presence of dielectrics, Boundary Conditions, Linear Dielectrics, Properties of Linear Dielectrics, Energy and Forces in Dielectric systems.

UNIT III: MAGNETIC VECTOR POTENTIAL **8 Hrs.**

Divergence and Curl of B, Ampere's law, Applications of Ampere's Law, The Vector Potential, Modified Ampere's law with Vector potential and its applications, Magnetostatic boundary conditions, Multipole Expansions in Vector Potential.

UNIT IV: MAGNETIC FIELDS IN MATTER **18 Hrs.**

Magnetization, Torques and Forces on Magnetic dipoles, Effect of magnetic field on atomic orbits, Field of Magnetized object, Bound Currents, The magnetic field inside matter, Auxiliary Field H, Ampere's law in Magnetized Materials, Boundary Conditions, Linear and Nonlinear Media, Magnetic Susceptibility and Permeability.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall fundamental principles of electromagnetism accurately.
CO2 : Explain electric and magnetic field behaviors in various mediums clearly.
CO3 : Apply methods like separation of variables effectively in problem-solving.
CO4 : Analyze the behavior of electromagnetic fields critically and systematically.
CO5 : Evaluate effectiveness of electromagnetism solving techniques systematically.
CO6 : Formulate new approaches to solve complex electromagnetism problems.

TEXT/REFERENCE BOOKS

1. David J. Griffiths, "**Introduction to Electrodynamics"**, PHI Learning.
2. Edvind Wichman, "**Electricity and Magnetism Berkley Physics Course Vol. II"**, Tata McGraw Hill.
3. B. B. Laud, "**Electromagnetics"**, New Age International.
4. Mathew N. O. Sadiku, "**Elements of Electromagnetics",** Oxford University Press.
5. Edward M. Purcell, "**Electricity and Magnetism"**, McGraw Hill Educations.
6. A. S. Mahajan and A. A. Rangwala, **"Electricity and Magnetism"**, McGraw Hill Educations.

<Course Code>					Introduction to Quantum Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To explain the fundamental principles of quantum mechanics, including the particle-wave duality
2. To apply the Schrödinger Equation to solve problems related to simple quantum systems.
3. To analyze the mathematical structure of quantum systems, solving radial and angular equations for the hydrogen atom.
4. To synthesize knowledge of quantum mechanics to describe and predict the behaviour of particles with spin

UNIT I: INTRODUCTION TO QUANTUM BEHAVIOUR **10 Hrs.**

Particle Nature of Light, Wave Nature of Matter, Two Slit Experiment with Waves and Electrons, Description of Particles by Wave Packets, Schrodinger Equation, Wave Function, The Probabilistic Interpretation of Wave Function, The Ehrenfest Theorem, Heisenberg's Uncertainty Principle and its Applications, Time Independent Schrodinger Equation, Particle In A Box, Stationary States, The Free Particle, Scattering States.

UNIT II: FORMALISM **10 Hrs.**

Hilbert Space, square integrable wave function, Dirac notations, Operators: Hermitian adjoint, Projection operators, Commutator algebra, inverse and unitary operators, Eigen value and Eigen vectors of operators, Generalized Uncertainty Principle, Minimum Uncertainty Wave Packet, Matrix representation of bra, ket and operators, Matrix representation of Eigen value problem, Wave and matrix mechanics, postulates of quantum mechanics, measurements in quantum mechanics, Time evolution of system's state

UNIT III: IDEAL SYSTEMS IN QUANTUM MECHANICS **18 Hrs.**

Dirac Delta Potential Well, Finite Square Well, Square Barrier, Quantum Tunnelling, Simple Harmonic Oscillator, Ladder Operators, Particle in three-dimensional potential, Particle in a spherically symmetric potential, Separation of Variables in three dimensions, The angular equation, The Radial Equation.

UNIT IV: HYDROGEN ATOM AND ANGULAR MOMENTUM **18 Hrs.**

The Radial Equation for Hydrogen Atom, Spectrum of Hydrogen, Angular Momentum, Eigen function of Angular Momentum operators, Spin of Particle, Quantum interpretation of Spin, Algebraic theory of Spin, Spin Operators, Particle with Spin-½, Particle with Spin-1, Larmor Precession, Stern Gerlach Experiment, Addition of Angular Momentum.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Explain the quantum mechanics principles and postulates.
CO2 : Interpret the probabilistic behaviour of the wave function in quantum systems.
CO3 : Apply the Schrödinger Equation to solve problems related to simple quantum systems.
CO4 : Analyze the mathematical structure of quantum systems.
CO5 : Develop solutions for complex quantum systems by combining knowledge of various mathematical techniques.
CO6 : Design experiments or theoretical scenarios demonstrating the application of quantum mechanics principles.

TEXT/REFERENCE BOOKS

1. David J. Griffiths, "**Introduction to Quantum Mechanics**", Pearson Educations.
2. Edvind Wichman, "**Quantum Physics Berkley Physics Course**", Tata McGraw Hill.
3. Mathews and Venkatesan, "**Quantum Mechanics**", Tata McGraw Hill.
4. G. Aruldhas, "**Quantum Mechanics",** PHI Learning.
5. N. Zettili, "**Quantum Mechanics: Concepts and Applications**", PHI Learning.
6. R. Shanker, **"Principles of Quantum Mechanics"**, Plenum Publishers.
7. L. I. Schiff, **"Quantum Mechanics"**, McGraw Hill Book Co.

<Course Code>					< Electronics >					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To introduce the operation of semiconductor devices
2. To introduce the fundamental concepts and working principle of JT, JFET, FET, MOSFET
3. To introduce the operation and fundamental concepts of OPAMP
4. To provide the understanding of basic boolean laws, K-MAPS, SOP and POS method to design logic circuits

UNIT I: PHYSICS OF SEMICONDUCTORS **12 Hrs.**

Introduction to semiconductors, Intrinsic and Extrinsic semiconductors, conduction in semiconductors, formation of depletion region, drift and diffusion current in semiconductors, Junction diode and its characteristics, ideal and practical diode model, diode applications: HWR, FWR, Bridge FWR, power supply filters and capacitor filters, diode limiting and clamping circuits, voltage multipliers, Zener diode and its applications.

UNIT II: TRANSISTORS AND ITS APPLICATIONS **12 Hrs.**

Junction Transistor: Potential curves in unbiased and biased transistor, Transistor current components, Early effect, Static Characteristics of CB & CE configuration, active, cut off and saturation regions. Transistor as an Amplifier, Transistor current gains (Alpha, Beta, Gama) Junctions Field Effect Transistor, Qualitative Description of JFET, Drain and transfer characteristics of JFET, FET, MOSFET -Depletion and enhancement and their drain & transfer characteristics.

UNIT III: OPERATIONAL AMPLIFIER (OPAMP) **8 Hrs.**

Introduction to operation amplifier (Op-Amp), Ideal Op-Amp, Equivalent Circuit, Open-loop Op-Amp Configuration, Op-Amp with Negative Feedback: Feedback Amplifier and Differential Amplifier, Practical Op-Amp, DC and AC Amplifier, Peaking Amplifier, Summing, Scaling and Averaging Amplifier.

UNIT IV: DIGITAL ELECTRONICS AND LOGIC GATES **10 Hrs.**

Number systems: Binary, Octal, Hexadecimal number system and base conversions, Binary Arithmetic operations, 1's and 2's complement representation, Sequential Codes: Binary codes-BCD, Grey. Logic Gates, Boolean Algebra: Postulates, Duality Principal, De Morgan's Law, Simplification of Boolean Identities, Standard SOP & POS Forms, Simplification using K-map, don't care condition implementation of SOP & POS form using NAND and NOR Gate.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Demonstrate and analyse the behaviour of semiconductor devices
CO2 : To get an insight about the operation of JT, JFET, MOSFET in order to design the basic circuits
CO3 : To get an insight about the operation of opamp
CO4 : Develop the digital logic to analyse the problems of number system and arithmetic operation
CO5 : Solve the sequential codes based problems of digital electronics
CO6 : Demonstrate the ability to use basic boolean laws, K-MAPS and SOP, POS methods

TEXT/REFERENCE BOOKS

1. V.K. Mehta, "**Principles of Electronics**", S. Chand & Company Ltd., New Delhi.
2. Thomas L. Floyd, "**Electronic Devices**", Pearson Education.
3. Allen Mottershed, "**Electronic Devices and Circuits**", Prentice-Hall, Pvt. Ltd, New Delhi.
4. Albert Malvino, "**Electronics Principles",** McGraw.
5. Anil K. Maini, "**Digital Electronics: Principles, Devices and Applications**", Wiley.

<Course Code>					<Electronics LAB >					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. To understand the working of various components of basic electronics.
2. To gain practical knowledge in the field of electronic circuits through experiments.
3. To understand basics concepts of electronic devices and amplification.

LIST OF EXPERIMENTS

1 To study the principle of kirchhoff's law
2 To verify the super position theorem
3 To verify the maximum power transfer theorem
4 To study the operation of diac used in triggering circuits of power electronics
5 To perform the gate triggering characteristics of an scr
6 To study the operation of photo-voltaic using variable light source
7 To observe the waveform of hartley oscillator and measure the output frequency
8 To study I-V characteristics of zener diode
9 To study areal characteristics of solar panel
10 To study LCR circuit
11 To study I-V characteristics of P-N junction diode
12 To study the input and output characteristics of an NPN transistor in common emitter mode and determine transistor parameters

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Apply and analyse the concepts of basic electronics and circuits
CO2 : Understand the concept of current addition at nodes
CO3 : Demonstrate and implement the concept of voltage division
CO4 : Investigate the effect of area on solar panel output
CO5 : Examine various electronic components including P-N junction diode, zener diode etc.
CO6 : Examine the I-V characteristics of solar cell with variation in the light intensity

TEXT/REFERENCE BOOKS

1. V.K. Mehta, "**Principles of Electronics**", S. Chand & Company Ltd., New Delhi.
2. Thomas L. Floyd, "**Electronic Devices**", Pearson Education.
3. Allen Mottershed, "**Electronic Devices and Circuits**", Prentice-Hall, Pvt. Ltd, New Delhi.
4. Albert Malvino, "**Electronics Principles",** McGraw.
5. Anil K. Maini, "**Digital Electronics: Principles, Devices and Applications**", Wiley.

24XXXXXX					Introduction to Astronomy and Astrophysics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	0	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Develop physical intuition about how observations are made in astrophysics.
2. To learn how the fundamental principles of physics are useful in explaining various processes happening in astronomical objects.
3. To prepare a base for an ambitious physics student who wants to go to advanced studies or research in relevant fields.

UNIT I: FUNDAMENTALS **13 Hrs.**

Overview of major contents of universe, The scale of the universe: Mass, length and time scales in astrophysics, Earth Rotation, Seasons, Phases of the Moon, Moon's orbit and eclipses, timekeeping (sidereal vs. synodic period); Planetary motions: Kepler's Laws, Gravity, Light & Energy; Planets: Formation of Solar System, planet types, planet atmospheres, extra solar planets.

UNIT II: BASICS OF ASTRONOMICAL OBSERVATIONS **08 Hrs.**

Celestial coordinates, Magnitude Scale, Sources of Astronomical information, Telescopes: Refracting and reflecting, Ground based and space based, Data handling, Astronomy in different bands of electromagnetic radiation: Optical, Radio, X-Ray Astronomy

UNIT III: STELLAR ASTROPHYSICS **13 Hrs.**

Properties of Ordinary stars: Stellar colors, Stellar distances, basic knowledge of stellar atmospheres, Spectral types, Hertzprung Russell Diagram, Binaries, variable stars. Stellar Evolution, White dwarfs, Supernovae, Neutron Stars, Black holes, Pulsars. Clusters of stars, open and globular cluster

UNIT IV: THE UNIVERSE AT LARGE **06 Hrs.**

Galaxies, Types of galaxies. Normal and active galaxies, Shape, size and contents of Milky Way galaxy, The dark matter problem, Cosmology, The standard model, The cosmic microwave background, Recent issues in the area of Astrophysics and Cosmology

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall fundamental astronomical concepts and planetary characteristics
CO2 : Understand principles of telescopes, celestial coordinates, and data handling techniques
CO3 : Utilize knowledge of stellar properties and celestial phenomena to interpret Astronomical data.
CO4 : Examine galaxy types and cosmological theories to evaluate our understanding of cosmos
CO5 : Assess recent advancements in astrophysics and cosmology
CO6 : Utilize information to construct informed perspectives on contemporary issues in Astrophysics

TEXT/REFERENCE BOOKS

1. Bradley Carroll & D.A. Ostlie, **"An Introduction to Modern Astrophysics**", Cambridge University Press (2017).
2. Arnab Rai Choudhuri , **"Astrophysics for Physicists",** Cambridge University Press (2010).
3. M. Zeilik and S. A. Gregory, "**Introductory Astronomy and Astrophysics**", Brooks/Cole Publications (1997).
4. Pankaj Jain, **An introduction to astronomy and astrophysics**, , Taylor & Francis (2015).
5. Jeffrey O.Bennett, Megan O. Donahue, Nichola Schneider, Mark Voit, "**The Cosmic Perspective, seventh edition"**, Pearson Publications (2012).
6. Marc Leslie Kutner , "**Astronomy: A Physical Perspective**", Cambridge University Press (2003).

<Course Code>					Renewable Energy and Energy Harvesting					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
2	**0**	**0**	**2**	**2**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To provide knowledge on renewable energy resources and applications.
2. To introduce basic concepts of aerodynamics, horizontal and vertical axis wind turbines.
3. To provide the knowledge of solar energy harvesting and their fundamental understanding.
4. To introduce the fundamental understanding of geothermal, hydro, piezo, electromagnetic and carbon renewable energy resources

UNIT I: FOSSIL FUELS AND ALTERNATE SOURCES OF ENERGY **07 Hrs.**

Present scenario, Fossil fuels and their limitation, need of renewable energy, non-conventional energy sources, Basics of energy, An overview of developments in alternate sources of energy, Energy and environment correlations: Environmental Impact Assessment

UNIT II: SOLAR ENERGY HARVESTING **06 Hrs.**

Solar energy, its importance, applications, basic terminology: sun angle, radiations, air mass etc., solar to thermal energy conversion, solar concentrator, solar pond, solar PV system, solar cells, characteristics, materials generation, and efficiency.

UNIT III: WIND AND OCEAN ENERGY HARVESTING **08 Hrs.**

Fundamentals of Wind Energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and Ocean Energy, Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices, Tide characteristics and Statistics, Tide Energy Technologies.

UNIT IV: OTHER RENEWABLE SOURCES **07 Hrs.**

Geothermal Energy, Geothermal Resources, Geothermal Technologies. Hydro Energy, Hydropower resources, hydropower technologies, the environmental impact of hydropower sources. Piezoelectric Energy harvesting, Introduction, Physics and characteristics of piezoelectric effect, Piezoelectric energy harvesting applications. Carbon captured technologies, Batteries.

TOTAL HOURS: 28 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify different renewable sources of energy and technologies to harness them.
CO2 : Explain the basics of energy, including unit conversions, and analyze the environmental impact.
CO3 : Evaluate various alternate sources of energy, such as solar, wind, geothermal, hydro, piezoelectric harvesting technologies.
CO4 : Identify and explain the different resources of solar energy harvesting.
CO5 : To explain and analysis the basic terminology of solar energy and analysis the solar cell characteristics.
CO6 : Explain design and analysis the basic operating mechanism of energy harvesting from geothermal, hydro, piezo, and carbon energy resources

TEXT/REFERENCE BOOKS

1. N. K. Bansal, "**Renewable energy sources and conversion technology"**, McGraw-Hill Book Company.
2. G. D. Rai, "**Non-conventional energy sources"**, Khanna Publishers.
3. S. P. Sukhatme, "**Solar Energy principles of thermal collection and storage**" McGraw-Hill Book Company.
4. Godfrey Boyle, "**Renewable Energy, Power for a Sustainable Future",** Oxford University Press.
5. G. S. Sawhney, "**Non-conventional energy sources**", PHI learning Pvt. Ltd.
6. S. Rao and Dr. B. B. Parulekar, "**Energy Technology**", Khanna Publishers.

24???T					Cybersecurity					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	-	-	100

COURSE OBJECTIVES

- Develop a foundational understanding of cybersecurity concepts.
- Identify and analyze various forms and types of cybercrime
- Apply best practices for secure usage of digital technologies:
- Analyze cybercriminal behavior through interdisciplinary perspectives

UNIT 1 FOUNDATIONS OF CYBERSECURITY	6 Hrs.
Definition – Crime, Cyber Crime, Information Security, Digital Forensics – Conventional Crime Vs. Cyber Crime - Uniqueness of Cyber Crime – History of Cyber Crimes.	
UNIT 2 FORMS AND TYPES OF CYBER CRIMES	**6 Hrs.**
Forms of Cyber Crimes – Hacking – types of hacking, hackers, Cracking, Dos, DDos, Cyber Bullying, Cyber Stalking, Pornography, Phishing, Intellectual Property Theft, Data Theft, Dada diddling, malwares, stegnography, salami attacks, ATM and Credit card frauds, Telecom Frauds	
UNIT 3 CYBER CRIMINAL BEHAVIOR	**8 Hrs.**
Understanding cyber criminal behavior – modus operandi - Criminological , Sociological and Psychological theories relating to cyber crime behavior.	
UNIT 4 SOCIAL MEDIA SECURITY AND BEST PRACTICES	**6 Hrs.**
Social Media – Definition, Types, advantages and disadvantages – Crimes through social media, victimization through social media – Do's and Don'ts in Social Media – Safe Surfing	
	28 Hrs.

COURSE OUTCOMES

Upon completion of the course, students will be able to:

CO1	:	Define key cybersecurity concepts and terminology with accuracy and clarity.
CO2	:	Explain various forms and motivations behind cybercriminal behavior comprehensively.
CO3	:	Implement effective strategies for safe and responsible social media usage.
CO4	:	Analyze cybercrime patterns through diverse disciplinary perspectives critically.
CO5	:	Assess cybersecurity measures and propose improvements for enhanced protection.
CO6	:	Design innovative solutions to address emerging cyber threats effectively.

TEXTS/REFERENCE BOOKS

1. Charles J. Brooks and Christopher Grow, **Cybersecurity Essentials**", Wiley.
2. Dafydd Stuttard and Marcus Pinto, **"The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws"** 2nd ed., Wiley.
3. Michael Cross," **Social Media Security: Leveraging Social Networking While Mitigating Risk**"Syngress.
4. Susan W. Brenner, "**Cybercrime: Criminal Threats from Cyberspace**"Praeger Publishers Inc.

Semester - 5

24XXXXXX					Solid State Physics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Gain insights into crystal structure and diffraction principles.
2. Explore conductor concepts and semiconductor properties.
3. Analyse lattice vibrations and thermal properties of materials.
4. Examine superconductors and dielectric materials properties and applications.

UNIT 1 Crystal Structure and Diffraction **10 Hrs.**

Introduction, Crystalline and amorphous materials, crystal systems, Unit Cells, Point Groups, Bravais lattices Miller Indices, reciprocal lattice, atomic packing, crystal imperfections. Diffraction of X-rays: Bragg's Law, experimental methods in X-ray diffraction, Laue method, rotating crystal method, powder photograph method.

UNIT- II: Band Theory and Semiconductors **12 Hrs.**

Conductors: Free electron theory, Bloch Theorem, Kronig Penny Model, Construction of Brillouin Zones, Extended, Reduced and Periodic Zone Schemes, Effective mass of an electron. Semiconductors: Types, Free Carrier Concentration in semiconductors, Mobility of Charge carrier, Electrical Conductivity, Hall Effect, Electronic specific heat.

UNIT-III: Lattice Vibrations and Thermal Properties **10 Hrs.**

Lattice dynamics: Concept of phonons, momentum of phonons, normal and Umklapp processes, vibrations of one-dimensional monatomic and diatomic linear lattices. Thermal properties: Theories of specific heat, Dulong and Petit's law, Einstein's theory & Debye's theory, Weidemann-Franz law.

UNIT-IV: Superconducting and Dielectrics Materials **10 Hrs.**

Superconductors: Properties, BCS theory, flux quantization, Josephson effects (AC & DC) - high Tc superconductors, applications. Dielectrics: local electric field, dielectric constant and polarizability, Clausius-Mossotti equation, measurement of dielectric constant.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall crystal structure principles in solid-state physics.
CO2 : Understand band theory concepts in semiconductors and conductors.
CO3 : Apply lattice vibration theories to analyse material behaviour.
CO4 : Analyse diffraction patterns and electronic properties of materials.
CO5 : Create solutions to problems involving the thermal properties of materials.
CO6 : Evaluate theoretical models and assess superconductors and dielectrics.

TEXT/REFERENCE BOOKS

1. M.A. Wahab, **"Solid State Physics: Structure and Properties of Materials"**, Narosa Publishing House Pvt. Ltd. - New Delhi
2. Charles Kittel, **"Introduction to Solid State Physics"**, John Wiley & Sons.
3. S. O. Pillai, **"Solid State Physics"**, Wiley Eastern Ltd..

24XXXXXX					Solid State Physics Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. Understand the principles of solid-state physics experiments accurately.
2. Explain phenomena observed in solid-state physics comprehensively.
3. Apply theoretical concepts to analyse experimental results effectively.
4. Assess experimental methods and results critically for validity.

LIST OF EXPERIMENTS

1 Measurement of magnetoresistance
2 Measurement of magnetic susceptibility
3 Study of thermoluminescence of colour centre
4 Measurement of resistivity by using a 4-probe technique
5 Study of Hall effect
6 Sputtering Techniques
7 Study of magnetic hysteresis
8 Measurement of dielectric constant
9 Study of Raman effect
10 Introduction to X-ray diffraction Pattern
11 Determination of band gap of semiconductor using DFT
12 Study of Meisner Effect

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall principles of solid-state physics experiments accurately.
CO2 : Explain phenomena observed in solid-state physics experiments comprehensively.
CO3 : Apply theoretical concepts to analyze experimental results effectively.
CO4 : Break down experimental data to identify underlying patterns and relationships.
CO5 : Assess experimental methods and results critically for validity.
CO6 : Develop innovative approaches to solve solid-state physics problems.

TEXT/REFERENCE BOOKS

1. M.A. Wahab, **“Solid State Physics: Structure and Properties of Materials”**, Narosa Publishing House Pvt. Ltd. - New Delhi
2. Charles Kittel, **“Introduction to Solid State Physics”**, John Wiley & Sons.
3. S. O. Pillai, **“Solid State Physics”**, Wiley Eastern Ltd..

<Course Code>					Classical Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To evaluate and introduce Lagrangian formulation of mechanics and its superiority over Newtonian mechanics.
2. To emphasis the understanding of Classical Mechanics using Lagrangian and Hamiltonian approach.
3. To analyze the reduction of a two-body problem to a one-body problem in a central force system.
4. To apply the theory of relativity for particles having relativistic speeds in the classical theory of mechanics.

UNIT I: LAGRANGIAN DYNAMICS **08 Hrs.**

Review of Newtonian Mechanics, Conservation laws, Inertial frames, Mechanics of a particle and a system of particles, Coordinate System, Degrees of freedom, Constraints, Generalized coordinates, Principle of Virtual work, D' Alembert's principle, Euler Lagrange's equations of motion, Generalized potential, Superiority of Lagrangian mechanics over Newtonian, Symmetry property of Space and Time and conservation laws, Problem solving using Lagrangian and Newtonian mechanics.

UNIT II: HAMILTONIAN DYNAMICS **08 Hrs.**

Generalized momentum, Cyclic coordinates, Conservation Theorems and symmetry properties, energy function and the conservation energy, Hamiltonian's Principle, Derivation of Lagrange's equations from Hamilton's Principle, Legendre Transformation and Hamilton's equation, Brachistochrone problem, Advantage of a Variational Principle formulation and examples.

UNIT III: CENTRAL FORCE PROBLEM **14 Hrs.**

Reduction of two-body to equivalent one-body problem, Central force equation and motion in a plane - differential equation for an orbit, Equations of Bound and unbound orbits, Noether's theorem, Bertrand's Theorem, Kepler's laws, Stability of orbits under central force, Artificial satellites, Virial Theorem.

UNIT IV: INTRODUCTION TO SPECIAL THEORY OF RELATIVITY **12 Hrs.**

Galiliean transformation, Principle of relativity, Transformation of force from one inertial system to another, Covariance of Physical laws, Principle of relativity and theory of light, Michelson-Morley Experiment, Ether hypothesis, Postulates of special theory of relativity, Lorentz transformations, Minkowski space, Time dilation, Length contraction, Simultaneity, Introduction to Four Vectors.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the motion of a mechanical system using Lagrange-Hamilton formalism.
CO2 : Apply the formalism of Lagrangian and Hamiltonian in generating equations of motion for complicated mechanical systems of classical mechanics.
CO3 : Determine the differential equation of orbit, stability of orbit under central force.
CO4 : Compare Lagrangian and Hamiltonian formalism, Galiliean and Lorentz transformation and various reference frames.
CO5 : Apply theory of relativity to determine Galiliean and Lorentz transformation equations.
CO6 : Determine the time dilation, length contraction and simultaneity from Lorentz transformation equations.

TEXT/REFERENCE BOOKS

1. H. Goldstein, C.P. Poole, J. L. Safko, **"Classical Mechanics"**, Pearson Education.
2. L. D. Landau and E. M. Lifshitz, **"Mechanics"**, Pergamon.
3. David Morin, "**Introduction to Classical Mechanics: With Problems and Solutions"** Cambridge University Press.
4. P. S. Joag, N.C. Rana, **"Classical Mechanics"**, McGraw Hall.
5. R. Douglas Gregory, **"Classical Mechanics"**, Cambridge University Press.

<Course Code>					<Atomic and Molecular Physics>					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce students with various atomic models.
2. To recognize and analyse the atomic structure and formation of atomic spectra.
3. To examine the molecular symmetry and build the solid concepts of matter and radiation interactions.
4. To empower students to be able to appraise various spectroscopic techniques.

UNIT I: ATOMIC STRUCTURE **14 Hrs.**

An introduction to various atomic models, Rutherford's model, Bohr's postulates and theory of spectra like hydrogen atom, electron energy levels and their spectral series in hydrogen atom, De Broglie hypothesis, Bohr's correspondence principle, Sommerfeld's extension of Bohr's model, quantum numbers associated with vector atom model, orbital angular momentum, types of spectra, Larmor precession, Electron spin, Space quantization, Vector atom model, quantum numbers associated with vector atom model.

UNIT II: ATOMIC SPECTRA **14 Hrs.**

Spin orbit interaction, Quantum-mechanical Relativity Correction, Introduction to L-S coupling, J-J coupling, Hydrogen Fine Structure, Total angular momentum in many electron atoms, Pauli exclusion principle, Electron configuration, Hund's rule, Energy levels and transitions of Helium, Alkali spectra, Shielding of core electrons, Selection rules.

UNIT III: ATOMIC SPECTROSCOPY **14 Hrs.**

Normal Zeeman effect, Anomalous Zeeman effect, Paschen-Bach effect, Stark effect, Characteristics X-ray spectrum, Moseley's law, Width of spectral lines, Compton scattering, Braggs law, Determination of wavelength of X-rays by crystal diffraction method, Energy levels and characteristic X-ray lines, X-ray absorption spectra, Auger effect, Metastable states, Spontaneous and Stimulated emissions.

UNIT IV: MOLECULAR SPECTRA AND RAMAN EFFECT **14 Hrs.**

Types of molecular spectra, Rotational energy levels, Pure Rotational spectra, Molecule as a rigid rotator, the non-rigid rotator, Isotope effect on rotational spectrum , Vibrational energy levels, Molecule as a harmonic oscillator, Molecule as anharmonic oscillator , Vibration-Rotation spectra, Fine structure of Infrared bands: Molecule as vibrating rotator, Electronic spectra, Frank-Condon principle, Raman effect, Pure rotational Raman spectra, Vibrational Raman spectra, Experimental set up for Raman effect, Applications of Raman effect, Fluorescence and Phosphorescence.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Explain the fundamental concepts of atomic structure and discriminate among different atomic models.
CO2 : Illustrate the impact of coupling and interaction between electron spin and orbit on atomic structure and spectra.
CO3 : Classify different atomic spectra and analyse their mechanisms to understand their diverse applications.
CO4 : Analyse the relationship between the symmetry of molecules and the interaction between matter and radiation to demonstrate their correlation.
CO5 : Examine various molecular spectra and elucidate the underlying principles behind them.
CO6 : Employ the principles of atomic and molecular spectroscopy to solve everyday life problems effectively.

TEXT/REFERENCE BOOKS

1. Arthur Beiser, **"Concepts of Modern Physics"**, McGraw-Hill Book Company.
2. J. B. Rajam & Louis De Broglie, **"Atomic Physics"**, S. Chand & Co.
3. H. E. White, **"Introduction to Atomic Spectra"**, McGraw Hill Book Company.
4. C. N. Banwell and E. M. McCash, **"Fundamentals of Molecular Spectroscopy"**, Tata McGraw Hill.
5. R. K. Gaur and S. L. Gupta, **"Engineering Physics"**, Dhanpat Rai Publication.
6. G. M. Barrow, **"Introduction to Molecular Physics"**, McGraw Hill Book Company.
7. Anne P. Thorne, **"Spectrophysics"**, Chapman and Hall.
8. Raj Kumar, **"Atomic and Molecular Physics"**, Campus Books International.
9. S. N. Ghoshal, **"Atomic Physics",** S. Chand & Co.

<Course Code>					Physics of Semiconductor devices					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To learn the fundamental physics of semiconductors.
2. To introduce the basics of working and applications of p-n junction devices.
3. To provide knowledge of the working and applications of bipolar junction transistors.
4. To introduce the fundamental understanding of field effect transistors and power devices.

UNIT I: PROPERTIES OF SEMICONDUCTORS **14 Hrs.**

Introduction, crystal structure, crystal planes and Miller Indices, growth of semiconductor, energy band, E vs. k plots, electron effective mass, density of states function, Fermi-Dirac distribution functions and Fermi energy, carrier Concentration at normal Equilibrium, thermal equilibrium concentration, intrinsic carrier concentration, Fermi level position, extrinsic semiconductors, Donors, Acceptors, charge neutrality, Dependence of Fermi Level on Temperature and Doping Concentration. carrier drift, mobility, conductivity, carrier diffusion, electric field, Carrier Generation and Recombination, Continuity Equations.

UNIT II: PN JUNCTION **14 Hrs.**

pn junction, formation of depletion layer, space charge, thermal Equilibrium condition, space charge width and junction capacitance, linearly graded junction, Derivation of Diode Equation and I-V Characteristics. Zener and Avalanche Junction Breakdown Mechanism. Tunnel diode, varactor diode.

UNIT III: BIPOLAR JUNCTION TRANSISTORS **14 Hrs.**

Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle. Base Width Modulation, Modes of operation, Input and Output Characteristics of CB, CE and CC Configurations. Metal Semiconductor Junctions: Ohmic Contacts.

UNIT IV: FIELD EFFECT TRANSISTORS AND POWER DEVICES **14 Hrs.**

JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. Geothermal Energy, Geothermal Resources, MOSFET, Operation, Working and Characteristic curves of Depletion type MOSFET and Enhancement type MOSFET Complimentary MOS (CMOS), SCR, Construction, Working, and Characteristics, Triac, Diac, IGBT, MESFET, Circuit symbols, Basic constructional features, Operation and Applications.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Explain the basic properties of semiconductors, such as density of states, Fermi-Dirac distribution and Fermi energy.
CO2 : Distinguish materials based on their band structure.
CO3 : Understand the concept of pn junction-based diodes and their applications.
CO4 : Enables to describe different types of transistors.
CO5 : Gain knowledge of the various semiconductor devices working, operation and applications
CO6 : Perform analysis and design semiconductor devices

TEXT/REFERENCE BOOKS

1. S.M. Sze, "**Physics of Semiconductor Devices**", Wiley Publications.
2. Donald Neamen, "**Semiconductors Physics and Devices**", Tata Mc Graw Hill.
3. Streetman, B. and Banerjee, S., "**Solid State Electronics**", Prentice Hall India.
4. S. M. Sze, "**Semiconductor Devices: Physics and Technology**", Wiley India edition.
5. S.M. Sze and Kwok K. Ng, "**Physics of Semiconductor Devices**", 3rd Edition, Wiley Publications.
6. Tyagi, "**Introduction to Semiconductor Materials and Devices**", Wiley Publications.
7. Jasprit Singh, "**Semiconductor Devices, Basic Principles**", Wiley Publications

<Course Code>					<Experimental Techniques>					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide a detailed account of some of common experimental techniques in physics areas of research.
2. To introduce the basic working principles, the operational knowhow, and the strength and the limitations of various techniques.
3. To demonstrate the ability to communicate orally and in writing the outcome of the experimental results.
4. To develop the experimental skills required to handle sophisticated instruments.

UNIT I: STRUCTURAL CHARACTERIZATION AND IMAGING TECHNIQUES **14 Hrs.**

X-ray diffraction (XRD), electron and neutron diffraction, elementary ideas of photoelectron spectroscopy (PES), basic principle of electron microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling and atomic force microscopy (STM, AFM) techniques.

UNIT II: OPTICAL CHARACTERIZATION AND SPECTROSCOPIC TECHNIQUES **14 Hrs.**

Near and far Infrared and ultraviolet / visible (IR, UV/Visible) absorption spectroscopy, Raman and Fluorescence spectroscopy, Fourier-transform infrared spectroscopy (FTIR).

UNIT III: PHYSICAL PROPERTY MEASUREMENTS **14 Hrs.**

Intensive and extensive properties, physical property measurements (DSC, DTA, TGA), transport properties (R-T, I-V), low conductivity measurement (Dielectric Spectroscopy), magnetic properties of bulk and nano phases of material.

UNIT IV: ACCELERATORS AND DETECTORS **14 Hrs.**

Particle and radiation interaction with material, Rutherford back scattering (RBS), Accelerators – LINAC, Van de Graaff, Synchrocyclotron, Pelletron; Introduction to particle induced x-ray emission (PIXE) and particle induced gamma-ray emission (PIGE). Detectors: thermal, photon and electron detectors, GM counters, Soild State and scintillation detectors.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Explain the phenomenological background of the techniques utilized and evaluate their applications.
CO2 : Recognize the assumptions that underlie experimental measurements conducted in the physics laboratory.
CO3 : Evaluate and elucidate the constraints of the hypotheses behind experimental measurements.
CO4 : Devise and execute an experiment independently.
CO5 : Utilize advanced scientific measurement equipment (under supervision) and execute quantitative and qualitative data processing.
CO6 : Demonstrate proficiency in communicating experiment outcomes orally and in writing, incorporating findings from relevant scientific literature.

TEXT/REFERENCE BOOKS

1. J.M. Hollas, **"Modern Spectroscopy"**, John Wiley & Sons.
2. Colin N Banwell, **"Introduction to Molecular Spectroscopy"**, McGraw-Hill.
3. Gareth Thomas and Michael J. Goringe, **"Transmission Electron Microscopy of Materials"**, John Wiley.
4. B. D. Cullity &S.R. Stock, **"Elements of X-ray Diffraction"**, Pearson Education Limited.
5. M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody, **"Atomic Force Microscopy/Scanning Tunneling Microscopy"**, Plenum Press.

<Course Code>					Microprocessors and Microcontrollers					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**1**	**2**	**2**	**3**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. Grasp Arduino programming basics and syntax comprehensively.
2. Master writing and executing Arduino sketches effectively.
3. Apply Arduino programming for interfacing with sensors and actuators.
4. Design creative Arduino projects to solve real-world problems.

LIST OF EXPERIMENTS

1 Introduction to 8085 microprocessor and the programming kit.
2 Addition of Hexadecimal and BCD numbers.
3 Subtraction of Hexadecimal and BCD numbers.
4 Multiplication and Division of BCD numbers.
5 Looping operations in microprocessors.
6 Delay Counter using microprocessors.
7 Variable delay between different operations.
8 Interfacing programmable timer with microprocessor.
9 Traffic light control using 8085 microprocessors.
10 Introduction to Arduino Microcontroller and simple operations.
11 Water level and humidity sensors with Arduino
12 BMP180 sensor interface with Arduino
13 OV7670 camera CMOS camera with Arduino
14 Temperature controller with Arduino
15 Stepper motor operations with Arduino.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall key concepts in microprocessor architecture and programming.
CO2 : Explain microprocessor operations and programming techniques.
CO3 : Apply microprocessor programming to perform arithmetic and logic operations.
CO4 : Analyze microprocessor-based systems for specific application functionalities.
CO5 : Determine the reliability of microprocessor implementations in various operational scenarios.
CO6 : Create advanced projects integrating multiple microprocessor functionalities.

TEXT/REFERENCE BOOKS

1. Ramesh S. Gaonkar, **“Microprocessor Architecture, Programming, and Applications with the 8085”**, Penram International Publishing.
2. Kenneth J. Ayala, **“The 8051 Microcontroller: Architecture, Programming, and Applications”**, Cengage Learning.
3. Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin D. McKinlay, **“The 8051 Microcontroller and Embedded Systems”**, Pearson Education.
4. Simon Monk, **“Programming Arduino: Getting Started with Sketches”**, McGraw-Hill Education.
5. Jeremy Blum, **“Exploring Arduino: Tools and Techniques for Engineering Wizardry”**, Wiley

Semester - 6

24XXXXXX					Statistical Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand principles of statistical mechanics and quantum statistics.
2. Interpret conditions for statistical equilibrium in quantum systems.
3. Apply statistical mechanics to solve problems in ensembles.
4. Analyse the behaviour of ideal Bose-Einstein and Fermi-Dirac systems.

UNIT-I: Principles of Statistical Mechanics **14 Hrs.**

Macroscopic states, Microscopic states, Phase spaces, μ-space, Γ-space, Postulate of equal a priori probabilities, Ergodic hypothesis, Density distribution in phase space, Liouville's theorem, Principle of conservation of density in phase and principle of conservation of extension in phase, Microcanonical ensemble, Canonical ensemble, Mean value and fluctuations, Grand canonical ensemble, Fluctuations in the number of particles of a system in a grand canonical ensemble, Statistical interpretation of basic thermodynamic variables, Ideal gas, Gibbs paradox, The equipartition theorem.

UNIT- II: Formulation of Quantum Statistics and Three Distributions **14 Hrs.**

Density matrix, Liouville's theorem in Quantum Statistical Mechanics, Condition for Statistical equilibrium, Ensemble in Quantum Mechanics, Symmetry of wave functions, the Quantum Distribution functions, Three Distributions: M-B, F-D, and B-E, the Boltzmann limit of Boson and Fermion Gases, Evaluation of the Partition function, Partition function for Diatomic Molecules (a) translation partition function (b) rotational partition function (c) vibration partition function (d) electronic partition function and (e) nuclear partition function, Equation of state for an Ideal gas.

UNIT-III: Ideal Fermi-Dirac Systems **14 Hrs.**

Ideal Fermi-Dirac Gas, Weakly and Strongly degenerate Fermi-Dirac gas, Fermi Energy, Mean Energy of Fermions at T=0k, Fermi Gas in Metals, Thermionic emission, White Dwarfs.

UNIT-IV: Ideal Bose-Einstein Systems **14 Hrs.**

Ideal Bose-Einstein Gas, Bose-Einstein gas at high and low temperature, Bose-Einstein Condensation, Planck's radiation law, Photon Gas, Debye's Model of Solids: Phonon Gas, Liquid He^4.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall fundamental principles of statistical mechanics and quantum statistics.
CO2 : Interpret concepts of statistical equilibrium and quantum distribution functions.
CO3 : Solve problems related to ensembles, partition functions, and equations of state.
CO4 : Examine behaviour of ideal Bose and Fermi systems.
CO5 : Assess the significance of statistical mechanics in understanding physical systems.
CO6 : Develop solutions for complex quantum statistics problems.

TEXT/REFERENCE BOOKS

1. F. Reif, **"Fundamentals of Statistical and Thermal Physics",** McGraw Hill Book Co.
2. R. K. Patharia. , **"Statistical Mechanics,"** (Oxford: Butterworth).
3. B.B. Laud, **"Fundamentals of Statistical Mechanics"**, New Age International Publishers.
4. Suresh Chandra, **"A Textbook of Statistical Mechanics,** CBS Publishers.
5. Mehran Kardar, **"Statistical Physics of Particles"**, Cambridge University Press.
6. S.K. Sinha, **"Introduction to Statistical Mechanics",** Narosa Publication
7. Evelyn Guha, **"Statistical Mechanics - An introduction"**, Narosa publication
8. S.Lokanathan and R.S. Gambhir, **"Statistical and Thermal Physics: an introduction"**, (P.H.I. Pubilcation)

<Course Code>					Nuclear and Particle Physics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To provide students with a comprehensive understanding of the properties of atomic nuclei.
2. To familiarize students with various nuclear models.
3. To enable students to analyze and interpret nuclear decay processes, including alpha, beta, and gamma decay.
4. To introduce students to the fundamental principles of elementary particle physics.

UNIT I: PROPERTIES OF THE NUCLEUS **08 Hrs.**

Nuclear Sizes and Densities, Nuclear Masses, Binding Energy, Semi empirical formula, valley of stability, Packing Fraction, Drip Lines, Nuclear Forces and evidences, Mass Parabola, Neutron and Proton Separation Energies, Mirror Nuclei, Nuclear Radii and Wood-Saxon potential.

UNIT II: NUCLEAR MODELS **08 Hrs.**

Nucleon mean potential, approximation by specific solvable potentials, Magic number, The Liquid Drop Model, , The Shell Model, Predictions of the Shell Model, Magnetic Dipole Moment, Electric Quadrupole Moment, Excited states.

UNIT III: NUCLEAR DECAY AND RADIOACTIVITY **14 Hrs.**

Alpha decay: Q value, Range, Stopping Power, Geiger–Nuttall law, Half Life, Angular Momentum and Parity in alpha decay, Quantum Theory of alpha particle emission, Gamow theory and branching ratios.

Beta Decay: Energetics, angular momentum and parity selection rules, Elementary ideas of Fermi theory. Fermi and Gamow - Teller transition probabilities, Fermi-Kurie plot and mass of a neutrino.

Gamma Decay: Energetics, angular momentum and parity selection rules.

UNIT IV: ELEMENTARY PARTICLES AND INTERACTIONS **12 Hrs.**

Nucleon Forces, Isospin, Pions, Leptons, Strangeness, Families of Elementary Particles, classification of particles, Types of Interactions: Weak and strong, Charged leptonic Weak Interactions, decay of muon, pion and neutron. Quark model: meson and baryon, Structure of protons and neutrons, Conservation Laws.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the basic properties of atomic nuclei, including their sizes, masses, moments, and binding energies.
CO2 : Interpret and explain the behavior of atomic nuclei using nuclear models and analyze phenomena such as magic numbers, magnetic dipole moments, and excited states.
CO3 : Apply theoretical concepts to analyze and predict nuclear decay processes, including alpha, beta, and gamma decay, by calculating properties such as Q-values, half-lives, and branching ratios.
CO4 : Analyze experimental data related to nuclear decay and radioactivity and evaluate the implications of theoretical models.
CO5 : Appraise information from different units to understand the broader context of elementary particle physics, and draw connections between nuclear and particle phenomena.
CO6 : Evaluate the validity and limitations of nuclear models and theoretical frameworks, and propose modifications or extensions to existing theories based on their understanding of conservation laws and empirical data.

TEXT/REFERENCE BOOKS

1. V. Devanathan. Narosa, **"Nuclear Physics"**, Narosa Publishing House, Delhi.
2. Kenneth S. Krane, "**Introductory Nuclear Physics"**, John Wiley & Sons.
3. Aaghe Bohr & Ben R. Mottelson, "**Nuclear Structure Vol. 1 & 2"** World Scientific.
4. Jean-Louis Basdevant, James Rich, Michel Spiro, "**Fundamentals in Nuclear Physics",** Springer.

<Course Code>					Nuclear and Particle Physics Laboratory					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. To introduce a range of experimental data acquisition and analysis techniques employed in nuclear physics.
2. To develop hands on experience of GM counter, Scintillator detectors, Multi channel analyser (MCA) and other electronics involved.
3. To learn basic precautions while handling alpha, beta and gamma sources in the laboratory.
4. To understand the interaction of radiation with matter and basic calculations of absorption coefficient, solid angle, dead time and lifetime.

LIST OF EXPERIMENTS

1 Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/slope.
2 Energy Calibration of CsI:Tl detector: Predict the energy of an unknown gamma source.
3 Depiction of Inverse square law (horizontal) using ZnS:Ag detector.
4 Dead time measurement of GM tube using alpha, beta and gamma source.
5 Energy Resolution of CsI:Tl detector and plot of variation of energy resolution with different energies and operating voltage.
6 Absolute total detection and photopeak efficiency measurements of CsI:Tl scintillator detector.
7 Linear and mass attenuation coefficient of Al absorber using GM counter and ZnS:Ag detector.
8 Determine the relative beta counting of two strong α and β sources of nuclear radiation and to determine the absorption coefficients.
9 To ascertain of the Random nature of nuclear radiation.
10 Study of Alpha particle using ZnS:Ag scintillation detector with varying operating voltage and time.
11 To measure half-life of the radioactive source.
12 Study of Alpha, beta and gamma radiation using GM detector with varying operating voltage and time.
13 To study the stochastic nature of nuclear decay by studying alpha counts of three different activity of 241Am sources with GM counter and ZnS:Ag detector.
14 NaI:Tl and CsI:Tl Scintillation detector-energy calibration, resolution and determination of gamma ray energy using single channel analyse and multi channel analyser (MCA).

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify and suggest detector for measuring the basic specific property in nuclear and particle physics.
CO2 : Determine the rate of decay of various alpha, beta and gamma sources.
CO3 : Extend the scope of an experiments for other unknown elements other than aluminium.
CO4 : Describe the working and detection principles of GM counter, scintillation detectors, surface barrier detector and so on.
CO5 : Analyse the properties of radiation in nuclear physics experiments of attenuation coefficients of Aluminium and other materials.
CO6 : Apply interaction of radiation with matter knowledge in the experiments along with basic electronics of MCA, SCA, cables and PMT.

TEXT/REFERENCE BOOKS

1. G. F. Knoll, "**Radiation Detection and Measurement"**, John Wiley and Sons, New York.
2. William R. Leo, "**Techniques for Nuclear and Particle Physics Experiments"**, Springer Berlin, Heidelberg.

<Course Code>					< Mathematical Physics-II >					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To build the concepts of complex variable and its theorems which have useful applications
2. To demonstrate the importance of integral transform and its application
3. To introduce fundamentals of tensors
4. To enable student to apply special functions widely used in physics.

UNIT I: COMPLEX VARIABLES **14 Hrs.**

Introduction, Analytical Function, Theorems, Illustrative examples, Contour Integral Theorem, Cauchy's Integral Formula Theorem, Illustrative examples, Laurent Series Theorem, Method of finding residues. The Residue Theorem, Evaluation of Definite Integrals by use of the residue theorem, Examples, Argument principle Example, Additional illustrative examples, The point at infinity, residue at infinity.

UNIT II: INTEGRAL TRANSFORMS **14 Hrs.**

Introduction, Laplace transforms, Solution of differential equations by Laplace transform, Convolution, Inverse Laplace transforms, Applications of Laplace Transform for different physical problems.

UNIT III: TENSORS **14 Hrs.**

Tensor**:** Introduction, n - dimensional space, superscripts and subscripts, Coordinate transformations, Indicial summation conventions, Dummy and Real indices, Kronekar delta symbol, Scalars, Contravariant vectors and covariant vectors, Tensors of higher ranks, Algebraic operations, Symmetric and Antisymmetric tensors, Invariant tensors.

UNIT IV: STATISTICS AND TREATMENT OF EXPERIMENTAL DATA **14 Hrs.**

Characteristics of Probability Distribution: Expectation Values, Distribution Moments, Variance and Covariance; Common Probability Distributions; Measurement Errors: Systematic and Random Errors; Sampling and Parameter Estimation; Propagation of Errors; Applications and Examples.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Translate the complex variables in desired mathematical form
CO2 : Identify and solve the problems including the complex variables
CO3 : Apply the laplace 's transforms for various application including fourier and differential equation solutions
CO4 : Build the fundamentals of tensors which will be useful in the advance courses involving tensors
CO5 : Differentiate and employ the special functions when required
CO6 : Manage the complex concepts of physics which inherently finds solution via special functions

TEXT/REFERENCE BOOKS

1. H.K. Dass, "**Advanced Engineering Mathematics"**, S. Chand & Company Ltd., New Delhi.
2. E. Kreyszig, "**Advanced Engineering Mathematics"**, John Wiley & Sons.
3. Peter V. O'Neil, "**Advanced Engineering Mathematics"**, Cengage Learning.
4. Chattopadhyaya P.K., "**Mathematical Physics**" Wiley Eastern Ltd.
5. Murray R. Spiegel, "**Complex Variables**", Tata Mcgraw-Hill Publishing Company Ltd.
6. Murray R. Spiegel, "**Theory And Problems Of Fourier Analysis**", Tata Mcgraw-Hill Publishing Company Ltd.

					LASER AND OPTOELECTRONICS					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES:

1. To develop understanding and to provide fundamental knowledge in the Laser system operations.
2. To introduce the working principles and applications of various Laser systems.
3. Explore optoelectronic transition processes and their application in diverse devices.
4. Define and analyze key optoelectronic device principles, comparing designs.

UNIT 1: LASER BASICS & CHARACTERISTICS **12 Hrs.**

Laser Basics: Introduction, Interaction of radiation with matter: Absorption, Spontaneous Emission and Stimulated Emission, Einstein coefficient, Population Inversion: Three- and Four-Level Laser Systems, Pumping Mechanisms, Gain of Laser Medium, Laser Resonators. LASER Characteristics**:** Characteristics of LASER beam**,** Important Laser Parameters

UNIT 2: TYPES OF LASERS & IT'S APPLICATIONS **12 Hrs.**

Types of LASERS: Solid-state Lasers: Introduction, Importance of Host Material, Lasing Species, Operational Mode: CW Output, Free-running Output, Q-switched Output, Neodymium-doped Lasers: Nd:YAG Lasers. Gas Lasers: Introduction, the Active Media, Inter-level Transitions, Pumping Mechanism, Helium-neon Lasers, Carbon Dioxide Lasers. Semiconductor Lasers: Introduction, Materials, Device structure and characteristics, LASER APPLICATIONS: Lasers in Industry: Material-processing Applications, Laser Cutting, Laser Welding, Laser Drilling Lasers in Printing. Lasers in Medicine: Light–tissue Interaction, Ophthalmology, Dermatology: Pigmented Lesions and Tattoos. Lasers in Science and Technology: Laser Doppler Velocimetry, Laser Doppler Vibrometry Satellite Laser Ranging Holography. Lasers in Military Applications: Laser Aiming Modules, Laser Rangefinders.

UNIT 3: OPTOELECTRONICS BASICS & ELECTRON PHOTON PROCESSES (LED) **12 Hrs.**

Optoelectronics Basics: Light Waves in a Homogeneous Medium: Maxwell's Wave Equation and Diverging Waves. Irradiance, and Poynting Vector. Fresnel's Equations: Amplitude Reflection and Transmission Coefficients (r and t), Intensity, Reflectance, and Transmittance. Electron Photon Processes (LED): Introduction to energy band and density of states. Light-Emitting Diodes: Principles, Homojunction LEDs, Heterostructure High Intensity LEDs, Output Spectrum, LED Materials and Structures, LED Efficiencies and Luminous Flux, Basic LED Characteristics, Optical Fiber Fundamentals: modes, types of optical fibers, LED fiber coupling.

UNIT 4: PHOTON–ELECTRON PROCESSES: PHOTO DETECTOR, PHOTOVOLTAIC EFFECT AND SOLAR CELLS **12 Hrs.**

Photo detectors: Principle of the pn Junction Photodiode: Basic Principles, Energy Band Diagrams and Photo detection Modes. The pin Photodiode, Avalanche Photodiode, Heterojunction Photodiodes, Photo detector: Schottky Junction Photo detector, Photoconductive Detectors and Photoconductive Gain. Photovoltaic effect and solar cells : Photovoltaic Devices: Solar Cells, Basic Principles, Operating Current and Voltage and Fill Factor, Equivalent Circuit of a Solar Cell, Types of solar cell, Solar Cell device Structures and Efficiencies.

COURSE OUTCOMES

On completion of the course, student will be able to;

CO1 : Understand and explain lasing processes and the various properties associated with the Laser beam
CO2 : Demonstrate understanding of working principle, operations and basic properties of the most common laser systems.
CO3 : Describe the fundamental physical processes of optoelectronic transitions and apply the concepts to different optoelectronic devices.
CO4 : Define, in depth, the principles/functionality of the most important optoelectronic devices, compare and evaluate the different device designs
CO5 : Acquire basic knowledge about interaction of radiation with matter and laser fundamentals.
CO6 : Develop the skills to apply Laser processes and system understanding in various real-world applications.

TEXT/REFERENCE BOOKS

1. S.O. Kasap: **" Optoelectronics and Photonics: Principles and Practice**s", 2nd edition, , Published by Pearson Education.
2. Dr Anil K. Maini, "**Lasers and optoelectronics: fundamentals, devices, and applications",** Published by Wiley.
3. Prem B. Bisht, "**Advances in Optics, Photonics and Optoelectronics**", IOP Publishing.
4. Kasap, Safa "**Cambridge Illustrated Handbook of Optoelectronics and Photonics**", New York Cambridge University Press.
5. K. Thyagarajan, Ajoy Ghatak, "**Lasers Fundamentals and Applications",** Springer US.

24BSP405E					Time Series Analysis					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**1**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To introduce the concept of random variables, central limit theorem & Fourier analysis.
2. To introduce the concept of correlogram and probabilitic models for time series.
3. To explain the methods for estimation of parameters and forecasting.
4. To introduce the methods of spectral density function estimation for a given time series.

UNIT I: Review of random variables and introduction to time series **12 Hrs.**

Review of Probability theory and random variables, central limit theorem. Review of Fourier analysis: Fourier series and Transforms, Introduction to Time series: Examples, simple descriptive techniques, trend, seasonality, the correlogram, correlogram behaviour for data with pure random numbers, trend and periodicity.

UNIT II:: Probability models for time series. **8 Hrs.**

Probability models for time series: stationarity process, weak stationarity, second-order stationary process, properties of autocorrelation function, purely random process, random walk model, Moving average (MA) process, Autoregressive (AR) process, ARMA and ARIMA models.

UNIT III: Parameter estimation and Forecasting: **11 Hrs.**

Estimating the autocovariance and autocorrelation function, fitting an autoregressive process, moving average process and estimation of parameters, estimating parameters for ARMA, ARIMA and Box-Jenkins, seasonal ARIMA models. Introduction to forecasting: forecasting in univariate processes, extrapolation of trend, simple exponential smoothing, Holt-Winters forecasting procedures, Box-Jenkins procedure.

UNIT IV: Introduction to Spectral analysis: **9 Hrs.**

Spectral distribution and density function, periodogram analysis, Estimation procedures, Fast Fourier Transform, Confidence intervals for the spectrum, Comparison of different estimation procedures..

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Understand the concept of random variables, central limit theorem & Fourier Analysis.
CO2 : Understand the concept of correlogram and probability models for a time series.
CO3 : Understand the concept of ergodicity used for model building from single time series.
CO4 : Understand the method of estimation of parameters for various models.
CO5 : Understand the methods of forecasting using the various time series models.
CO6 : Understand the methods of spectral density function estimation for a given time series.

TEXT/REFERENCE BOOKS

1. Chris Chatfield, **“The Analysis of Time Series: An Introduction”,** 6th edition, Chapman and Hall / CRC, 2003.
2. William Wei, **“Time Series Analysis: Univariate and Multivariate Methods”**, 2nd edition, Pearson/Addison Wesley, 2006.
3. R. H. Shumway and D. S. Stoffer, **“Time Series Analysis and Its Applications: With R Examples”**, 2nd edition, , 2006.
4. James D. Hamilton, **“Time Series Analysis”**, Princeton, NJ: Princeton University Press, 1994.

24xxxXXXX					Advanced Python Programming					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**1**	**2**	**2**	**3**	**--**	**--**	**--**	**50**	**50**	**100**

COURSE OBJECTIVES

1. Apply numpy and matplotlib for data analysis and visualization.
2. Explain and implement object-oriented programming principles in Python.
3. Design Python applications for specific computational tasks

LIST OF EXPERIMENTS

1 Functionalities of Python.
2 Introduction to python modules math, cmath, matplotlib and numpy.
3 Introduction to object oriented programming.
4 Histrograms using numpy and matplotlib.
5 Histograms using “boost” libraries.
6 Gauss Seidal method for solving algebraic and transcendental equations.
7 Preparing graphs and plots using matplotlib.
8 Chi2 fitting.
9 Maximum Likelihood Fitting.
10 Hough Transformation for straight line.
11 Image analysis for astrophysics.
12 Spectrum Analysis, Peak Finding and Peak Resolution.
13 ML algorithms for decision making problems.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recognize common programming errors and debugging techniques.
CO2 : Interpret Python code and predict its output
CO3 : Use object-oriented principles to design Python classes.
CO4 : Compare and contrast different Python libraries for data analysis.
CO5 : Judge the appropriateness of Python libraries for given problems.
CO6 : Design Python applications to address complex computational problems.

TEXT/REFERENCE BOOKS

1. Mark Lutz, **“Learning Python”**, O'Reilly Media.
2. Wes McKinney, **“Python for Data Analysis”**, O’Reilly Media.
3. Eric Matthes, **“Python Crash Course”**, No Starch Press.
4. Jake VanderPlas, “**Python Data Science Handbook”**, O'Reilly Media.

Semester - 7

24xxXXXX					Classical Electrodynamics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
4	**0**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Apply Maxwell's equations to solve electromagnetic problems.
2. Analyze electromagnetic wave behaviour in various mediums.
3. Integrate classical and relativistic electromagnetism principles.
4. Develop simulations to validate electromagnetic theories computationally.

UNIT I: MAXWELL'S EQUATIONS **14 Hrs.**

Electromagnetic Induction, Faraday's Law, Induced Electric Field, Energy in Electric and Magnetic fields, Electrodynamics before Maxwell, Maxwell's correction to Ampere's Law, Maxwell's Equations, Maxwell's Equations in Matter, Continuity Equation, Poynting's Theorem, Maxwell's Stress Tensor, Conservation of Momentum and Angular Momentum, Applications.

UNIT II: ELECTROMAGNETIC WAVES **14 Hrs.**

Waves in One Dimension, Reflection, Transmission and Polarization, Electromagnetic Waves in Vaccum, The Wave Equation for E and B, Monochromatric Plane waves, Electromagnetic Waves in Matter, Propagation in Linear Media, Reflection and Transmission, Absorption and Dispersion, Wave Guides.

UNIT III: POTENTIALS, FIELDS AND RADIATION **16 Hrs.**

The Potential Formulation, Scalar and Vector Potentials, Gauge Transformations, Retarded Potentials, Jefimenko's Equations, Lienard-Wiechart Potentials, Dipole Radiation, Multipole Expansion in Radiation, Radiation Reaction, The Physical Basis of Radiation Reaction.

UNIT IV: RELATIVISTIC ELECTRODYNAMICS **12 Hrs.**

The Geometry of Relativity, The Lorentz Transformations, Relativistic Mechanics, Relativistic Energy and Momentum, Relativistic Kinematics and dynamics, Relativistic Electrodynamics, Magnetism as a Relativistic Phenomenon, The Field Tensor, Applications of Field Tensor.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall fundamental principles of electromagnetism and Maxwell's equations.
CO2 : Explain electromagnetic wave behavior in different mediums clearly.
CO3 : Apply Maxwell's equations to solve practical electromagnetism problems effectively.
CO4 : Analyze the electromagnetic phenomena using Maxwell's equations in practical terms.
CO5 : Assess the validity of electromagnetic theories in various contexts.
CO6 : Develop advanced computational models to simulate complex electromagnetic phenomena

TEXT/REFERENCE BOOKS

1. David J. Griffiths, "**Introduction to Electrodynamics**", PHI Learning Pvt. Ltd, New Delhi
2. John David Jackson, **"Classical Electrodynamics"**, Wiley India.
3. Matthew N. O. Sadiku, "**Elements of Electromagnetics**", Oxford University Press.
4. A. S. Mahajan and A. A. Rangwala, "**Electricity and Magnetism",** TMH Publishing.
5. B. B. Laud, "**Electromagnetics**", New Age International.

24XXXXXX					Introduction to Relativity					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	0	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand the concept of space-time as a unified four-dimensional framework that incorporates both space and time.
2. Comprehend the geometric interpretation of space-time in the context of general relativity.
3. Learn mathematical foundations of general relativity and apply it to understand behavior of black hole, gravitational waves etc.
4. Learn how general relativity provides framework for understanding the evolution of the universe.

UNIT I: SPECIAL THEORY OF RELATIVITY AND FLAT SPACE-TIME **12 Hrs.**

Newtonian Gravity, Gravitational and Inertial mass, Inertial frames, Revision of Special Theory of Relativity, spacetime diagrams, Four-vectors and space-time metric, Examples of metric in flat space-time, Relativistic Kinematics and dynamics: Four Momentum, Energy and Momentum of relativistic particles, Stress-energy tensor in four-vector notation.

UNIT II: CURVED SPACE-TIME AND GENERAL RELATIVITY **16 Hrs.**

Experimental evidence of equality of gravitational and inertial mass, The equivalence principle, gravity as geometry of spacetime; Coordinates in curved space-time, The idea of metric, summation convention, Scalars, vectors and tensors under general coordinate transformations, Tensor Algebra, coordinate transformations, Global Positioning System (GPS), static weak field metric, local Inertial frames, light Cones and world lines, surfaces in spacetime, geodesics, solving the geodesic equation, null geodesicsfrom metric to Einstein tensor; The Stress-Energy Tensor

UNIT III: APPLICATIONS OF GENERAL RELATIVITY **16 Hrs.**

Schwarzschild geometry, gravitational red-shift, Orbits of test particles in schwarzschild geometry, Gravitational lensing, accretion disks, binary pulsars, Schwarzschild Black holes, X-ray binaries, Active Galactic nuclei (AGN), Supermassive blackholes, Gravitational Waves,

UNIT IV: CURVED SPACE AND EXPANDING UNIVERSE **12 Hrs.**

Homogeneity and Isotropy, Cosmological Expansion and Redshift, Hubble's law, Distances in Cosmology, Total energy density of the Universe.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Analyze space-time in Newtonian physics and Special Relativity, covering concepts like time dilation and Lorentz transformations.
CO2 : Apply principles of curved space-time and General Relativity, understanding gravity as the geometry of space-time.
CO3 : Evaluate relativistic astrophysical phenomena such as gravitational redshift and black holes.
CO4 : Investigate the expanding universe, including Hubble's law and total energy density
CO5 : Interpret experimental evidence to understand gravitational phenomena in astrophysics
CO6 : Synthesize knowledge to discuss the implications of General Relativity on our understanding of the cosmos.

TEXT/REFERENCE BOOKS

1. J. B. Hartle, **"Gravity: An introduction to Einstein's General Relativity"**, Pearson Publications (2003)
2. B. F. Schutz, **"A first course in general relativity"**, Cambridge University Press (2009)
3. S. Weinberg, **"Gravitation and Cosmology",** John Wiley & Sons (1972).
4. C. W. Misner, K. S. Thorne & J. A. Wheeler**, "Gravitation"**, W. H. Freeman (1973).
5. S. Carroll, Spacetime and Geometry: **"An Introduction to General Relativity"**, Pearson Publications (2003).
6. T. Padmanabhan, **"Gravitation: Foundations and Frontiers"**, Cambridge University Press (2010).

24XXXXXX					Quantum Field Theory and Astroparticle Physics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand the foundational concepts of quantum field theory and its application to describe many-particle systems.
2. Classify the fundamental subatomic particles by their possible interactions.
3. Explain how particle probes can open a new window on the universe compared to astrophysical observations using electromagnetic radiation.
4. Examine the impact of dark matter and dark energy on the overall dynamics of the universe.

UNIT I: BASICS OF QUANTUM FIELD THEORY- I **14 Hrs.**

Quantum Mechanics and Special relativity, Need for many particles/antiparticles and quantum fields, Fock Space, the quantum field as coupled harmonic oscillators, Classical Field Theory: Lagrangians, Hamiltonians and equation of motion, Noether's theorem, Symmetries (space-time and internal), conserved currents, energy-momentum tensor, Canonical Quantization.

UNIT II: BASICS OF QUANTUM FIELD THEORY- II **14 Hrs.**

Spinorial representations of the Lorentz Group. Weyl Spinors and Weyl equation. Dirac equation and plane wave solutions, quantisation of the Dirac field, anti-commutation relations, Majorana fermions. Propagator and Feynman diagrams and Feynman rules, Basic Quantum Electrodynamics, Feynman rules and amplitudes for simple processes.

UNIT III: ELEMENTARY PARTICLES AND THEIR ROLE IN COSMOS **14 Hrs.**

Remind of elementary particles and their interactions: leptons, quarks, gluons, photons, W+, W-, Z0, strong, weak and electromagnetic interactions. The Standard Model of electroweak interactions, Neutrino interactions and the electroweak theory, Dirac and Majorana neutrinos, Neutrino oscillation, Beyond the Standard Model Physics, Weakly Interactive Massive Particles.

UNIT IV: THEORETICAL AND ASTOPHYSICAL ASPECTS OF DARK MATTER AND DARK ENERGY **14 Hrs.**

Dark matter: cold and hot dark matter. Candidates for DM, Direct and Indirect Searches for Dark Matter, Neutrinos as Dark Matter, Dark Energy: experimental evidence, Experiments for the search of Dark Energy, Baryonic Acoustic Oscillations, Latest results of the Planck satellite, Multimessenger approach.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall fundamental principles of quantum mechanics and classical field theory.
CO2 : Understand mathematical formalism of quantum field theory and its application to particle physics.
CO3 : Apply principles of quantum field theory to analyze particle interactions and phenomena.
CO4 : Analyze experimental evidence and observational data related to dark matter and dark energy.
CO5 : Evaluate theoretical models and experimental methodologies in particle physics and cosmology.
CO6 : Develop hypotheses and design experiments to address gaps in understanding of particle physics and cosmology.

TEXT/REFERENCE BOOKS

1. Stefano Profumo, **"An Introduction to Particle Dark Matter",** World Scientific (2017)
2. Amitabha Lahiri and Palash B. Pal, "**A First Book of Quantum Field Theory"**, Narosa publications (2007).
3. Daniel Baumann, **"Cosmology",** Cambridge University Press (2022)
4. David Griffiths, **"Introduction to Elementary Particles",** Wiley-VCH (2008).
5. Palash B. Pal, **"An Introductory Course of Particle Physics"**, CRC Press (2014).

<Course Code>					Fundamentals of Radiation Physics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
4	**0**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To identify the properties of different Ionizing Radiation and principles of their production.
2. To introduce the basics of radiation protection and related safety for handling of radiation sources.
3. To provide knowledge of the interaction of radiation with matter and physics of energy losses mechanism.
4. To introduce basic of radiation protection and related safety for handling of radiation source

UNIT I: FUNDAMENTAL OF RADIATION PHYSICS **08 Hrs.**

Radiation and Radioactivity, Electromagnetic Radiation, Ionizing Radiation and non-Ionizing Radiation; Natural and Man-Made Radiation; Types and Properties of Ionizing Radiation: Alpha, Beta, Gamma, X-ray, Neutron; Radioactive decay, Laws of radioactivity, Radioactive half-lives, Principles of radiation interactions with matter.

UNIT II: RADIATIONS UNITS AND SOURCES **08 Hrs.**

Units and Quantities Used in Radiation Protection: Radiation Dose, Equivalent dose, and Effective dose. Principle of Radiation Protections, ALARA principle of radiation protection, Internal Exposure. Evaluation of external hazards: Specific exposure rate constant, Dose Calculation, Radiation shielding calculations.

UNIT III: RADIATION INTERACTION WITH MATTER **14 Hrs.**

Interaction of heavy charged particles: alpha particles; Interaction of Fast electrons; Interaction of Gamma rays; Interaction of Neutrons: Slow and fast neutrons.

UNIT IV: GENERAL PROPERTIES OF RADIATION DETECTORS **12 Hrs.**

Simplified Detector Model, Modes of Detector operation, Pulse height Spectra, Counting Curves, Energy Resolution, Detection Efficiency, counting statistics, Detector dead time and quenching in counter.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the units and types of radiations along with their sources.
CO2 : Understand the natural and man-made radiation sources and radiation interaction with matter.
CO3 : Discuss and solve problems relating to radiation protection.
CO4 : Describe the principle and working of various radiation detectors.
CO5 : Apply the basic radiation physics for minimizing the risks of low and high-level radiation.
CO6 : Demonstrate the ability to calculate the parameters such as energy resolution, efficiency, and dead time of radiation detectors.

TEXT/REFERENCE BOOKS

1. G. F. Knoll, "**Radiation Detection and Measurement"**, John Wiley and Sons, New York.
2. William R. Leo, "**Techniques for Nuclear and Particle Physics Experiments"**, Springer Berlin, Heidelberg.
3. Nicholas Tsoulfanidis, "**Measurement and Detection of Radiation**", Taylor & Francis.
4. Jacob Shapiro, "**Radiation Protection**", Harvard University Press.
5. G. Orton, "**Radiation Dosimetry: Physical and Biological Aspects**", Plenum Press.

<Course Code>					Radiation Detection and Measurement					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
4	**0**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To overview various types of radiation detectors and measurement techniques.
2. To identify the properties of different types of gas, scintillation and semiconductor detectors.
3. To familiarize with the operational principles of gas, scintillation and semiconductor detectors.
4. To provide knowledge of all miscellaneous detectors either cryogenics or superheated.

UNIT I: GAS DETECTORS **08 Hrs.**

Ionization Chamber, proportional counter, GM counter; Operating and working Principles of Gas Detectors for alpha, beta and gamma detection, Design and Operation, Gas Multiplication, Townsend Avalanche, geometry and dimension, Pulse Mode Operation, Time Behavior, Operating voltage calculation in GM counter.

UNIT II: SCINTILLATION DETECTORS **08 Hrs.**

Characteristics of Scintillation Detectors, Types: Organic, Inorganic; Working principles of Organic, Inorganic scintillators; Energy resolution, detection efficiency and timing resolution, Light Collection and Scintillator Mounting.

UNIT III: SEMICONDUCTOR DETECTORS **14 Hrs.**

Semiconductor Properties, Action of Ionizing Radiation in Semiconductors, Semiconductors as Radiation Detectors, Semiconductor Detector Configurations, Operational Characteristics, Applications of Silicon Diode Detectors, HPGe Detector: Operational characteristics, Gamma-Ray Spectroscopy with Germanium Detectors.

UNIT IV: MISCELLANEOUS DETECTOR TYPES **12 Hrs.**

Cherenkov Detectors, High-Pressure Xenon Spectrometers, Cryogenic Detectors, Thermoluminescent Dosimeters and Image Plates, Track-Etch Detectors, Superheated Drop or "Bubble Detectors".

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the principles and functionalities of different types of gas detectors.
CO2 : Understand the pulse mode operation and best characteristics of various gas, scintillation and semiconductor detectors.
CO3 : Apply the principles of different types of gas, scintillation and semiconductor detectors, demonstrating the ability to operate and understand their functionalities.
CO4 : Discuss and create an understanding of the introduction, components, and characteristics of photosensors, illustrating the knowledge of their roles in radiation detection systems.
CO5 : Apply the knowledge of different types of gas, scintillation and semiconductor detectors in selecting a detector based on the end user requirements.
CO6 : Demonstrate proficiency in designing a radiation detector coupled to an appropriate spectral response photosensor.

TEXT/REFERENCE BOOKS

1. G. F. Knoll, "**Radiation Detection and Measurement"**, John Wiley and Sons, New York.
2. William R. Leo, "**Techniques for Nuclear and Particle Physics Experiments"**, Springer Berlin, Heidelberg.
3. Mann, G. L., & Kerker, M., "**Radiation Detection and Measurement: Concepts, Methods, and Devices",** John Wiley & Sons.
4. Lamarsh, J. R., & Baratta, A. J., "**Introduction to Nuclear Engineering**'', Prentice Hall.

Semester - 8

<Course Code>					Quantum Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concepts of time-independent perturbation theory and their applications to physical situations.
2. To impart knowledge about the approximation methods corresponding to time-dependent perturbation theory.
3. To enable the students to extract the structure of matter from the scattering of particles.
4. To provide an understanding of the formalism and language of relativistic quantum mechanics.

UNIT I: APPROXIMATION METHODS FOR STATIONARY STATES **16 Hrs.**

Brief introduction to identical particles and symmetry, Time-independent perturbation theory for discrete levels, non-degenerate cases and degenerate case, removal of degeneracy, Zeeman effect, Stark effect, spin-orbit coupling, fine structure of hydrogen, Variational method and its application, WKB approximation.

UNIT II: TIME DEPENDENT PERTURBATION THEORY **14 Hrs.**

Time dependent perturbation theory, Interaction picture, Transition amplitude, First- order perturbation, Harmonic perturbation, Transition probability, Second -order perturbation, Adiabatic and sudden approximation, Interaction of an atom with electromagnetic radiation Absorption and emission of radiation.

UNIT III: SCATTERING THEORY **12 Hrs.**

Non-relativistic scattering theory, scattering amplitude and cross-section, the integral equation for scattering, Born approximation, partial wave analysis, optical theorem.

UNIT IV: RELATIVISTIC QUANTUM MECHANICS **14 Hrs.**

Klein-Gordon equations, charge & current densities, physical interpretations and short comings of K-G equation, Dirac equation; Dirac matrices and their properties, spin of Dirac particle, free particle solution of Dirac equation, negative energy states and the concept of hole, electron in electromagnetic field, Spin-orbital interaction energy, Dirac equation for spherically symmetric potential.

Max Hrs: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the key principles and techniques of time-independent and time-dependent perturbation theory.
CO2 : Understand the differences between non-degenerate and degenerate cases in perturbation theory.
CO3 : Describe the principles of scattering theory.
CO4 : Apply time-independent perturbation theory to calculate energy corrections and wave function mixing in discrete energy levels.
CO5 : Synthesize theoretical frameworks to explain scattering phenomena in non-relativistic systems using Born approximation and optical theorem.
CO6 : Critically evaluate the physical interpretations and shortcomings of Klein-Gordon and Dirac equations in describing relativistic particles.

TEXT/REFERENCE BOOKS

1. J. J. Sakurai, “**Modern Quantum Mechanics”**, Benjamin /Cummings, 1985.
2. **“Principles of quantum Mechanics”**, R. Shankar, Plenum Publishers.
3. L. Schiff, “**Quantum Mechanics**”, McGraw-Hill, 1968.
4. N. Zetilli, “**Quantum Mechanics: Theory and applications**”, Willey Publishers.

24XXXXXX					Introduction to Cosmology and Early Universe					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
4	**0**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Understand the stanadard cosmological model that explain the origin and evolution of the universe.
2. Gain the knowledge of thermal history of the universe, including the processes of cosmic inflation, big-bang nucleosynthesis, and recombination.
3. Examine the impact of dark matter and dark energy on the overall dynamics of the universe.
4. Analyze the formation and evolution of structure in the universe.

UNIT I: THE HOMOGENEOUS AND ISOTROPIC UNIVERSE **16 Hrs.**

Homogeneity and Isotropy and spatial flatness of the expanding universe, Robertson-Walker Metric, co-moving coordinates and physical distances, Geodesics and redshift, Cosmic inventory: photons, neutrinos, baryonic matter, dark matter, dark energy, Stress-energy tensor of a fluid, equation of state parameter. Hubble's law, Friedmann equations for a single and multicomponent universe component universe and their solutions, Standard cosmological model (Lambda-CDM).

UNIT II: PROBLEM WITH HOT BIG BANG MODEL AND COSMIC INFLATION **14 Hrs.**

Problems of the Hot Big Bang: brief introduction to Horizon and flatness problem; Introduction to classical and Quantum Scalar fields, Cosmic Inflation.

UNIT III: THERMAL HISTORY OF THE UNIVERSE **16 Hrs.**

Epoch of recombination and nucleosynthesis, Distribution functions: calculation of pressure, energy and number density from distribution function, Relativistic vs. non-relativistic particles. Interaction rates, decoupling, thermal relics, dark matter as thermal relic; thermal freeze out, cosmic microwave background; cosmic neutrino background.

UNIT IV: CLUMPY UNIVERSE **10 Hrs.**

Fluid equations: continuity, Euler's equation, Poisson's equations; Jeans instability: evolution of small density perturbations, presence of gravity, presence of expanding background; Spherical collapse

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Analyze the homogeneous and isotropic universe, including its expansion and cosmic inventory.
CO2 : Evaluate challenges to the Hot Big Bang model and explore cosmic inflation.
CO3 : Examine the thermal history of the universe and analyze distribution functions.
CO4 : Investigate the clumpy universe, understanding fluid equations and density perturbations.
CO5 : Apply theoretical concepts to interpret cosmic phenomena like the cosmic microwave background and dark matter.
CO6 : Synthesize knowledge from all units to discuss the current standard cosmological model and its implications, demonstrating a comprehensive understanding of cosmology.

TEXT/REFERENCE BOOKS

1. S. Dodelson, **"Modern Cosmology**", 2nd Edition, Academic Press (2020).
2. Barbara Ryden, "**Introduction to Cosmology"**, Cambridge University Press (2016)
3. Edward W. Kolb, Michael S. Turner**, "Cosmology"**, CRC Press (1990)
4. Daniel Baumann, **"Cosmology",** Cambridge University Press (2022)
5. S. Weinberg, **"Cosmology"**, Oxford University Press (2008).
6. P. J. E. Peebles, **"Principles of Physical Cosmology**", Princeton University Press (1993).

<Course Code>					EXPERIMENTAL METHODS IN ASTROPHYSICS					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Master Telescope Functionality and Image Formation Techniques.
2. Apply Probability and Error Analysis in Astrophysical Instrumentation.
3. Conduct Interferometry for Mapping Celestial Objects and Distributions.
4. Explore Neutrino, Cosmic-ray, and Gravitational Wave Detection Techniques.

UNIT I: Electromagnetic radiation and detection **14 Hrs.**

Photon and non-photon astronomy, Electromagnetic frequency bands, Photons and atmosphere. Telescopes: Information from radiation, Image formation, Focusing systems, non-focusing systems, Some real telescopes, Antenna beams, Point spread function, Resolutions, Resolution enhancements, Resolutions in Non Optical Telescope.

UNIT II: Detectors and Statistics **14 Hrs.**

Detectors introduction, Position sensitive and insensitive detectors, in optical and X-ray band, examples of ground-based and space-based observatories, Gamma-ray instrumentation, Ground based gamma ray detection, HAGAR, ASTROSAT. Probabilities, Properties of distribution, Errors, Propagation of errors.

UNIT III: Space-based Astrophysical Observations and Surveys **14 Hrs.**

Two-telescope interference: Principle of interferometry, Point-source response, Mapping the Sky, Array of telescopes, Multiple base lines, Radio arrays, Optical and X-ray interferometry, Analysis of radio data, Techniques for mapping the large-scale distribution of galaxies and galaxy clusters, analyzing and interpreting data from ground-based and space-based observatories, Introduction to cosmological data analysis, including cosmic microwave background.

UNIT IV: Astronomy beyond Photons **14 Hrs.**

Neutrino Observatories: Neutrinos from Sun, HomeStake mine experiment, Cerenkov Neutrino Telescopes, ICECUBE experiment. Neutrinos from Supernovas, Cosmic-ray Observatories: Components of cosmic rays, Extensive Air Showers (EAS), Detection of EAS, Muon and shower detection, Gamma ray detection; Gravitational wave Observatories: Detectors, Laser Interferometer, Multiple antennas, Low frequency detection in space, multi-wavelength astronomy.

TOTAL HOURS: 56 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Recall electromagnetic frequency bands and telescope components in astronomy.
CO2 : Explain principles of detectors, their types, and statistical analysis.
CO3 : Utilize interferometry principles to study data from radio arrays.
CO4 : Assess large-scale galaxy distributions and interpret cosmological data.
CO5 : Critically assess the capabilities and limitations of various astrophysical instruments.
CO6 : Design a comprehensive approach to observe astronomical phenomena beyond photons.

TEXT/REFERENCE BOOKS

1. H. Bradt, "**Astronomy Methods: A Physical Approach to Astronomical Observations**", Cambridge University Press.
2. G. W. Fraser, "**X-ray Detectors in Astronomy**", Cambridge University Press.
3. R. Giaconni and H. Gursky, "**X-ray Astronomy**", Springer.
4. Malcolm S. Longair, "**High Energy Astrophysics**", Cambridge University Press.
5. F. D. Seward and P. A. Charles, "**Exploring the X-ray Universe**", Cambridge University Press.

<Course Code>					Radiation Detection Instrumentation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To identify the error propagation in counting statistics.
2. To provide knowledge photoelectron multiplication in the photosensors.
3. To familiarize with the pulse processing and shaping mechanisms in radiation detectors.
4. To overview various types of electronics and units of multichannel analyzer techniques.

UNIT I: COUNTING STATISTICS AND ERROR PREDICTION **08 Hrs.**

Characterization of Data, Statistical Models, Applications of Statistical Models, Error Propagation, Optimization of Counting Experiments, Limits of Detectability, Distribution of Time Intervals.

UNIT II: PHOTOMULTIPLIER TUBES AND PHOTODIODES **08 Hrs.**

Introduction, Photocathode, Electron multiplication, PMT characteristics, Ancillary equipment; Photodiodes, Pulse Shape Analysis, Hybrid PMTs, Position sensing PMTs, Photoionization Detectors.

UNIT III: PULSE PROCESSING AND SHAPING **14 Hrs.**

Device impedances, Pulse shaping, Linear and logic pulses, Instrument standards, Application Specific Integrated Circuits (ASICs); Pulse processing units, Pulse counting system, Pulse height analysis systems, Digital Pulse processing, Systems involving pulse Timing, Pulse Shape Discrimination.

UNIT IV: MULTICHANNEL PULSE ANALYSIS **12 Hrs.**

Single Channel Methods, General multichannel Characteristics, Multichannel analyzer, Spectrum stabilization and relocation, Spectrum analysis, Compton rejection by anticoincidence, sum coincidence mode.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the statistical models for the characterization of data and error propagation in counting statistics of radiation detectors.

CO2 : Discuss and create an understanding of the introduction, components, and characteristics of photosensors, illustrating the knowledge of their roles in radiation detection systems.

CO3 : Describe the knowledge of device impedances, linear and logic pulses, and the application of ASICs in radiation detection systems.

CO4 : Determine the pulse shape discrimination and coincidence summing via spectrum analysis using digital pulse processing.

CO5 : Apply the knowledge of types of detectors, photosensors and electronics in designing a detector based on the end user requirements.

CO6 : Demonstrate proficiency in analysing the data from detector system using multichannel analyzers.

TEXT/REFERENCE BOOKS

1. J. Kenneth Shultis & Richard E.Faw, "**Fundamentals of nuclear science and engineering"**, CRC Press.
2. G. F. Knoll, "**Radiation Detection and Measurement"**, John Wiley and Sons, New York.
3. William R. Leo, "**Techniques for Nuclear and Particle Physics Experiments"**, Springer Berlin, Heidelberg.
4. Mann, G. L., & Kerker, M., "**Radiation Detection and Measurement: Concepts, Methods, and Devices",** John Wiley & Sons.
5. Lamarsh, J. R., & Baratta, A. J., "**Introduction to Nuclear Engineering**'', Prentice Hall.

<Course Code>					Radiation Physics Applications					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
4	**0**	**0**	**4**	**4**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To understand the various radioisotopes production methods.
2. To learn the biological effect of radiation and radiation protection.
3. To familiarize the students with medical applications of radiations, radioisotopes and radiation technology.
4. To provide knowledge of radioisotopes and radiation detectors in radiation therapy and diagnostics.

UNIT I: RADIOISOTOPES FUNDAMENTAL AND PRODUCTION **08 Hrs.**

Introduction to Radioisotopes, Modes of Radioisotope Production, Neutron induced reactions, charged particle induced reactions, Irradiations in nuclear reactor, Irradiation in accelerator, Radioisotope production in Reactors: Various steps, Preparation of some important radioisotopes like ^{99}Mo production, ^{60}Co production etc, Therapeutic radioisotopes, Cyclotron produced radioisotopes, Radioisotope production in India.

UNIT II: BIOLOGICAL EFFECTS OF RADIATION **08 Hrs.**

Internal and external types of exposure, Characteristics of different radionuclides, Mechanism of cell damage by radiation cellular level effects, Effect of ionizing radiation on tissue, Acute exposure and chronic exposure, Somatic effects and hereditary effects of radiation, stochastic effects and deterministic effects of radiation, effect of radiation on specific organ systems, acute whole body syndromes, pre-natal effects radiation biological and effective half-lives, risk compared to risk in other activities.

UNIT III: DIAGNOSTIC RADIOLOGY AND NUCLEAR MEDICINE **14 Hrs.**

Medical Imaging – X-rays, Computer Technology Scanning (CT), Magnetic Resonance Imaging (MRI), Single Photon Emission Computed Tomography (SPET), Positron Emission Tomography Scanning (PET), Radiopharmaceuticals (Diagnostic and Therapeutic), Some important organ specific diagnostic radiopharmaceuticals, Sterilization of medical products. Blood Irradiator

UNIT IV: RADIATION THERAPY AND PROTECTION **12 Hrs.**

Application of radiation in therapy, Type of radiation therapy, Therapeutic applications - Cancer, external radiation therapy, internal radionuclide therapy - Brachytherapy, Concepts of teletherapy, Boron Neutron Capture Therapy (BNCT). Gamma Knife Radiosurgery (Cyber Knife), Radiation protection in diagnostic, Regulatory agencies and Radiation exposure limits.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Identify the various isotopes, their characteristics and production methods.
CO2 : Understand the biological effect of radiation and radioisotopes.
CO3 : Apply various radioisotope and radiation in healthcare.
CO4 : Analyze various applications of radioisotope and radiation in diagnostic and therapy.
CO5 : Evaluate the safety system and protection during working with radiation and radioisotopes in medical field.
CO6 : Design the new application of radiation in healthcare.

TEXT/REFERENCE BOOKS

1. D. D. Sood, A. V.R. Reddy, N. Ramamoorthy, "**Fundamentals of Radiochemistry"**, Indian Association of Nuclear Chemists and Allied Scientists (IANCAS).
2. IAEA, "**Radiotracer generators for industrial applications"**, IAEA radiation technology series no.5.
3. H.N. Wagner Jr., Z. Szabo, J.W. Buchanan, "**Principles of Nuclear Medicine",** Springer.
4. Bushberg J. T., Seibert J. A., Leidholdt E. M. Jr., Boone J. M., Lippincott Williams & Wilkins, "**Essential Physics of Medical Imaging**'', MD.