B.Sc. PHYSICS
CORE PROGRAMMES SYLLABUS

Core Course I
PHY1 B01: MECHANICS – I
36 hours (Credit - 2)

	Course Outcome	PSO	CL	KC	Class Sessions Allotted
C01	Understand and apply the basic concepts of Newtonian Mechanics to Physical Systems	PSO1	Ap	C,P	16
C02	Understand and apply the basic idea of work-energy theorem to physical systems	PSO1	Ap	C,P	8
C03	Understand and apply the rotational dynamics of rigid bodies	PSO1	Ap	C,P	12

Unit I– Newton's Laws **16 Hrs**

Newton's First Law, Second Law and Third Law – Astronauts in space : Inertial systems and fictitious forces – Standards and units – Some applications of Newton's laws – The astronauts' tug of war, Freight train, Constraints, Block on string, The whirling block, The conical pendulum – The everyday forces of physics – Gravity and Weight; Gravitational force of a sphere; Turtle in an elevator; Gravitational field – Electrostatic force – Contact forces; Block and string; Dangling rope; Whirling rope; Pulleys; Tension and Atomic forces; Normal force; Friction; Block and wedge with friction; Viscosity – Linear restoring force; Spring and block : The equation for simple harmonic motion; Spring and gun : Illustration of initial conditions – Dynamics of a system of particles – The Bola – Centre of mass – Drum major's baton – Centre of mass motion – Conservation of momentum – Spring Gun recoil

[Sections 2.1 to 2.5, 3.1 to 3.3 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow]

Unit II – Work and Energy **8 Hrs**

Integrating the equation of motion in one dimension – Mass thrown upward in a uniform gravitational field; Solving the equation of simple harmonic motion – Work-energy theorem in one dimension – Vertical motion in an inverse square filed – Integrating the equation of motion in several dimensions – Work-energy theorem – Conical pendulum; Escape velocity – Applying the work-energy theorem – Work done by a uniform force; Work done by a central force; Potential energy – Potential energy of a uniform force field; Potential energy of an inverse square force – What potential energy tells us about force – Stability – Energy diagrams – Small oscillations in a bound system – Molecular vibrations – Nonconservative forces – General law of conservation of energy – Power

[Sections 4.1 to 4.13 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow. The problems in chapter 5 should be discussed with this.]

Unit III – Angular Momentum **12 Hrs**

Angular momentum of a particle – Angular momentum of a sliding block; Angular momentum of the conical pendulum – Torque – Central force motion and the law of equal areas – Torque on a sliding block; Torque on the conical pendulum; Torque due to gravity – Angular momentum and fixed axis rotation – Moments of inertia of some simple objects – The parallel axis theorem – Dynamics of pure rotation about an axis – Atwood's machine with a massive pulley – The simple pendulum – The physical pendulum – Motion involving both translation and rotation – Angular momentum of a rolling wheel – Drum rolling down a plane – Work-energy theorem for a rigid body – Drum rolling down a plane : energy method – The vector nature of angular velocity and angular momentum – Rotation through finite angles – Rotation in the xy-plane – Vector nature of angular velocity – Conservation of angular momentum

[Sections 6.1 to 6.7, 7.1, 7.2 and 7.5 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow]

Books of Study :

1. An Introduction to Mechanics, 1stEdn. – Daniel Kleppner and Robert J. Kolenkow – McGraw-Hill

Reference Books :

1. Berkeley Physics Course : Vol.1 : Mechanics, 2ndEdn. – Kittel*et al.* – McGraw-Hill

Mark Distribution for Setting Question Paper

Unit/ Chapter	Title	Marks
1	Newton's laws	36
2	Work and Energy	18
3	Angular Momentum	25
*Total Marks**		79

*Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 2 | Core Course II
PHY 2 B02: MECHANICS – II
36 hours (Credit - 2)

	Course Outcome	**PSO**	**CL**	**KC**	**Class Sessions Allotted**
C01	Understand the features of non-inertial systems and fictitious forces	PSO1	U	C	8
C02	Understand and analyze the features of central forces with respect to planetary forces	PSO1	An	C,P	10
C03	Understand the basic ideas of Harmonic Oscillations	PSO1	U	C	8
C04	Understand the analyze the basic concepts of wave motion	PSO1	An	C,P	10

Unit I – Noninertial Systems and Fictitious Forces **8 Hrs**

Galilean transformations – Uniformly accelerating systems – The apparent force of gravity – Pendulum in an accelerating car – The principle of equivalence – The driving force of the tides – Physics in a rotating coordinate system – Time derivatives and rotating coordinates – Acceleration relative to rotating coordinates – The apparent force in a rotating coordinate system – The Coriolis force – Deflection of a falling mass – Motion on the rotating earth – Weather systems – Foucault's pendulum

[Sections 8.1 to 8.5 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow]

Unit II – Central Force Motion **10 Hrs**

Central force motion as a one-body problem – General properties of central force motion – Motion is confined to a plane – Energy and angular momentum are constants of the motion – The law of equal areas – Finding the motion in real problems – The energy equation and energy diagrams – Noninteracting particles – Planetary motion – Hyperbolic orbits – Satellite orbit – Kepler's laws – The law of periods – Properties of the ellipse

[Sections 9.1 to 9.7 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow]

Unit III – Harmonic Oscillator **8 Hrs**

Introduction and review – Standard form of the solution – Nomenclature – Initial conditions and the frictionless harmonic oscillator – Energy considerations – Time average values – Average energy – Damped harmonic oscillator – Energy and Q-factor – Q factor of two simple oscillators

– Graphical analysis of a damped oscillator – Solution of the equation of motion for the undriven damped oscillator – Forced harmonic oscillator – Undamped forced oscillator – Resonance
[Sections 10.1 to 10.3 (except the topic, *The Forced Damped Harmonic Oscillator*) and Note 10.1 of An Introduction to Mechanics (1st Edn.) by Daniel Kleppner and Robert J. Kolenkow]

Unit IV – Waves **10Hrs**

What is a wave ? – Normal modes and travelling waves – Progressive waves in one direction – Wave speeds in specific media – Superposition – Wave pulses – Motion of wave pulses of constant shape – Superposition of wave pulses – Dispersion; Phase and Group Velocities – Energy in a mechanical wave – Transport of energy by a wave – Momentum flow and mechanical radiation pressure – Waves in two and three dimensions
[Chapter 7 – Progressive Waves (except the topic, *The Phenomenon of Cut-off*) of Vibrations and Waves by A. P. French]

Books of Study :

1. An Introduction to Mechanics, 1st Edn. – Daniel Kleppner and Robert J. Kolenkow – McGraw-Hill
2. Vibrations and Waves – A. P. French – The M.I.T. Introductory Physics Series – CBS Publishers & Distributors

Reference Books :

1. Berkeley Physics Course : Vol.1 : Mechanics, 2nd Edn. – Kittel *et al.* – McGraw-Hill

Unit/ Chapter	Title	Marks
1	Non-inertial systems and fictitious forces	18
2	Central force motion	22
3	Harmonic Oscillator	18
4	Waves	21
	*Total Marks**	79

*Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 3 | Core Course III

PHY3B03: ELECTRODYNAMICS I

54 hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand and apply the fundamentals of vector calculus	PSO1	Ap	C	10
CO2	Understand and analyze the electrostatic properties of physical systems	PSO1	An	C, P	16
CO3	Understand the mechanism of electric field in matter.	PSO1	U	C,P	8
CO4	Understand and analyze the magnetic properties of physical systems	PSO1	An	C,P	12
CO5	Understand the mechanism of magnetic field in matter.	PSO1	U	C,P	8

Unit 1 – Vector Calculus **10 Hrs**

Vector Algebra: Vector operations - Vector algebra: Component form – Triple products – Position, Displacement and Separation vectors – How vectors transform. Differential Calculus: "Ordinary" derivatives – Gradient – The Del operator – Divergence – Curl – Product rules – Second derivatives. Integral Calculus: Line integral, surface integral and volume integral – Fundamental theorem of calculus – Fundamental theorem for Gradients – Fundamental theorem for divergences: Gauss's Divergence Theorem (no proof needed) – Fundamental theorem for curls: Stoke's theorem (no proof needed). Spherical polar coordinates – Cylindrical coordinates – Their relationship to Cartesian coordinates – Expressing differential displacement vector, differential area vectors, differential volume element, gradient operator, divergence operator and curl operator in spherical polar and cylindrical coordinates. Dirac delta function: Divergence of $\frac{\hat{r}}{r^2}$ – One-dimensional delta function – Three-dimensional delta function. Helmholtz theorem (no proof needed) – Divergence-less vector fields – Curl-less vector fields – Potentials.

[Sections 1.1 to 1.6 of Introduction to Electrodynamics (4^{th} Edn.) by David J Griffiths.]

Unit 2 – Electrostatics **16 Hrs**

Electrostatic field – Coulomb's law, Electric field, Continuous charge distributions - Divergence and curl of electrostatic field, Field lines and Gauss's law, The divergence of **E**, Applications of Gauss law, Curl of **E** – Electric potential – Comments on potential, Poisson's equation and Laplace's equation, The potential of a localized charge distribution, Electrostatic boundary

conditions – Work and energy in electrostatics, The work done in moving a charge, The energy of point charge distribution, The Energy of a continuous charge distribution, Comments on Electrostatic energy – Conductors, Basic properties of conductors, Induced charges, The Surface charge on a conductor, The force on surface charge, Capacitors.

[Sections 2.1 to 2.5 of Introduction to Electrodynamics by David J Griffiths. Additional problems should be done from chapters 1, 2 and 3 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Unit 3 – Electric fields in matter **8 Hrs**

Polarization – Dielectrics, Induced dipoles, Alignment of polar molecules, Polarization – The field of a polarized object , Bound charges, Physical interpretation of bound charges, The field inside a dielectric – The electric displacement – Gauss's law in presence of dielectrics, Boundary conditions for **D** – Linear dielectrics, Susceptibility, Permittivity, Dielectric constant, Boundary value problems with linear dielectrics, Energy in dielectric systems, Forces on dielectrics.

[Sections 4.1 to 4.4 of Introduction to Electrodynamics (4^{th} Edn.) by David J Griffiths. Additional problems should be done from chapter 10 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Unit 4 – Magnetostatics **12 Hrs**

The Lorentz force law – Magnetic fields, Magnetic forces, cyclotron motion, cycloid motion, Currents, Linear, Surface and Volume current density – Biot -Savart law, The magnetic field of steady current – Divergence and curl of **B,** Straight line currents, Applications of Ampere's law, Magnetic field of a toroidal coil, Comparison of magnetostatics and electrostatics – Magnetic vector potential , Vector potential, Magnetostatic boundary conditions.

[Sections 5.1 to 5.4.2 of Introduction to Electrodynamics (4^{th} Edn.) by David J Griffiths. Additional problems should be done from chapter 6 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Unit 5 – Magnetostatic fields in matter **8 Hrs**

Magnetization – Diamagnets, Paramagnets and Ferromagnets, Torques and forces on magnetic dipoles, Effect of a magnetic field on atomic orbits, Magnetization – Field of a magnetised object, Bound Currents, Physical interpretation of bound currents, Magnetic field inside matter – Auxiliary field **H**, Ampere's law in magnetized materials, Boundary conditions – Linear and nonlinear media, Magnetic susceptibility and permeability, Ferromagnetism.

[Sections 6.1 to 6.4 of Introduction to Electrodynamics (4th Edn.) by David J Griffiths. Additional problems should be done from chapter 11 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Books of Study:

1. Introduction to Electrodynamics, 4th Edn. – David J Griffiths – Prentice Hall India Learning Pvt. Ltd
2. Berkeley Physics Course: Vol.2: Electricity and Magnetism, 2nd Edn. – Edward M. Purcell – McGraw-Hill

Reference Books:

1. Electricity and magnetism by Arthur F Kip
2. Physics Vol. II by Resnick and Halliday
3. Electricity and Magnetism-Hugh D Young and Roger A Freedman
4. Vector Analysis M R Spiegel,S Lipschutz,D Spellman -Schaum's outline-McGraw Hill
5. Div, Grad, Curl and all that ; An informal text on vector calculus H M Schey (Norton)
6. Electromagnetics by Edminister – Schaum's Outline – Tata McGraw Hill
7. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	**Title**	**Marks**
1	Vector Calculus	15
2	Electrostatics	22
3	Electric fields in matter	12
4	Magnetostatics	18
5	Magnetostatic fields in matter	12
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 4 | Core Course IV

PHY4B04: ELECTRODYNAMICS II

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the basic concepts of electrodynamics	PSO1	U	C	15
CO2	Understand and analyze the properties of electromagnetic waves	PSO1	An	C, P	15
CO3	Understand the behavior of transient currents	PSO1	U	C	8
CO4	Understand the basic aspects of ac circuits	PSO1	An	C,P	8
CO5	Understand and apply electrical network theorems	PSO1	Ap	C,P	8

Unit 1 – Electrodynamics **15 Hrs**

Electromotive force – Ohm's law, electromotive force, motional emf – Electromagnetic induction - Faraday's law, induced electric field, inductance, energy inmagnetic fields – Maxwell's equations – Electrodynamics before Maxwell, Maxwell's modification of Ampere's law, Maxwell's equations, Magnetic charge, Maxwell'sequations inside matter, Boundary conditions – Continuity equation – Poynting's theorem

[Sections 7.1 to 7.3 and 8.1 of Introduction to Electrodynamics by David J Griffiths. Additional problems should be done from chapter 7 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Unit 2 – Electromagnetic waves **15 Hrs**

Waves in one dimension, The wave equation, sinusoidal waves, boundary conditions :reflection and transmission, Polarization – Electromagnetic waves in vacuum , Waveequation for **E** and **B**, monochromatic plane waves in vacuum, energy and momentum ofE.M. waves, Poynting vector - Electromagnetic waves in matter, Propagation throughlinear media, reflection and transmission at normal incidence.Potential formulation – Scalar and vector potentials, Gauge transformations, Coulomb gauge and Lorentz gauge.

[Sections 9.1 to 9.3.2 and 10.1of Introduction to Electrodynamics by David J Griffiths. Additional problems should be done from chapter 9 of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.]

Unit 3 – Transient currents **8 Hrs**

Types of transients – DC transient currents in R-L circuits – Short circuit current – Time constant – DC transient currents in R-C circuits – Double energy transients – Theory ofBG

[Sections 22.1, 22.2, 22.4, 22.5, 22.6, 22.8, 22.10 and 10.52 of Electrical Technology Vol. 1 by B. L. Theraja and A. K. Theraja]

Unit 4 – AC circuits **8 Hrs**

A resonant circuit – Alternating current – Alternating current networks – Admittance and impedance – Power and energy in AC circuits

[Sections 8.1 to 8.5of Berkeley Physics Course: Vol.2: Electricity and Magnetism (2nd Edn.) by Edward M Purcell.Additional problems should be done from the relevant sections from chapters 13 and 14 of the book of Electrical Technology Vol. 1 by B. L. Theraja and A. K. Theraja]

Unit 5 – Network theorems **8 Hrs**

Kirchhoff's laws, Voltage sign and current direction, Solution of simultaneous equations using determinants, Source conversion, Superposition theorem, Ideal equivalent circuits,Thevenin's theorem, Reciprocity theorem, Delta / Star transformation – Star / Delta transformation – Norton's theorem, Maximum powertransfer theorem.

[Sections 2.2 to 2.6, 2.14 to2.23, 2.25, 2.26, 2.27 and 2.30 from ElectricalTechnology Vol. 1 by B. L. Theraja and A. K. Theraja]

Books of Study :

1. Introduction to Electrodynamics, 4thEdn. – David J Griffiths – Prentice Hall India Learning Pvt. Ltd
2. Berkeley Physics Course: Vol.2: Electricity and Magnetism, 2nd Edn. – Edward M. Purcell – McGraw-Hill
3. A Text Book of Electrical Technology Vol. 1 – B. L. Theraja, A. K. Theraja – S. Chand Publishers, 1997

Reference Books :

1. Electricity and magnetism by Arthur F Kip
2. Physics Vol. II by Resnick and Halliday
3. Electricity and Magnetism by D.N Vasudeva (12threvised edition)
4. Introductory AC Circuit theory – K Mann & G J Russell- Universities Press
5. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Electrodynamics	22
2	Electromagnetic waves	22
3	Transient currents	12
4	AC circuits	12
5	Network theorems	11
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 5 Core Course –VI

PHY5B06: COMPUTATIONAL PHYSICS

54 Hours (Credit – 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the Basics of Python programming	PSO4	U	C	14
CO2	Understand the applications of Python modules	PSO4	U	C	8
CO3	Understand the basic techniques of numerical analysis	PSO4	U	C	18
CO4	Understand and apply computational techniques to physical problems	PSO4	Ap	C,P	14

Unit 1

Chapter 1: Introduction to Python Programming **16 Hrs**

Introduction to algorithm, flowchart and high level Computer programming languages Compilers- Interpreters - Introduction to Python language- Advantages and unique features of Python language - Interactive mode and script mode- Writing and execution of programs -various data types in Python- Reading keyboard input: The raw_input function and input function - print command, formatted printing- open and write function - Variables, operators, expressions and statements- String operations, Lists, list operations (len, append, insert, del, remove, reverse, sort, +, *, max, min, count, in, not in, sum), sets, set operations (set, add, remove, in, not in, union, intersection, symmetric difference)-Tuples and Dictionaries, various control and looping statements: (if, if..else, if..ellif, while, for, break, continue) - user defined functions- Modules - File input and file output- Pickling.

Books for study:

1.Introduction to Python for Engineers and Scientists by Dr.Sandeep Nagar, Apress publications.

2.Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from www.expeyes.in/documents/mapy.pdf

3. Python Tutorial Release 3.0.1 by Guido van Rossum, Fred L. Drake, Jr., editor. (http://www.altaway.com/resources/python/tutorial.pdf)

Chapter 2: Numpy and Matplotlib modules **6 Hrs**

Numpy module: Introduction, creation of arrays and matrices, various array operations, matrix multiplication, inversion. Matplotlib module: Introduction, plot( ), show( ) functions, syntax for plotting graphs , multiple plots, polar plots, labeling, scaling of axes and coloring plots - Plotting of functions – sin(x), cos(x), exp(x), $\sin^2(x)$, $\sin(x^2)$

Books for study:

Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from www.expeyes.in/documents/mapy.pdf

Unit 2

Chapter 3: Numerical Methods in Physics **18 Hrs**

Introduction to numerical methods, Comparison between analytical and numerical methods - Curve Fitting: Principle of least squares, Least square fitting of a straight line -Interpolation: Finite difference operator, Newton's forward difference interpolation formula, difference table, First and second derivative by Numerical differentiation- Solution of algebraic equations: Bisection method, Newton-Raphson method - Newton Cote's quadrature formula- Numerical integration by Trapezoidal and Simpson's (1/3) method- Solution of differential equations: Euler's method, Runge- Kutta method (Second order) -Taylor's Series expansion of Sin(x) and Cos(x).

Books for study:

1. Introductory methods of numerical analysis, S.S.Shastry , (Prentice Hall of India,1983)
2. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from www.expeyes.in/documents/mapy.pdf

Unit 3

Chapter 4: Computational Physics **14 Hrs**

Formulation: From analytical to numerical methods -Significance of Computer in numerical methods- Applications of Euler's method: Theory, and graphical simulation by programming: motions of a freely falling body, a body dropped into a highly viscous medium, two dimensional projectile motion and radioactive decay - Accuracy considerations (elementary ideas)

(All programs should be written using Python language Version 3.0)

Books for study:

1. Computational Physics, V.K.Mittal, R.C.Verma & S.C.Gupta-Published by Ane Books
2. Introductory methods of numerical analysis, S.S.Shastry , (Prentice Hall of India,1983)

3. Introduction to Python for Engineers and Scientists by Dr.Sandeep Nagar, Apress publications.

References:

1. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from www.expeyes.in/documents/mapy.pdf
2. Programming in Python 3: A Complete Introduction to the Python Language by Mark Summerfield-2nd edition-Developer's library
3. Introduction to Python for Engineers and Scientists by Dr.Sandeep Nagar, Apress publications.
4. www.python.org
5. Python Essential Reference, David M. Beazley, Pearson Education
6. Core Python Programming, Wesley J Chun, Pearson Education
7. Python Tutorial Release 3.0.1 by Guido van Rossum, Fred L. Drake, Jr., editor. (http://www.altaway.com/resources/python/tutorial.pdf)
8. How to Think Like a Computer Scientist: Learning with Python, Allen Downey , Jeffrey Elkner , Chris Meyers, http://www.greenteapress.com/thinkpython/thinkpython.pdf
9. Numerical Methods in Engineering and Science, Dr. B S Grewal, Khanna Publishers, Newdelhi
10. Numerical methods for scientists and engineers, K. Sankara Rao, PHI
11. Introductory methods of numerical analysis, S.S.Shastry , (Prentice Hall of India,1983)
12. Computational Physics, V.K.Mittal, R.C.Verma & S.C.Gupta-Published by Ane Books

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Introduction to Python Programming	23
2	Numpy and Matplotlib modules	10
3	Numerical Methods in Physics	26
4	Computational Physics	20
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 5 Core Course –VII

PHY5B07: QUANTUM MECHANICS

54 Hours (Credit – 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the particle properties of electromagnetic radiation	PSO2	U	C	8
CO2	Describe Rutherford – Bohr model of the atom	PSO2	U	C	10
CO3	Understand the wavelike properties of particles	PSO2	U	C	10
CO4	Understand and apply the Schrödinger equation to simple physical systems	PSO2	Ap	C,P	16
CO5	Apply the principles of wave mechanics to the Hydrogen atom	PSO2	Ap	C,P	10

Unit 1

1. Particle like Properties of Electromagnetic Radiation 8 Hrs

Review of electromagnetic waves – Photoelectric effect – Blackbody radiation – Compton effect – Other photon processes – What is a photon?

[Sections 3.1 to 3.6 of Modern Physics by Kenneth Krane]

2. Rutherford-Bohr Model of the Atom 10 Hrs

Basic properties of atoms – Thomson model – Rutherford nuclear atom – Line spectra – Bohr model – Frank-Hertz experiment – Correspondence principle – Deficiencies of Bohr model

[Sections 6.1 to 6.8 of Modern Physics by Kenneth Krane]

Unit 2

3. Wavelike Properties of Particles 10 Hrs

De Broglie hypothesis - Uncertainty relationships for classical waves – Heisenberg uncertainty relationships – Wave packets - Probability and randomness – Probability amplitude

[Sections 4.1 to 4.6 of Modern Physics by Kenneth Krane]

Unit 3

4. The Schrodinger Equation 16 Hrs

Justification of the Schrodinger equation – The Schrodinger recipe – Probabilities and normalization – Applications – Free particle, Particle in a box (one dimension), Particle in a box

(two dimensions), Simple harmonic oscillator – Time dependence – Potential energy steps and potential energy barriers

[Sections 5.1 to 5.7 of Modern Physics by Kenneth Krane]

5. Hydrogen Atom in Wave Mechanics 10 Hrs

Schrodinger equation in spherical coordinates – Hydrogen atom wave functions – Radial probability densities – Angular momentum and probability densities – Intrinsic spin – Energy levels and spectroscopic notation – Zeeman effect – Fine structure

[Sections 7.1 to 7.8 of Modern Physics by Kenneth Krane]

Book of study:

1. Modern Physics, 2nd Edn. – Kenneth S. Krane – John Wiley & sons

Reference Books :

1. Concepts of Modern Physics, 7th Edn. – Arthur Beiser – Tata McGraw-Hill

2. Modern Physics, 3rd Edn. – Raymond A. Serway, Clement J. Moses, Curt A. Moyer – Cengage

3. Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles By R.Eisberg & R. Resnick - John Wiley

4. Modern Physics, 2nd Edn – Randy Harris – Pearson

5. Modern Physics for Scientists and Engineers, 2nd Edn. – John R. Taylor, Chris D. Zafiratos, Michael A. Dubson – Prentice-Hall of India Pvt. Ltd.

6. Berkeley Physics Course: Quantum Physics by Wichmann

7. Theory and Problems in Modern Physics by Gautreau & Savin – Schaum's Outlines Series – TMH

8. Quantum mechanics: Concepts & Applications by Zettilli N, Second Edition, Wiley

9. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Particle like Properties of Electromagnetic Radiation	11
2	Rutherford-Bohr Model of the Atom	15
3	Wavelike Properties of Particles	15
4	The Schrodinger Equation	23
5	Hydrogen Atom in Wave Mechanics	15
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 5 | Core Course VIII

PH5B08: OPTICS

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the fundamentals of Fermat's principles and geometrical optics	PSO2	U	C	5
CO2	Understand and apply the basic ideas of interference of light	PSO2	Ap	C, P	14
CO3	Understand and apply the basic ideas of diffraction of light	PSO2	Ap	C, P	13
CO4	Understand the basics ideas of polarization of light	PSO2	U	C	8
CO5	Describe the basic principles of holography and fibre optics	PSO2	U	C	14

Unit 1

Fermat's Principle, verification of laws of reflection and refraction **2 Hrs**

[Sections 2.1 to 2.6 of Brijlal, Subramaniyam, & Avadhanuluand Sections 3.1 to 3.2 ofAjoyGhatak]

Refraction and reflection by spherical surfaces : **3 Hrs**

Refraction and reflection at a single spherical surfaces. The thin lens, The Principal Foci, and Focal length of a lens, The Newton formula, Lateral magnification.

[Sections 4.1 to 4.7 of Ajoy Ghatak]

Unit 2

2. Interference by division of wave front **6 Hrs**

Superposition of two sinusoidal waves, Interference, coherence ,conditions for interference, the interference patterns, intensity distribution .Fresnel's two mirror arrangement, Fresnel's Biprism, Determination of λ and dλ of Sodium Light

[Sections 14.1 to 14.4, 14.6 to 14.9 of Brijlal, Subramaniyam, & Avadhanulu, and Sections 14.1 to 14.8 of Ajoy Ghatak. Additional problems should be done from chapter 7 of Introduction to Optics by Frank.L,Pedrotti,Leno M Pedrotti and Leno S Pedrotti.]

3. Interference by division of amplitude **8 Hrs**

Interference by a plane film illuminated by a plane wave, cosine law, non reflecting films (the

subsections excluded), interference by a film with two nonparallel reflecting surfaces, colours of thin films, Newton's rings, The Michelson interferometer, white light fringes-

[Sections 15.1 to 15.4,15.7, 15.9, 15.11 of Ajoy Ghatak, and Sections 2.1 to 2.6 of Brijlal, Subramaniyam, &Avadhanulu. Additional problems should be done from chapter 7 of Introduction to Optics by Frank.L,Pedrotti, Leno M Pedrotti and Leno S Pedrotti.]

Unit 3

4. Fraunhofer Diffraction **10 Hrs**

Preliminaries, single slit diffraction pattern, diffraction by circular aperture, limit of resolution, two slit Fraunhofer diffraction pattern, N slit diffraction pattern, plane diffraction grating, resolving power.

[Sections 18.1 to 18.3, 18.5 to 18.8 of Ajoy Ghatak. Additional problems should be done from chapters 11 and 12 of Introduction to Optics by Frank.L,Pedrotti, Leno M Pedrotti and Leno S Pedrotti.]

5. Fresnel Diffraction **3 Hrs**

Preliminaries, Fresnel half period zones, explanation of rectilinear propagation of light, zone plate [Sections 20.1 to 20.3 of Ajoy Ghatak]

Unit 4 **8 Hrs**

6. Polarization

Huygene's explanation of double refraction, positive and negative uniaxial crystals, quarter and half wave plates, types of polarized light, production and analysis of plane, circularly and elliptically polarized light, optical activity, Laurentz half shade polarimeter

[Sections 20.9,20.17 to 20.20,20.24 of Brijlal, Subramaniyam, & Avadhanulu and corresponding sections of Ajoy Ghatak]

Unit 5 **6 Hrs**

7. Holography

Principles of holography, theory of construction and reconstruction of Hologram, Applications of Holography. [Sections 23.1 to 23.6 of Brijlal, Subramaniyam & Avadhanulu and Sections 21.1 to 21.4 of Ajoy Ghatak]

Unit 6 **8 Hrs**

8. Fibre Optics

Optical fibre, Numerical aperture, step index fibre, pulse dispersion, graded index fibre, fibre optic sensors.

[Sections 27.4, 27.7, 27.10, 27.12 of Ajoy Ghatak and corresponding sections from Brijlal, Subramaniyam, & Avadhanulu]

Books of study:

1. Optics by Ajoy Ghatak – 4th edition
2. Optics by Subramaniam, Brijlal&Avadhanulu – 2018(Reprint)
3. Introduction to Optics by Frank.L,Pedrotti,Leno M Pedrotti and Leno S Pedrotti

Reference Books :

1. Optics – EugineHetch and A RGanesan
2. Optics by D S Mathur– New edition
3. Wave Optics and its Applications – Rajpal S Sirohi – Orient Longman
4. Optical Communications – M MukundaRao – Universities Press
5. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Fermat's Principle, verification of laws of reflection and refraction Refraction and reflection by spherical surfaces	7
2	Interference by division of wave front	9
3	Interference by division of amplitude	12
4	Fraunhofer Diffraction	15
5	Fresnel Diffraction	4
6	Polarization	12
7	Holography	9
8	Fibre Optics	11
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 5 Core Course –IX

PHY5B09: ELECTRONICS (ANALOG & DIGITAL)

54 Hours (Credit – 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the basic principles of rectifiers and dc power supplies	PSO3	U	C	6
CO2	Understand the principles of transistor	PSO3	U	C	14
CO3	Understand the working and designing of transistor amplifiers and oscillators	PSO3	Ap	C, P	12
CO4	Understand the basic operation of Op – Amp and its applications	PSO3	U	C	6
CO5	Understand the basics of digital electronics	PSO3	U	C	16

Unit 1

1. Semiconductor rectifiers and DC Power supplies 6 Hrs

Preliminaries of rectification- Bridge rectifier- Efficiency- Nature of rectified output- Ripple factor- different types of filter circuits- voltage multipliers- Zener diode- voltage stabilization

[Sections 6.13-6.15, 6.17 - 6.27 of V.K Mehta]

2. Transistors 14 Hrs

Different transistor amplifier configurations:- CB, CE, CC and their characteristics- amplification factors- their relationships- Load line Analysis- Expressions for voltage gain- current gain and power gain of C.E amplifier- cut-off and saturation points- Transistor biasing- Different types of biasing - Base resistor, voltage divider bias method- single stage transistor amplifier circuit- load line analysis- DC and AC equivalent circuits

[Section 8.7 - 8.10, 8.12-8.22, 9.2-9.8, 9.11-9.12, 10.4-10.5, 10.7-10.9 of V K Mehta]

Unit 2

3. Multistage Transistor amplifiers 4 Hrs

R.C coupled amplifier- frequency response and gain in decibels- Transformer coupled Amplifiers -Direct Coupled Amplifier-Comparison [Section 11.1-11.8 of VK Mehta]

4. Feedback Circuits and Oscillators 8 Hrs

Basic principles of feedback- negative feedback and its advantages- positive feedback circuits- Oscillatory Circuits-LC, RC oscillators- tuned collector oscillator- Hartley, Colpitt's, phase shift

oscillators - their expressions for frequency [Sections 13.1-13.5, 14.1 - 14.13 of VK Mehta]

5. Operational amplifier and its applications **6 Hrs**

Differential amplifier (basic ideas only), OP-amp: basic operation, application, inverting, Non-inverting, summing amplifiers, Differentiator integrator [Sections 25.1 – 25.5, 25.16, 25.15-25.17,25.23-25.26, 25.32, 25.34-25.35, 25.37 of VK Mehta]

Unit 3

6. Number systems **6 Hrs**

Binary number system, conversions from one system to another (Binary, octal, Hexa decimal), Binary arithmetic, Compliments and its algebra.
(Sections - 2.2 to 2.8 of Aditya P Mathur).

7. Logic gates and circuits **10 Hrs**

Fundamental gates, Universal gates, De Morgan's theorem, Exclusive OR gate, Boolean relations,

Half adder, Full adder, RS Flip Flop, JK Flip flop

[Sections - 2.2 to 2.4, 3.1 to 3.5, 5.1 to 5.6, 6.3, 6.4, 7.1, 7.3, 7.5, 7.6, 8.2 Malvino & Leach)

Text books for study :

1. Principles of electronics - VK Mehta - 2008 edition (S. Chand)
2. Introduction to Micro Processors - Aditya P Mathur (Tata McGarw Hill)
3. Digital principles and applications - Leach and Malvino (Tata McGraw Hill)

References

1. Electronic Principles by Malvino - (Tata McGraw Hill)
2. Digital Computer Fundamentals (Thomas. C. Bartee)
3. Physics of Semiconductor Devices- Second Edition – Dilip K Roy – Universities Press
4. Digital Fundamentals –Thomas L Floyd – Pearson Education
5. The Art of Electronics-Paul Herowitz & Winfield Hill
6. Digital Technology – Principles and practice by Virendrakumar
7. Electronic Principles and Applications – A B Bhattacharya
8. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Semiconductor rectifiers and DC Power supplies	9
2	Transistors	20
3	Multistage Transistor amplifiers	6
4	Feedback Circuits and Oscillators	12
5	Operational amplifier and its applications	9
6	Number systems	9
7	Logic gates and circuits	14
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 | Core Course X

PHY6B10: THERMODYNAMICS

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the zero and first laws of thermodynamics	PSO2	U	C	14
CO2	Understand the thermodynamics description of the ideal gas	PSO2	U	C	8
CO3	Understand the second law of thermodynamics and its applications	PSO2	U	C, P	12
CO4	Understand the basic ideas of entropy	PSO2	U	C	8
CO5	Understand the concepts of thermodynamic potentials and phase transitions	PSO2	U	C	12

Unit 1 – Zeroth Law and First Law of Thermodynamics **14 Hrs**

Macroscopic point of view – Microscopic point of view – Macroscopic versus Microscopic points of view – Scope of Thermodynamics – Thermal equilibrium and Zeroth Law – Concept of temperature – Ideal-Gas temperature – Thermodynamic equilibrium – Equation of state – Hydrostatic systems – Intensive and extensive coordinates – Work – Quasi-static process – Work in changing the volume of a hydrostatic system – PV diagram – Hydrostatic work depends on the path – Calculation of work for quasi-static processes – Work and Heat – Adiabatic work – Internal energy function – Mathematical formulation of First Law – Concept of Heat – Differential form of the First Law – Heat capacity – Specific heat of water; the Calorie – Quasi-static flow of heat; Heat reservoir

[Sections 1.1 to 1.6, 1.10, 2.1 to 2.3, 2.10, 3.1 to 3.6 and 4.1 to 4.8, 4.10 of Heat and Thermodynamics by Zemansky and Dittman]

Unit 2 – Ideal Gas **8 Hrs**

Equation of state of a gas – Internal energy of a real gas – Ideal gas – Experimental determination of heat capacities – Quasi-static adiabatic process – The microscopic point of view – Kinetic theory of the ideal gas

[Sections 5.1 to 5.5, 5.8 and 5.9 of Heat and Thermodynamics by Zemansky and Dittman]

Unit 3 – Second Law of Thermodynamics **12 Hrs**

Conversion of work into heat and vice versa – Heat engine; Kelvin-Planck statement of the Second Law – Refrigerator; Clausius' statement of the Second Law – Equivalence of Kelvin-Planck and Clausius statements – Reversibility and Irreversibility – Conditions for reversibility – Carnot engine and Carnot cycle – Carnot refrigerator – Carnot's Theorem and corollary – Thermodynamic temperature scale – Absolute zero and Carnot efficiency – Equality of ideal-gas and thermodynamic temperatures

[Sections 6.1, 6.6 to 6.9, 6.14, 7.1 and 7.3 to 7.7 of Heat and Thermodynamics by Zemansky and Dittman]

Unit 4 – Entropy **8 Hrs**

Reversible part of the Second Law – Entropy – Entropy of the ideal gas – TS diagram – Entropy and reversibility – Entropy and irreversibility – Irreversible part of the Second Law – Heat and entropy in irreversible processes – Principle of increase of entropy – Applications of the Entropy Principle – Entropy and disorder – Exact differentials

[Sections 8.1, 8.2, 8.4 to 8.9, 8.11 to 8.14 of Heat and Thermodynamics by Zemansky and Dittman]

Unit 5 – Thermodynamic Potentials and Phase Transitions **12 Hrs**

Characteristic functions – Enthalpy – Joule-Thomson expansion – Helmholtz and Gibbs functions – Condition for an exact differential – Maxwell's relations – TdS equations – PV diagram for a pure substance – PT diagram for a pure substance; Phase diagram – First-order phase transitions and Clausius-Clapeyron equation – Clausius-Clapeyron equation and phase diagrams

[Sections 10.1 to 10.6, 9.1, 9.2, 11.3 and 11.4 of Heat and Thermodynamics by Zemansky and Dittman]

Book of Study :

1. Heat and Thermodynamics, 7thEdn. – Mark W. Zemansky and Richard H. Dittman – McGraw-Hill

Reference Books :

1. Classical and Statistical Thermodynamics – Ashley H. Carter – Pearson, 2012
2. Basic Thermodynamics – Evelyn Guha – Narosa, 2002
3. Heat and Thermodynamics – D. S. Mathur – S. Chand Publishers, 2008
4. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Zeroth Law and First Law of Thermodynamics	20
2	Ideal Gas	12
3	Second Law of Thermodynamic	18
4	Entropy	12
5	Thermodynamic Potentials and Phase Transitions	17
Total Marks *		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 Core Course XI

PHY6B11: STATISTICAL PHYSICS, SOLID STATE PHYSICS, SPECTROSCOPY & PHOTONICS

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the basic principles of statistical physics and its applications	PSO2	U	C	16
CO2	Understand the basic aspects of crystallography in solid state physics	PSO2	U	C	14
CO3	Understand the basic elements of spectroscopy	PSO2	U	C	4
CO4	Understand the basics ideas of microwave and infra red spectroscopy	PSO2	U	C	10
CO5	Understand the fundamental ideas of photonics	PSO2	U	C	10

Unit 1 Statistical Physics **16 Hrs**

Statistical Analysis – Classical versus quantum statistics – Distribution of molecular speeds – Maxwell-Boltzmann distribution – Quantum Statistics – Applications of Bose-Einstein statistics – Blackbody radiation – Applications of Fermi-Dirac statistics

[Sections 10.1 to 10.7 of Modern Physics by Kenneth Krane]

Unit 2 Solid State Physics **14 Hrs**

Lattice Points and Space Lattice-Basis and crystal structure, unit cells and lattice Parameters, Unit cells versus primitive cells, Crystal systems, Crystal symmetry, Bravais space lattices – Metallic crystal structures – simple cubic, body-centered cubic, face-centered cubic and hexagonal closed packed structure – Other crystal structures – Diamond, Zinc sulphide, Sodium chloride, Caesium chloride – Directions, Planes and Miller indices – Important features of Miller indices – Important planes and directions, distribution of atoms and separation between lattice planes in a cubic crystal – X-Ray diffraction – Bragg's law – Bragg's X-ray spectrometer – Powder crystal method

[Sections 4.1 to 4.7, 4.14 to 4.22 and 5.7 to 5.10 of Solid State Physics by S.O. Pillai**]**

Unit 3 Basic Elements of Spectroscopy **4 Hrs**

Quantization of Energy-Regions of Spectrum-Representation of Spectra-Basic Elements of Practical Spectroscopy-Signal to Noise Ratio-Resolving Power-Width and Intensity of Spectral Transitions

[Sections 1.2 to 1.7 of Fundamentals of Molecular Spectroscopy by Banwell and McCash**]**

Unit 4

Microwave Spectroscopy **5 Hrs**

Rotation of molecules – Rotational spectra – Rigid diatomic molecules – Bond length of CO molecule – Intensities of spectral lines

[Sections 2.1 to 2.3.2 of Fundamentals of Molecular Spectroscopy by Banwell and McCash]

Infra Red Spectroscopy **5 Hrs**

Energy of a diatomic molecule – Simple harmonic oscillator – Anharmonic oscillator – Morse curve – Selection rules and spectra – The spectrum of HCl – Hot bands – Diatomic vibrating rotator – Born-Oppenheimer approximation

[Sections3.1 to 3.2 of Fundamentals of Molecular Spectroscopy by Banwell and McCash]

U**nit 5 Photonics** **10 Hrs**

Interaction of light with matter – Absorption, spontaneous emission, stimulated emission, Einstein coefficients – Einstein relations – Light amplification – condition for stimulated emission to dominate spontaneous emission – condition for stimulated emission to dominate absorption – population inversion – metastable states – components of laser – lasing action – types of laser – Ruby laser, NdYAG laser, He-Ne laser, semiconductor laser – Applications – Raman effect – Classical explanation – quantum theory

[Sections 22.4 to 22.9, 22.14, 22.15, 22.19 and 22.20 of Textbook of optics by Brijlal, Subramanium & Avadhanulu]

Books of Study:

1. Solid State Physics, 3rd Edn. – S. O. Pillai – New Age International Pvt. Ltd.

2. Fundamentals of Molecular Spectroscopy, 4th Edn. – Colin N. Banwell and Elaine M. McCash – McGraw-Hill

3. A Text Book of Optics, 25thEdn. – Subrahmanyam and Brijlal, S. Chand & Company Ltd., 2016

ReferenceBooks :

1. Solid State Physics by M A Wahab

2. Molecular Structure & Spectroscopy by G Aruldhas

3. Introduction to Molecular Spectroscopy by G M Barrow

4. Raman Spectroscopy by Long D A

5. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Statistical Physics	23
2	Solid State Physics	21
3	Basic Elements of Spectroscopy	6
4	Microwave Spectroscopy	7
5	Infra Red Spectroscopy	7
6	Photonics	15
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 Core Course XII

PHY6B12: NUCLEAR PHYSICS AND PARTICLE PHYSICS

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the basic aspects of nuclear structure and fundamentals of radioactivity	PSO2	U	C	14
CO2	Describe the different types of nuclear reactions and their applications	PSO2	U	C, P	12
CO3	Understand the principle and working of particle detectors	PSO2	U	C, P	8
CO4	Describe the principle and working of particle accelerators	PSO2	U	C, P	8
CO5	Understand the basic principles of elementary particle physics	PSO2	U	C	12

Unit 1

1. Nuclear Structure and Radioactivity **14 Hrs**

Nuclear Constituents – Nuclear sizes and shapes – Nuclear masses and binding energies – Liquid drop model – Shell model - Nuclear force – Radioactive decay – Conservation laws in radioactive decay – Alpha decay – Beta decay – Gamma decay – Natural radioactivity – Mossbauer effect

[Sections 12.1 to 12.11 of Modern Physics by Kenneth Krane; Sections 11.5, 11.6 of Beiser]

2. Nuclear Reactions and Applications **12 Hrs**

Types of nuclear reactions – Radioisotope production in nuclear reactions – Low-energy reaction kinematics – Fission – Fission reactors – Fusion – Fusion processes in stars – Fusion reactors – Applications of nuclear physics – Neutron activation analysis, Medical radiation physics, Alpha decay applications, Synthetic elements

[Sections 13.1 to 13.6 of Modern Physics by Kenneth Krane]

Unit 2

3. Particle Detectors **8 Hrs**

Particle Detectors – Wilson Cloud Chamber – Bubble Chamber – Ionization Chambers – Proportional Counter – Geiger-Muller Counter – Scintillation Counters and Semiconductor Counters – Spark Chamber – Cerenkov Counter – Neutron Counting – The Photographic Plate.

[Sections 17.1 to 17.11of Atomic and Nuclear Physics – An Introduction by Littlefield and Thorley]

4. Particle Accelerators **8 Hrs**

Particle Accelerators – Cockcroft-Walton Proton Accelerator – Van de Graaff Electrostatic Generator – Linear Accelerator – Lawrence Cyclotron – Synchrocyclotron – Electron Accelerating Machines : Betatron– Electron Synchrotron – Proton Synchrotron – Alternating-Gradient Synchrotron – Intersecting Beam Accelerators – The Growth and Future of Large Accelerating Machines

[Sections 18.1 to 18.12 of Atomic and Nuclear Physics – An Introduction by Littlefield and Thorley]

Unit 3

5. Elementary Particles **12 Hrs**

The four basic forces – Particles and antiparticles – Families of particles – Conservation laws – Particle interactions and decays – Resonance particles – Energetics of particle decays – Energetics of particle reactions – The Quark Model – The Standard Model

[Sections 14.1 to 14.9 of Modern Physics by Kenneth Krane]

Books of study:

1. Modern Physics, 2ndEdn. – Kenneth S. Krane – John Wiley & sons

2. Atomic and Nuclear Physics – An Introduction, 3rdEdn. – T.A. Littlefield and N. Thorley – Springer

3. Concepts of Modern Physics, 7thEdn. – Arthur Beiser – Tata McGraw-Hill

Reference Books:

1. Modern Physics, 3rdEdn. – Raymond A. Serway, Clement J. Moses, Curt A. Moyer – Cengage
2. Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles By R.Eisberg & R. Resnick – John Wiley
3. Theory and Problems in Modern Physics by Gautreau & Savin – Schaum's Outlines Series – TMH
4. Modern Physics for Scientists and Engineers, 2nd Edn. – John R. Taylor, Chris D. Zafiratos, Michael A. Dubson – Prentice-Hall of India Pvt. Ltd
5. Modern Physics, 2nd Edn – Randy Harris – Pearson
6. A practical approach to Nuclear Physics, 1st Edition, K. Muraleedhara Varier- Narosa Publishing House
7. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Nuclear Structure and Radioactivity	20
2	Nuclear Reactions and Applications	18
3	Particle Detectors	12
4	Particle Accelerators	12
5	Elementary Particles	17
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 | Core Course XIII

PHY6B13: RELATIVISTIC MECHANICS AND ASTROPHYSICS

54 Hours (Credit - 3)

	Course Outcome	PSO	CL	KC	Class Sessions allotted
CO1	Understand the fundamental ideas of special relativity	PSO2	U	C	18
CO2	Understand the basic concepts of general relativity and cosmology	PSO2	U	C	8
CO3	Understand the basic techniques used in astronomy	PSO2	U	C	10
CO4	Describe the evolution and death of stars	PSO2	U	C	12
CO5	Describe the structure and classification of galaxies	PSO2	U	C	12

Unit 1

1. Special Relativity **18 Hrs**

The need for a new mode of thought – Michelson-Morley experiment – Postulates of Special Relativity – Galilean transformations – Lorentz transformations – Simultaneity – The order of events : Timelike and spacelike intervals – Lorentz length contraction – The orientation of a moving rod – Time dilation – Muon decay – Role of time dilation in an atomic clock - Relativistic transformation of velocity – Speed of light in a moving medium - Doppler effect – Doppler shift in sound – Relativistic Doppler effect – Doppler effect for an observer off the line of motion – Doppler navigation – Twin paradox – Relativistic Momentum and Energy – Momentum – Velocity dependence of the electron's mass – Energy – Relativistic energy and momentum in an inelastic collision – The equivalence of mass and energy – Massless particles – Photoelectric effect – Radiation pressure of light – Photon picture of the Doppler effect – Does light travel at the velocity of light ? – The rest mass of the photon – Light from a pulsar

[Sections 11.1 to 11.5, 12.1 to 12.6, 13.1 to 13.4 of An Introduction to Mechanics (1stEdn.) by Daniel Kleppner and Robert J. Kolenkow]

Unit 2

2. General Relativity and Cosmology **8 Hrs**

The principle of equivalence – General theory of relativity – Tests of general relativity – Stellar evolution – Nucleosynthesis – White dwarf stars – Neutron stars – Black holes – The expansion

of the universe – Cosmic microwave background radiation – Dark matter – Cosmology and general relativity – The big bang cosmology – Formation of nuclei and atoms – Echoes of the big bang – The future of the universe

[Sections 15.1 to 15.8 and 16.1 to 16.8 of Modern Physics (2nd Edn.) by Kenneth Krane]

Unit 3

3. Basic Tools of Astronomy **10 Hrs**

Stellar distance – Relationship between stellar parallax and distance – Brightness and luminosity – Relationship between Luminosity, brightness and distance – Magnitudes – Apparent magnitude and brightness ratio – Relationship between apparent magnitude and absolute magnitude – Color and temperature of stars – Size and mass of stars – Relationship between flux, luminosity and radius – Star constituents – Stellar spectra – Stellar classification – Hertzsprung-Russell diagram – H-R diagram and stellar radius – H-R diagram and stellar luminosity – H-R diagram and stellar mass

[Sections 1.1 to 1.12 of Astrophysics is Easy : An Introduction for the Amateur Astronomer by Mike Inglis]

4. Stellar Evolution **12 Hrs**

Birth of a Star – Pre-Main-Sequence evolution and the effect of mass – Galactic star clusters – Star formation triggers – The Sun – Internal structure of the sun – Proton-proton chain – Energy transport from the core to the surface – Binary stars – Masses of orbiting stars – Life times of main-sequence stars – Red giant stars - Helium burning – Helium flash – Star clusters, Red giants and the H-R diagram – Post-Main-Sequence star clusters : Globular clusters – Pulsating stars – Why do stars pulsate – Cepheid variables and the period-luminosity relationship – Temperature and mass of Cepheids – Death of stars – Asymptotic giant branch – The end of an AGB star's life – Planetary nebulae – White dwarf stars – Electron degeneracy – Chandrasekhar limit – White dwarf evolution – White dwarf origins – High mass stars and nuclear burning – Formation of heavier elements – Supernova remnants – Supernova types – Pulsars and neutron stars – Black holes

[3.1, 3.2, 3.4 to to 3.15, 3.19 to 3.24 of Astrophysics is Easy : An Introduction for the Amateur Astronomer by Mike Inglis]

5. Galaxies **6 Hrs**

Galaxy types – Galaxy structure – Stellar populations – Hubble classification of galaxies – Observing galaxies – spiral, barred spiral, elliptical, lenticular galaxies – Active galaxies and active galactic Nuclei (AGN) – Gravitational lensing – Hubble's law – Clusters of galaxies

[Sections 4.1 to 4.11 of Astrophysics is Easy : An Introduction for the Amateur Astronomer by Mike Inglis]

Books of Study:

1. An Introduction to Mechanics, 1st Edn. – Daniel Kleppner and Robert J. Kolenkow – McGraw-Hill
2. Modern Physics, 2nd Edn. – Kenneth S. Krane – John Wiley & sons
3. Astrophysics is Easy : An Introduction for the Amateur Astronomer – Mike Inglis – Springer

ReferenceBooks :

1. Introduction to Special Relativity – Robert Resnick – Wiley & Sons
2. Special Relativity – A P French – Viva Books India
3. An introduction to Astrophysics – BaidyanathBasu, PHI
4. Introduction to Cosmology -3rd Edn.–J.V.Narlikar, Cambridge University Press, 2002.
5. Principles of Cosmology and Gravitation – Michael Berry, Overseas Press, 2005.
6. Concepts of Modern Physics – Arthur Beiser, Tata McGraw-Hill
7. The Big and the Small (Vol II) by G. Venkataraman, Universities Press (India)
8. Chandrasekhar and His Limit by G. Venkataramn. Universities Press (India)
9. A Brief History of Time by Stephen Hawking, Bantam Books
10. NPTEL video lectures available online

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Special Relativity	27
2	General Relativity and Cosmology	12
3	Basic Tools of Astronomy	15
4	Stellar Evolution	17
5	Galaxies	8
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 | Core Course XIV (Elective)
PHY6B14 (EL1): BIOMEDICAL PHYSICS
54 Hours (Credit - 3)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Understand the basic principles of biophysics	U	C	14
CO2	Understand the fundamentals of medical instrumentation	U	C	11
CO3	Understand the principles of ultrasound and x-ray imaging	U	C	10
CO4	Understand the basic principles of NMR	U	C	10
CO5	Describe the applications of lasers in medicine	U	C	9

Unit 1 Physical foundations of biophysics 14 Hrs

Free energy, Internal energy, Thermodynamics and Statistical mechanics, Reaction kinetics. *(Sections 4.1 to 4.4 from "Biophysics: An Introduction " by Rodney Cotterlie ,Wiley.)* Transport Processes: Diffusion, Osmosis, Surface tension, Viscosity, thermal conduction. *(Sections 5.1 to 5.3 from "Biophysics: An Introduction " by Rodney Cotterlie ,Wiley .*

Oxidation and reduction, redox potential, examples of redox potential in biological systems. *Sections 4.5 and 9.3 from "Biophysics: An Introduction" by Rodney Cotterlie ,Wiley .*

Membrane Physics: Diffusion through cell membrane, factors affecting diffusion

Membrane potentials: Resting potentials, action potentials, Hodgkin-Huxley model for membrane transport . Donnan equilibrium, Goldman equation.

(Sections 11.1, 11.2, 12.1, 12.2 from "Biophysics: An Introduction" by Rodney Cotterlie ,Wiley . Also refer: Principles of Biomedical engineering by Sundararajan V Madihally , Artech house.

Unit 2 Fundamentals of medical instrumentation 11 Hrs

Physiological systems of the body, sources of biomedical signals, basic medical instrumentation systems, performance, constraints and regulations, intelligent medical instrumentation systems. Origin of bioelectric signals, ECG, EEG, EMG. Recording electrodes and microelectrodes. Transducers and biosensors.

(Sections 1.1 to 1.8, 2.1 to 2.8 & 3.1 to 3.10 from " Handbook of Biomedical Instrumentation", R S Khandpur, Tata Mcgraw Hill)

Unit 3 Ultrasound and X ray medical imaging systems 10 Hrs

Ultrasonic Imaging-properties of ultrasound, modes of ultrasound transmission-pulsed, continuous, pulsed Doppler, ultrasound imaging, ultrasonic diagnosis, ultrasonic transducers.

(Sections 9.2, 9.3 from Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi)

X-rays- Instrumentation for diagnostic X-rays, visualization of X-rays-flouroscopy, X-ray filters, X-ray films, Image intensifiers, Special technique-grid, contrast media, Angiography.

(Sections 14.1 to 14.3 from Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi)

X-ray computed tomography – Computed tomography, basic principle, contrast scale, system components-scanning system, processing unit, viewing part, storage unit, Helical CT scanner.

(Sections 20.1, 20.2 from Handbook of Biomedical Instrumentation by R S Khandpur, Tata Mc GrawHill)

Unit 4 Nuclear medical imaging systems 10 Hrs

Nuclear Medical imaging systems-radio isotopes in medical imaging systems, physics of radioactivity, uptake monitoring equipment, radioisotope rectilinear scanner, gamma camera, Emission computed tomography, Positron emission tomography (PET Scanner)

(Sections 21.1, 21.2 from Handbook of Biomedical Instrumentation by R S Khandpur, Tata Mc GrawHill)

Principles of NMR, Image reconstruction techniques, Basic NMR components, Biological effects of NMR imaging, advantages of NMR imaging .

(Sections 22.1, 22.2, 22.3, 22.4, 22.5 from Handbook of Biomedical Instrumentation by R S Khandpur, Tata Mc GrawHill Publications)

(Reference- Medical Imaging Physics, William Hendee, John Wiley and Sons Publications)

Unit 5 Lasers in medicine 9 Hrs

Special properties of laser beam (coherence, collimation, monochromaticity), laser active medium, focal length of the laser lens, Laser-tissue interactions, Basic principles of Nd-YAG, CO2, and Argon Lasers, An overview of their clinical applications with special reference to Gynecology, pulmonary, neurosurgery, dermatology, ophthalmology. Photodynamic therapy, Laser safety measures.

(Sections of Chapter 1, Chapter 2, Chapter 3, Chapter 5 from Lasers in Medicine - An Introductory Guide, Gregory Absten, Springer Science Publications)

Books of Study

1. Biophysics: An Introduction" by Rodney Cotterlie ,Wiley

2. Handbook of Biomedical Instrumentation", R S Khandpur, Tata Mcgraw Hill

3. "Biomedical Instrumentation and measurement", Leslie Cromwell, Prentice hall of India

4. Lasers in Medicine - An Introductory Guide, Gregory Absten, Springer Science Publications

Books for Reference

1. Medical Physics by J R Cameron and J G Skofonick, Wiley Eastern)
2. The physics of medical imaging by S Webb, Hilger Publications
3. Techniques for radiation dosimetry by K Mahesh and D R Vij, Wiley Eastern Limited
4. Clinical nuclear medicine by Maisey, Britton, Chapman and Hall
5. Ultra sound in Medicine, by F Duck, IOP Publications
6. Medical Instrumentation Application and Design, by John G. Webster, John Wiley and sons, New York
7. Introduction to Biomedical equipment technology, John M. Brown, John Wiley and sons, New York
8. Medical Imaging Physics, W.R.Hendee & E.R.Ritenour, (3rd eds), Mosbey Inc.,

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Physical foundations of biophysics	20
2	Fundamentals of medical instrumentation	16
3	Fundamentals of medical instrumentation	15
4	Nuclear medical imaging systems	15
5	Lasers in medicine	13
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 | Core Course XIV (Elective)

PHY6B14 (EL2): NANOSCIENCE AND TECHNOLOGY

54 Hours (Credit - 3)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Understand the elementary concepts of nanoscience	U	C	6
CO2	Understand the electrical transport mechanisms in nanostructures	U	C	10
CO3	Understand the applications of quantum mechanics in nanoscience	U	C	13
CO4	Understand the fabrication and characterization techniques of nanomaterials	U	C	19
CO5	Enumerate the different applications of nanotechnology	U	C	6

Unit 1: Introduction: 6 Hrs

Length scales in Physics- nanometer- Nanostructures: Zero, One Two and Three dimensional nanostructures (Chapter 3, Text 2)

Band Structure and Density of State at nanoscale: Energy Bands, Density of States at low dimensional structures. (Chapter 3, Text 1)

Unit 2: Electrical transport in nanostructure: 10 Hrs

Electrical conduction in metals, The free electron model. Conduction in insulators/ionic crystals - Electron transport in semiconductors - Various conduction mechanisms in 3D (bulk), 2D(thin film) and low dimensional systems: Thermionic emission, field enhanced thermionic emission (Schottky effect), Field assisted thermionic emission from traps (Poole-Frenkel effect), Arrhenius type activated conduction, Variable range, Hopping conduction, Polaron conduction. (Chapter 4, Text 1)

Unit 3: Introductory Quantum Mechanics for Nanoscience: 13 Hrs

Size effects in small systems, Quantum behaviors of nanometric world: Applications of Schrodinger equation - infinite potential well, potential step, potential box; trapped particle in 3D (nanodot), electron trapped in 2D plane (nanosheet), electrons moving in lD (nanowire, nanorod, nanobelt), Excitons, Quantum confinement effect in nanomaterials (Chapter 5, Text 1)

Unit 4: Growth techniques of nanomaterials (Elementary ideas only): **9 Hrs**

Top down vs bottom up techniques, Lithographic process, Non Lithographic techniques: Plasma arc discharge, sputtering. Evaporation: Thermal evaporation, Electron beam evaporation, Chemical Vapour Deposition (CVD), Pulsed Laser Deposition, Molecular Beam Epitaxy, Sol-Gel Technique, Electro-deposition., Ball-milling. (Chapter 6, Text.1:Sections6.1, 6.2. 6.3, 6.4.1, 6.4.2, 6.4.2.1, 6.4.3, 6.4.3.1. 6.4.3.2, 6.4.4, 6.4.5, 6.4.6,6..7,6.4.8,6.4.9)

Unit 5: Characterisation tools of nanomaterials: 10 Hrs

Scanning Probe Microscopy (SPM): Basic Principles of SPM techniques, details of STM, tunneling current, local barrier height, local density of states. Some applications of STM. (Section 7.1.1- 7.1.3.3, 7.1.3.5, Text 1), General concepts of AFM (Section
7.2.1 - 7.2.4, Text-l), Electron microscopy (7.3.1-7.3.6, Text -1).

Unit 6: Applications of nanotechnology: (Elementary ideas only) **6 Hrs**

Buckminster fullerene, Carbon nanotube, nano diamomd, BN Nanotube, Nanoelectronics - single electron transistor (no derivation), Molecular machine, Nanobiomatrics (Chapter 8, Text 1).Applications of nanomaterials in energy, medicine and environment (Text 2)

Text books:

1. Introduction to Nanoscience & Nanotechnology by K. K. Chattopadhyaya and A. N. Banerjee, Publisher: PHI Learning and Private Limited
2. Nanotechnology, Rakesh Rathi, S Chand & Company, New Delhi

References:

1. Nanoparticle Technology Handbook- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama (Eds.), Elsevier 2007
2. Encyclopaedia of Materials Characterization, Surfaces, Interfaces, Thin Films, Eds. Brundle, Evans and Wilson, Butterworth- Heinmann, 1992
3. Springer Handbook of nanotechnology, Bharat Bhushan (Ed.), Springer-Verlag, Berlin, 2004
4. Nano Science and Technology, VS Muraleedharan and A Subramania, Ane Books Pvt. Ltd, New Delhi
5. A Handbook on Nanophysics, John D, Miller, Dominant Publishers and Distributors, Delhi-51
6. Introduction to Nanotechnology, Charles P Poole Jr. and Frank J Owens, Wiley Students Edition

7. Nano-and micro materials, K Ohno et. a!, Springer International Edition 2009, New Delhi

Mark distribution for setting Question paper.

Unit/ chapter	Title	Marks
1	Introduction	9
2	Electrical transport in nanostructure	15
3	Introductory Quantum Mechanics for Nanoscience	19
4	Growth techniques ofnanomaterials	12
5	Characterisation tools of nanomaterials	15
6	Applications of nanotechnology	9
Total Marks *		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

Semester 6 | Core Course XIV (Elective)
PHY6B14 (EL3): MATERIALS SCIENCE
54 Hours (Credit - 3)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Understand the basic ideas of bonding in materials	U	C	7
CO2	Describe crystalline and non crystalline materials	U	C	8
CO3	Understand the types of imperfections nad diffusion mechanisms in solids	U	C	12
CO4	Describe the different properties of ceramics and polymers	U	C	15
CO5	Describe the different types of material analysis rechniques	U	C	12

Unit 1 **15 Hrs**

Introduction

What is material science, Classification of materials-metals, ceramics, polymers, composites, Advanced materials, smart materials. (Section 1.1 to 1.6 of Callister's Material science and Engineering)

Bonds in materials

Atomic bonding in solids-bonding forces and energies, Primary bonding - Ionic bonding, Covalent bonding, metallic bonding, Secondary bonding- van der waals bonding, fluctuating induced dipole bonds, polar molecule induced dipole bonds, permanent dipole bonds example of anomalous volume expansion of water. (Section 2.5 to 2.8 of Callister's Material science and Engineering)

Crystals

Crystalline and Non Crystalline materials -Single crystals, polycrystals, Anisotropy, metallic crystal structures, atomic packing factors of FCC, BCC, Hexagonal close packed crystal structure, Density computations, Linear and planar densities, polymorphism and allotropy, non crystalline solids. (Section 3.8 to 3.11, 4.2 to 4.9 of Callister's Material science and Engineering)

Unit 2 **12 Hrs**

Imperfections in Solids

Point defects, Vacancies and selfinterstitials, substitutional impurities, atomic point defects-Schottky defect, Frenkel defect, Dislocations-edge and screw dislocations, burgers vector, Interfacial defects-External surfaces, Grain boundaries, twin boundaries, stacking faults, Bulk and volume defects.(Section 5.2 to 5.8 of Callister's Material science and Engineering)

Diffusion in solids

Introduction, Diffusion mechanism, Vacancy diffusion, Interstitial diffusion, Steady state diffusion and Non-steady state diffusion, fick's laws, Factors that influence diffusion-temperature, diffusion species, example of aluminium for IC interconnects. diffusion in ionic and polymeric materials (section 6.1 to 6.8 of Callister's Material science and Engineering)

Unit 3 **15 Hrs**

Ceramics and its properties

Glasses, Glass ceramics, properties, refractories -fire clay and silica refractories, Abrasives, cements, advanced ceramics-optical fibers, ceramic ball bearings, piezo electric ceramics, stress-strain behaviour of ceramics, flexural strength and elastic behaviour.(Section 12.1 to 12.8, 12.11 of Callister's Material science and Engineering)

Polymers and its properties

Different forms of Carbon-Diamond, Graphite, Fullerenes, Carbon nano tubes. (Qualitative aspects only)(Section 4.17 of Callister's Material science and Engineering)

Hydro carbon molecules, polymer molecules, homo polymers and copolymers, molecular weight calculation, linear polymers, branched polymers, cross linked polymers, network polymers, thermo setting and thermo plastic polymers, stress-strain behaviour and viscoelastic deformation of polymers. (Section 13.1 to 13.9, 14.2, 14.3, 14.4 of Callister's Material science and Engineering)

Unit 4 **12 Hrs**

Material Analysis Techniques

Single crystal and powder diffraction techniques with diffractometer, Laue's technique and rotating crystal method, Microscopic techniques-Optical microscopy, electron microscopy, transmission electron microscopy, scanning electron microscopy, Scanning probe microscopy, construction and working of each device, Grain size determination technique. (Section 4.20, 5.12, 5.13 of Callister's Material science and Engineering)

Book for study

1. Material Science and Engineering by William D. Callister, Adapted by R. Balasubramanyam (IIT, Kanpur), Published by Wiley India Pvt Ltd (Reprint 2011)

Book for reference

1. Materials science and engineering- Vth Edn- V Raghavan(PHI)
2. Material science by S.L.Kakani & Amit Kakani, 2nd edition 2010, reprint 2011
3. Material Science & Engineering, R.K. Rajput (Jain Book Agency)
4. Material Science and Engineering, I. P . Singh, & Subhash Chander (Jain Book Agency)

Mark distribution for setting Question paper.

Unit/ chapter	**Title**	**Marks**
1	Unit 1	22
2	Unit 2	18
3	Unit 3	22
4	Unit 4	17
*Total Marks **		79

*****Total marks include that for choice of questions in sections A, B and C in the question paper.

B.Sc PROGRAMME IN PHYSICS (CORE)

PRACTICAL

All centres must arrange sufficient number of apparatus before the Practical Examination. All apparatus must be in proper condition before the Practical examination.

The external practical examination will be conducted at the end of 4^{th} & 6^{th} semesters. At the time of external examination, a student has to produce **certified fair record** with a minimum of **75%** of the experiments, listed in the syllabus. Valuation of the record must be done internally and externally. **A maximum of 1/2 mark can be awarded to an experiment which is neatly recorded.** Total mark for record in external valuation is 10. The principle or the logic and the relevant expressions of the experiment must be shown at the time of examination

Two test papers for practical internals could be conducted by including test papers in any two convenient cycles in the place of an experiment. A batch of students can be evaluated in each class. If there are a total of 4 cycles for a practical course, a test paper each can be included in the 3^{rd} and 4^{th} cycles. If there are a total of 3 cycles for a practical course, a test paper each can be included in the 2^{nd} and 3^{rd} cycles. A model examination can also conducted after completion of all cycles. Internal grade for test papers can be awarded based on the best two performances. Digital balance is allowed for mass measurements.

Number of questions in the question paper shall be 8 for Paper I & II: and 6 from Electronics & 2 from Python programs PAPER- III: out of these a minimum of 75% of the questions are to be set for the examination at a centre.

Semesters 1 to 4 | Core Course V

PHY4B05: PRACTICAL I

36 Hours in each semester (Credit - 5)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Apply and illustrate the concepts of properties of matter through experiments	Ap	P	36
CO2	Apply and illustrate the concepts of electricity and magnetism through experiments	Ap	P	36
CO3	Apply and illustrate the concepts of optics through experiments	Ap	P	36
CO4	Apply and illustrate the principles of electronics through experiments	Ap	P	36

(Any 20 experiments)

1. Young's modulus-non uniform bending-using pin and microscope-(load-extension graph)
2. Young's modulus-Uniform bending-using optic lever
3. Moment of inertia-Flywheel (Calculate percentage error and standard deviation)
4. Moment of Inertia-Torsion Pendulum
5. Rigidity modulus-static torsion
6. Compound pendulum-acceleration due to gravity, Radius of gyration
7. Katers pendulum- Acceleration due to gravity
8. Liquid lens-Refractive index of liquid and glass -a) determine R using a)water& b) Buoy's method
9. Spectrometer-solid prism-Refractive index of the material of the prism , measuring angle of minimum deviation
10. Spectrometer-solid prism- Dispersive power
11. a. Searle's vibration magnetometer- ratio of moments b. Searle's and box type vibration magnetometers-m & Bh.
12. Melde's string arrangement-Frequency, relative density of liquid and solid (both modes)
13. Mirror Galvanometer-figure of merit
14. Potentiometer-calibration of ammeter
15. Ballistic Galvanometer- BG constant using HMS-then find Bh.
16. Ballistic galvanometer-Comparison of capacitance- Desauty's method

17. Spectrometer- i-d curve
18. Verification of Thevenin's theorem and maximum power transfer theorem
19. Lissajous figures – Measurement of frequency and phase shift of sinusoidal signals using CRO
20. Cantilever –scale and telescope /pin and microscope
21. Single slit diffraction using LASER
22. Determination of dielectric constant of liquid/thin sheet
23. Thermo emf measurement using digital multimeters - study of Seebeck effect
24. Thermal conductivity of a good conductor by Searle's method.

Books of Study:

1. Electronics lab manual- K A Navas (vol 1 &2)
2. B.Sc Practical Physics- C L Arora
3. Practical Physics- S L Gupta & V Kumar

Reference Books:

1. Advanced Practical Physics for students – B L Worksnop and H T Flint

Semesters 5-6 | Core Course XV

PHY6B15: PRACTICAL II

72 Hours in each semester (Credit - 5)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Apply and illustrate the concepts of properties of matter through experiments	Ap	P	36
CO2	Apply and illustrate the concepts of electricity and magnetism through experiments	Ap	P	36
CO3	Apply and illustrate the concepts of optics and spectroscopy through experiments	Ap	P	36
CO4	Apply and illustrate the principles of heat through experiments	Ap	P	36

(Any 20 experiments)

1. e/m measurement -Thomson's apparatus
2. Spectrometer-Cauchy's constants
3. Spectrometer-Diffraction Grating-Normal incidence
4. Spectrometer- Diffraction Grating-minimum deviation
5. Spectrometer $i_1 - i_2$ curve
6. Laser-wavelength using transmission grating
7. Spectrometer-Quartz prism-Refractive indices of quartz for the ordinary and extra ordinary rays
8. Newton's rings-wavelength of sodium light
9. Air wedge-angle of the wedge, radius of a thin wire
10. Lee's Disc –thermal conductivity of a bad conductor
11. Potentiometer-calibration low range and high range voltmeters
12. Potentiometer- Reduction factor of TG
13. Variation of field with distance-Circular coil-moment of magnet & Bh
14. Resolving power of grating
15. Carey Foster's bridge-Temperature coefficient of Resistance
16. Conversion of Galvanometer to voltmeter and calibrating using Potentiometer. (Plot using software)
17. Conversion of Galvanometer to ammeter and calibrating using Potentiometer.

18. BG Absolute Capacity
19. BG-High resistance by leakage method
20. Dispersive power of grating
21. Planck's constant using LED's (Minimum 4 nos.)
22. Polarimeter-Specific rotation of sugar solution.
23. Numerical aperture of an optical fibre by semiconductor laser
24. Frequency of AC using Sonometer

Books of Study:

1. Electronics lab manual- K A Navas (vol 1 &2)
2. B.Sc Practical Physics- C L Arora
3. Practical Physics- S L Gupta & V Kumar

Reference Books:

1. Advanced Practical Physics for students – B L Worksnop and H T Flint
2. A practical approach to Nuclear Physics, 1st Edition, K. Muraleedhara Varier- Narosa Publishing House.

Semester 5-6 | Core Course XVI

PHY6B16: PRACTICAL III

72 Hours in each semester (Credit - 5)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Apply and illustrate the principles of semiconductor diode and transistor through experiments	Ap	P	36
CO2	Apply and illustrate the principles of transistor amplifier and oscillator through experiments	Ap	P	36
CO3	Apply and illustrate the principles of digital electronics through experiments	Ap	P	36
CO4	Analyze and apply computational techniques in Python programming	Ap	P	36

Unit: 1 (Any 15 experiments)

1. Construction of full wave a) Centre tapped and b) Bridge rectifiers
2. Characteristics of Zener diode and construction of Voltage regulator.
3. Transistor input, output & transfer characteristics in Common Base Configuration and calculation of current gain.
4. Transistor input, output & transfer characteristics in Common emitter Configuration and calculation of current gain
5. CE Transistor Amplifier-Frequency response.(Design the circuit for a given collector current I_C)
6. Negative feedback amplifier
7. Half adder using NAND gates
8. Full adder using NAND gates-construction & verification
9. LC Oscillator (Hartley or Colpitt's)
10. Phase shift oscillator
11. Operational Amplifier –inverting, non inverting, Voltage follower
12. LCR circuits-Resonance using CRO
13. Construction of basic gates using diodes (AND, OR) & transistors (NOT), verification by measuring voltages
14. Voltage multiplier (doubler, Tripler) (Connections to be realized through soldering. The de-soldering has to be carried out at the end of the experiment.)
15. Multivibrator using transistors.

16. Flip-Flop circuits –RS and JK using IC's
17. Verification of De-Morgan's Theorem using basic gates.
18. Photo diode V-I characteristics. Determine quantum efficiency and responsivity of the PD
19. Study the characteristics of LED (3 colours) and LDR.
20. Wave shaping R-C circuits -integrator and differentiator
21. OPAMP- adder, subtractor

Unit: II Numerical Methods Using Python: Minimum 5 programs to be done.

21. Solution of equations by bisection and Newton-Raphson methods
22. Least square fitting – straight line fitting.
23. Numerical differentiation using difference table.
24. Numerical Integration – Trapezoidal and Simpson's 1/3 rd rule.
25. Taylor series - Sin θ, Cos θ
26. Solution of 1^{st} order differential equation Runge-Kutta method
27. Simulation of freely falling body. Tabulation of position, velocity and acceleration, as function of time.
28. Simulation of projectile – Tabulation of position, velocity and acceleration as a function of time – Plot trajectory in graph paper from tabulated values.

Books of Study:

1. Electronics lab manual- K A Navas (vol 1 &2)
2. B.Sc Practical Physics- C L Arora
3. Practical Physics- S L Gupta & V Kumar
4.Computational Physics, V.K.Mittal, R.C.Verma & S.C.Gupta-Published by Ane Books
5. Introductory methods of numerical analysis, S.S.Shastry , (Prentice Hall ofIndia,1983)
6.Introduction to Python for Engineers and Scientists by Dr.Sandeep Nagar, Apress publications.
7.Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from www.expeyes.in/documents/mapy.pdf

Reference Books:

1. Advanced Practical Physics for students – B L Worksnop and H T Flint

Semester 5-6 | Core Course XVII
Course: PHY6B17(P) – PROJECT
36 Hours in each semester (Credits: 2)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Understand research methodology	U	P	18
CO2	Understand and formulate a research project	C	P	18
CO3	Design and implement a research project	C	P	18
CO4	Identify and enumerate the scope and limitations of a research project	C	P	18

Semester 5-6 | Core Course XVII
PHY6B17(R): RESEARCH METHODOLOGY (In lieu of Project)
36 Hours in each semester (Credits: 2)

	Course Outcome	CL	KC	Class Sessions allotted
CO1	Understand research methodology	U	C, P	18
CO2	Understand the concept of measurement in research	C	C, P	16
CO3	Understand the significance and limitations of experimentation in research	C	C, P	16
CO4	Understand and formulate a research project, ethics and responsibility of scientific research	C	C, P	22

Unit 1 Methodology of Science **18 Hrs** Science as facts, science as generalization, Some distinctions when describing science, Science as a social activity, scientific revolutions and paradigms, Science and pseudo-science, Science and democratic development, The limitations of science-presuppositions, fundamental questions on reality: Rationality, Description, Causality - Prediction and Explanation in science - Mathematics and science, Hypothesis, Theories and laws, Verification, Falsification, Acceptance - Peer Review in Science - Scientific method. *(Sections 2.2.1 to 2.2.5, 2.3.1, 2.4.1, 2.5.1 to 2.5.4, 2.6.1 to 2.6.4, 2.8.1 to 2.8.4, 3.1 to 3.3, 4.1 to 4.4, 7.1 The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited)*

Unit 2 Measurement **16 Hrs**

Processes, Instruments and Operationalization, (Variables and Indicators), Criteria in Measurement, Validity, Reliability, Reproducibility/Replicability, Measurement Error, Potential Sources of Measurement Error, Random and Systematic Errors.

(Sections 5.2.1 to 5.2.2, , 5.2.3, The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited)

Unit 3 Experimentation **16 Hrs**

The Roles and Limitations of Experimentation, Natural Experiments, Manipulative Experiments, Comparative Experiments, Experimentation and Research, Conducting Experiments, Validity and Reliability in Experimentation, Reliability, Epistemological Strategies, Design of Experiments.

[Sections 6.1.1 to 6.1.2, , 6.1.3, 6.2, 6.3, 6.4 *The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited*]

Unit 4 Scientific Method and Design of Research **22 Hrs**

Design

The Scientific Method, Research Design, Components, Research Design and Your Proposal, Purpose of Your Proposal, Proposal Structure, Conceptual Framework (or Literature Review), Research Questions/Hypotheses, Methods/Methodology, Validity, Concluding sections to your proposal,

[Sections 7.1 to 7.2, , 7.2.1, 7.2,2, *The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited*]

Research

Basic, Applied and Evaluation Research, Multidisciplinary and Interdisciplinary Research, The Value of Having Research Skills, Formulating a Research Problem, Research in Relation to Teaching and Publishing. Ethics and Responsibility in Scientific Research, Ethics, Western and Eastern Perspectives on the Source of Ethics, Unethics, Guidelines for Ethical Practices in Research**,** Plagiarism, Integrity of data, Use and misuse of data, Ownership of and access to data, Obligation to report, Conflict of Interest, From Unethics to Ethics in Research, The Responsibility of Scientists and of Science as an Institution

[Sections 9.1, 9.2, , 9.3, 9.4, 9.5, 10.1, 10.2, 10.3, 10.4 The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited]

Book for study

1.The Aims, Practices and Ethics of Science, Peter Pruzan, Springer International Publishing Limited

Reference Books

1. Research Methodology – Methods and Techniques (3rd ed.) by C R Kothari & Gaurav Garg, New Age International Publishers, 2014

2. Research Methodology and Scientific Writing by C George Thomas, Ane Books Pvt. Ltd., 2016