Department of Physics
University of Lucknow

Syllabus for Four Year Undergraduate Programme
As per New Education Policy - 2020

Applicable From Session 2021-22 Onward

Four Year B. Sc. Programme Structure, Department of Physics, University of Lucknow

Semesters	Major 1 @4 credits	Major 2 @4 credits	Minor 1 @4 credits	@4 credits
Semester I	P1 PHY101 P2 PHY102	P1' P2'	P1 PHY101 Mechanics and Wave motion	CC1
Semester II	P3 PHY201 P4 PHY202	P3' P4'	P3 PHY201 Electricity and Magnetism	VC1
Semester III	P5 PHY301 P6 PHY302	P5' P6'	P5 PHY301 Heat and Thermodynamics	CC2
Semester IV	P7 PHY401 P8 PHY402	P7' P8'	P7 PHY401 Electronics	VC2
Semester V	P9 PHY501 P10 PHY502 P11 → P11x PHY503 P11 → P11y PHY504	P9' P10'		Internship / Term Paper
Semester VI	P12 PHY601 P13 PHY602 P14 → P14x PHY603 P14 → P14y PHY604	P11' P12'		Minor Project
Semester VII	P15 PHY701 P16 PHY702 P17 PHY703 P18 → P18x PHY704 P18 → P18y PHY705 P19 → P19x PHY706 P19 → P19y PHY707			Research Methodology
Semester VIII	P20 PHY801 P21 PHY802 **Major Project (16 credits) PHY803**			

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4 Year B.Sc. Programme
Physics Syllabus
Department of Physics, University of Lucknow
The Programme Structure

Year	*Semester*	*Name of the Paper*	*Credits*
First Year	I	P1 PHY101 Mechanics and Wave motion	4
		P2 PHY102 Optics	4
	II	P3 PHY201 Electricity and Magnetism	4
		P4 PHY202 Mechanics/ EM & Optics Lab	4
Second Year	III	P5 PHY301 Heat and Thermodynamics	4
		P6 PHY302 Perspectives of Quantum Physics	4
	IV	P7 PHY401 Electronics	4
		P8 PHY402 Heat and Electronics Lab	4
Third Year	V	P9 PHY501 Solid State Physics	4
		P10 PHY502 Nuclear Physics	4
		P11x PHY503 Lasers and Optoelectronics I	4
		P11y PHY504 The Second Quantum Revolution	4
	VI	P12 PHY601 Advanced Lab	4
		P13 PHY602 Atomic & Molecular Spectroscopy	4
		P14x PHY603 History of Science in India	4
		P14y PHY604 Plasma Physics and Space Science	4
Fourth Year	VII	P15 PHY701 Classical and Statistical Mechanics	4
		P16 PHY702 Mathematical Physics	4
		P17 PHY703 Classical Field Theory of Electrodynamics and General Relativity	4
		P18x PHY704 Lasers and Opto-electronics II	4
		P18y PHY705 Advanced Electronics	4
		P19x PHY706 X-rays	4
		P19y PHY707 Mathematical Methods & Numerical Techniques	4
	VIII	P20 PHY801 Advanced Quantum Mechanics	4
		P21 PHY802 Material Science and Nanotechnology	4
		PHY803 Major Project	16

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 multidisciplinary Bachelor's programme allows the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.

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

Title of the Paper: P1 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, Relations 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 Credit 04

Title of the Paper: P2 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; Etalon

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
Title of the Paper: P3 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.

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 II Credits 04
Title of the Paper: P4 PHY202-Mechanics, Electricity & Magnetism and Optics 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.
4. Online Virtual Lab Experiments are expected to give insight in the simulation techniques, and provide basis for modeling.

Lab Experiment List

Students have to do total of 06 experiments from the following list taking any two experiments from each group.

Students have to do three virtual experiments taking one each from the groups.

(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.

WEB REFERENCES:

Online Virtual Lab Experiment List/Link MECHANICS

MIT Open Learning - Massachusetts Institute of Technology,
https://openlearning.mit.edu/
Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=74

1. Torque and angular acceleration of a fly wheel
2. Torsional oscillations in different liquids
3. Moment of inertia of flywheel
4. Newton's second law of motion
5. Ballistic pendulum
6. Collision balls
7. Projectile motion
8. Elastic and inelastic collision

Online Virtual Lab Experiment List / Link OPTICS

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=189

1. Newton's Rings: Wavelength of light
2. Newton's Rings: Refractive index of liquid
3. Brewster's angle determination
4. Laser beam divergence and spot size

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/index.php?sub=1&brch=281

5. Spectrometer: Refractive index of the material of a prism
6. Spectrometer: Dispersive power of a prism

Online Virtual Lab Experiment List / Link ELECTRICITY AND MAGNETISM

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=192

1. Tangent galvanometer
2. Magnetic field along the axis of a circular coil carrying current
3. Deflection magnetometer
4. Van de Graaff generator
5. Barkhausen effect
6. Temperature coefficient of resistance
7. Anderson's bridge
8. Quincke's method

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

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

Physics B. Sc. Semester III   Credits 04
Title of the Paper: P5 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

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 - 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. 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. JouleThomson Cooling.

UNIT - III

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 - 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

Title of the Paper: P6 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 analyzing 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

Title of the Paper: P7 PHY401 -Electronics

Course Outcomes

The learning of this paper on electronics will enhance the understanding of the

1. Utility of resonant circuits and AC bridges.
2. The basic electronic devices and their applications.
3. Transistor biasing.
4. Concept of frequency response, bandwidth and audio amplifiers.
5. Feedback circuits
6. The importance of amplitude modulation and demodulation
7. Applications of various electronic instruments.

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. Measurements of High resistance by leakage method ,

A C circuits :
Alternating currents in LCR circuit, Method of imaginaries, Complex impedances, Q factor, Series and parallel resonant circuit, Coupled circuits, Impedance matching, Maximum power transfer theorem,
AC Bridges : measurement of inductance (Maxwell's bridge),—and measurement of capacitance (Schering's and Wein's bridge).

UNIT - II

Diodes: 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,

Application of PN junction diodes : Transistor as a switch , Half wave rand Full wave (centre tap and bridge) rectifiers, calculation of ripple factor and rectification efficiency, Clippers and Clampers
Zener Diode : Characteristics and applications of Zener diode, Avalanche and Zener breakdown,
Filter circuits: choke input, capacitor input, L type and pi type filters, voltage regulated power supply.

UNIT - III

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

Transistor Biasing: Faithful amplification and need for biasing. Fixed Bias (Base Resistor Method), Collector to Base Bias (Base Bias with Collector Feedback) Emitter Bias (Fixed Bias with Emitter Resistor) and Voltage Divider Bias, DC Load Line and Q-point stabilization, thermal runaway, Stability Factors,

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

UNIT - IV

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

Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self sustained oscillations, types of oscillator , introduction to sinusoidal and square wave oscillators, tank circuit , qualitative analysis of Hartley oscillator

Basic principle of transmission and reception : principles of amplitude modulation, modulation index, demodulation

Electronic Instruments :

Multimeter: linear and digital multimeters, measurement of dc voltage, dc current, ac voltage, ac current and resistance.

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, applications of CRO

Electronic components: colour codes of resistors and capacitors, identification ans testing of active and passive components

REFERENCES:

1. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
2. W.D. Stanley, "Electronic Devices: Circuits and Applications", Longman Higher Education, 1989
3. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e

4. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e
5. J. Millman, C.C. Halkias, Satyabrata Jit, “Electronic Devices and Circuits”, McGraw Hill, 2015, 4e
6. A. Sudhakar, S.S. Palli, “Circuits and Networks: Analysis and Synthesis”, McGraw Hill, 2015, 5e
7. B. L. Theraja, “ Basic Electronics ”, S. Chand, Lucknow
8. S.L. Gupta, V. Kumar, “Handbook of Electronics”, Pragati Prakashan, Meerut, 2016, 43e

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

Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Equivalent Online Courses

1. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy
2. edX, https://www.edx.org/course/subject/physics
3. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/
4. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics

National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html

B.Sc. Semester IV   Credits 04

Title of the Paper: P8 PHY402-Heat 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 do three experiments from Group A and three experiments from Group B

Students have to do one experiment each from virtual labs of Heat and Thermodynamics, and Electronics

Group A Heat and 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

1. PN Junction/ Zener diode characteristics
2. Half wave & full wave rectifiers and Filter circuits
3. Characteristics of a transistor (PNP / NPN) in CE, CB and CC configurations
4. Unregulated and Regulated power supply
5. Diode as clipper and Clamper
6. Frequency response of RC coupled amplifier
7. Diode as clipper and Clamper
8. Various measurements with Cathode Ray Oscilloscope (CRO)
9. Charging and discharging in RC circuits
10. A.C. Bridges: experiments based on measurement of L and C
11. Resonance in series and parallel RCL circuit

HEAT:

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

1. Heat transfer by radiation
2. Heat transfer by conduction
3. Heat transfer by natural convection
4. The study of phase change
5. Blackbody radiation: Determination of Stefan's constant
6. Newton's law of cooling
7. Lee's disc apparatus
8. Thermo-couple: Seebeck effect

ELECTRONICS:

Virtual Labs an initiative of MHRD Govt. of India
http://vlabs.iitkgp.ernet.in/be/index.html#

1. Familiarisation with resistor
2. Familiarisation with capacitor
3. Familiarisation with inductor
4. Ohm's Law
5. VI characteristics of a diode
6. Half & Full wave rectification
7. Capacitative rectification
8. Zener Diode voltage regulator
9. BJT common emitter characteristics
10. BJT common base characteristics
11. Studies on BJT CE amplifier
12. RC frequency response

http://vlabs.iitkgp.ac.in/psac/#

13. Diode as Clippers
14. Diode as Clampers
15. BJT as switch and Load Lines

http://vlabs.iitkgp.ac.in/be/#

16. RC frequency response

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/index.php?sub=1&brch=201

17. Hartley oscillator
18. Colpitt oscillator

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

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 V Credits 04

Title of the Paper: P9 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, Caesium 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.

Intoduction 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.

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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
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
Title of the Paper: P10 PHY502-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)

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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 V   Credits 04

Title of the Paper: P11x PHY503-Lasers and Optoelectronics I

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, Optical Resonators – Modes of a rectangular cavity and open planar resonator, Modes of a confocal resonator system, General Spherical resonator, Higher order modes.

UNIT - II

Essential criterion to observe non linear optical effects, First experimental demonstration of non-linear phenomena, Classical theory of non-linear response in one dimension, Generalization to three dimensions, General properties of the polarizability tensor – Reality condition, Intrinsic symmetry, general form and frequency dependence, overall symmetry, Second harmonic generation and phase matching techniques, Basic idea of self-focusing.

UNIT - III

Fiber as a guiding medium, Total Internal reflection, Acceptance angle, Numerical aperture, Types of fiber, Refractive index profiles, Concept of modes, Electromagnetic analysis of guided modes in symmetric step index planar wave guide and step index fiber, Concept of Normalized Frequency, V Parameter, Pulse dispersion in step index fibers, Concept of Dispersion shifted and Dispersion flattened Fibers, Fiber attenuation, Misalignment losses, Fiber material, Fiber fabrication, Splices and Connectors.

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, Principle of the operation of photo-detector, Materials for Photo-detectors, Types of photodetectors.

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

B.Sc. Semester V Credits 04

Title of the Paper: P11y PHY504-The Second Quantum Revolution

Course Outcomes:

In the 1970s and 1980s instead of looking at quantum systems purely as phenomena to be explained scientists began looking at these systems that could be designed to accommodate computer science and information theory.
An enormous amount of progress has taken place in the field of quantum information science in the last twenty years. The most remarkable progress has been in the actual implementation of these quantum systems via superconducting circuits or nuclear spins or single photon systems or trapped ions.
It becomes imperative that we develop at least a basic understanding of things to come.
Quantum Computation is the future.
The main outcomes this course aims to achieve are as follows:

1. To understand the main ideas of quantum computation.
2. To develop an understanding of the fundamental concepts of the field.
3. To equip the student with enough technical expertise to may be take up a career in this new, exciting and rich field of research.
4. To introduce some experimental developments pertaining to quantum computers.

UNIT - I

INTRODUCTION AND OVERVIEW
History of Quantum Computation and Quantum Information, Linear Algebra and quantum mechanics, Frequentlyused quantum gates and circuit symbols, Qubits, multiple qubits, single qubit gates, quantum circuits.

UNIT - II

QUBIT COPYING CIRCUITS
Bell states,hidden variables, quantum teleportation, classical computation on a quantum computer.

UNIT - III

ACTUALIZING QUANTUM COMPUTATION
Quantum jumps, quantum measurement in continuous time, entanglement, negativity of quasi-probabilities, contextuality, decoherence, no-cloning, quantum trajectories.

UNIT - IV

A NEW FRAMEWORK

Laser cooling and trapping, nonclassical light sources such as squeezed light and entangled photons , and cavity QED, circuit QED .

REFERENCES:

1. Michael A. Nielsen and Isaac L. Chuang, "Quantum computation and quantum information" Cambridge University Press, reprint 2020.
2. J.J. Sakurai, "Modern quantum mechanics" Pearson Education, 2001.
3. William H. Gotthman, "Digital electronics: An Introduction to Theory and Practice", Prentice-Hall series in Electronic Technology, 2002.
4. Ivan H. Deutsch, "Harnessing the Power of the Second Quantum Revolution" PRX QUANTUM **1,** 020101, 2020.

ADDITIONAL READINGS:

1. R. P. FEYNMAN Simulating physics with computers, *Int. J. Theor. Phys.,* 21:467, 1982.
2. QUANTUM EFFECTS IN THE BRAIN: A REVIEW, Bettony Adams and Francesco Petruccione, arXiv:1910.08423[q-bio-NC]

B.Sc. Semester VI Credits 04

Title of the Paper: P12 PHY601-Advanced 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.

Lab Experiment List

Students will do any six experiments out of the following list and any three virtual experiments:

1. Characteristics of Silicon Controlled Rectifier
2. To observe the characteristics of UJT and to calculate the interbase resistance and Intrinsic Stand-Off Ratio .
3. To study IC amplifier
4. Effect of voltage and current feedback on frequency response of RC coupled amplifier
5. To study the process of amplitude modulation and demodulation
6. To study negative feedback amplifier
7. To study characteristics of FET/ MOSFET
8. To study FET as voltage variable attenuator and its application as voltage controlled attenuator
9. To study frequency response of IC amplifier.
10. To determine wavelength of sodium light/ difference between two lines of sodium / refractive index of mica sheet using Michelson Interferometer.
11. To analyse elliptically polarized light with the help of Babinet compensator.
12. To calibrate a spectrometer by the method of Edser and Butler
13. To determine the wavelength of mercury spectral lines with the help of diffraction grating
14. To determine the wavelength of mercury spectral lines with the help of reflection grating
15. To determine the wavelength of sodium light with the help of

Fresnel biprism.

16. Verification of Fresnel’s Formula

Online Virtual Lab Experiment List / Link Electronics

http://vlabs.iitkgp.ac.in/be/#

7. RC frequency response

Virtual Labs at Amrita Vishwa Vidyapeetham

https://vlab.amrita.edu/index.php?sub=1&brch=201

8. Hartley oscillator
9. Colpitt oscillator

Online Virtual Lab Experiment List / Link Optics

Virtual Labs at Amrita Vishwa Vidyapeetham

https://vlab.amrita.edu/?sub=1&brch=189

1. Michelson's Interferometer: Refractive index of glass plate
2. Michelson's Interferometer: Wavelength of laser beam
3. Newton's Rings: Wavelength of light
4. Newton's Rings: Refractive index of liquid
5. Brewster’s angle determination
6. Laser beam divergence and spot size

Virtual Labs at Amrita Vishwa Vidyapeetham

https://vlab.amrita.edu/index.php?sub=1&brch=281

7. Spectrometer: Refractive index of the material of a prism
8. Spectrometer: Dispersive power of a prism
9. Spectrometer: Determination of Cauchy’s constants

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

WEB REFERENCES:

1. Virtual Labs at Amrita Vishwa Vidyapeetham,https://vlab.amrita.edu/?sub=1&brch=194
2. Virtual Labs an initiative of MHRD Govt. of India,http://vlabs.iitkgp.ac.in/be/#
3. Digital Platforms/Web Links of other virtual labs may be suggested /added to this lists by individual Universities

B.Sc. Semester VI Credits 04
Title of the Paper: P13 PHY602-Atomic and Molecular Spectroscopy

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 VI **Credits 04**

Title of the Paper: P14x 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).
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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**

Title of the Paper: P14y 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 magnetoplasma: 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 VII **Credits 04**

Title of the Paper: P15 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 underconstraints-Lagrange's multipliers,Principle of least action, Hamilton's principle, Hamilton's equations and its applications.

UNIT - II

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

The Rigid body motion- Euler Angles, Euler'sEquation of motion, Motion of heavy symmetrical Top, Theory of small oscillations- Freevibration 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
Title of the Paper: P16 PHY702-Mathematical Physics

Course Outcomes:

1. The primary objective is to teach the students basic mathematical methods that will be used in solving physical problems.
2. Students will learn the required mathematical techniques which will be useful in many other courses in higher education.
3. The emphasis will be to teach Mathematical Physics as a tool to create and develop new knowledge.
4. Understanding the mathematical Physics will enable students to solve advanced problems in various fields of Physics.

UNIT - I

Vector Calculus: Vector differentiation :- Scalar and vector fields, space curves, unit tangent vector and unit normal vector (without Frenet-Serret formulae), directional and normal derivative, gradient of a scalar field, divergence and curl of a vector field, vector identities.

Vector Integration: Line, surface and volume integrals, flux of a vector field , Gauss's divergence theorem, Green's theorem and Stoke's theorem.

UNIT - II

Matrices: Addition and multiplication of matrices, transpose of a matrix, conjugate of a matrix, Symmetric and skew-symmetric matrices, Hermitian, orthogonal and unitary matrices, inverse of a matrix, similarity transformations, trace of a matrix, eigenvalue problems, Cayley-Hamilton theorem and diagonalization of matrices (non-degenerate and degenerate cases)

UNIT - III

Tensor Analysis: Algebra of tensors, Cartesian, covariant and contravariant tensors, contractions and direct products, pseudo, dual, isotropic, symmetric and anti-symmetric tensors. Tensorial character of physical quantities, moment of inertia tensor, stress and strain tensors, elasticity tensor, generalized Hooke's law.

UNIT - IV

Theory of Probability and Statistics: Random variables, binomial, Poisson and normal distributions, central limit theorem, hypothesis testing and data analysis in statistics.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics"

2. Louis A. Pipes & Lawrence R Harvill,"Applied Mathematics for Engineer & Physicists"
3. Arfken and Weber, "Mathematical Methods for Physicists"
4. V. Balakrishnan, "Mathematical Physics"
5. B.D. Gupta, "Mathematical Physics"
6. B.S. Rajput, "Mathematical Physics"
7. H.K. Dass&RamaVerma, "Mathematical Physics"
8. A.W. Joshi, "Matrices and tensors in Physics"

B.Sc. Semester VII Credits 04

Title of the Paper: P17 PHY703-Classical Field Theory of Electrodynamics and General Relativity

Course Outcomes:

1. The primary focus of this course lies at the stimulating understanding of classical field theories and their applications in the modern research.
2. The students will learn to design and use the mathematical apparatus for building Lagrangian and Hamilitonian formulations of Electrodynamics and General relativity as the two fundamental force fields of nature.
3. They will appreciate how electromagnetic fields behave in the presence of gravity, as quite a realistic situation.
4. The students will grasp and appreciate the amazing insights into the equivalence principle and the whole edifice of Einstein's General Relativity applicable up to Planckian scales.
5. They will feel the excitement and learn about the recently observed messengers of gravitational waves, in addition to the already existing electromagnetic signals.
6. Students will learn about the monumental contributions of Indian scientists like A. K. Raychaudhuri, P.C. Vaidya and C.V. Vishveshwara in the field of gravitation and gravitational waves.
7. The students will eventually learn how to formulate a field theory on their own by considering the key conditions as constraints on the action principle and viability with observations.

UNIT - I

Poincare transformations in spacetime structure. World lines on Light cone diagrams. Space-like, time-like and light-like Four-vectors. Contravariant and Covariantfour-vectors. Orthogonality. Four-tensors, Symmetric and Antisymmetric tensors, Inner and outer products, Contraction and Trace of a tensor. Quotient Law. Metric tensor, Pseudo-tensors. Ccompletely antisymmetric unit tensor of rank four. Four-velocity, four-momentum and four-acceleration. Mass shell. Examples of scalar, vector and tensor fields.

UNIT - II

Canonical formulation of Maxwell's electrodynamics. Electromagnetic Field strength tensor and the field equations. Symmetry and conservation laws related to the Lagrangian. Effects of (possible) mass of Photon on Lagrangian and field equations and on local phase conservation (gauge invariance). Off-shell and on-shell photons. Hamiltonian density as the time-

time component of Electromagnetic energy-momentum tensor and the dynamical properties of this tensor.

UNIT - III

Equivalence principle. Relation between gravitation and spacetime curvature, Christoffel's symbols and the metric. Riemannian geometry, covariant differentiation, Parallel transport and geodesics, Ricci and Einstein tensors. Einstein's field equations. Weak field approximation and comparison to Newtonian field. Minimal coupling of gravitation with Maxwell's electrodynamics. The Schwarzschild solution and concept of singularity. **Basic Ideas about the Vaidya Metric and the Raychaudhuri equation.** Modern tests of General Relativity.

UNIT - IV

Linearized Gravity. Basic concepts of Gravitational Waves (GW's). Comparison with electromagnetic dipole and quadrupole radiation. Generation, propagation and detection of GW's. The experimental laser interferometers at advanced LIGO, VIRGO **and Indian LIGO (IndIGO) detectors.** Polarisation of Gravitational waves. Energy loss due to GW's. Recent GW sources. **Vishveshwara's predictions of quasi-normal modes and their recent observation in GW events.**

REFERENCES:

1. Ray D'Inverno, "Introducing Einstein's Relativity"Clarendon Press, Oxford.
2. J. D. Jackson, "Classical Electrodynamics", Wiley India.
3. L.D. Landau and E. M. Lifshitz, "The Classical Theory of fields": 4ed, Pergamon Press.
4. Bernard Schutz, "A First Course in General Relativity"2nd ed. Cambridge University Press, 2009.
5. Sean M. Carroll, "Spacetime and Geometry" Pearson, 2018.
6. T. Pamanabhan, "Gravitation: Foundation and Frontiers" Cambridge University Press 2010.
7. M. Maggiore,"Gravitational Waves: Theories and experiments", Vol 1: Oxford University Press, 2007.
8. **LIGO India resources webpage: gw-indigo.org.**

B.Sc. Semester VII Credits 04

Title of the Paper: P18x PHY704-Lasers and Opto-electronics II

Course Outcomes:

1. Using their knowledge of optical fibers students will learn optical communication, required coding, bandwidth budget, waveguides and optical couplers.
2. Students will learn about fabrication of integrated optical devices, various optic effects and various types of sensors using optical fibers.
3. Students will learn the fundamental mechanism in Lasers like Mode selection, Mode Locking and Q-switching.
4. Students will know about various types of lasers available and their applications.
5. Students will learn how the optical fibers are used in sensor applications.
6. Students will learn concepts of fiber optic communication.

UNIT - I

Losses in the cavity – quality factor, line width of the laser, Mode selection – Transverse and longitudinal, free spectral range and finesse of etalon, Q – Switching – Peak Power, Total Energy, Pulse duration, Techniques for Q Switching- Mechanical, electro-optic and acousto-optic, Mode locking in lasers – Theory, Techniques for mode locking – Acousto-optic and electro-optic, Laser Systems –Nd:YAG, Nd:Glass, CO_2 Laser, Excimer Laser, Free Electron Lasers – Introduction, Single particle dynamics, wiggler, electron trajectory, FEL Gain, Spontaneous Emission, effect of input wave polarization on FEL gain, Properties of Lasers – Directionality, Coherence etc (01 Lecture).

UNIT - II

Quantization of Analog signal, A/D and D/A conversion, Bit Rate, Pulse Code Modulation, NRZ, RZ and Manchester Coding, Base Line Wander Effect Advantages of Optical Communication, Eye pattern Technique Direct Detection and Coherent Heterodyne Detection, NEP Heterodyne, Erbium Doped Fiber Amplifier, Fiber Bragg Grating., System Design, Power Budget, Band width Budget and Rise Time Budget Calculations.

UNIT - III

Time Division Multiplexing, Wave length Division Multiplexing, Multiplexers and De-Multiplexers, Concept of Optical Frequency Division Multiplexing, Electro-optic Effects, Acousto-optic Effect, Raman-Nath acousto-optic modulator Bragg modulator, Acousto-optic deflectors, Acousto-optic spectrum analyzer, Beam and waveguide couplers: Transverse couplers, prism-coupler, Grating coupler, thin-film tapered coupler, wave guide-to-fiber couplers.

UNIT - IV

Basic idea of asymmetric planar waveguides, slab guide geometries: strip, raised strip, embedded strip, ridge, strip coated guides, Fabrication of Integrated optical Devices: Substrate, cleaning of the substrate., Methods used to produce wave guiding layers, Sputtering and Dipping, Ion migration, Fiber optic sensors: Phase and polarization fiber sensors, Intrinsic sensors, Extrinsic fiber sensors, Sagnac Effect, Gyroscope.

REFERENCES:

1. David J. Griffiths, “Introduction to Electrodynamics”, Prentice-Hall of India, New Delhi.
2. John David Jackson, “Classical Electrodynamics”, Wiley India.
3. Joseph A. Edminster, “Theory and Problems of Electromagnetics”, Tata Mc Graw Hill.
4. E.M. Purcell, “Electricity and Magnetism”, Berkeley Physics Course , Vol II, Mc GrawHill.
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”Spinger.
9. A. Zangwill, “Modern Electrodynamics”, Cambridge University Press.

ADDITIONAL READINGS:

1. R. P. Khare, “Fiber Optics and Optoelectronics”, OXFORD University Press.
2. Govind P. Agrawal, “Fiber-Optic Communication Systems”, Wiley India (P) Ltd.
3. John M. Senior, “Optical Fiber Communications”, Pearson Education Limited.
4. R. K. Singh, “Fiber-Optic Communication Systems”, Wiley India Pvt. Ltd.
5. Vivekanand Mishra and Sunita P. Ugale, “Fiber-Optic Communication Systems and Components”, Wiley India Pvt. Ltd.
6. R.K. Shukla, “Optical fiber Communication Systems”, MKSES Publication.

7. S. C. Gupta, “Textbook on Optical Fiber Communication and its Applications”, PHI Learning Private Limited.
8. P. R. Sasi, “KumarPhotonics An Introduction”, PHI Learning Private Limited

B. Sc. Semester VII Credits 04

Title of the Paper: P18y PHY705- Advanced Electronics

Course Outcomes:

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

UNIT - I

Network Theorems and Semiconductor Junction:

Thevnin, Nortan and Superposition theorems and their applications, Brief about PN junction properties. Tunnel diode: junction formation, current characteristics and applications. Point contact diode: current characteristics and applications. Light emitting diodes: current characteristics, applications, limitation of silicon and germanium in LEDs. Photodiodes: I-V characteristics, applications, advantages & disadvantages. Thermistors: applications

UNIT - II

Transistors:

Transistor parameters, base width modulation, transit –time and life-time of minority carriers, base-emitter resistance, collector conductance, base spreading resistance, Diffusion capacitance, reverse feedback ratio, equivalent circuit for transistors, Basic model, Hybrid model and h-parameter equivalent circuit and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).

Transistor circuit application at low frequencies, their AC and DC equivalent for three different modes of operation, large signal operation of transistors, transistors power amplifiers, Class A and B operation, maximum power output, effect of temperature, heat sinks, thermal resistance. Distortion in amplifiers, cascading of stages, frequency response,

UNIT - III

Field Effect Transistors:

JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions, Important Terms, Expression for Drain Current (Shockley equation); Characteristics; Parameters; Biasing with respect to CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs).

MOSFET: Construction, Working and Characteristics of DE-MOSFET (N channel & P channel) and E-MOSFET (N channel & P channel); Comparison with JFFET.

Other Devices: SCR: Construction; Equivalent Circuits (Two Diodes, Two Transistors & One Diode-One Transistor); Working; Characteristics; Applications (Static switch, Phase control system & Battery charger). UJT: Construction; Equivalent Circuit; Working, Characteristics (Peak & Valley points); Applications (Trigger circuits, Relaxation oscillators & Sawtooth generators).

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, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e
6. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e

7. William H. Gothmann, “Digital Electronics: An Introduction to Theory and Practice”, Prentice-Hall of India Private Limited, 1982, 2e
8. R.P. Jain, “Modern Digital Electronics”, McGraw Hill, 2009, 4e

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
Course Outcomes: P19x PHY706- X-rays

Course Outcomes:

1. Students learn about the various methods of X-rays generation, safety concerns in the X-ray generation.
2. Students will be able to learn the theoretical background of the X-rays diffraction.
3. Students will get knowledge about the X-ray Films and their processing.
4. They will also understand the Diffraction of X-rays via several methods to obtained photograph pattern of various crystals and their studies.
5. Students will learn about the X-ray absorption and spectroscopic techniques.

UNIT - I

X-ray Generation, Properties and Applications, Basics Concept of Continuous and Characteristics X-ray spectra, X-ray tubes: Conventional Coolidge tube, Sealed off tube, demountable tube, Problems in tube design, High Tension equipment's, tube rating and tube life, Target: stationary target, rotating target Operation of X-ray tube at high current, Tube rating charts, windows for X-ray tubes, Synchrotron radiation as an X-ray source, X-ray detection, Safety devices for the Protection of X-rays.

UNIT - II

X-ray Films, X-ray cassettes, Intensifying screens X-ray films types – basic film structure & quality, choosing films for different studies, basics on hard copies of radiographic images – dry & wet processing, Fixer –Developer –film processing methods, manual and automatic processing – conventional &modern image processing rooms, image processing equipment's, types & maintenance – day light systems advantages & disadvantages – processing faults.

UNIT - III

Diffraction of X-rays by Crystals, Laue's and Bragg's equations for X-ray diffraction and their equivalency, Neutron and electron diffraction, relative merits and demerits of electron, neutron and X-ray diffraction. Various methods of X-ray diffraction; Collimation and recording of X-ray beam, Laue, Powder, Rotating/oscillating and moving film methods in details. Interpretation of diffraction pattern with the help of various tools, factors affecting X-ray intensities.

UNIT - IV

X-ray absorption, Absorption coefficients, Characteristic absorption limits and associated fine structure. Absorption jump ratios, Theory of absorption curve shape, Nature of the main absorption edge and the white line. X-ray absorption near edge structure, X-ray absorption main edge structure, Introduction of Extended X-ray absorption fine structure, Spectroscopic techniques: X-ray photoelectron and Auger electron Spectrometers (XPS/AES), X-ray fluorescence Spectrometer.

REFERENCES:

1. B. D. Cullity and S. R. Stock, "Elements of X-Ray Diffraction", T*hird Edition*. Prentice-Hall, 2001.
2. Ajit Ram Verma and Onkar Nath Srivastava, "Crystallography for Solid State Physics", John Wiley and Sons Ltd, 1982.
3. B.K. Agarwal, "X-Ray Spectroscopy", 2nd edition, Springer Berlin Heidelberg, 1991.
4. Tafti D, Maani CV., "X-ray Production", 2020 Sep 10. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan–. PMID: 30725731.
5. Surface X-Ray and Neutron Scattering : Proceedings of the 2nd International Conference, Publishing: Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, 2011 Edited by Hartmut Zabel and Ian K. Robinson.

B. Sc. Semester VII Credits 04

Course Outcomes: P19y PHY707-Mathematical Methods and Numerical Techniques

Course Outcome:

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 VIII **Credits 04**

Course Outcomes: P20 PHY801-Advance Quantum Mechanics

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, Spherical harmonics.

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 VIII   Credits 04

Course Outcomes: P21 PHY802-Materials Science and Nano Technology

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 behavior 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 Jo-won Lee.

Major Project PHY803
Credits 16

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.