लखनऊ विश्वविद्यालय
University of Lucknow
(Accredited A++ by NAAC)

Department of Physics
University of Lucknow
Lucknow

Syllabi for the Four Year Undergraduate Programme
As per the National Education Policy 2020

As per Ordinance 2023

FRAMEWORK

If P-1, P-2, P-3,……………P-20 are courses taught in major subjects and Q-1, Q-2, Q-3 and Q-4 are courses taught in Minor subject, then the proposed structure of UG programmes in NEP at the University of Lucknow, would be as follows:

Year	Sem	Major A (Subject 1)		Major B (Subject 2)		Minor (Subject 3)	CC/ VC			Total Credits	Degree
		Courses	Credits	Courses	Credits	Courses	Credits	Courses	Credits		
1	Sem 1	P-1	4	P-1	4	Q-1	2	CC-1	2	20	CERTIFICATE
		P-2	4	P-2	4						
	Sem 2	P-3	4	P-3	4	Q-2	2	VC-1	2	20	
		P-4	4	P-4	4						
2	Sem 3	P-5	4	P-5	4	Q-3	2	CC-2	2	20	DIPLOMA
		P-6	4	P-6	4						
	Sem 4	P-7	4	P-7	4	Q-4	2	VC-2	2	20	
		P-8	4	P-8	4						
3	Sem 5	P-9	4	P-9	4		Internship/ Term Paper/ Minor Project in Major A (to be decided by student in Semester 5)		4	20	GRADUATION DEGREE
		P-10	4	P-10	4						
	Sem 6	P-11	4	P-11	4					20	
		P-12	4	P-12	4						
		P-13A/ B/ C*	4								
4	Sem 7	P-14	4							20	GRADUATION HONOURS WITH RESEARCH
		P-15	4								
		P-16	4								
		P-17	4								
		P-18A/ B/ C	4								
	Sem 8	P-19 (Research Methodology)	4					Major Research Project or Dissertation	12	20	
		P-20 (Term paper)	4								
Rashtra Gaurav (Compulsory Non credited)**											
Total Credits										**160**	

Note:

*Students will study courses P-13 to P-20 in the subject that they chose to continue in year 4.

**All students will have to pass the Rashtra Gaurav for obtaining certificate, diploma, undergraduate degree or undergraduate honours degree with research, only once.

CC: Co-curricular Course; VC: Vocational Course

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4 Years B.Sc. Programme

Physics Syllabus (Major A, Subject 1)

Department of Physics, University of Lucknow
Lucknow

The Programme Structure

Year	Semester	Paper Title	Credits
First Year	I	P01. PHY 101 Mechanics and Wave motion	4
		P02. PHY 102 Optics	4
	II	P03. PHY 201 Electricity and Magnetism	4
		P04. PHY 202 Mechanics, Optics and Electricity & Magnetism Lab	4
Second Year	III	P05. PHY 301 Heat and Thermodynamics	4
		P06. PHY 302 Perspectives of Quantum Physics	4
	IV	P07. PHY 401 Thermodynamics and Electronics Lab	4
		P08. PHY 402 Electronics	4
Third Year	V	P09. PHY 501 Solid State Physics	4
		P10. PHY 502 Introductory Nuclear Physics	4
	VI	P11. PHY 601 General Physics Lab	4
		P12. PHY 602 Mathematical Methods & Numerical Techniques	4
		P13. PHY 603 History of Science in India PHY 604 Plasma Physics and Space Science PHY 605 Lasers and Opto-electronics	4
Fourth Year	VII	P14. PHY 701 Classical and Statistical Mechanics	4
		P15. PHY 702 Electromagnetic Theory and Electrodynamics	4
		P16. PHY 703 Quantum Mechanics I	4
		P17. PHY 704 Adv. Physics Lab	4
		P18. PHY 705 Atomic and Molecular Physics PHY 706 Frontiers of Physics PHY 707 Materials Science and Nanotechnology	4
	VIII	P19. PHY 801 Research Methodology	4
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PROGRAMME OUTCOMES

The undergraduate degree will be of 4-year duration, with multiple exit options within this period, with appropriate certifications, e.g., a certificate after completing 1 year, or a diploma after 2 years of study, or a Bachelor's degree after a 3-year programme.

The 4-year programme shall lead to a degree 'with Research' as the student will complete a rigorous research project in major area(s) of study.

For students completing a 4-year Bachelor's programme with Research, there will be a 1-year Master's programme.

The 4-year Bachelor's degree with Research will make students eligible for entry to Ph. D. degree.

B. Sc. Semester I Credits 04

P01 - PHY101-Mechanics and Wave Motion

Course outcomes:

1. The students would clearly understand the conflict between Newtonian mechanics and Special Relativity and thus would know how the progress of the revolutionary scientific ideas is made through logical evidences and observations.
2. They would be able to understand the differences between inertial and non-inertial frames and see how pseudo-forces arise in non-inertial frames.
3. They would have a clear understanding of the dynamics of conservative and non-conservative forces in real life such as in gravitational fields or mechanical systems having friction etc.
4. They would feel the thrill to know that the same set of laws that work for planetary and galactic motions also work in our daily life. Further, they would be able to do mathematical calculations with application of these laws to various objects and artificial satellites.
5. They would be able to understand and calculate various macroscopic elastic properties as the response of the widely used materials through the application of simple classical laws.
6. The students would be able to understand and apply the properties of oscillations (natural, damped and forced), and waves and appreciate their omnipresence in various phenomena around us.

UNIT – I

Galilean transformations of space and time and their relation to Newton's laws of motion. Strong and weak form of the Newton's third law of motion. Difference between Inertial and non-inertial frames. Action-at-a-distance and Mach's principle. Conclusions of Michelson-Morley experiment. Chief arguments against Galilean relativity. Postulates of Special Relativity. Simple ideas of length contraction and time dilation. Energy and momentum in relativistic mechanics and modification of Newton's laws of motion. Concepts of gradient, divergence and curl of physical quantities. Simple application of Gauss's divergence and Stoke's curl theorems. Conservative and non-conservative forces, Conservation laws for energy and linear momentum and their relation to symmetries. Pseudo- forces in rotating frame. Coriolis force.

UNIT - II

Elastic and inelastic collisions and one and two dimensions. Centre of mass frame as the zero-momentum frame. Angular momentum, Torque, Conservation of angular momentum and its relation to isotropy of space. Rotational energy and inertia tensor. Moment of inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes

Elasticity, Relation between elastic constants. Twisting of hollow and solid cylinders. Torsional rigidity. Bending moment and Flexural rigidity in bending of beam. Geometrical moment of inertia. Depression for cantilever and supported beams.

UNIT - III

Reduction of a two-body central force problem in to one-body problem. Reduced mass for a pair of bodies. Relative and centre of mass motion with reduced mass. Motion of Planets, satellites and our solar system. Kepler's laws of planetary motion and their implications. Role of the inverse-square form of Newton's law of gravitation in determination of orbit. Motion of geo- synchronous and geo-stationary satellites. Elementary concepts of Global Positioning System (GPS) based on relativistic mechanics. Structure and motion of our Galaxy due to self gravity.

UNIT - IV

Differential equation of simple harmonic motion and its solution. Damped and Forced harmonic oscillations, Sharpness of Resonance. Quality factor. Plane progressive waves in fluid media and pressure and energy distribution along the waves. Transport of energy along strings. Reflection of waves from free and fixed boundaries and phase change at the boundaries. Principle of superposition of waves. Standing waves and resonance. Phase and group velocity.

REFERENCES:

1. Daniel Kleppner and Robert Kolenkow, "An Introduction to Mechanics", (Mc Graw Hill), 2017. 2e.
2. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SI Units): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e.
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 2012.
4. Halliday, Resnick and Walker, "Principles of Physics", (Wiley) 2018, 10e.
5. Frank S. Crawford, Jr, "Waves": Berkeley Physics Course Vol 3", McGraw Hill, 2017.
6. D.S. Mathur, "Mechanics", S. Chand Publishing, 1981, 3e.
7. R.K. Shukla and Anchal Srivastava, "Mechanics" Published by: New Age International (P) Limited Publishers.

WEB REFERENCES :

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx
   SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

B.Sc. Semester I Credits 04

P02 - PHY102-Optics

Course outcomes:

1. The student will get an introduction to the discipline of optics and its role in daily life.
2. The optics course will give the student a basic knowledge of interference, diffraction and polarization.
3. The student will be able to analyze and calculate interference between light waves and application of the theory to various interferometers along with their practical applications.
4. The student would know the conditions for near and far-field diffraction and be able to calculate the far-field diffraction from gratings and simple aperture functions.
5. The student would understand how the polarization of light changes at reflection and transmission at interfaces.

UNIT - I

Electromagnetic nature of light; Superposition of light waves; Coherence, Spatial and temporal coherence; Interference, Division of Wavefront – Young's double slit experiment, Fresnel's Biprism, Lloyd's Mirror; Division of amplitude – Thin films (parallel and wedge shaped films), Newton's rings.

Interferometers: Michelson's Interferometer, (i) Idea about form of fringes, (ii) Determination of wavelength, (iii) wavelength difference, (iv) refractive index and visibility of fringes; Fabry-Perot interferometer.

UNIT – II

Diffraction; Fresnel Diffraction - Half period zones, Zone plate, diffraction at a straight edge and narrow wire; Fraunhoffer Diffraction – Diffraction at circular aperture, diffraction at single and double slits with derivation of equation for intensity and visibility; Diffraction grating, principal maxima and missing orders.

UNIT - III

Resolving power; Rayleigh's criterion of resolution, Resolving power of grating and telescope.
Polarization: polarization by reflection, polarizing angle, Brewster's law, Law of Malus; Polarization by dichroic crystals, birefringence, anisotropic crystals; Nicol prism, Retardation plates, Babinet compensator; Analysis of polarized light.

UNIT - IV

Optical activity and Fresnel's explanation; Specific rotation, Half shade and Biquartz polarimeters.
Jones matrix, matrix representation of plane polarized waves, matrices for polarizers, retardation plates and rotators.

REFERENCES:

1. F.A. Jenkins and H.E. White, Fundamentals of Optics, Tata McGraw Hill.
2. Brij Lal and N. Subrahmaniyam, Optics, S. Chand.
3. E.Hecht, Optics, Pearson.
4. A.K.Ghatak, Optics, Tata Mc Graw Hill.

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx
   SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Physics B. Sc. Semester II Credits 04
P03 - PHY201-Electricity and Magnetism

Course outcomes:

After successful completion of this course, students will:

1. Understand the basic mathematical concepts related to Electromagnetic fields, and use the understanding of calculus along with basic principles to solve problems encountered in science.
2. Comprehend and apply the understanding of fundamental laws and concepts in electricity and magnetism, primarily with regard to Maxwell's laws, to explain natural physical processes and related technological advancements.
3. Learn about the origin and basic properties of static as well as dynamic Electric and Magnetic fields, and the kinds of physical phenomena they generate - Electromagnetic waves and their properties.
4. Account for the importance of electricity and magnetism in society, especially with regard to technological applications.
5. Visualize and design experiments based on the basic concepts of electricity and magnetism, and obtain information in order to explore physical principles.

UNIT - I

Electrostatics: Electric charge & types of electric charge densities, Coulomb's Law. General expression for Electric field **E**. Electric flux, Gauss's law (applications included). Divergence & Curl of Electrostatic field. Line integral of Electric field, Electric potential (V), Electric field as negative of gradient of electric potential ($\mathbf{E} = -\nabla V$), conservative nature of Electrostatic field. Electric potential and Electric field due to a Dipole, and Quadrupole. Force and torque on a Dipole in uniform as well as non-uniform Electric field. Electrostatic Energy of a configuration of charges, and uniformly charged sphere.

Electric fields in Matter: Polarization, Polarization vector (**P**), Bound charges, Electric displacement vector (**D**), Electric Susceptibility and Dielectric constant. Relation between **E**, **P** and **D.** Lorentz local field, Clausius-Mossotti equation, Debye equation.

UNIT - II

Magnetostatics: Magnetic effect of currents, Magnetic field (**B**), Biot-Savart's Law (applications included). Ampere's Circuital law and its applications. Divergence and Curl of magnetic field. Scalar and Vector magnetic potential. Forces on a moving charge. Magnetic Force on a current carrying wire and its loop. Torque on a current loop in a uniform Magnetic Field. Current loop as a magnetic dipole and its dipole moment.

Magnetic Properties of Matter: Magnetization vector (**M**), Magnetic Intensity(**H**), Magnetic Susceptibility and permeability. Relation between **B**, **M** and **H**. Types of Magnetic materials. B-H curve and Hysteresis.

UNIT - III

Time Varying Electromagnetic Fields: Faraday's laws of Electromagnetic Induction and Lenz's law. Induced Electric field, non- conservative nature of Induced electric field. Self and Mutual Induction (applications included). Self-inductance of a solenoid and toroid, Mutual inductance of two Coils. Energy stored in Magnetic Field. Skin effect.

Motion of Electron in a changing Magnetic field – Betatron equation.
Theory and working of the moving coil Ballistic galvanometer (applications included).

UNIT - IV

Electromagnetic Waves: Equation of continuity of current, Displacement current, derivation of Maxwell's equations and physical significance of Maxwell Correction term. Electromagnetic waves in vacuum and isotropic Dielectric medium, Transverse nature of Electromagnetic waves, Energy density in Electromagnetic wave - Poynting vector.

REFERENCES:

1. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, (2017), 2e.
2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 2", Pearson Education Limited, (2012).
3. David J. Griffiths, "Introduction to Electrodynamics" 4th Edition, (Cambridge Univ. Press 2020)
4. W.K.H Panofsky and M. Philips, "Classical Electricity and Magnetism" (Dover Books on Physics, 2012)
5. Arthur F. Kip, "Fundamentals of Electricity and Magnetism", (McGraw-Hill, 1968)
6. J.H. Fewkes& John Yarwood, "Electricity and Magnetism", Vol. I (Oxford Univ. Press, 1991).
7. B B Laud, "Electromagnetics", New Age International (P) Limited.
8. D.C. Tayal, "Electricity and Magnetism", Himalaya Publishing House Pvt. Ltd., 2019, 4e
9. N. Wadhwani, "Electricity and magnetism", PHI Learning, ISBN: 9788120339651, 9788120339651
10. R.K. Shukla, "Introduction to Electricity & Magnetism", HP Hamilton Limited.

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1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

B. Sc. Semester II   Credits 04

P04 - PHY202-Mechanics, Optics and Electricity & Magnetism LAB

Course Outcomes

Experimental physics has the most striking impact on the industry wherever the instruments are used to determine the thermal and electronic properties. The following outcomes are expected by this laboratory course:

1. Students will achieve measurement precision.
2. Students will verify the conceptual learning through experiments in these areas.
3. Students will better appreciate the theoretical concepts in mechanics, electricity and magnetism, and optics through experiments.

Lab Experiment List

Students have to do total of eight experiments from the following list taking at least two experiments from each group.

(A) Mechanics:

1. Determination of Young Modulus of the material of a beam by flexure
2. Determination of modulus of rigidity of a wire by statical method
3. Determination of 'g' by compound pendulum.
4. Determination of Surface Tension of water by capillary rise method.
5. Determination Coefficient of Viscosity of water.
6. Determination of the frequency of A.C. Mains

(B) Optics

1. Measurement of Dispersive power of a given prism
2. Determination of the wavelength of light by Newton's ring.
3. Measurement of height of tower by a Sextant
4. Verification of Brewster's Law
5. Determination of specific rotation of an optically active substance by polarimeter
6. Diffraction at a wire

(C) Electricity and Magnetism

1. Determination of High resistance by leakage method.
2. Determination of Mutual Induction by Ballistic galvanometer.
3. Determination of Horizontal component of earth's magnetic field by earth inductor.
4. Determination of Magnetic field of a electro magnet by Ballistic galvanometer.
5. Determination of Time constant striking & extension Potential of neon bulb in CR circuit.
6. Magnetic field by Helmholtz coil.

REFERENCES:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015, 1e
3. Anchal Srivastava and R.K. Shukla,“Practical Physics (Electricity, Magnetism and Electronics)”, Published by: New Age International (P) Limited Publishers
4. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e
5. A. Sudhakar, S.S. Palli, “Circuits and Networks: Analysis and Synthesis”, McGraw Hill, 2015, 5e

Physics B. Sc. Semester III Credits 04
P05 - PHY301-Heat and Thermodynamics

Course outcomes

1. The students will understand the fundamental principles of thermodynamics, including the first and second laws.
2. They would learn the idea of entropy and associated theorems, and the thermodynamic potentials and their physical meanings.
3. Students will have an understanding of Maxwell's thermodynamic relations.
4. They will acquire the knowledge about the fundamentals of gas kinetic theory and transport phenomenon.

UNIT - I

Real Gases: Deviations from the Ideal Gas Equation, behaviour of Real Gases, The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule Thomson Cooling.

UNIT - II

Kinetic Theory of Gases: RMS speed, Kinetic Interpretation of temperature, Degree of Freedom, Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic Gases. Mean free path, Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Derivation of Maxwell's law of distribution of velocities and its experimental verification.

UNIT - III

Thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_p & C_v, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot 's cycle & theorem, Entropy changes in reversible & irreversible processes. Clausius Inequality, entropy and unavailable energy, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications (1) Clausius-Clapeyron Equation, (2)Expression for (C_P– C_V), (3)C_P/C_V (4) TdS equations.

UNIT - IV

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan-Boltzmann Law and Wien's displacement law from Planck's law. Solar Constant.

REFERENCES:

1. S. Garg, R. Bansal and C. Ghosh,"Thermal Physics" McGraw Hill Education 1993.
2. Meghnad Saha, and B.N. Srivastava, "A Treatise on Heat"Indian Press 1969.
3. Enrico Fermi , "Thermodynamics" Dover Publications, 2013.
4. M.W. Zemansky and R. Dittman, "Heat and Thermodynamics" McGraw-Hill College 1996.
5. F.W. Sears & G.L. Salinger, "Thermodynamics, Kinetic theory & Statistical thermodynamics" Pearson 1975.

B.Sc. Semester III Credits 04

P07 – PHY302-Perspectives of Quantum Physics

Course Outcomes

Study of the syllabus in Perspectives of Quantum Physics will have the following outcomes:

1. It will help students understand the basics concepts of Quantum Physics.
2. It will make students understand the development of quantum mechanics as a continuity of classical concepts and also as a leap jump from classical to quantum world of Physics.
3. A student will be able to understand as to how the inadequacies of classical Physics were overcome by various concepts and theoretical developments of modern Physics i.e. Understand how major concepts developed and changed over time.
4. A study of the Heisenberg's Uncertainty principle and its applications will make students understand the most modern concept of wave particle duality as to how a wave could behave like a particle and how a particle could behave like a wave.
5. An appreciation of the Schrödinger Wave Equation and its application to various problems in quantum mechanics will make students more analytical. This will give them the needed tool to solve problems across science subjects as Schrödinger equation appears in multidisciplinary subjects.
6. It will make students capable of analysing and solving problems using reasoning skills based on the concepts of modern physics.

UNIT - I

Inadequacy of Classical Physics, The Black Body Radiation, Spectral Distribution of Black Body Radiation, Rayleigh Jeans Law, Wien's Displacement Law, Planck's Radiation Law, Photoelectric Effect, The Quantum Theory of Light, Continuous and characteristic X-ray, X-ray generation and uses, Compton effect, Gravitational Red Shift, de Broglie waves, de Broglie Wave Function and its Properties, Interpretation of wave function, de Broglie Wave Velocity, Complementary principle, Principle of Superposition, Wave and Group Velocity, Motion of Wave Packets, Davisson and Germer Experiment-Diffraction of Electrons, Wave-particle duality Experiment.

UNIT - II

Heisenberg's Uncertainty principle and its applications, Estimating minimum energy of a confined particle using uncertainty principle, Estimate of Hydrogen Ground State Energy; Wave Equation, Wave Equivalent of an unrestricted Particle, Time Dependent Schrödinger wave equation: Eigenvalues and Eigen Functions, Probability Current; Expectation Value, Expectation Values of Energy and Momentum Operators, Ehrenfest theorem.

UNIT - III

Continuity of wave Function, Boundary Condition and Discrete Energy Levels, Steady State Schrödinger Equation, Application of Schrödinger Wave Equation for Particle in an infinitely Rigid Box: Energy and Momentum Quantization, Normalization, Quantum Dot as an example; One Dimensional Step Potential, Rectangular Barrier, Square Well Potential

UNIT - IV

Bohr atomic model, de Broglie Waves and Stationary Orbits, Hydrogen Atom Spectrum, Atomic Excitation-Franck Hertz Experiment, Correspondence Principle, Sommerfeld Elliptic Orbits. Electron Angular Momentum, Space Quantization, Electron Spin and Spin Angular Momentum, Spin Magnetic Moment, Stern – Gerlach Experiment, Pauli's Exclusion Principle and Periodic Table. Fine structure, Spin Orbit Coupling, Spectral Notation for Atomic States, Total Angular Momentum, Vector Model, Coupling schemes (LS and jj) for two electron systems. Zeeman Effect for one Electron System.

REFERENCES:

1. Arthur Beiser, "Concepts of Modern Physics", McGraw-Hill, 2009.
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, "Modern Physics",PHI Learning2009.
3. Thomas A. Moore, "Six Ideas that Shaped Physics: Particles Behave like Waves" McGraw Hill, 2009.
4. R.A. Serway, C.J. Moses, and C.A. Moyer "Modern Physics" Third Edition, 2005, Cengage Learning.
5. P.M. Mathews & K. Venkatesan, "A Text book of Quantum Mechanics", 2nd Ed., 2010, McGraw Hill.
6. AjoyGhatak, S. Lokanathan, "Quantum Mechanics: Theory and Applications", Macmillan Publishers India Limited.
7. R.M. Eisberg, "Fundamentals of Modern Physics" Wiley, New York.
8. H.E. White, "Introduction to Atomic Spectra" ,McGraw-Hill, New York.

B.Sc. Semester IV Credits 04
P06 – PHY401-Thermodynamics and Electronics LAB

Course Outcomes

1. Experimental physics has the most striking impact on the industry wherever the instruments are used to determine the thermal and electronic properties.
2. Measurement precision and perfection is achieved through Lab Experiments.
3. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Lab Experiment List

Students have to perform four experiments from Group A and four experiments from Group B

Group A Thermodynamics

1. Mechanical Equivalent of Heat by Callender and Barne's method
2. Coefficient of thermal conductivity of copper by Searle's apparatus
3. Value of Stefan's constant
4. Variation of thermo-emf across two junctions of a thermocouple with temperature
5. Temperature coefficient of resistance by Platinum resistance thermometer

Group B Electronics

01. PN Junction/ Zener diode characteristics
02. Half wave & full wave rectifiers and Filter circuits
03. Characteristics of a transistor (PNP / NPN) in CE, CB and CC configurations
04. Unregulated and Regulated power supply
05. Diode as clipper and Clamper
06. Frequency response of RC coupled amplifier
07. Various measurements with Cathode Ray Oscilloscope (CRO)
08. Charging and discharging in RC circuits
09. A.C. Bridges: experiments based on measurement of L and C
10. Resonance in series and parallel RCL circuit

REFERENCES:

2. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
3. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
4. Anchal Srivastava and R.K. Shukla,"Practical Physics (Electricity, Magnetism and Electronics)", Published by: New Age International (P) Limited Publishers
5. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
6. A. Sudhakar, S.S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill, 2015, 5e

WEB REFERENCES:

Virtual Labs at Amrita Vishwa Vidyapeetham,https://vlab.amrita.edu/?sub=1&brch=194

Virtual Labs an initiative of MHRD Govt. of India,http://vlabs.iitkgp.ac.in/be/#

Digital Platforms/Web Links of other virtual labs may be suggested /added to this lists by individual Universities

B.Sc. Semester IV Credits 04
P08 - PHY402 - Electronics

Course Outcomes:
1. Utility of resonant circuits,
2. Knowledge of Network theorems,
3. Study the drift and diffusion of charge carriers in a semiconductor.
4. Study of special diodes and Junction Transistors,
5. Study of the working, properties and uses of FETs and MOSFET
6. Comprehend the design and operations of SCRs and UJTs.
7. Understand various number systems and binary codes.
8. Familiarize with binary arithmetic.
9. Study the working and properties of various logic gates.

UNIT - I

Circuit fundamentals: Time varying currents, Growth and decay of currents in LR circuit., Charging and discharging of capacitor in RC and LCR circuits. Introduction to Network Theorems. Semiconductor Junction: Qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field and potential at the depletion layer. Barrier width, Qualitative idea of current flow mechanism in forward and reverse biased diode, current conduction in PN junction diode and its characteristics. Half wave and Full wave rectifiers, calculation of ripple factor and rectification efficiency.

UNIT - II

Bipolar transistors: PNP and NPN transistors. Study of CB, CE and CC configurations w.r.t. characteristics; active, cutoff and saturation regions, current gains and relations between them, applications of transistors.

Amplifiers : single stage and multistage transistor amplifier, Theory and working of RC coupled voltage amplifier (Uses of various resistors & capacitors) , frequency response of RC coupled amplifier and its analysis .

Feedback Circuits: Effects of positive and negative feedback. Feed back factor, loop gain. advantages of negative feedback amplifiers , Input Impedance and Output Impedance.

UNIT – III

Field Effect Transistors: JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions, Characteristics; Parameters and applications. MOSFET: Construction, Working and Characteristics of D-MOSFET and E-MOSFET and their application;

Comparison with JFET. Other Devices: SCR: Construction; Equivalent Circuits; Working; Characteristics; Applications (Static switch, Phase control system & Battery charger).

UNIT - IV

Digital Electronics: Logic Gates and Boolean algebra: Introduction to Boolean Algebra and Boolean operators, Truth Tables of OR, AND, NOT, Basic postulates and fundamental theorems of Boolean algebra, Truth tables, construction and symbolic representation of XOR, XNOR, Universal gates: NOR and NAND gates. De Morgan`s theorems. Number System and Codes: Decimal, Binary, Hexadecimal and Octal number systems. Inter-conversion of numbers systems. Binary arithmetics (addition, subtraction, multiplication and division), Binary coded decimal (BCD) codes. Gray codes.

REFERENCES:

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975,
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016,
6. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010,
7. Malvino, Albert Paul," Electronic principles", McGraw-Hill Education,2015.

B.Sc. Semester V Credits 04

P09 - PHY501 - Solid State Physics

Course Outcomes:

This syllabus aims to introduce the theoretical and experimental topics in solid state physics. On successful completion of the units students would get an understanding of

1. The crystal geometry with respect to symmetry operations
2. The power of X-ray diffraction and the concept of reciprocal lattice
3. The various properties based on crystal bindings
4. Lattice dynamics and its influence on the properties of materials,
5. Physics of electrons in solids and
6. Magnetic, dielectric and superconducting properties of solids along with recent published results by various researchers.
7. Such study would provide a foundation for research in condensed matter physics, material science and nanotechnology.

UNIT - I

Crystal Structure: Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures – bcc, fcc & hcp, Diamond, Cubic Zinc sulphide, Sodium Chloride, Cesium Chloride and Glasses.
Crystal Diffraction: X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods (including XRD patterns of new materials),. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to sc, bcc and fcc lattices. Atomic Form factor and Crystal Structure factor.

UNIT - II

Crystal Bindings: Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals-London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.
Lattice Vibrations: Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit law and Einstein's and Debye theories of specific heat of solids. T3 law

UNIT - III

Free Electron Theory: Drude Model, Wiedemann-Franz law, Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals & semiconductors.

Band Theory: Origin of band theory, Bloch theorem (Proof and analysis), , Kronig-Penny model (proof and analysis of results), Effective mass of an electron , Concept of Hole, Surface states, Classification of solids on the basis of band theory. Qualitative idea of Simulation of Band structure of solids

UNIT - IV

Magnetic Properties of Matter: Origin of magnetism Dia-, Para-, Ferri- , Ferro- and anti-ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Curie's law, Weiss"s Theory of Ferromagnetism and ferromagnetic domains, Qualitative discussion of B- H Curve. Hysteresis, soft and hard material and Energy Loss.

Dielectric Properties of Materials: Polarization, Depolarization Field , Electric Susceptibility. Polarizability.

Introduction to Superconductivity: Qualitative idea and Recent published results in research journals. Defects in solids: Point defects, vacancies, concentration of defects -Schottky, Frenkel (including recent published results in research journals)

REFERENCES:

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. S.O. Pillai, "Solid State Physics", New Age International Publishers
4. S.O. Pillai, "Modern Physics and Solid State Physics (Problems and Solutions)", New Age International Publishers
5. J. P. Shrivastava, " Elements of Solid State Physics" PHI
6. R. L. Singhal, " Solid State Physics" Kedar Nath Ram Nath &Co. Publishers
7. H.C. Gupta, "Solid State Physics" Vikas Publishing/S.Chand Publishers
8. Ashcroft and Mermin, "Solid State Physics", Cengage Learning, Incorporated.

WEB REFERENCES

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

B.Sc. Semester V Credits 04
P10 - PHY502-Introductory Nuclear Physics

Course Outcomes:

After successful completion of the course on Nuclear Physics, students will:

1. Grasp the knowledge about basic nuclear properties and nuclear models for a better understanding of nuclear reaction dynamics.
2. Analyze quantum mechanical phenomena in nuclear physics and develop an understanding of quantum mechanics also.
3. Comprehend the general understanding of phenomena like nuclear fusion and fission and develop the skills required for solving basic problems in nuclear physics at different nuclear energy ranges.
4. Develop the basic understanding of accelerator physics and particle detectors.
5. Acquire and apply basic nuclear physics knowledge in subjects such as medicinal, archaeology, geology, and other multidisciplinary fields of Physics and Chemistry.

UNIT - I

Quantitative facts about mass, radii, charge density, matter density, binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, nuclear fission and fusion, valley of stability N/Z plot. Angular momentum, parity, magnetic dipole, and electric quadrupole moments (qualitative aspects only). System with two nucleons (deuteron), P-P, N-P, N-N interactions.

UNIT - II

Theory of α-emission, α-decay spectroscopy. β-decay: Energetics in β-decay, β spectrum, neutrino hypothesis, parity violation in beta decay, Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion, nuclear isomerism.Compound nucleus formation, reaction cross-section.
Interactions of radiation with matter; Gas detectors: GM counter and Proportional counter, Scintillation Detectors and photo-multiplier tube; Semiconductor detectors (Si and Ge); (basic properties, basic working method, resolution and efficiency of detectors), Accelerators: DC and AC; Van-de Graaff generator (Tandem accelerator) and Linear accelerator (Linac). Cyclotron, synchrocyclotron and Collider.

UNIT - III

Liquid Drop Model and semi-empirical mass formula, fission explanation, Single particle Shell model (odd-A ground state and excited state spin and parity, ground state spin and parity of odd- odd nuclei; Collective model: vibrational and rotational model, theirspectra and energy level schemes.

UNIT - IV

Particle interactions; basic features, types of particles and its families. Symmetries and conservation laws(energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness), concept of quark model, color quantum number and gluons, basic idea about Standard model.

REFERENCES:

1. Krane, K.S.,"Introductory Nuclear Physics", Wiley India Pvt. Ltd., (2008).
2. Roy, R.R. and Nigam, B.P., "Nuclear Physics", New Age International Ltd., (2001).
3. Kaplan Irving, "Nuclear Physics", Narosa Publishing House, (2000).
4. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, (1974).
5. C. M. H. Smith. Pergamon, "A Textbook of Nuclear Physics", New York, (1965).
6. John Lilley, "Nuclear Physics: Principles and Applications" Willey Publication (2006).
7. Glen F. Knoll, "Radiation detection and measurement" 4th Edition, Wiley (2010), ISBN: 978-0-470-13148-0.
8. Wiedemann, Helmut, "Particle accelerator Physics", Springer
9. David Griffiths, "Introduction to Elementary Particles" Wily (1987)

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx

B.Sc. Semester VI Credits 04
P11 - PHY601-General Physics LAB

Course Outcomes:

1. Measurement precision and perfection is achieved through Lab Experiments.
2. The experiments in advance laboratory will enable students to be industry ready in the field of electronics.
3. The exposure to this laboratory will enable students to do research in applied optics and optoelectronics.
4. The students will be able to appreciate the concept of electronic communication.
5. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

List of Experiments:

Students have to perform a total of eight experiments from the following list:

01. To study effect of feedback on frequency response of RC coupled amplifier
02. To study the process of amplitude modulation and demodulation
03. To study characteristics of FET/ MOSFET
04. To study FET as voltage variable attenuator and its application as voltage-controlled attenuator.
05. S.C.R.
06. I.C. Regulated Power Supply
07. To study frequency response of IC amplifier.
08. To determine the wavelength of mercury spectral lines with the help of diffraction grating.
09. To determine the wavelength of sodium light with the help of Fresnel biprism.
10. Hysteresis loop for a ferromagnetic material (B-H curve)

REFERENCES:

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. Anchal Srivastava and R.K. Shukla,"Practical Physics (Electricity, Magnetism and Electronics)", Published by: New Age International (P) Limited Publishers
4. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
5. A. Sudhakar, S.S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill, 2015, 5e

B.Sc. Semester VI Credits 04
P12 - PHY602-Mathematical Methods and Numerical Techniques

Course Outcomes:

On completion of this course students will be able to

1. Understand numerical techniques to find the roots of equations and solution of system of linear equations.
2. Understand the difference operator, use of interpolation and matrices.
3. Understand numerical differentiation and integration and numerical solutions of ordinary and partial differential equations.
4. Applying numerical techniques to solve physics problems.

UNIT - I

Concepts of errors in numerical computation, solution of algebraic and transcendental equation, fixed point iteration method, bisection and Regula falsi method, Newton-Raphson method, Ramanujan's method, secant method, finite difference operators, differences of a polynomial.

UNIT - II

Numerical interpolation, Newton’s interpolation formula and Lagrange interpolation formula, interpolation by iteration, numerical differentiation (using Newton's forward and backward formulae), numerical integration, trapezoidal rule, Simpson’s 1/3 rule and 3/8 rule, Gauss quadratic formula.

UNIT - III

Matrices, Gauss elimination, partial and full pivoting, matrix inversion and Gauss-Jordon method, LU decomposition, LU decomposition from Gauss elimination, solution of linear system of equations- iterative methods (Jacobi’s iteration method and Gauss Seidel iteration method), Eigen value problem.

UNIT - IV

Numerical methods for solutions of ordinary differential equations, Euler's method, Runge-Kutta method, finite difference methods for solving second order two-point linear boundary value problems, solution of 2D Laplace’s and Poisson’s equations, solution of 1D heat equation and 1D wave equation.

REFERENCES:

1. S.S. Sastry, “Introductory Methods of Numerical Analysis”, Fourth Edition, PHI.
2. S. Sankara Rao, “Numerical Methods of Scientists and Engineer”, 3rd ed., PHI.
3. F.B. Hidebrand, “Introduction to Numerical Analysis”, TMH.
4. J.B. Scarborough,“Numerical Mathematical Analysis”, Oxford and IBH.

B.Sc. Semester VI Credits 04
P13 - PHY603 - History of Science in India

Course Outcomes:

1. Students will realize and sense the excitement how deeply the mysteries of the starry sky and several socio-cultural aspects of human coexistence with nature have puzzled the great minds of all times in India and motivated them into extensive enquiry.
2. Students will learn about the long tradition of the monumental ancient-to-modern wisdom in science contributed by Indian scientists with their sheer dedication and intellect despite the obvious lack of adequate resources and experimental facilities.
3. They would clearly understand how the scientific ideas progress through the application of mathematics built on reason and logical methods and ultimately lead to scientific revolutions.
4. Thus, students will appreciate the role of human observations in verification of the scientific principles and necessity of the technological tools to add to or modify or overturn the already acquired knowledge along the line of history.

UNIT - I

Emergence of science in India. Methods of Indian numerals. Ten digits based numerals (*dashmic sthanmaan*) including zero. Sidddhantic Astronomy. "*Aryabhatiya*" as the first *paurusheya* Indian text in astronomy: Revolutionary Principles of the spin motion of the earth at its axis as described in "*Dashgitikapaad*" and "*Golapaad*" . Aryabhat's rebuttal of the Rahu-Ketu (ascending and descending nodes) eclipse beliefs in *"Golapaad"*. Relative orientation of earth's equatorial plane and the lunar orbital plane from the ecliptic. Motion of intersecting nodes. Brahmgupta's criticism of Aryabhat's *sidhhants.* Bhaskar II's (12 century AD) ideas about attractive nature of earth's gravitation in his text, *"Sidhhant-shiromani"*.

UNIT - II

Progress of empirical science in India. Calculation tables and observational verification, streams of medicine (Susrut, Charak and Vagbhata I—*vridhha trayi*), chemical (Nagarjuna) and agricultural sceience. Development of technological tools from ancient - to - medieval civilizations. Compilation of of Zij tables by Raja Jai Singh Sawai. Writing of Monographs e.g., *Yantra-Raj* (1370 AD*)* (the first monograph on instrumentation in Sanskrit) . Establishment of observatories at Delhi, Jaipur, Mathura, Ujjain and Varanasi in medieval period. Progress in chemical science: Nagarjuna's accounts of distillation of ores for extraction of metals (mercury from cinnabar).

UNIT - III

Advances in physical sciences through observations with light. Transit of Mercury (1651 AD) observed at Surat. Discovery of the binary nature of the bright star *Alpha Centauri* at Pondicherry (1689 AD). Accomplishments with Madras observatory as Meridian for Great Trigonometric Survey of India. Discovery of vaiable star *R Reticuli* by Chintamani Ragoonathchaari. Historical outline of observatory at Trivendrum and the Lucknow Observatory. Discovery of spectral line due to Helium during Total Solar Eclipse at Guntur.

The first helioscope at Simla. Spectroscopic Solar photography in Calcium K and Hydrogen *alpha* light.

UNIT - IV

Transition of science to modern period. Brief summary of monumental contributions by J. C. Bose, S. N. Bose, Meghnad Saha, Sir C. V. Raman, H. J. Bhabha and N.S. Kapany about the nature of electromagnetic waves and their interaction with matter. Raman Effect and its modern applications. Discovery of Comet (C/1949N1- Bappu-Bok-Newkirk comet) by M. K. Vainu Bappu. Wilson-Bappu Effect about emission of Ca II K spectral lines. Contributions by
N. N. Sen, V. V. Narlikar, P.C. Vaidya, A. K. Raychaudhri, S. Chandrasekhar and C.V. Vishveshwara and E.C.G. Sudarshan, V. A. Sarabhai and Harish-Chandra in modern physics, P. C. Ray in Chemistry, S. Ramanujan in Mathematics, P.C. Mahalnobis in Statistics, P.N. Bose and B. Sahni in geology and palaeobotany.

REFERENCES:

1. Indian National Science Academy Publications:
   - (i) *"Aryabhatiya":* original by Aryabhat and Hindi Translation by Ram Niwas Rai. (INSA, New Delhi)
   - (ii) *"Aryabhatiya":*Aryabhat's original text with English Translation by Kripa Shankar Shukla and K.V. Sharma (INSA, New Delhi).
2. Indian Journal of History of Science: Vol 18, 2. (on Aryabhat's works).
3. *"Brahmasphut-siddhanta*", (original with commentary): Pt. Sudhakar Dwivedi (Varanasi, 1902).
4. *"Siddhanta-shiromani":* original by Bhaskar II: Commentary byBapudev Shastri (Varanasi, 1913).
5. GunakarMuley,*"Bhaskaracharya"*, RajkamalPrakashan, 2011.
6. D. M. Bose, S.N. Sen and B.V. Subbbarayappa,"A Concise History of Science in India": (Universities Press, 2009).
7. J. V. Narlikar," The Scientific Edge"Penguin India, 2003.
8. P. Kutumbiah, "Ancient Indian Medicine"Orient Longmans, 1999, 2nd ed.
9. Patrick Geddes ,"Life and Work of Sir Jagdish C. Bose"Longman Greens, 1920.
10. G. Venkataraman,"Bose and his Statistics" Universities Press, 1992.
11. G. Venkataraman,"Saha and his Formula"Universities Press, 1997.
12. G. Venkataraman,"Raman and his Effect", Universities Press, 1995.
13. G. Venkataraman,"Bhabha and his Magnificent Obsession" Universities Press, 1994.
14. G. Venkataraman,"Chandrasekhar and his Limit", Universities Press, 1992.
15. N. Mukunda,"The Life and Work of E.C. George Sudarshan": Resonance, **24 (2)**, 129 (2019.
16. K. P. Singh,"In Memory of Narinder Singh Kapany": (Nature Photonics, **15**, 403, 2021).
17. Robert Kanigel,"The man who knew infinity -- A life of the Genious Ramanujan", Abacus, 1992. Also an adaptation into a film by Matthew Brown in 2015.
18. D. D. Majumdar ,"Scientific Contributions of Prof. P.C. Mahalnobis": Current Science **65 (1)** , 97-101, 1993.
19. U. R. Rao and K. Kasturirangan,"Vikram Sarabhai: the Scientist": Resonance **6** (12), 2001.

20. V.S. Varadrajan,"Harish-Chandra and his mathematical Work": Current Science, 65 (12), 918, 1993.
21. "https://vigyanprasar.gov.in/digital-repository/biographies-of-scientists/ (Vigyan Prasar, Department of Science and Technology, New Delhi).

B. Sc. Semester VI Credits 04

P13 - PHY604 - Plasma Physics and Space Science

Course Outcomes:

1. After completing the course the students will understand the basic concepts of plasma physics and will have very good knowledge of mathematical models for plasma and will be able to distinguish the dynamics of plasmas and neutral fluid media.
2. They will be able to describe the propagation of waves in plasmas and will have good insight into plasma instabilities.
3. Students will be able to know about the atmospheric structures, the Sun-Earth system and space weather.
4. The students will feel a great deal of excitement with our current understanding into the mysteries of the stars and universe, especially with the modern state-of-the-art technology like "Hubble Space Telescope" and "Planck" spacecraft..

UNIT – I

Elementary Concept of Plasma: Definition of Plasma, Plasma as ionized gas, Saha's ionization equation, Concept of Plasma temperature, Debye shielding, Quasi-neutrality, Plasma parameters, Plasma approximation, Hydro dynamical description of plasma, fundamental equations.

Occurrence of Plasma, Applications of Plasma in brief with special reference to nuclear fusion and particle acceleration.

Single-particle motion, Dynamics of charged particles in electro-magnetic fields, particle drifts, EXB drifts, Grad-B drift, Curvature drift, Polarization drift

UNIT – II

Wave phenomena in magneto-plasma: polarization, phase velocity, group velocity, cutoff, resonance for electromagnetic wave propagating parallel, perpendicular to magnetic field, Appleton-Hartree formula. Kinetic theory of Plasma: Vlasov equations, Solution of linearized Vlasov equation, Langmuir waves, Wave-particle interaction and Landau damping. Fluid theory of Plasma - Plasma oscillations, Electron-acoustic waves, Ion-acoustic waves. Applications of plasma physics (only theory in brief) to nuclear fusion and particle acceleration.

UNIT – III

Atmosphere, atmospheric layers, composition. Elements of Ionosphere and Magnetosphere, structure and density profile, ionosphere-magnetosphere coupling. Structure of the Sun: solar interior, solar atmosphere, photosphere, chromosphere, corona. Sunspots and their properties, Sun- Earth interactions, basic concept of storm and substorm phenomena. Solar activity cycles, solar wind, solar flares, coronal mass ejections (CMEs), Space weather, causes and consequences, space climate.

UNIT – IV

Stellar structure (equilibrium, nuclear reactions, energy transport) and stellar evolution (with example of our Sun). Chandrasekhar limit for white dwarfs. Neutron stars and Blackholes. Exoplanets. Morphology and types of galaxies: Our Milky Way. Concept of dark matter. Cosmic microwave background radiation. HST and Planck observations. Redshifts. Accelerated expansion of the Universe and current explanations with and without dark energy. Evolution of the Universe.

REFERENCES:

1. Bittencourt, J. A., “Fundamentals of Plasma Physics”, Springer, New York, 2004).
2. Bellan, P. M., “Fundamentals of Plasma Physics”, Cambridge, UK, 2006.
3. Chen, F. F., “Introduction to Plasma Physics and Controlled Fusion”, 2nd ed., Plenum, New York, 1984.
4. Piel, A., “Plasma Physics: An Introduction to Laboratory, Space and Fusion Plasmas”, Springer, Heidelberg, 2010.
5. Ackerman, S.A. and Knox, J.A.,“Meteorology Understanding the Atmosphere, Thomson Learning”.
6. Kevilson, M.G. and Russell, C.T., “Introduction to Space Physics”, Cambridge University Press, 1995.
7. Singhal, R.P., “Element of Space Physics”, Prentice Hall of India, New Delhi.
8. BasuBaidyanath, “Introduction to Astrophysics”, Prentice Hall of India, 2013.
9. Frank Shu, “The Physical Universe”, University Science Books.
10. Weinberg, S., “The First Three Minutes”, Basic Books, 1993.
11. Hawking, S.W., “A Brief History of Time”, Bantam, 1995.

B.Sc. Semester VI Credits 04

P13 - PHY 605 - Lasers and Optoelectronics

Course Outcomes:

1. Opting for this course will give the students an opportunity to know and understand applications of fiber optics and laser technology.
2. Students will be able to appreciate the importance of lasers, fiber optical methods and sensors in all spheres of life i.e. various communication requirements, medical, travel etc.
3. Students will learn about optical fibers in detail and will be able to appreciate the current communication system existing globally.
4. They will also gain the knowledge of basic concepts of optical communication and of different types of optical fibers thereby getting enabled to appreciate the huge advantage of such systems.
5. Students will be able to know about various types of fiber optic sensors and their use in the areas of security, safety, medical and space ventures.
6. Finally, students may emerge with an idea for new sensor or a new application of the existing ones.

UNIT - I

Laser theory, Light Amplification, threshold condition, Laser Rate Equations-two, three and four level systems, Laser power around threshold, optimum output coupling, Line Broadening Mechanisms–Natural, Collision and Doppler.

UNIT - II

Some lasers systems: Ruby laser, Neodymium based lasers, He-Ne laser, excimer laser. Principle, construction and working. Spatial coherence, temporal coherence, Application of lasers. Quasi monochromatic light.

UNIT - III

Gaussian beam, Beam waist, Rayleigh range, confocal parameter, Gaussian beam through thin lens. Abbe's theory of imaging, two-lens imaging system, spatial filter to produce a plane wave, diffraction limiting resolution.

UNIT - IV

Luminescence, Direct and indirect band gaps materials, Principle of electroluminescence, LED source materials and emission wavelengths (01 Lectures), Surface emitting and Edge emitting LED structures, Double hetrojunction (DH) LED structure, Emission properties and efficiency of LED, Semiconductor Lasers, Laser Modes, Condition for lasing action.

REFERENCES:

1. David J. Griffiths, “Introduction to Electrodynamics”, Prentice-Hall of India, New Delhi.
2. John David Jackson, “Classical Electrodynamics”,Wiley India.
3. Theory and Problems of Electromagnetics: Joseph A. Edminster, Tata McGraw Hill.
4. E.M. Purcell, “Electricity and Magnetism”, Berkeley Physics Course , Vol II, McGrawHill.
5. J. R. Reitz, F. J. Milford and R. W. Christy, “Foundations of Electromagnetic Theory” Pearson.
6. J. V. Narlikar, “An Introduction to Relativity”, Cambridge Univ. Press.
7. Ray D’Inverno, “Introducing Einstein’s Relativity”Clarendon Press, Oxford.
8. G. Lehner, “Electromagnetic Field Theory for Engineers and Physicists”Springer.
9. A. Zangwill, “Modern Electrodynamics”,Cambridge University Press.

Additional Readings:

1. Fiber Optics and Optoelectronics, R. P. Khare, OXFORD University Press.
2. Fiber-Optic Communication Systems, Govind P. Agrawal, Wiley India (P) Ltd.
3. Optical Fiber Communications, John M. Senior, Pearson Education Limited.
4. Fiber-Optic Communication Systems, R. K. Singh, Wiley India Pvt. Ltd.
5. Fiber-Optic Communication Systems and Components, Vivekanand Mishra and Sunita P. Ugale, Wiley India Pvt. Ltd.
6. Optical fiber Communication Systems, R.K. Shukla, MKSES Publication.
7. Textbook on Optical Fiber Communication and its Applications, S. C. Gupta, PHI Learning Private Limited.
8. Photonics An Introduction, P. R. Sasi Kumar, PHI Learning Private Limited
9. Optoelectronics: Fundamentals and Applications, R.K. Shukla, Aryabhat Publication House

B.Sc. Semester VII Credits 04

P14 - PHY701 - Classical & Statistical Mechanics

Course Outcome:

Students will be able to

1. Understand the concepts of generalized coordinates and D'Alembert's principle.
2. Understand the Lagrangian dynamics and the importance of cyclic coordinates.
3. Comprehend the difference between Lagrangian and Hamiltonian dynamics.
4. Recognize the difference between macro-state and microstate.
5. Comprehend the concept of ensembles and partition function.
6. Applications of Bose-Einstein and Fermi-Dirac distribution laws.
7. Understand the White Dwarf Stars, Chandrasekhar Mass Limit.

UNIT - I

Mechanics of a system of particles, Constraints, Classification of Constraints, Generalized Co-ordinates, Generalized momenta, Cyclic Co-ordinates, Virtual displacement and principle of virtual work, D'Alembert Principle, Lagrange's Equation.

Calculus of variation- Euler- Lagrange Equation, Application of Variational Principle, Variation under constraints-Lagrange's multipliers, Principle of least action, Hamilton's principle, Hamilton's equations and its applications.

UNIT - II

Canonical Transformation, Generating function, Infinitesimal canonical transformation, Conditions for canonical transformation and problems, Poisson Brackets and their properties, Invariance of Poisson Bracket under canonical transformation, Hamilton-Jacobi Equations, Action and Angle Variables.

The Rigid body motion- Euler Angles, Euler's Equation of motion, Motion of heavy symmetrical Top, Theory of small oscillations- Free vibration of a linear tri-atomic molecule, Transition from a discrete to a continuous system.

UNIT - III

Macrostates and Microstates, Phase Space and Quantum states, Ludwig Boltzmann relation and Entropy, Condition for statistical equilibrium, Postulate of equal a prior probability, Ergodic hypothesis, chemical potential, Ensembles, Partition Function, Partition function for microcanonical, canonical and grand canonical ensembles. Partition function for Magnetic substance. Thermodynamic Functions of an Ideal monoatomic gas by Partition function, Gibbs Paradox, Sackur-Tetrode equation.

UNIT - IV

Maxwell-Boltzmann distribution law, Bose-Einstein Distribution law, Density of states for relativistic and non-relativistic particles, Degeneracy of Boson gas, Derivation of energy, pressure and specific heat of Boson gas. Bose-Einstein condensation, Properties of liquid Helium II, Laszlo Tisza two-fluid model.

Fermi-Dirac Distribution Law, Degeneracy of Fermi gas, Energy and pressure of Fermi gas at absolute zero, Fermi energy, Fermi temperature, Heat capacity of electron gas, White Dwarf Stars, Chandrasekhar Mass Limit.

REFERENCES:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017
4. R.K. Patharia, Paul D. Beale, "Statistical Mechanics", Elsevier Ltd.
5. Keith Stowe, "An Introduction to Thermodynamics and Statistical Mechanics, Second Edition, Cambridge University Press.
6. Richard Fitzpatrick, " Thermodynamics and Statistical Mechanics".
7. Sanchez and Bowley, "Introductory Statistical Mechanics", Oxford; 2nd
8. F. Reif, "Fundamentals of Statistical and Thermal Physics" McGraw-Hill, New York NY, 1965.
9. S.C. Garg, R.M. Bansal & C.K. Ghosh, "Thermal Physics" Tata McGraw-Hill Education.

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

B.Sc. Semester VII Credits 04
P15 - PHY702 – Electromagnetic Theory and Electrodynamics

Course Outcomes:
After attending this course, students would be able to apply knowledge of mathematics and physics in understanding the coupled nature of electromagnetic fields.

1. Students will gain a deep understanding of how mathematics and physics intertwine to explain electromagnetic fields, utilizing various coordinate systems and vector calculus.

2. They will be adept at explaining the core laws that govern electromagnetic fields, such as Gauss's Law and Faraday's Law, and will be able to calculate field intensity and flux density across different media.

3. The course provides insight into Maxwell's equations, highlighting that they are field equations that, unlike gravity, do not include the motion of charged particles. Students will explore the distinctions between real and gauge-invariant quantities.

4. Students will learn about the propagation of electromagnetic waves in various media, their role in energy and information transfer, and their application in communication through waveguides.

5. There will be an exploration of the impact of electrodynamics on special relativity, understanding Poincare and Lorentz transformations, and applying tensor calculus to these concepts.

Finally, students will explore the nature of radiation from accelerated charges and its interaction with matter, enabling them to understand and explore applications in radiative scattering, particularly in high-energy particle colliders.

UNIT- I

Maxwell's Equations in vacuum and matter, Maxwell's correction to Ampere's law for non-steady currents and concept of Displacement current, Boundary conditions for electromagnetic fields, Poynting's theorem, Conservation of energy and momentum for a system of charged particles and electromagnetic field. Vector and scalar potentials, Maxwell's Equations in terms of Electromagnetic Potentials, Electromagnetic wave equation, Non-uniqueness of Electromagnetic Potentials and Concept of Gauge. Gauge Transformations: Coulomb and Lorenz Gauge.

UNIT- II

Propagation of Electromagnetic Plane Waves in Vacuum and Plasma, Reflection and Refraction of Electromagnetic Waves, Fresnel Formulae, Frequency Dispersion Characteristics of Dielectrics and Conductors; Normal and Anomalous Dispersion, Kramer Kronig Relations. Basic concept of waveguide, Propagation of Electromagnetic Waves in Rectangular and Waveguides, TE and TM Modes, Cavity resonator, Radiation due to electric and magnetic dipoles.

UNIT- III

Light cone and Matrix representation of Lorentz transformations, Spacelike, time like and light like Four-vectors, orthogonality, Four-tensors, Contravariant and Covariant tensors, Trace of a tensor, Contraction, Symmetric and Antisymmetric tensors, Metric tensor, Pseudo tensors, completely antisymmetric unit tensor of rank four, four velocity, four-momentum, four-acceleration, Minkowski force. Covariant form of continuity equation, Covariant formulation of Maxwell's field equations with gauge invariance, Lorentz force equation in covariant form, Canonical approach to electrodynamics, Lagrangian and Hamiltonian formulation for a relativistic charged particle in external electromagnetic field, Canonical and Symmetric Stress Tensors, Solution of the wave equation in covariant form.

UNIT- IV

Retarded and advanced potentials, Lienard-Wiechert potentials for a moving point charge, Fields produced by a charge in uniform and accelerated motion, Radiation from an accelerated charge, Radiated power, Larmor's formula and its relativistic generalization, Thomson scattering of radiation, Rayleigh Scattering, Resonance fluorescence. Radiation damping, Radiative reaction force and its derivation, Abraham-Lorentz model, Integro-differential equation of motion, Pre-acceleration. Line breadth and Level shift of an oscillator.

REFERENCES:

1. Introduction to Electrodynamics: David J. Griffiths (Prentice-Hall of India, New Delhi).
2. Classical Electrodynamics: John David Jackson (Wiley India).
3. Theory and Problems of Electromagnetics: Joseph A. Edminster (Tata Mc Graw Hill).
4. Electricity and Magnetism: E.M. Purcell (Berkeley Physics Course , Vol II, Mc GrawHill).
5. Foundations of Electromagnetic Theory: J. R. Reitz, F. J. Milford and R. W. Christy

B. Sc. Semester VII Credits 04
P16 - PHY 703 - Quantum Mechanics I

Course Outcomes:

1. Students will learn the basic concepts of Quantum mechanics which applies to all the physical systems irrespective of their size and can be beautifully perceived at atomic and subatomic level.
2. Students will be able to understand the various operators used to represent dynamic variables.
3. The eigen values and eigen functions of linear harmonic oscillator and Hydrogen atom will help students to understand the behaviour of microscopic systems.
4. The students shall have a good exposure to the approximation methods**.**

UNIT- I

Journey from Classical to Quantum Mechanics, Concept of normalized and orthogonal wave functions, expectation value of a dynamic variable, Equation of continuity, Coordinate and momentum representation, Schrodinger equation in momentum representation, Uncertainty Principle and its applications, Schwarz inequality and Uncertainty Relation. Hilbert space, Introduction to Dirac's bra-ket notation.

UNIT- II

Operator formulations, Hermitian operators and their spectrum, Projection operator, Parity operator, Commuting operators, Eigen values and eigen functions of Linear harmonic oscillator by Schrodinger equation and by operator method. Motion in a central field, Schrodinger Equation in spherical coordinates, Hydrogen atom problem, Eigen values and eigen functions of angular momentum operators L^2 and Lz, Sphericalharmonics.

UNIT- III

Linear vector spaces and transformations, Special Matrices, Transformation and Diagonalization of matrices. Matrix Formulation, Equations of motion: Schrödinger, Heisenberg and Interaction pictures. Quantization of Classical system, motion of a particle in electromagnetic field, Matrix theory of Harmonic oscillator.

UNIT- IV

Approximation Methods for Stationary Systems: Time-independent perturbation theory - (a)non- degenerate and (b) degenerate, Variational Method; WKB method and its applications. Time Dependent Perturbation theory, Transition to a continuum of final states-Fermi Golden

Rule, Applications, Semi-Classical theory of radiation.

REFERENCES:

1. B.H. Bransden& C.J. Joachain, "Quantum Mechanics", Pearson,2000.
2. NouredineZettili, "Quantum Mechanics: Concepts and Applications" Wiley,2016.
3. David J Griffiths, "Introduction to Quantum Mechanics" Pearson,2015.
4. Ajoy Ghatak, "Quantum Mechanics -Theory and Applications" Trinity, 2015.
5. R. Shankar, "Principles of Quantum Mechanics"3rd Ed., Springer,2008.
6. J.J. Sakurai, "Modern Quantum Mechanics" Addison-Wesley,1993.
7. Eugen Merzbacher, "Quantum Mechanics"3rd Ed., Wiley,1997.

DIGITAL RESOURCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx
   SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

B.Sc. Semester VII Credits 04
P17 - PHY704 - Adv Physics Lab

Course Outcomes: At the end of this laboratory course, each and every student is expected to understand the basic concepts of Optics and Electronics through experiments. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

Students have to perform a total of eight experiments from the following list:

List of Experiments:

01. Michelson Interferometer
02. Etalon
03. Edser Butler
04. Polarization
05. Babinet Compensator
06. To determine the wavelength of mercury spectral lines with the help of reflection grating.
07. Hall Effect
08. E.S.R.
09. Four Probe
10. Forbidden Energy Gap
11. Gm Counter
12. β-Energy
13. Klystron

REFERENCES:

1. Advanced Practical Physics for Students: B.L. Worsnop & H.T. Flint
2. Fundamentals of Optics: Francis Jenkins, Harvey White
3. Geometrical and Physical Optics: RS Longhurst
4. Principles of Optics: Born and Wolf
5. Electronic Devices and Circuit Theory: Robert L. Boylestad
6. Integrated electronics: Millman and Halkias
7. Solid State Physics: Streetman
8. Electronic Principles: Albert Malvino and David bates (Eighth edition)
9. Electronic Communication systems: Kennedy

B.Sc. Semester VII Credits 04
P18 - PHY 705 -Atomic and Molecular Physics

Course Outcomes:

1. After completion of the course students will be able to understand the spectra produced by one and two valence electron systems, intensity of spectral lines and effect of magnetic field on one electron systems as well as origin of hyperfine structure.
2. Students will acquire knowledge of rotational, vibrational and electronic spectra of molecules in addition to acquaintance with the principle of electron spin and nuclear magnetic resonance, nuclear quadrupole spectroscopy and their applications.
3. They will also learn the Laser principle, basic Lasers and its applications.

UNIT - I

Introduction to Quantum theory, Spin-Orbit interaction energy, Doublet separation, Spectroscopic Description of Atomic Electronic States–Term Symbols, Intensity rules for fine structure doublet, Fine structure of Hydrogen lines. Optical spectra of alkali metals, Non penetrating and penetrating orbits, Rydberg-Schruster law, Runge's Law, The Ritz Combination Principle, Optical spectra of alkaline earth elements, Singlet and triplet terms.

UNIT - II

Coupling scheme for two electron systems– non-equivalent and equivalent electron cases, Hund's rule, Lande's interval rule. Normal and Anomalous Zeeman Effect, Paschen-Back effect of one electron system. Hyperfine structure, Isotope effect in atomic spectra, distinction between isotope effect and hyperfine structure, Normal and inverted terms, Applications of Hyperfine structure, Lamb Rutherford Shift.

UNIT - III

Microwave Spectroscopy – Rotational spectra, Diatomic and polyatomic molecules, Infrared Spectroscopy – Vibrating diatomic molecule, the diatomic vibrating rotator, Rotation- Vibration spectra of diatomic molecules, Raman Spectroscopy- Pure rotational Raman spectra, Vibrational Raman spectra, Structural determination from Raman Spectroscopy, Selection rules, P.Q and R branches, Isotopic shift.

UNIT - IV

Electronic Spectra of Diatomic molecules -Breakdown of Born Oppenheimer Approximation, Intensity of Vibrational -Electronic Spectra-The Franck Condon Principle, Dissociation energy and Dissociation Products, Rotational Fine Structure of Electronic-Vibration transitions, The Fortrat diagram, Predissociation, Effect of anharmonicity, Coriolis force.

Coherence-spatial and temporal, He-Ne gas laser, ruby laser, Raman spectroscopy, uses of lasers in Raman spectroscopy, Principle of Electron Spin Resonance (E.S.R), Nuclear Magnetic

Resonance (N.M.R), and Nuclear Quadrupole Resonance (N.Q.R.) spectroscopy and their applications.

REFERENCES:

1. H.E. White,“Introduction to Atomic Spectra”, McGraw Hill,1934.
2. Gerhard Herzberg,“Atomic Spectra and Atomic Structure”, Dover Publications, 2010.
3. C.N. Banwell and E.M. McCash, “Fundamentals of molecular spectroscopy” Tata McGraw Hill 2007.

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx

B.Sc. Semester VII Credits 04
P18 - PHY 706 - Frontiers of Physics

Course Outcomes:
At the end of the course the student will be able to appreciate Physics at a fundamental science and to understand the working of the world around us.

UNIT- I

Space and Time, Einstein's Special and General Relativity, Unified reality, Does time flow?, Strings and all that, The elegant universe, Black holes, Dark matter.

UNIT- II

Basics of Nanotechnology, Application in medicine, Nano-therapy for combating cancer, What is green nanotechnology? Multi-dimensional impact of nanotechnology on health, nanotechnology in warfare, nano art, nano electronics, nano bots.

UNIT- III

The quantum world, Basic idea of probability, concept of continuous and discrete, quantum healing, quantum computation, quantum biology, QUBITS the new buzzword.

UNIT- IV

The Physics of climate change, structure of the atmosphere, composition of the earth's atmosphere, the ozone problem, greenhouse gases, carbon footprints and how to minimize them, factors controlling climate.

B.Sc. Semester VII Credits 04
P18 - PHY707 - Materials Science and Nanotechnology

Course Outcomes:

Upon completion of this course students will be able to

1. Develop the basic concept of materials science and acquire an understanding of various characterization techniques and potential applications of Nanomaterials as well.
2. Understand about the structure of materials and classification of nanostructures and effects of quantum confinement on the electronic structure of nanomaterials.
3. Comprehend the behaviour of nanostructures in quantum mechanical approach.
4. Identify the different ways of nanomaterials synthesis and their characterization techniques.
5. Gain knowledge of basic theories of thin films, their deposition techniques and applications.

UNIT I

Introduction and structure of materials and study of properties of materials, Structure of atoms - Quantum states-Atomic bonding in solids-binding energy interatomic spacing - variation in bonding characteristics - Single crystals –polycrystalline - Non crystalline solids - Imperfection in solids – Schmid´s law- Surface imperfection - grain size distribution

UNIT II

Film deposition techniques: Physical method of film deposition, Sputter deposition of thin films and coatings by RF, MF, DC, Magnetron, Pulsed laser, Ion beam, Ion implantation; Chemical method of film deposition electroplating, electroless plating, electro polishing, electroforming, chemical vapour deposition (CVD) and plasma enhanced CVD; Other techniques Langmuir Blodgett, Spin coating Inter diffusion, reactions and transformations in thin films.

UNIT III

Applications of coatings as finishes for various substrates: UV resistant, Atomic oxygen resistant and antistatic coating; Optical coatings for thermal control application- thermal barrier and thermal protective coating; Self-healing coating, Testing and evaluation of coatings

UNIT IV

Introduction to Nanomaterials and properties Brief history and overview of nanomaterials; Synthesis techniques: Top down and Bottom up approaches (High energy ball milling, Sol-gel process, Chemical bath deposition, Plasma Arc discharge, Chemical vapor deposition, Sputtering, Pulsed Laser deposition, Molecular beam epitaxy). Characterization tools of Nanomaterials .

Carbon based Nanomaterials Nature of carbon bond, Carbon structures, Small carbon clusters; Introduction to Synthesis and Applications of Fullerenes, Graphene and Carbon nanotubes.

REFERENCES:

1. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley & Sons, 2007.
2. C. Kittel, In troduction to Solid State Physics, Wiley Eastern Ltd, 2005.
3. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall, 2006.
4. K. L. Chopra, Thin Film Phenomena, McGraw Hill, 1979.
5. M. H. Francombe, S. M. Rossnagel, A. Ulman, Frontiers of Thin Film Technology, Vol. 28, Academic press, 2001.
6. R.F. Bunshah, Deposition Technologies for Films and Coatings, Noyes Publications, New Jersey, 1982.
7. F. A. Lowenheim, Electroplating, McGraw Hill, New York, 1978.
8. Introduction to Nanotechnology by C.P. Poole Jr. and F.J. Oweus, Wiley Interscience.
9. Nano-Technology by Gregory Timp (Editior), AIP Press, Springer
10. Pradeep T., A Textbook of Nanoscience and Nanotechnology, Tata McGraw Hill Education Pvt. Ltd.
11. Hari Singh Nalwa, Nanostructured Materials and Nanotechnology, Academic Press.
12. Graphene: Synthesis and applications, edited by Wonbong Choi and Jowon Lee.

B.Sc. Semester VIII Credits 04
P19 - PHY801 - Research Methodology

Course Outcomes:

A course on research methodology typically aims to equip students with the essential skills and knowledge required to conduct rigorous and systematic research. The course outcomes often include:

1. Essential research skills development
2. Understanding of key research concepts
3. Proficiency in research design
4. Skills in data collection and analysis
5. Critical evaluation of research findings
6. Adherence to ethical research standards
7. Enhancement of effective communication skills
8. Practical application of research knowledge

UNIT I

Introduction to Research Methodology: Objectives, motivation, different types of research, significance, approaches, perception of research , criteria of good research, characteristics of good hypothesis, History of research, Ancient and modern Indian research methodologies.

UNIT II

Techniques of Research: Literature search and review, defining research topic, plan of work (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, field data collection, safety in the field.

UNIT III

Data Analysis for Scientific Research: Data collection, Data Processing, data Modelling, Elements of Data Analysis, Error Analysis, Tools for Data analyses and its significance, various software tools for statistical analysis, errors in the measurements.

UNIT IV

Research Publications: Research paper writing, abstract, project report, making a presentation, writing a research proposal, and intellectual property rights, academic integrity and antiplagiarism.

B.Sc. Semester VIII Credits 04
P20 - PHY 802 - Term Paper

Major Project
PHY803 - Credits 12

Course Outcomes:

Through a supervised project, a student will get exposure to one of the areas of research, preferably of his own choice. During the project, the student will learn about the literature survey, identification of the research problem and then work on the problem during the project duration. The student will get the feel and methodology of the research work and rigorously do focused work in the area of the topic of the major research project chosen. The endeavour will be to prepare the student research-ready in the fourth year of graduation, as the student will have the opportunity to directly enter into the Ph. D. programme immediately after the B.Sc. degree with research. The student will learn to focus and complete desired task within a specified time frame.

4 Y ears B.Sc. Programme
Physics Syllabus (Minor, Subject -3)
Department of Physics, University of Lucknow
Lucknow
The Programme Structure

Year	Semester	Paper Title	Credits
First Year	I	Q-1 PHYM 103 Mechanics and Optics	2
	II	Q-2 PHYM 203 Introduction to Electricity and Magnetism	2
Second Year	III	Q-3 PHYM 303 Thermodynamics and Quantum Physics	2
	IV	Q-4 PHYM 403 Electronics	2

B.Sc. Semester I   Credits 02

Q1 PHYM 103: Mechanics and Optics

Course outcomes:

1. The students able to understand the differences between inertial and non-inertial frames and see how pseudo-forces arise in non-inertial frames.
2. They would be able to understand and calculate various macroscopic elastic properties as the response of the widely used materials through the application of simple classical laws.
3. The student will get an introduction to the discipline of optics and its role in daily life. They will get a basic knowledge of interference, diffraction and polarization. Students will be able to analyze and calculate interference and diffraction between light waves and application of the theory to various interferometers and gratings along with their practical applications.
4. The student would know the polarization of light.

UNIT – I

Galilean transformations of space and time and their relation to Newton's laws of motion. Difference between Inertial and non-inertial frames. Conservative and non-conservative forces, Conservation laws for energy and linear momentum. Pseudo-forces in rotating frame. Coriolis force. Angular momentum, Torque, Conservation of angular momentum. Moment of inertia for simple bodies.

UNIT – II

Elasticity, Relations between elastic constants. Differential equation of simple harmonic motion and its solution. Damped and Forced harmonic oscillations, Sharpness of Resonance. Quality factor.

UNIT – III

Superposition of light waves; Coherence, Spatial and temporal coherence; Interference, Division of Wavefront, Division of amplitude. Fresnel Diffraction - diffraction at a straight edge and narrow wire; Fraunhofer Diffraction; Diffraction grating, Resolving power; Rayleigh's criterion of resolution

UNIT – IV

Electromagnetic nature of light; Polarization: polarization by reflection, polarizing angle, Brewster's law. Specific Rotation.

REFERENCES:

1. Halliday, Resnick and Walker, "Principles of Physics", (Wiley) 2018, 10e.
2. Frank S. Crawford, Jr, "Waves": Berkeley Physics Course Vol 3", McGraw Hill, 2017.
3. D.S. Mathur, "Mechanics", S. Chand Publishing, 1981, 3e.
4. R.K. Shukla and Anchal Srivastava, "Mechanics" Published by: New Age International (P) Limited Publishers.
5. F.A. Jenkins and H.E. White, Fundamentals of Optics, Tata McGraw Hill.
6. Brij Lal and N. Subrahmaniyam, Optics, S. Chand.
7. E. Hecht, Optics, Pearson.
8. A.K. Ghatak, Optics, Tata Mc Graw Hill.
9. Introduction to Optics, Anchal Srivastava, R.K. Shukla, T.P. Pandya, New Age International (P) Ltd. ISBN 9788122430813.

B.Sc. Semester II Credits 02

Q2 PHYM 203: Introduction to Electricity and Magnetism

Course outcomes:

Course outcomes:

1. The course on Electricity and Magnetism at the undergraduate level typically provides students with a comprehensive understanding of the fundamental principles governing the behavior of electric and magnetic fields.
2. Enhance the problem-solving skills by applying theoretical knowledge to real-world scenarios, fostering critical thinking and analytical abilities. students should be well-prepared to tackle more advanced coursework in electromagnetism and related fields and may apply their knowledge to various technical and scientific endeavors.

UNIT - I

Electrostatics: Coulombs Law. Electric field (E). Electric flux, Gauss's law, Divergence and curl of Electrostatic field, The line integral of Electric field, Electric potential (V), Electric field as negative of the gradient of electric potential (E = - GradV), conservative nature of Electrostatic field, Electrostatic Energy of a configuration of charges. Electric fields in Matter: Polarization, Polarization vector (P), Bound charges, Electric displacement vector (D), Electric Susceptibility, and Dielectric constant. Relation between E, P, and D.

UNIT - II

Magnetostatics: Magnetic effect of currents, Magnetic field (B), Biot-Savart's Law, Ampere's Circuital law and its applications, Divergence and Curl of magnetic field. Scalar and Vector magnetic potential. Magnetic Properties of Matter: Magnetization vector (M), Magnetic Intensity(H), Magnetic Susceptibility and permeability. Relation between B, M, and H. Types of Magnetic Materials.

UNIT - III

Time-Varying Electromagnetic Fields: Faradays laws of Electromagnetic Induction and Lenz law. Self and Mutual Induction (applications included).

UNIT - IV

Electromagnetic Waves: Maxwell's equations and their physical significance, Electromagnetic waves in vacuum, Transverse nature of Electromagnetic waves,

REFERENCES:

1. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, (2017), 2e.

2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, “The Feynman Lectures on Physics - Vol. 2”, Pearson Education Limited, (2012).
3. David J. Griffiths, “Introduction to Electrodynamics” 4th Edition, (Cambridge Univ. Press 2020)
4. W.K.H Panofsky and M. Philips, “Classical Electricity and Magnetism”(Dover Books on Physics, 2012).
5. Arthur F. Kip, “Fundamentals of Electricity and Magnetism”, (McGraw-Hill, 1968)
6. J.H. Fewkes& John Yarwood, “Electricity and Magnetism”, Vol. I (Oxford Univ. Press, 1991).
7. B B Laud, “Electromagnetics”, New Age International (P) Limited.
8. D.C. Tayal, “Electricity and Magnetism”, Himalaya Publishing House Pvt. Ltd., 2019, 4e
9. N. Wadhwani, “Electricity and magnetism”, PHI Learning, ISBN: 9788120339651, 9788120339651
10. R.K. Shukla, “Introduction to Electricity & Magnetism”, HP Hamilton Limited.

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

B.Sc. Semester III Credits 02

Q3 PHYM 303: Thermodynamics and Quantum Physics

Course outcomes :

1. The students will understand the fundamental principles of thermodynamics, including the first and
second laws. They would learn the idea of entropy and associated theorems.
2. It will help students understand the preliminary concepts of Quantum Physics. It will make students
understand the development of quantum mechanics as a continuity of classical concepts and also as a
leap jump from classical to quantum world of Physics.
3. A study of the Heisenberg's Uncertainty principle and its applications will make students grasp the
most modern concept of wave particle duality as to how a wave could behave like a particle and vice-versa.

UNIT - I

Thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot 's cycle & theorem.
Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions.

UNIT - II

Real Gases: Deviations from the Ideal Gas Equation, Behaviour of Real Gases, The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Free Adiabatic Expansion of a Perfect Gas.

UNIT - III

Origin of Quantum mechanics-The Black Body Radiation, Spectral Distribution of Black Body Radiation, Rayleigh Jeans Law, Wien's Displacement Law, Planck's Radiation Law, Photoelectric Effect, Compton effect, de Broglie waves, Interpretation of wave function, Probability Current density, de Broglie Wave Velocity, Complementary principle, Principle of Superposition, Wave and Group velocity, Heisenberg's Uncertainty principle.

UNIT - IV

Time dependent and time independent Schrödinger wave equation: Eigenvalues and Eigen Functions, Expectation Value, Expectation Values of Energy and Momentum Operators, Ehrenfest theorem.

REFERENCES:

1. S. Garg, R. Bansal and C. Ghosh,“Thermal Physics” McGraw Hill Education 1993.
2. MeghnadSaha, and B.N. Srivastava, “A Treatise on Heat”Indian Press 1969.
3. Enrico Fermi , ”Thermodynamics” Dover Publications, 2013.
4. M.W. Zemansky and R. Dittman, “Heat and Thermodynamics” McGraw- Hill College 1996.

5. F.W. Sears & G.L. Salinger, “Thermodynamics, Kinetic theory & Statistical thermodynamics”
Pearson 1975.
6. Arthur Beiser, “Concepts of Modern Physics”, McGraw-Hill, 2009.
7. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, “Modern Physics”,PHI Learning2009.
8. Thomas A. Moore, “Six Ideas that Shaped Physics: Particles Behave like Waves” McGraw Hill, 2009.
9. R.A. Serway, C.J. Moses, and C.A. Moyer “Modern Physics” Third Edition, 2005, Cengage Learning.
10. P.M. Mathews & K. Venkatesan, “A Text book of Quantum Mechanics”, 2nd Ed., 2010, McGraw Hill.
11. AjoyGhatak, S. Lokanathan, “Quantum Mechanics: Theory and Applications”, Macmillan Publishers India Limited.
12. R.M. Eisberg, “Fundamentals of Modern Physics” Wiley, New York.
13. H.E. White, “Introduction to Atomic Spectra” ,McGraw-Hill, New York.

B.Sc. Semester IV Credits 02
Q4 PHYM 403: Electronics

Course Outcomes:
The learning of this paper on electronics will enhance the understanding of the following:
1. Utility of basic circuits.
2. Fundamental skills to understand the basic of semiconductor devices and their applications.
3. Gaining the knowledge about Feedback circuits
4. Applications of various electronic instruments.

UNIT I

Circuit fundamentals: Growth and decay of currents in LR circuit., Charging and discharging of capacitor in RC and LCR circuits.

UNIT II

Diodes: Qualitative idea of Fermi level, formation of depletion layer in PN junction diode, barrier width, current conduction in PN junction diode and its characteristics.

UNIT III

Bipolar transistors: PNP and NPN transistors. Study of CB, CE and CC configurations; active, cutoff and saturation regions, current gains and relations between them. Applications of transistor. Amplifiers : single stage and multistage transistor amplifier.

UNIT IV

Feedback Circuits: Effects of positive and negative feedback, Barkhausen criterion for self sustained
Oscillations Electronic Instruments :Multimeter: linear and digital multimeters, measurement of dc voltage, dc current, ac voltage, ac current and resistance. Cathode Ray Oscilloscope.

REFERENCES:
1. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”,Prentice-Hall of India Pvt. Ltd.
2. J. Millman, C.C. Halkias, SatyabrataJit, “Electronic Devices and Circuits”,McGraw Hill
3. B. L. Theraja, “ Basic Electronics ”, S. Chand, Lucknow
4. S.L. Gupta, V. Kumar, “Handbook of Electronics”, PragatiPrakashan,Meerut,
5. K. C. Lal and S. I. Ahmad, Electronics, S. Chand , Lucknow

4 Years B.Sc. Programme
Physics Syllabus (Co-Curricular Course/ Vocational Courses)
Department of Physics, University of Lucknow
Lucknow

Co-curricular and Vocational Programme Structure

Year	Semester	Paper Title	Credits
First Year	I	CC-1 PHYCC 104 Effective Science Communication	2
	II	VC-1 PHYVC 204 Materials and Devices-I PHYVC 205 Solar Photovoltaic Technology	2
Second Year	III	CC-2 PHYCC 304 Indian Knowledge System- Development of Calculus	2
	IV	VC-2 PHYVC 404 Materials and Devices-II PHYVC 405 Nuclear Radiations and Detectors PHYVC 406 Solar Thermal Energy Conversion	2
Third Year	V	Internship/Term Paper/Minor Project in Major A	4

B.Sc. Semester I Credits 02

CC-1 PHYCC 104: Effective Science Communication

Course outcome:

1. Improved ability to communicate scientific findings to the general public effectively.
2. Enhanced skills in public engagement with science to foster greater science literacy.
3. Knowledge of using scientific evidence as a basis for discussing scientific issues, as opposed to relying on personal beliefs or feelings.
4. Understanding of how to develop evidence-based methods for effective science communication.
5. Insight into major theories of human learning relevant to science communication.
6. Awareness of cognitive phenomena such as bias and motivated reasoning that can impede understanding of science.
7. Ability to identify and counteract the factors that contribute to the rapid spread of mis/disinformation.
8. Tools for implementing strategies that can help mitigate the influence of mis/disinformation i in science communication.

Unit I

Introduction to Science Communication, Importance of being a Science Communicator, Informal communication of science, Discussing important scientific phenomenon and issues.

Unit II

Writing Science for the public. Writing science using special techniques- Story telling, painting a Picture etc.

Unit III

Strategies for designing science communication activities that will help mitigate the influence of bias.

Unit IV

Communicating Science to Policymakers, Communicating to the Media. Project Work.

REFERENCES:

1. An introduction to communicating science (researchgate.net)
2. Readings | Science Communication: A Practical Guide.
3. Science, Technology, and Society | MIT Open Course Ware.

B.Sc. Semester II Credits 02

VC-1 PHYVC 204: Materials and Devices-I

Course outcome:

1.Ability to select appropriate optical materials for various applications.
2.Competency in engineering optical materials tailored to specific needs.
3.Skills to fabricate and prepare interference filters.
4.Understanding of the fundamental concepts of LED display technology.
5.Knowledge of the physics underlying the operation of optoelectronic devices.
6.Practical understanding of how various optoelectronic devices function.

Unit -I

Optical materials: types of optical materials, dielectrics. Optical, mechanical and thermal properties of optical materials in visible and IR region,

Unit -II

Polishing and figuring of IR materials, Ge, ZnSe, ITO, graphene. Glass and Chalcogenide, principle of ATR. Use of ray optics and wave optics.

Unit -III

Incandescent and luminescent sources, pn junction: various materials, Semiconductor materials, LED, introduction to OLED. Comparative study. Use of LED and OLED. Merits of LED technology in general lightning due to its energy efficiency.

Unit -IV

Solar energy: Photovoltaic effect, homo and hetero junction effect, I-V characteristics, output change of PV module under partial and complete shading, series and parallel combination of solar cells, solar lamp.

REFERENCES:

1. Handbook of optical materials by Marvin J. Weber, CRC Press.
2. Principle of optics by Born and Wolf
3. Optical Fiber Communications by Gerd Keiser
4. Advancement in materials for energy-saving lighting devices, Front. Chem. Sci. Eng. 6 (1), Pg:13-26, DOI 10.1007/s11705-011-1168-y
5. Emerging Biomedical Applications of Organic Light-Emitting Diodes, Caroline Murawski, and Malte C. Gather, Advance Optical materials, 2100269, (2021) DOI: 10.1002/adom.202100269.B.Sc. Sem III Credits 02

B. Sc. Semester II Credits 02

VC - 1 PHYVC 205: Solar Photovoltaic Technology

Course Objectives and Outcomes:

The course

1. Intends to give the necessary and significant learning regarding solar Photovoltaic conversion systems.
2. Covers the fundamental knowledge about the solar cell and preparation techniques.
3. Provides the modern knowledge and on-field practices of solar PV systems.
4. Presents the manual and computer-based designing methods of kilowatt to megawatt level photovoltaic systems.

UNIT I

Solar cell physics: p-n junction, homo and hetro-junctions, Metal-semiconductor interface; Dark and illumination characteristics.

UNIT II

Figure of merits of solar cell; Variation of efficiency with band-gap and temperature; Spectral response of solar cell; Efficiency limits. Optical properties of solar cell; Different losses and mitigation

UNIT III

Solar Photovoltaic modules: Cell matrix, Lamination and curing, Encapsulation and framing, Testing.

UNIT IV

Electrical and thermal properties, Module and circuit designing, Identical and non- identical modules, Module mismatching, Shading and hot-spot formation, Environmental effect on PV module performance.

Reference Books and Material:

1. Bent Sorensen, Renewable Energy, Academic press, New York.
2. Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, Delhi
3. Tiwari, G N, Green M A, Third Generation Photovoltics: Advanced Solar Energy, Springer.
4. Alan L Fahrenbruch, Richard H Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, New York.
5. Larry D Partain Ed, Solar Cells and Their Applications, John Wiley and Sons, Inc, New York.
6. Richard H Bube, Photovoltaic Materials, Imperial College Press.
7. Rauschenbach H S, Van Nostrand, Solar Cell Array Design Handbook, Reinfold Company, New York.
8. Duffie JA, Beckman WA, Solar Engineering of Thermal Processes, John Wiley.
9. Goswami D Y, Frank Kreith and Kreider, Principles of Solar engineering, Taylor and Francis, USA.

B.Sc. Semester III Credits 02

CC-2 PHYCC 304: Indian Knowledge System-Development of Calculus

Course Outcomes:

1. Recognize the historical development of calculus within the Indian knowledge system.
2. Understand the contributions of Indian mathematicians to the field of calculus.
3. Analyze the mathematical techniques developed in ancient India that prefigured aspects of modern calculus.
4. Evaluate the impact of these developments on both ancient Indian society and the global mathematical community.
5. Apply traditional Indian calculus techniques to solve contemporary mathematical problems.
6. Integrate knowledge of the Indian calculus system into the broader history of mathematics.

Unit I

Development of Calculus: The classical period (c. 500 to 1350 CE); Zero and infinity in Brahmasphut siddhanta, Bhaskaracharya on khahara, multiplication and division by zero. Discussion in terms of related modern day principles.

Unit II

Irrationals and iterative approximation, algorithm for square root in Aryabhatiya, approximating the square root of a non square number. Discussion in terms of related modern day principles.

Unit III

Value of Pi, Circumscribing polygon. Discussion in terms of related modern day principles.

Unit IV

Summation of power of natural numbers; Summation of geometrical series. Discussion in terms of related modern day principles.

REFERENCES:

Development of calculus in India, K. Rama Subramanian, M.D. Srinivas

B.Sc. Semester IV Credits 02

VC-2 PHYVC 404: Materials and Devices-II

Course outcomes:

On the completion of this course students would

1. Know the basics of solid state physics and fiber optics.
2. Learn the principle of optical detection mechanism in different detection devices.
3. Understand transmission in optical fibers.
4. Gain experimental knowledge about various aspects of fibers and optical communication. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

UNIT -I

Historical development of Optical fiber communication, the general system, advantages of optical fiber communication, optical fiber waveguide: ray theory in transmission, phase and group velocity, step index fiber, single mode and multi- mode fibre, cut-off wavelength. Fiber materials.

UNIT – II

Characteristics of optical fiber: attenuation, materials absorption losses, fiber bending losses, fiber alignment and joint loss. Intensity modulated fiber optic sensor (IMFOS).

UNIT-III

Solar radiation, its measurement, solar constant, radiation solar intensity at earth surfaces, solar thermal energy conversion, solar water heater, solar cooker.

UNIT - IV

Lab - study of characteristics of LED,
Study of solar cell
Virtual lab: Bending losses in optical fibers,
Study of noise in optical receivers.

Experiments related to optical fibers, sources and detectors on the following links:

1. https://vlab.amrita.edu/index.php?sub=1&brch=201
2. http://vlabs.iitkgp.ac.in/be/#

TEXTBOOK

1. Keiser, G., Optical Fiber Communications, McGraw-Hill International. (2000).

REFERENCES:

1. Seniors, J.M., Optical Fiber Communications – Principles and Practice, PrenticeHall of India, (1996).
2. Cherin, A.H., An Introduction to Optical Fibers, McGraw Hill Book Company, (1983).
3. Yariv, A., Quantum Electronics, Wiley, (1989).

4. Optical Electronics: A. Ghatak and K. Thyagrajan (Cambridge University Press)
5. Fiber Optics and Optoelectronics: R P Khare: Oxford University Press
6. Optical fiber Communication Systems:R.K. Shukla;MKSES Publication

B.Sc. Semester IV Credits 02

VC-2 PHYVC 405: Nuclear Radiations and Detectors

Course outcomes:

The course outcomes for a course on nuclear radiations and detectors, covering the specified key areas, would likely include:

1. Understanding the fundamental principles of nuclear radiation, including alpha, beta, and gamma rays.
2. Gaining knowledge of the effects of nuclear radiation on different materials and biological systems.
3. Learning the core principles and methods of radiation detection and measurement.
4. Acquiring skills in using various types of radiation detectors and interpreting the data they provide.
5. Exploring the processes involved in electric power generation in nuclear reactors.
6. Applying principles of nuclear science in practical scenarios related to health, safety, and engineering.

Unit I

Basic interaction processes of charged particles and γ-rays with matter: Energy loss of charged particles by atomic collisions, Excitation and Ionization, Bethe-Bloch formula, Elementary idea of production of gamma rays, Basic interaction of γ-rays with matter, photo electric effect, Compton Effect and pair production,

Unit II

Nuclear Detector characteristics and reactors: Basic need of nuclear detectors, General characteristics of nuclear detectors, dead time, risetime, sensitivity, detector response, energy resolutions, detector efficiency, Basic principle of nuclear reactors, Applications of nuclear reactors in medicine, industry, and research

Unit III

Gas filled nuclear detectors: Gamma ray attenuation, Radiation Damage, Basic property of Gas filled detectors, ionization chamber, proportional counter, Geiger Muller counter, pulse formation and its shape, electronic circuit for pulse detection.

Unit IV

Semiconductor detectors: Basic semiconductor properties, energy band structure, intrinsic charge carrier concentration, mobility, doped semiconductors, diffused junction diode, Surface barrier detectors and High purity germanium (HPGe) –gamma detectors.

REFERENCES:

1. Radiation Detection and Measurements: by G. F. Knoll, Wiley (1979), John Wiley & Sons Publication)
2. Techniques for nuclear and particle physics experiments: by S Tavernier (2010),Springer publication
3. Experimental methods in nuclear and particle physics: William R. Leo, (2006) Springer publication
4. Nuclear Reactor Physics and Engineering: John C. Lee, (2020) John Wiley & Sons Publication

B. Sc. Semester IV Credits 02

VC – 2 PHYVC 406: Solar Thermal Energy Conversion

Course Objectives and Outcomes:
The course
1. Intends to give the necessary and significant learning regarding solar energy conversion systems operation and installation.
2. Covers the information about the solar radiation used for solar energy systems.
3. Provides the modern knowledge and on-field practices of solar thermal systems.
4. Presents the designing methods of kilowatt to megawatt level solar thermal energy systems in by in-situ methods.

UNIT I

Solar radiation: its measurement and prediction. The Solar Constant; Radiation solar intensity at earth surface; Direct and diffuse radiation; Solar geometry; Sun-path diagrams.

UNIT II

Available solar radiation: Pyranometers, Pyrheliometric scales, Estimation of solar radiation on horizontal surface; Radiation on sloped surfaces: Isotropic sky model, Anisotropic sky; Solar radiation Data.

UNIT III

Solar thermal energy conversion: Principle of direct and indirect energy conversion; Flat plate collectors: Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat plate collectors: types; Thermal analysis; Thermal drying. Introduction and classification of concentrating collectors.

UNIT IV

Fundamentals, design and applications of Solar still; Solar cooker; Solar dryer; Solar Pond and other solar thermal systems.

REFERENCES

1. Sukhatme S P, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw- Hill.
2. Duffie JA, Beckman WA,   John Wiley.
3. Goswami D Y, Frank Kreith and Kreider,   Taylor and Francis, USA.
4. Garg H P, Prakash S, Solar Energy: Fundamental and Application, Tata McGrow-Hill, New Delhi.
5. Kreith F, Kreider J F, Principles of Solar Engineering,
6. Kreider J F, Kreith F, McGraw-Hill. Solar Engineering of Thermal Processes,
7. Bent Sorensen, Renewable Energy, Academic press, New York.
8. Tiwari, G N, Solar Energy, Fundamentals Design, Modeling and Applications, Narosa, New Delhi.

## B.Sc. Semester V		Credits 04

Internship/Term Paper/Minor Project in Major A