LINGAYA'S VIDYAPEETH
SCHEME OF STUDIES
SESSION: 2021-24

School: School of Basic and Applied Sciences	Batch: 2021-2024
Department: Physics	Year: 1st
Course: B.Sc. Hons. Physics	Semester: 1st

SN	Category	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	PCC	BS-101	Electricity and Magnetism	3	1	0	4	15	25	60	-	-	100
2	GE	BS-103	Algebra	3	1	0	4	15	25	60	-	-	100
3	GE	BS-105	Inorganic Chemistry	3	1	0	4	15	25	60	-	-	100
4	PCC	BS-151	Physics Laboratory-I	0	0	3	2				40	60	100
5	GE	BS-155	Chemistry Laboratory-I	0	0	3	2				40	60	100
6	AECC	HSS-107	English and Communication Skills	2	0	0	2	15	25	60	-	-	100
			Total---->	**12**	**3**	**6**	**18**	**60**	**100**	**240**	**80**	**120**	**600**

School: School of Basic and Applied Sciences	Batch: 2021-2024
Department: Physics	Year: 1st
Course: B.Sc. Hons. Physics	Semester: 2nd

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	PCC	BS-102	Statistical Physics	3	1	0	4	15	25	60	-	-	100
2	GE	BS-104	Calculus	3	1	0	4	15	25	60	-	-	100
3	GE	BS-106	Organic Chemistry	3	1	0	4	15	25	60	-	-	100
4	PCC	BS-152	Physics Laboratory-II	0	0	3	2				40	60	100
5	GE	BS-156	Chemistry Laboratory-II	0	0	3	2				40	60	100
6	AEC	CE-108	Environmental Science & Ecology	2	0	0	2	15	25	60	-	-	100
			Total---->	**12**	**3**	**6**	**18**	**60**	**100**	**240**	**80**	**120**	**600**

School: School of Basic and Applied Sciences														Batch: 2021-2024
Department: Physics														Year: 2nd
Course: B.Sc. Hons. Physics														Semester: 3rd
SN	**Cate-gory**	**Course Code**	**Course Name**	**Periods**			**Credits**	**Evaluation Scheme**					**Subject Total Marks**	
								Theory			**Practical**			
				L	**T**	**P**		**ABQ**	**MSE**	**ESE**	**IP**	**EXP**		
1	PCC	**BPH-201**	**Mathematical Physics-I**	4	0	0	4	15	25	60	-	-	100	
2	PCC	**BPH-203**	**Waves and Optics**	4	0	0	4	15	25	60	-	-	100	
3	PCC	**BPH-205**	**Mechanics**	4	0	0	4	15	25	60	-	-	100	
4	PCC	**BPH-207**	**Thermal physics**	4	0	0	4	15	25	60	-	-	100	
5	SEC	**BPH-209**	**Renewable energy and energy harvesting**	2	0	0	2	15	25	60	-	-	100	
6	PCC	**BPH-251**	**Mathematical Physics lab -I**	0	0	4	2				40	60	100	
7	PCC	**BPH-253**	**Wave optics lab**	0	0	4	2				40	60	100	
8	PCC	**BPH-255**	**Mechanics Lab**	0	0	4	2				40	60	100	
9	PCC	**BPH-257**	**Thermal Physics Lab**	0	0	4	2				40	60	100	
			Total---->	**18**	**0**	**16**	**26**	**75**	**125**	**300**	**160**	**360**	**900**	

School: School of Basic and Applied Sciences														Batch: 2021-2024
Department: Physics														Year: 2nd
Course: B.Sc. Hons. Physics														Semester: 4th
SN	**Cate-gory**	**Course Code**	**Course Name**	**Periods**			**Credits**	**Evaluation Scheme**					**Subject Total Marks**	
								Theory			**Practical**			
				L	**T**	**P**		**ABQ**	**MSE**	**ESE**	**IP**	**EXP**		
1	PCC	**BPH-202**	**Mathematical Physics-II**	4	0	0	4	15	25	60	-	-	100	
2	PCC	**BPH-204**	**Elements of modern physics**	4	0	0	4	15	25	60	-	-	100	
3	PCC	**BPH-206**	**Analog system and applications**	4	0	0	4	15	25	60	-	-	100	
4	PCC	**BPH-208**	**Digital system and applications**	4	0	0	4	15	25	60	-	-	100	
5	SEC	**BPH-210**	**Applied optics**	2	0	0	2	15	25	60	-	-	100	
6	PCC	**BPH-252**	**Mathematical Physics Lab-II**	0	0	4	2				40	60	100	
7	PCC	**BPH-254**	**Elements of modern physics lab**	0	0	4	2				40	60	100	
8	PCC	**BPH-256**	**Analog system and application lab**	0	0	4	2				40	60	100	
9	PCC	**BPH-258**	**Digital system and application lab**	0	0	4	2				40	60	100	
			Total---->	**18**	**0**	**16**	**26**	**75**	**125**	**300**	**160**	**360**	**900**	

School: School of Basic and Applied Sciences															Batch: 2021-2024
Department: Physics															**Year: 3rd**
Course: B.Sc. Hons. Physics															**Semester: 5th**
SN	**Cate-gory**	**Course Code**	**Course Name**	**Periods**			**Credits**	**Evaluation Scheme**					**Subject Total Marks**
								Theory			**Practical**		
				L	**T**	**P**		**ABQ**	**MSE**	**ESE**	**IP**	**EXP**	
1	PCC	**BPH-301**	**Mathematical Physics-III**	4	0	0	4	15	25	60	-	-	100
2	PCC	**BPH-303**	**Quantum Mechanics and applications**	4	0	0	4	15	25	60	-	-	100
3	PCC	**BPH-305**	**Solid State Physics**	4	0	0	4	15	25	60	-	-	100
4	DSE	**BPH-307**	**Physics of devices and communications**	4	0	0	4	15	25	60	-	-	100
5	DSE	**BPH-309**	**Nuclear and particle phyiscs**	5	1	0	6	15	25	60	-	-	100
6	PCC	**BPH-351**	**Mathematical Physics Lab-III**	0	0	4	2				40	60	100
7	PCC	**BPH-353**	**Quantum Mechanics and applications Lab**	0	0	4	2				40	60	100
8	PCC	**BPH-355**	**Solid State Physics Lab**	0	0	4	2				40	60	100
9	DSE	**BPH-357**	**Physics of devices and communications lab**	0	0	4	2				40	60	100
			Total---->	**21**	**1**	**16**	**30**	**75**	**125**	**300**	**160**	**240**	**900**

School: School of Basic and Applied Sciences	**Batch: 2021-2024**
Department: Physics	**Year: 3rd**
Course: B.Sc. Hons. Physics	**Semester: 6th**

S N	**Cate-gory**	**Course Code**	**Course Name**	**Periods**			**Credits**	**Evaluation Scheme**					**Subject Total Marks**
								Theory			**Practical**		
				L	**T**	**P**		**ABQ**	**MSE**	**ESE**	**IP**	**EXP**	
1	PCC	**BPH-302**	**Electromagnetic theory**	4	0	0	4	15	25	60	-	-	100
2	DSE	**BPH-304**	**Experimental Techniques**	4	0	0	4	15	25	60	-	-	100
3	DSE	**BPH-306**	**Nano materials and applications**	4	0	0	4	15	25	60	-	-	100
4	PCC	**BPH-352**	**Electromagnetic theory lab**	0	0	4	2				40	60	100
5	DSE	**BPH-354**	**Experimental Techniques Lab**	0	0	4	2				40	60	100
6	DSE	**BPH-356**	**Nanomaterials and applications lab**	0	0	4	2				40	60	100
7	PROJ	**BPH-358**	**Project**	0	0	12	6					100	100
			Total---->	**12**	**0**	**24**	**24**	**45**	**75**	**180**	**120**	**280**	**700**

Abbreviations:

PCC: Programme Core Course

AECC: Ability Enhancement Compulsory Course

AEC: Ability Enhancement Course

SEC: Skill Enhancement Course

GE: Generic Elective

DSE: Discipline Specific Elective

PROJ: Project

ABQ: Assignment Based Quiz

MSE: Mid Semester Examination

ESE: End Semester Examination

IP: Internal Practical

EXP: External Practical

L: Lecture

T: Tutorial

P: Practical

SEMESTER-I

Course Code BS-101	Subject Name ELECTRICITY AND MAGNETISM (Semester I)	L T P	Cr.
		3+1+0	4

OBJECTIVES: Learn the mathematical methods to solve the problems involving electric potential and fields.
Course OUTCOMES: CO1: Master the mathematical tools to find electric potential and fields. CO2: Learning of important theorems as Gauss theorem. CO3: Calculating the electric fields around conductors. CO4: The use of Coulomb's law and Gauss' law for the electrostatic force.

Unit	Contents	Lectures
I	Vector Calculus : Differentiation of vectors, scalar and vector fields, conservative fields and potentials, line integrals, gradient of a scalar field, divergence of a vector field and divergence theorem, curl of a vector field and its physical significance, Stokes' theorem, combination of grad, div and curl.	8
II	Electric field and electric potential: Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.	14
III	Dielectric properties of matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.	10
IV	Magnetic field: Magnetic force between current elements and definition of Magnetic FieldB. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.	10
V	Electromagnetic induction & ballistic galvanometer: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Energy stored in a Magnetic Field. Behavior of various substances in magnetic fields. Magnetic permeability and susceptibility and their interrelation. Orbital motion of electrons and diamagnetism. Electron spin and paramagnetic. Ferromagnetism. Domain theory of ferromagnetism, magnetization curve, hysterics loss, ferrites.	10

REFERENCE BOOKS:

1. Mathematical Methods in the Physical Sciences: ML Boas, Wiley, 2002.
2. Introduction to Mathematical Physics: C Harper, Prentice Hall of India, 2004.
3. Electricity and Magnetism (Berkley, Phys. Course 2): EM Purcell, Tata McGraw Hill, 1981
4. Elements of Electromagnetics: MNO Sadiku, Oxford University Press, 2001.
5. Electricity and Magnetism: AS Mahajan, AA Rangwala, Tata McGraw Hill, 1988.

Course Code BS-103	Subject Name ALGEBRA (Semester I)	L T P	Cr.
		3+1+0	4

Unit	Contents	Lectures
I	Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.	10
II	Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.	11
III	Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.	11
IV	Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices.	10
V	Subspaces of Rn, dimension of subspaces of Rn and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix, special matrices	10

REFERENCE BOOKS:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007

Course Code BS-105	Subject Name INORGANIC CHEMISTRY (Semester I)	L T P	Cr.
		3+1+0	4

OBJECTIVES:
1. To understand the shapes of different orbitals. 2. To understand different principles for filling electrons. 3. To understand how to draw energy diagrams. 4. To understand how to calculate bond order. 5. To understand how to calculate lattice energy through Born Haber Cycle 4. Why any chemical compound behaves totally different on changing their states only
COURSE OUTCOMES: CO1: Student will evaluate the periodic properties of elements. CO2: To learn and explain electronic structure of atom. CO3: To learn, understand and relate the quantum numbers and atomic orbitals. CO4: Illustrate the explanation of atomic structure.

Unit	Contents	Lecture/ Tutorials/ Tutorials
I	**Atomic Structure:** Bohr's theory; its limitations and atomic spectrum of hydrogen atom; de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ2. Quantum numbers and their significance. Sign of wave functions. Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.	9
II	**Periodicity of Elements I:** s, p, d, f block elements, the long form of periodic table; Discussion of following properties with reference to s and p-block elements: Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Atomic radii (van der Waals) Ionic and crystal radii; Covalent radii (octahedral and tetrahedral)	12
III	**Periodicity of Elements II:** Ionization enthalpy; Successive ionization enthalpies and factors affecting ionization energy; Applications of ionization enthalpy; Electron gain enthalpy; trends of electron gain enthalpy. Electro negativity, Pauling's/Mulliken's/Allred Rachow's and Mulliken-Jaffé's electronegativity scales; Variation of electronegativity with bond order, partial charge, hybridization.	11
IV	**Chemical Bonding and Molecular Structure:** Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation; Born-Haber cycle and its application, Covalent bond: Lewis structure, Valence Bond theory, Bent's rule, concept of resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules; VSEPR theory, covalent character in ionic compounds, polarizing power and polarizability. Ionic character; Semiconductors and insulators, defects in solids.	13
	Oxidation-Reduction: Redox reactions, Standard Electrode Potential and its application to inorganic reactions, Oxidation state, rules for the determination of oxidation states, electrochemical series, applications of electrochemical series.	7

REFERENCE BOOKS:

1. Lee, J.D., Concise Inorganic Chemistry, 5th edn, Blackwell Science, London.
2. Douglas, B.E. and McDaniel, D.H., *Concepts & Models of Inorganic Chemistry,*Oxford,1970
3. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
4. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2007.

Course Code BS-151	Subject Name PHYSICS LABORATORY-I (Semester I)	L T P	Cr.
		0+0+3	2

OBJECTIVES:
The objective of the course General Physics Laboratory is to expose the students of B.Sc. class to experimental techniques in electronics, so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

COURSE OUTCOMES:
CO1: Experimental knowledge of Katter's pendulum.
CO2: Understanding of modulus of rigidity.
CO3: Experimental knowledge coefficient of viscosity.
CO4: Knowledge of gravitation force and its value by using bar pendulum.

S. No.	Practical Description
1.	Use of Vernier calipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Light meter, dry and wet thermometer, TDS/conductivity meter and other measuring instruments based on applications of the experiments. Use of Plumb line and Spirit level.
2.	Determination of 'g' by Katter's pendulum.
3.	To study the variation of period with distance between centre of suspension and centre of gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
4.	Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum (ii) Forced torsional oscillations excited using electromagnet
5.	Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.
6.	To study moment of inertia of a flywheel.
7.	Determination of modulus of rigidity by static method
8.	To determine the Young's modulus by (i) bending of beam using traveling microscope/laser, (ii) Flexural vibrations of a bar.
9.	To study one dimensional collision using two hanging spheres of different materials
10.	Determination of height (of inaccessible structure) using sextant.
11.	Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12.	Determine a high resistance by leakage method using Ballistic Galvanometer.
13.	To determine self-inductance of a coil by Rayleigh's method.
14.	To determine the mutual inductance of two coils by Absolute method.
15.	To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
16.	To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
17.	To determine the value of g using Bar Pendulum.
18.	To determine the height of a building using a Sextant.

REFERENCE BOOKS:

1. A Text Book of Practical Physics: I Prakash, Ramakrishna, Kitab Mahal, 11th ed., 2011.
2. BSc Practical Physics: Geeta Sanon, R. Chand & Co., 1st ed., 2007.
3. BSc Physics Practical – I, II, III: Jain, Sharma, Agarwal, Krishan Prakashan, 2014.
4. B.Sc. Practical Physics: CL Arora, S Chand & Company Ltd., 2010.

Course Code BS-155	Subject Name CHEMISTRY LAB-I (Semester I)	L T P	Cr.
		0+0+3	2

LEARNING OBJECTIVES:
The objective of the course Chemistry Laboratory is to expose the students of B.Sc. class to experimental techniques in surface tension, viscosity and pH meter; so that they can verify some of the things read in theory here or in earlier classes and develop practical understanding.

S. No.	Practical Description
1	**Titrimetric Analysis:** Calibration and use of apparatus Preparation of solutions of different Molarity/Normality of titrants
2	Estimation of carbonate and hydroxide present together in mixture.
3	Determination of viscosity of (i) ethanol (ii) amyl alcohol and (iii) aqueous solution of sugar at room temperature
4	Estimation of free alkali present in different soaps/detergents
5	Determine the surface tension of given solution using drop number method.
6	**Preparation and purification through crystallization or distillation and ascertaining their purity through melting or boiling point**: (i) Phenyl benzoate from phenol and benzoyl chloride (ii) M-dinitrobenzene from nitrobenzene (use 1:2 conc. HNO_3 - H_2SO_4 mixture if fuming HNO_3 is not available). (iii) Picric acid (iv) Aspirin from salicylic acid
7	Crystallization and decolourization of impure naphthalene from ethanol.

REFERENCE BOOKS:

1. O.P. Pandey, D.N. Bajpai& S. Giri, Practical Chemistry, S. Chand & CompanyLtd.
2. B. D. Khosla, V. C. Garg& A. Gulati, *Senior Practical Physical Chemistry,* S. Chand & Co.: New Delhi(2011).

SEMESTER-II

Course Code BS-102	Subject Name STATISTICAL PHYSICS (Semester II)	L T P	Cr.
		3+1+0	4

OBJECTIVES:
The main objective of this course is to familiarize students with Statistical Physics that are essential for solving advanced problems in Statistical thermodynamics.

COURSE OUTCOMES:

CO1: Understanding of basics of Statistical Physics.

CO2: Use of the Maxwell- Boltzmann statistics.

CO3: Use of the Bose-Einstein and Fermi-Dirac Statistics.

CO4: Understanding the ensembles.

Unit	Contents	Lectures
I	Basic Ideas of Statistical Physics: Introduction, Basic ideas of probability and their applications, Macrostates and microstates, Effect of constraints on the system.	11
II	Distribution of n particles in two compartments, deviation from the state of maximum probability, Equilibrium state of a dynamic system, distribution of N distinguishable particles in unequal compartments, Division into cells, Phase space and its division into cells.	10
III	Maxwell-Boltzmann Statistics: Phase space and its division into cells. Three kinds of statistics and their basic approach. Maxwell-Boltzmann Statistics for an ideal gas: Volume in phase space, values of α and β. Experimental verification and graphical depiction of Maxwell-Boltzmann distribution of molecular speeds	11
IV	Isolated System: Micro canonical Ensemble, Closed System : Canonical Ensemble, Open System : Grand Canonical Ensemble Bose-Einstein Statistics : Need for quantum statistics, Bose-Einstein statistics and its application to Black body radiation, photon gas, deductions from Planck's law.	11
V	Fermi-Dirac Statistics: Fermi-Dirac statistics and its application to electron gas, Fermi energy, comparison of M.B., B.E. and F.D. statistics	9

REFERENCE BOOKS:

1. Statistical Physics, Thermodynamics and Kinetic Theory: VS Bhatia, Vishal Pub. Co. Jalandhar, 2003
2. Introduction to Statistical Physics: Kerson Huang Taylor & Francis Inc. 2002
3. An Introduction to Statistical Mechanics and Thermodynamics: Robert H. Swendsen. Oxford University Press Inc. 2012.
4. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
5. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
6. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.

Course Code BS-104	Subject Name CALCULUS (Semester II)	L T P	Cr.
		3+1+0	4

LEARNING OBJECTIVES:

1. Understand the major problems of differential and integral calculus.
2. Appreciate how calculus allows us to solve important practical problems in an optimal way.

Course Outcome

CO1: Calculate limits, derivatives and indefinite integrals of various algebraic and trigonometric functions of a single variable.

CO2: Use the fact that the derivative is the slop of the tangent line to the curve at a given Point.

CO3: Use the properties of limits and the derivative to analyze graphs of various functions of a single variable

CO4: Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life Sciences and a host of other disciplines.

Unit	Contents	Lectures
I	Limit & Continuity :The real line and its geometrical representation; e-δ treatment of limit and continuity; Properties of limit and classification of discontinuities; Properties of continuous functions.	11
II	Differentiability: Successive differentiation; Leibnitz Theorem; Statement of Rolle's Theorem; Mean Value Theorem; Taylor and Maclaurin's Theorems; Indeterminate forms.	10
III	Applications of Differentiation : Asymptotes; Concavity, convexity and points of inflection; Curvature; Extrema; elementry curves, tangent and normal in parametric form; Polar Coordinates.	11
IV	Partial Differentiation: Limits and continuity of functions of two variables; Partial derivatives; Taylor’s theorem and Maclaurin’s Theorem for function of two variable; Maxima and minima for function of two variable.	10
V	Double and triple integrals; Change of order in double integrals. Application of Integration : length of a curve; Arc length as a parameter; Evoute & Envelope; Volumes and surface areas of solids of revolution.	10

REFERENCE BOOKS:

1. Gorakh Prasad, Differential Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
2. Gorakh Prasad, Integral Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
3. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar Inc. New York 1975.
4. Shanti Narayan, Elements of Real Analysis, S. Chand & Company, New Delhi.
5. Shanti Narayan, A Text Book of Vector Calculus, S. Chand & Company, New Delhi.
6. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
7. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Ltd. (Pearson Education), Delhi, 2007.

Course Code BS-106	Subject Name ORGANIC CHEMISTRY-I (Semester II)	L T P	Cr.
		3+1+0	4

OBJECTIVES:
1. Differentiate chiral and achiral molecules. 2. Recognize and draw structural isomers (constitutional isomers), stereoisomers including enantiomers and diastereomers, racemic mixture, and meso compounds. 3. Identify the stereo centers in a molecule and assign the configuration as R or S.
COURSE OUTCOMES: 1. To learn the involvement of reactive intermediates and understand their structure and reactivity. 2. To learn and understand the orbital interactions (Woodward Hoffmann rules) in concerted reactions. 3. To calculate optical purity and enantiomer excess,

Unit	Contents	Lecture/ Tutorials/ Tutorials
I	**Basics Of Organic Chemistry-I:** Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.	13
II	**Basics Of Organic Chemistry-II:** Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.	10
III	**Stereochemistry:** Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.	13
IV	**Chemistry of Aliphatic Hydrocarbons: (i) Carbon-Carbon sigma bonds:** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.	9
V	**Chemistry of Aliphatic Hydrocarbons (ii) Carbon-Carbon pi bonds:** Mechanism of E1 and E2 reactions. Saytzeff and Hofmann eliminations. Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). Diels-Alder reaction.	9

REFERENCE BOOKS:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. Pearson Education).
2. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005

Course Code BS-152	Subject Name PHYSICS LABORATORY-II (Semester II)	L T P	Cr.
		0+0+3	2

OBJECTIVES:
The objective of the course General Physics Laboratory is to expose the students of B.Sc. class to experimental techniques in electronics, so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

COURSE OUTCOMES:
CO1: Understanding of resolving power of prism, telescope, and diffraction grating.
CO2: Experimental knowledge of Newton's ring method.
CO3: Experimental knowledge of resolving power.
CO4: Understanding of the electrical and thermal conductivity.

S. No.	Practical Description
1.	To determine Cauchy's constants and resolving power of a given prism.
2.	To find the refractive index of a given liquid using a prism spectrometer.
3.	To determine the wavelength of sodium light using Newton's rings method.
4.	To find the resolving power and magnification of a telescope.
5.	To find the resolving power and magnification of a diffraction grating.
6.	To study hydrogen/Neon gas discharge tube spectrum using diffraction grating.
7.	To study temperature dependence of refractive index of organic liquid using Abbe's refractometer.
8.	To study the variation of specific rotation of sugar solution with concentration.
9.	To measure power distribution and divergence parameters of He-Ne and Semiconductor Lasers.
10.	Study of G.M. Counter characteristics. Measurements of Background radiation and alpha, beta and gamma rays using natural sources.
11.	To find the first ionization potential of mercury.
12.	To determine the value of Stefan's Constant of radiation
13.	Determination of mechanical equivalent of heat by Calendar and Barne's constant flow method.
14.	To measure the thermal conductivity and thermal diffusivity of a conductor.
15.	To determine thermal conductivity of a bad conductor disc (i) Lees and Chorlton method using steam heating and thermometers (ii) Advance kit involving constant current source for heating and thermocouples for temperature measurements.
16.	Measurement of the electrical and thermal conductivity of copper to determine its Lorentz number.

REFERENCE BOOKS:

1. A Textbook of Practical Physics: I Prakash, Ramakrishna, Kitab Mahal, 11th ed., 2011.
2. BSc Practical Physics: Geeta Sanon, R. Chand & Co., 1st ed., 2007.
3. BSc Physics Practical – I, II, III: Jain, Sharma, Agarwal, Krishan Prakashan, 2014.
4. B.Sc. Practical Physics: CL Arora, S Chand & Company Ltd., 2010.

Course Code	Subject Name CHEMISTRY LABORATORY -II	L T P	Cr.
		0+0+3	2

BS-156	(Semester II)		

OBJECTIVES:
The objective of the course is to present a theory of classical electrodynamics. Thus, Maxwell equations and their consequences are considered in detail. It is concerned with principles of the electromagnetic field theory and the description using Maxwell's equations.

COURSE OUTCOMES:
Understanding of motion of charged particles in electromagnetic fields, principles of the special theory of relativity and invariance of Maxwell equations under the Lorentz transformation and their related problems.

S. No.	Practical Description
1.	**Preparation of the following inorganic compounds** (I) $VO(acac)_2$ (II) Cis-$K[Cr(C_2O_4)_2(H_2O)_2$ (III) $Na[Cr(NH_3)_2(SCN)_4]$ (IV) $K_3[Fe(C_2O_4)_3]$
2.	**Quantitative Analysis** (a) Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe, Ba-Cu etc. involving volumetric and gravimetric methods.
3.	**Spectrophotometric Determinations** 1. Ni by extractive Spectrophotometric method. 2. Fe by Job's method of continuous variations 3. Fe in vitamin tablets 4. Nitrite in water in colorimetric method.
4.	Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
5.	Determination of enthalpy of hydration of copper sulphate.

REFERENCE BOOKS:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

SEMESTER-III

Course Code	Subject Name	L T P	Cr.

BPH-201	Mathematical Physics-I	4-0-0	4

Objective- The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely based on problems, seen and unseen.

Unit-I: Calculus: **(12 Lectures)**
Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor.
Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.
Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Unit-II: Vector Calculus: **(10 Lectures)**
Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.
Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates.

Unit-III: Vector integration **(10 Lectures)**
Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Unit-IV: Orthogonal Curvilinear Coordinates: **(8 Lectures)**
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Unit-V: Probability & Dirac Delta function and its properties: **(10 Lectures)**
Independent random variables: Probability distributions functions, binomial, Gaussian, and Poission, with examples, Mean and Variance.
Definition of Dirac delta function. Representation as limit of Gaussian function and rectangular function. Properties of Dirac delta function.

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7thEdn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning.
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book.

Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Lea

Course Code	Subject Name	L T P	Cr.

BPH-203	Waves and Optics	4-0-0	4

Objectives: The course aims to introduce the basic concepts required for a mathematical description of oscillations and waves, and to provide expertise for solving the differential equations which arise in simple mathematical models for oscillations and waves.

UNIT-I: Motion and oscillations **(10 Lectures)**

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

UNIT-II Superposition of collinear harmonic oscillations **(12 Lectures)**

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

Unit-III: Wave Motion & Velocity of Waves **(13 Lectures)**

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport, Intensity of wave, Water Waves. Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound waves and Laplace's Correction.

Unit-IV: Superposition of Two Harmonic Waves **(12 Lectures)**

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.

Unit-V: Wave Optics **(12 Lectures)**

Interference: Division of amplitude and wavefront. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment, Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light.

Reference Books:

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7thEdn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

Course Code	Subject Name	L T P	Cr.

BPH-205	Mechanics	4-0-0	4

Objectives: To acquire skills allowing the student to identify and apply formulas of optics and wave physics using course literature.

UNIT-1: Wave optics-I **(10 Lectures)**

Interference: Interference of light and its necessary conditions, path & Phase difference for reflected & transmitted rays, Interference in thin films (parallel and wedge-shaped film), Newton's rings. Diffraction: Single, double and N- Slit Diffraction, Diffraction grating, grating spectra, dispersive power, Rayleigh's criterion and resolving power of grating

Unit-II Fundamentals of Dynamics **(10 Lectures)**

Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Unit-III Special Theory of Relativity **(10 Lectures)**

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Kinematics. Transformation of Energy and Momentum. Energy-Momentum Four Vector.

Unit-IV Work Energy and Collisions **(10 Lectures)**

Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

UNIT-V Magnetic & superconducting properties: **(10 Lectures)**

Magnetization, Origin of magnetic moment, Dia, para and ferro magnetism, Langevin's theory for diamagnetic material, Applications of Magnetism. Superconductors: Temperature dependence of resistivity in superconducting materials, Effect of magnetic field (Meissner effect), Temperature dependence of critical field, Type I and Type II superconductors. Applications of Superconductors.

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Course Code	Subject Name	L T P	Cr.

BPH-207	**Thermal Physics**	**4-0-0**	**4**

Objectives: The objective of this course is to develop a working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics and to use this knowledge to explore various applications.

Unit I: Introduction to Thermodynamics **(14 Lectures)**

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Unit II: Second Law of Thermodynamics: **(8 Lectures)**

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit III: Entropy **(10 Lectures)**

Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

Unit IV: Maxwell's Thermodynamic Relations **(10 Lectures)**

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. Kinetic Theory of Gases: Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases

UNIT V: Molecular collisions: **(11 Lectures)**

Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States.

Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

Reference books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Course Code	Subject Name	L T P	Cr.
BPH-209	Renewable energy & Energy Harvesting	4-0-0	4

UNIT-1 Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. (6 Lectures)

UNIT-2 Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. (4 Lectures)

UNIT-3 Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. (6 Lectures)

UNIT-4 Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity
Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power (5 Lectures)

UNIT-5 Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications
Carbon captured technologies, cell, batteries, power consumption
Environmental issues and Renewable sources of energy, sustainability. (5 Lecture)

Reference Books:

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004,
- Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy

Course Code	Subject Name	L T P	Cr.
BPH-251	**Mathematical Physics Lab - I**	**0-0-4**	**2**

Objective: The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single, and double precision arithmetic, underflow & overflow, emphasize the importance of making equations in terms, of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative, errors, Floating point computations
EXP-1 Mat Lab Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
EXP-2 Random number generation	Area of circle, area of square, volume of sphere, value of Pi
Exp-3 Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving α tanα *IIo* $[(\mathrm{Sin}\alpha)/\alpha]^2$ in optics
Exp-4 Interpolation Method	Evaluation of trigonometric function sin, cos, tan . First order differential equation
Exp-5 Solution of ordinary differential equation	Radioactive decay Current in RC, LC Circuits and DC circuits
Exp-6 First order differential equation	Differntial equation describing the motion of a

	pendulum. Differntial equation describing the motion of a pendulum
Exp-7 Programs:	Sum and average of a list of numbers, largest of a given list of number, sorting of numbers in ascending and descending order.
Exp-8 Ploting	Basic curve and their fitting
Exp-9 Roots	Roots of a polynomial, Roots of a Quadratic equation Conversion of Temp

Referred Books:

- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn. , 2007, Cambridge University Press.
- Introduction to Numerical Analysis, S.S. Sastry, 5thEdn. , 2012, PHI Learning Pvt. Ltd.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T. Pang, 2nd Edn.2006, Cambridge Univ. Press

Course Code	Subject Name	L T P	Cr.
BPH-253	Waves & Optics Lab	0-0-4	2

Objective: The aim of this Lab is skill the students with various experiments involved in optical physics.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ 2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.
13. To determine the time period of bar pendulum.
14. To determine the time period of Keters pendulum.

Note: Each student is required to perform at least seven experiments.

Reference Books:

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

Course Code	Subject Name	L T P	Cr.
BPH-255	Mechanics Lab	0-0-4	2

Objective: The aim of this Lab is skill the students with various experiments involved in mechanics.

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine “g” and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
10. To determine the elastic Constants of a wire by Searle’s method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater’s Pendulum.

Reference Books:

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

Course Code	Subject Name	L T P	Cr.
BPH-257	Thermal Physics Lab	0-0-4	2

Objective: The aim of this Lab is skill the students with various experiments involved in thermal physics.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement

Reference Books:

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal,1985, Vani Pub.

SEMESTER-IV

Course Code	Subject Name	L T P	Cr.
BPH-202	Mathematical Physics-II	4-0-0	4

Objectives: The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined based on problems, seen and unseen.

Unit I: Fourier Series **(11 Lectures)** Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series.

UNIT II: Special functions **(10 Lectures)**
Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality.

Unit III: Some Special Integrals **(09 Lectures)** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

UNIT IV: Theory of Errors **(09 Lectures)** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. variables

UNIT V: Partial differential equations **(10 Lectures)** Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.

Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford Universe.

Course Code	Subject Name	L T P	Cr.
BPH-204	Elements of Modern Physics	4-0-0	4

Objectives: Students will apply understanding and skill related to the principles and concepts of modern physics essential for graduate school and/or professional employment in the field.

Unit I: Basics of quantum physics **(10 Lectures)** Planck’s quantum, Planck’s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves., Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

Unit II: Quantum physics **(10 Lectures)** Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude.

Unit III: Quantum physics **(10 Lectures)** Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example. Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

Unit IV: Nuclear Physics **(15 Lectures)** Size and structure of atomic nucleus and its relationship with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi -empirical mass formula and binding energy, Nuclear Shell Model, and magic numbers Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum, Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Unit V: Fission and fusion **(9 Lectures)** Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G. and G.R. Pickrell, 2014, McGraw Hill.
- Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmill.

Course Code	Subject Name	L T P	Cr.
BPH-206	Analog Systems and Applications	4-0-0	4

Objectives: Ability to apply knowledge of mathematics, science and engineering to the solution of complex engineering problems Strong b Ability to design and conduct experiments, analyze, interpret data and synthesize valid conclusions.

Unit I: Semiconductor Diodes **(10lectures)** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in

Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

Unit II: Two-terminal Devices and their Applications **(12lectures)** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Unit III: Amplifiers-I **(10 lecturers)** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

Unit IV: Amplifiers-II **(10 Lectures)** Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Unit V: Applications of Op-Amps **(12 Lectures)** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G. Streetman & S.K. Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S. Salivahanan & N.S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall 2 9
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India

Course Code	Subject Name	L T P	Cr.
BPH-208	Digital Systems and Applications	4-0-0	4

Objectives: In particular, students will be able to explain the elements

of digital system abstractions such as digital representations of information, digital logic, Boolean algebra.

Unit I: Introduction to CRO **(06 Lectures)**

Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

Unit II: Digital Circuits **(12 Lectures)**

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Unit III: Data processing circuits **(12 Lectures)**

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops.Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

Unit IV: Shift registers **(12 Lectures)**

Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

Unit V: Intel 8085 Microprocessor Architecture **(12 Lectures)**

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.

Reference Books:

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw.
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J. Tocci, N.S. Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Course Code	Subject Name	L T P	Cr.
BPH-210	Applied Optics	4-0-0	4

Objectives: To make the student understand the principles of Lasers and to enable the student to explore the field of Holography and Nonlinear optics.

Unit-I: Fiber Optics **(11 lectures)**

Optical fiber modes and configuration, fiber types, Ray optics, representation, Wave equation for Step index fiber, Model equation, modes in step index fiber, Fiber Material fabrication attenuation, Absorption, Scattering losses. Radiative losses, Core & Cladding Losses, Material Dispersion, Wave Guide Dispersion.

Unit II: Basic Laser Theory & Laser Systems **(10 lectures)**

Historical background of laser, Einstein coefficients and stimulated light amplification: population inversion, creation of population inversion in three level & four level lasers. Gas Laser: CO2 laser, Solid State Laser: Host material and its characteristics, doped ions, Nd: YAG laser. Liquid laser: Dye laser, Semiconductor laser.

Unit III: Laser Beam Propagation **(10 lectures)**

Laser beam propagation, properties of Gaussian beam, resonator, stability, various types of resonators, resonator for high gain and high energy lasers, Gaussian beam focusing. Concept of spatial frequency filtering. Fourier transforming property of a thin lens.

Unit IV: Nonlinear Optics & Fourier Optics **(10 lectures)**

Origin of nonlinearity, susceptibility tensor, phase matching, second harmonic generation, methods of enhancement, frequency mixing processes. nonlinear optical materials.

Unit V: Holography **(8 lectures)**

Importance of coherence, resolution, types of hologram, white light reflection, hologram, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructive testing.

Reference Book:

- Principles of lasers- O Svelto
- Solid State Laser Engineering- W Koechner
- Laser- B A Labgyel
- Gas laser- A J Boom
- Methods of Experimental Physics Vol. 15B ed. By C L Tang
- Industrial Application of Lasers – J F Ready

Course Code	Subject Name	L T P	Cr.
BPH-252	Mathematical Physics-II Lab	0-0-4	2

Objectives: The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but based on formulating the problem.

Topics	**Description with Applications**
Introduction to Numerical computation software Scilab, Mat lab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure, window, edit window, Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying. output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2Dand 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems.	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods p Second order differential difference method equation Fixed difference method	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion Second order Differential Equation • Harmonic oscillator (no friction) • Damped Harmonic oscillator • Over damped • Critical damped • Oscillatory • Forced Harmonic oscillator • Transient and

Partial differential equations	• Steady state solution • Solve With the boundary condition at $$x^2\frac{d^2y}{dx^2}-4x(1-x)\frac{dy}{dx}+2(1+x)y=x^3$$ $$x^2\frac{d^2y}{dx^2}-y\frac{1}{2}e^2\frac{dy}{dx}=-\frac{3}{2}e^2-0.5$$ In the range $1\leq x\leq 3$. Plot y and dy/dx against x in the given range on the same graph. Partial Differential Equation • Wave equation • Heat equation • Poisson equation • Laplace equation
Using Scicos / xcos	• Generating square wave, sine wave, saw tooth wave • Solution to harmonic oscillator • Study of beat phenomenon • Phase space plots

Note: Each student is required to perform at least seven experiments.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A.S. Fokas& M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
- Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Course Code	Subject Name	L T P	Cr.
BPH-254	**Elements of Modern Physics Lab**	**0-0-4**	**2**

Objective: the aim of this lab is to familiarize students with various experiments involved in modern physics

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Note: Each student is required to perform at least seven experiments**.**

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11thEdn, 2011,Kitab Mahal

Course Code	Subject Name	L T P	Cr.
BPH-256	Analog Systems and Applications Lab	0-0-4	2

Objective: The aim of this lab is to familiarize students with various experiments involved in analog systems and its applications in physics.

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt`s oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741,351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response

Course Code	Subject Name	L T P	Cr.
BPH-258	Digital Systems and Applications Lab	0-0-4	2

Objectives: Students will be able to explain the elements of digital system abstractions such as digital representations of information, digital logic, Boolean algebra.

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
    a) Addition and subtraction of numbers using direct addressing mode
    b) Addition and subtraction of numbers using indirect addressing mode
    c) Multiplication by repeated addition.

d) Division by repeated subtraction.

e) Handling of 16-bit Numbers.

f) Use of CALL and RETURN Instruction.

g) Block data handling.

h) Other programs (e.g. Parity Check, using interrupts, etc.).

Note: Each student is required to perform at least seven experiment.

REFERENCE BOOKS:

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.

SEMESTER-V

Course Code	Subject Name	L T P	Cr.
BPH-302	Mathematical Physics-III	4-0-0	4

Objectives: The course aims to demonstrate the utility and limitations of a variety of powerful calculation techniques and to provide a deeper understanding of the mathematics underpinning theoretical physics.

Unit-I: Complex Analysis I **(15 Lectures)** Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts.

Unit II: Complex Analysis II **(10 lectures)** Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Unit III: Integral Transforms I **(12 lectures)** Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives. Inverse Fourier transform, Convolution theorem.

Unit IV: Integral transforms II **(10 lectures)** Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. .

Unit V: Laplace Transform **(10 lectures)** LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill

Course Code	Subject Name	L T P	Cr.
BPH-303	Quantum Mechanics & Applications	4-0-0	4

Objective: This course develops concepts in quantum mechanics such that the behavior of the physical universe can be understood from a fundamental point of view. It provides a basis for further study of quantum mechanics. Content will include: Review of the Schrodinger equation, operators, eigenfunctions, compatible observables, infinite well in one and three dimensions, degeneracy; Fourier methods and momentum space; Hermiticity; scalar products of wave functions, completeness relations, matrix mechanics; harmonic oscillator in one and three dimensions; sudden approximation; central potentials, quantization of angular momentum, separation of radial and angular variables, spherical harmonics, hydrogen atom, spin.

Unit-I: Time dependent Schrodinger equation **(10 lectures)** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum, and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Unit-II: Time independent Schrodinger equation **(10 Lectures)** Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

Unit-III: General discussion of bound states in an arbitrary potential **(10 Lectures)** Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle.

Unit-IV: Quantum theory of Hydrogen-like atoms **(12 Lectures)** Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m, s, p, d, shells. Many electron atoms: Pauli's Exclusion Principle. Symmetric &Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Unit-V: Atoms in Electric & Magnetic Fields **(9 Lectures)**
Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

Reference Books:

- A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill.
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Course Code	Subject Name	L T P	Cr.
BPH-305	Solid State Physics	4-0-0	4

Objectives: The aim of this course is to give you an extended knowledge of the principles and techniques of solid-state physics. The course covers the physical understanding of matter from an atomic viewpoint. Topics covered include the structure, thermal and electrical properties of matter. Fundamental theories in solid state physics are introduced and then extended to show the irrelevance to important applications in current -day technology, industry, and research. The course has a theoretical lecture component and makes extensive use of examples and exercises to illustrate the material.

Unit-I: Crystal Structure **(12 Lectures)____**Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

Unit-II: Elementary Lattice Dynamics **(10 Lectures)____**Lattice Vibrations and Phonons: Linear, Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the 34 Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein, and Debye theories of specific heat of solids.

Unit-III: Properties of Matter **(12 lectures)** Magnetic Properties: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.; Dielectric Properties: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. Ferroelectric Properties: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Unit-IV: Elementary band theory **(8 Lectures)_**Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Unit-V: Superconductivity **(8 Lectures)** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid-State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India.
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer. Solid State Physics, Rita John, 2014, McGraw Hill.
- Elementary Solid-State Physics, 1/e M. Ali Omar, 1999, Pearson India.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Course Code	Subject Name	L T P	Cr.
BPH-307	Physics of Devices and Communication	4-0-0	4

Objectives: To understand the basic working of electronic devices and Linear Integrated Circuits. To give an emphasis to the student to know the various semiconductor devices and its working. To give clear understanding of various fabrication techniques of electronic devices. To introduce the basic building blocks of linear integrated circuits.

Unit I: Measurement Science **(10 Lectures)**

Static characteristics of measuring instruments - accuracy, precision sensitivity, non-linerarity, hysteresis - dynamic characteristics - I order and II order instruments - Standards and calibration-errors and error analysis

Unit II: Transducers **(10 Lectures)**

Variable resistance transducers - potentiometer, strain gauge RTD, thermistor, hygrometer-Variable inductance transducers - LVDT - variable relectance accelerometer – variable capacitance transducers for differential pressure, sound, and thickness measurement-piezoelectric transducer – smart transducers.

Unit III: Industrial Instruments **(10 Lectures)**

Temperature measurement - thermocouples, cold-junction compensation for thermocouple, radiation and optical pyrometers - pressure measurements - bourdon gauge, bellows, diaphragme, differential pressure transmitter, vacum gauges, melead gauge, pirani gauge-flow measurement-office meter, venturimeter, electro-magnetic flow meter, ultrasonic flow meter, rotameter positive displacement meters, mass flowmeters.

Unit IV: Fundamentals of Networks **(10 Lectures)**

Dc And Ac Series And Parallel Circuits - Kirchhoffs Law - Network Graph – Matrix Representation- Solution Of Steady State, equations - transients in AC networks-frequency response of RL, RC, RIC series and parallel circuits.

Unit V: Fundamentals Electronics and Bio-Medical Measurements **(10 Lectures)**

Electronics Instruments: BJT, FET and MOSFET voltmerters - solid state multimeter - DMM - audio and Radio frequency signal generators - AM signal generator. Bio-Medical Instruments: Measurement of biological signals - ECG,EEG, EMG - blood pressure and blood flow measurements-defibrillators-pace maker.

Reference Books:

- Electrical Measurements and Measuring Instruments By S. Kamakshaiah, J. Amarnath, Krishna Murthy, Published by I K International Publishing House Pvt. Ltd, 2011.
- Helfrick and Cooper, “Modern Electronic Instrumentation and
- Jones, B.E., “Instrumentation Measurement and Feedback”, Tata McGraw-Hill, 1986.
- Golding, E.W., “Electrical Measurement and Measuring Instruments”, 3rd Edition, Sir
- Issac Pitman and Sons, 1960.
- Buckingham, H. and Price, E.N., “Principles of Electrical Measurements”, 1961.

Course Code	Subject Name	L T P	Cr.
BPH-309	Nuclear & Particle Physics	4-0-0	4

Objectives: Introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems. Provide students with opportunities to develop basic knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts, theories, scientific vocabulary, terminology, conventions, scientific quantities and their determination.

Unit I: Structure of Nuclei and Radioactivity **(12 Lectures)**

Basic Properties of Nuclei: (1) Mass, (2) Radii, (3) Charge, (4) Angular Momentum, (5) Spin, (5) Magnetic Moment (μ), (6) Stability and (7) Binding Energy. Radioactivity: Law of Radioactive Decay. Half-life, Theory of Successive Radioactive Transformations. Radioactive Series, Binding Energy, Mass Formula. α-decay :- Range of α-particles, Geiger-Nuttal law and α-particle Spectra. Gamow Theory of Alpha Decay, β-decay. Energy Spectra and Neutrino Hypothesis, γ-decay :- Origin of γ-rays, Nuclear Isomerism, and Internal Conversion.

Unit II: Nuclear Reactions **(10 Lectures)**

Types of Reactions and Conservation Laws. Concept of Compound and Direct Reaction. Compound Nucleus. Scattering Problem in One Dimension : Reflection and Transmission by a Finite Potential Step. Stationary Solutions, Attractive and Repulsive Potential Barriers, Scattering Cross-section. Reaction Rate. Q-value of Reaction. Fission and Fusion.

Unit III: Nuclear Models and Accelerators **(8 Lectures)**

Liquid Drop Model. Mass formula. Shell Model. Meson Theory of Nuclear Forces and Discovery of Pion. Van de Graaff Generator, Linear Accelerator, Cyclotron, Betatron.

Unit IV: Detectors of Nuclear Radiations **(8 Lectures)**

Interaction of Energetic particles with matter. Ionization chamber. GM Counter. Cloud Chambers. Wilson Cloud Chamber. Bubble Chamber. Scintillation Detectors. Semiconductor Detectors (Qualitative Discussion Only).

Unit V: Elementary Particles **(12 Lectures)**

Cosmic Rays: Nature and Properties, Fundamental Interactions, Classification of Elementary Particles. Particles and Antiparticles. Baryons, Hyperons, Leptons, and Mesons. Elementary Particle Quantum Numbers: Baryon Number, Lepton Number, Strangeness, Electric Charge, Hypercharge and Isospin0. Conservation Laws and Symmetry. Different Types of Quarks and Quark Contents of Spin ½ Baryons. Photons.

Reference Books:

- Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987)
- Concepts of nuclear physics by Bernard L.Cohen.(New Delhi: Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei and particles by R.A. Dunlap. (Singapore: Thomson Asia, 2004).
- Nuclear physics by Irving Kaplan. (Oxford & IBH, 1962).
- Introductory nuclear physics by Kenneth S. Krane. (John Wiley & Sons, 1988)

Course Code	Subject Name	L T P	Cr.
BPH-351	Mathematical Physics Lab-III	0-0-4	2

Objectives: The aim of this lab is to familiarize students with mathematical physics tools along with programming skills.

Experiments: Scilab/C++ based simulations experiments based on Mathematical Physics problems like

Solve differential equations:

$$dy/dx = e^{-x} \text{ with } y = 0 \text{ for } x = 0$$
$$dy/dx + e^{-x}y = x^2$$
$$d^2y/dt^2 + 2\, dy/dt = -y$$
$$d^2y/dt^2 + e^{-t}dy/dt = -y$$

Dirac Delta Function, Evaluate

$$\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx, \quad \text{for } \boldsymbol{\sigma} = 1,\ 0.1,\ 0.01$$

and show it tends to 5.

3. Fourier Series:

Program to sum $\sum_{n=1}^{\infty}(0.2)^n$

Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

$$\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$$

Plot $P_n(x), j_v(x)$

Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. *sinθ,* Given Bessel's function at N

points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

8. Compute the n^{th} roots of unity for *n* = 2, 3, and 4.

Course Code	Subject Name	L T P	Cr.
BPH-353	Quantum Mechanics & Applications Lab	0-0-4	2

Objective: Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{h^2}\left[V(r) - E\right] \text{ where } V(r) = \frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x106 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{h^2}\left[V(r) - E\right]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential.

$$aV(r) = \frac{e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511x106 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass

$$m\frac{d^2y}{dx^2} = A(r)u(r), A(r) = \frac{2m}{h^2}V(r) - E$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2 , k = 100 33 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3} .In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen

$$\frac{d^2y}{dx^2} = A(r)u(r), \qquad A(r) = \frac{2m}{h^2}V(r) - E$$

Where m is the reduced mass of the two-atom system for the Morse potential.

$$V(r) = D\left(e^{-2r} - e^{-r}\right), r = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: m = 940x106 eV/C^2, D = 0.755501 eV, α = 1.44, r_O = 0.131349 Å

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs.

NOTE: Each student is required to perform at least five experiments.

Reference Books:

- Schaum's outline of Programming with C++.J. Hubbard, 2000, McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.

Course Code	Subject Name	L T P	Cr.
BPH-355	Solid State Physics Lab	0-0-4	2

Objectives: The aim of this course is to give you an extended practical knowledge of the principles and techniques of solid-state physics. The course covers the physical understanding of matter from an atomic viewpoint.

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{0}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Note: Each student is required to perform at least five experiments.

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Textbook of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Course Code	Subject Name	L T P	Cr.
BPH-357	**Physics of Devices and Communication lab**	**0-0-4**	**2**

Experiments from both Section A and Section B:
Section-A
1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Section-B:
SPICE/MULTISIM simulations for electrical networks and electronic circuits
1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of given cutoff frequency
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

Reference Books:

- Basic Electronics:A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller,1994, Mc-Graw Hill
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics : Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.
- Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
- PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

SEMESTER-V

Course Code	Subject Name	L T P	Cr.
BPH-301	Mathematical Physics-III	4-0-0	4

Objectives: The course aims to demonstrate the utility and limitations of a variety of powerful calculation techniques and to provide a deeper understanding of the mathematics underpinning theoretical physics.

Unit-I: Complex Analysis I **(15 Lectures)** Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts.

Unit II: Complex Analysis II **(10 lectures)** Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Unit III: Integral Transforms I **(12 lectures)** Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives. Inverse Fourier transform, Convolution theorem.

Unit IV: Integral transforms II **(10 lectures)** Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat

Flow Equations. Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. .

Unit V: Laplace Transform **(10 lectures)** LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill

Course Code	Subject Name	L T P	Cr.
BPH-303	Quantum Mechanics & Applications	4-0-0	4

Objective: This course develops concepts in quantum mechanics such that the behavior of the physical universe can be understood from a fundamental point of view. It provides a basis for further study of quantum mechanics. Content will include: Review of the Schrodinger equation, operators, eigenfunctions, compatible observables, infinite well in one and three dimensions, degeneracy; Fourier methods and momentum space; Hermiticity; scalar products of wave functions, completeness relations, matrix mechanics; harmonic oscillator in one and three dimensions; sudden approximation; central potentials, quantization of angular momentum, separation of radial and angular variables, spherical harmonics, hydrogen atom, spin.

Unit-I: Time dependent Schrodinger equation **(10 lectures)** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum, and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Unit-II: Time independent Schrodinger equation **(10 Lectures)** Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

Unit-III: General discussion of bound states in an arbitrary potential **(10 Lectures)** Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle.

Unit-IV: Quantum theory of Hydrogen-like atoms **(12 Lectures)** Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m, s, p, d, shells. Many electron atoms: Pauli's Exclusion Principle. Symmetric &Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Unit-V: Atoms in Electric & Magnetic Fields **(9 Lectures)**
Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

Reference Books:

- A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill.
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Course Code	Subject Name	L T P	Cr.
BPH-305	Solid State Physics	4-0-0	4

Objectives: The aim of this course is to give you an extended knowledge of the principles and techniques of solid-state physics. The course covers the physical understanding of matter from an atomic viewpoint. Topics covered include the structure, thermal and electrical properties of matter. Fundamental theories in solid state physics are introduced and then extended to show the irrelevance to important applications in current -day technology, industry, and research. The course has a theoretical lecture component and makes extensive use of examples and exercises to illustrate the material.

Unit-I: Crystal Structure **(12 Lectures)**____Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

Unit-II: Elementary Lattice Dynamics **(10 Lectures)**____Lattice Vibrations and Phonons: Linear, Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the 34 Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein, and Debye theories of specific heat of solids.

Unit-III: Properties of Matter **(12 lectures)** Magnetic Properties: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.; Dielectric Properties: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. Ferroelectric Properties: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Unit-IV: Elementary band theory **(8 Lectures)** Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Unit-V: Superconductivity **(8 Lectures)** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid-State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India.
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer. Solid State Physics, Rita John, 2014, McGraw Hill.
- Elementary Solid-State Physics, 1/e M. Ali Omar, 1999, Pearson India.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Course Code	Subject Name	L T P	Cr.
BPH-307	Physics of Devices and Communication	4-0-0	4

Objectives: To understand the basic working of electronic devices and Linear Integrated Circuits. To give an emphasis to the student to know the various semiconductor devices and its working. To give clear understanding of various fabrication techniques of electronic devices. To introduce the basic building blocks of linear integrated circuits.

Unit I: Measurement Science **(10 Lectures)**
Static characteristics of measuring instruments - accuracy, precision sensitivity, non-linerarity, hysteresis - dynamic characteristics - I order and II order instruments - Standards and calibration-errors and error analysis

Unit II: Transducers **(10 Lectures)**

Variable resistance transducers - potentiometer, strain gauge RTD, thermistor, hygrometer-Variable inductance transducers - LVDT - variable relectance accelerometer – variable capacitance transducers for differential pressure, sound, and thickness measurement-piezoelectric transducer – smart transducers.

Unit III: Industrial Instruments **(10 Lectures)**

Temperature measurement - thermocouples, cold-junction compensation for thermocouple, radiation and optical pyrometers - pressure measurements - bourdon gauge, bellows, diaphragme, differential pressure transmitter, vacum gauges, melead gauge, pirani gauge-flow measurement-office meter, venturimeter, electro-magnetic flow meter, ultrasonic flow meter, rotameter positive displacement meters, mass flowmeters.

Unit IV: Fundamentals of Networks **(10 Lectures)**

Dc And Ac Series And Parallel Circuits - Kirchhoffs Law - Network Graph – Matrix Representation- Solution Of Steady State, equations - transients in AC networks-frequency response of RL, RC, RIC series and parallel circuits.

Unit V: Fundamentals Electronics and Bio-Medical Measurements **(10 Lectures)**

Electronics Instruments: BJT, FET and MOSFET voltmerters - solid state multimeter - DMM - audio and Radio frequency signal generators - AM signal generator. Bio-Medical Instruments: Measurement of biological signals - ECG,EEG, EMG - blood pressure and blood flow measurements-defibrillators-pace maker.

Reference Books:

- Electrical Measurements and Measuring Instruments By S. Kamakshaiah, J. Amarnath, Krishna Murthy, Published by I K International Publishing House Pvt. Ltd, 2011.
- Helfrick and Cooper, “Modern Electronic Instrumentation and
- Jones, B.E., “Instrumentation Measurement and Feedback”, Tata McGraw-Hill, 1986.
- Golding, E.W., “Electrical Measurement and Measuring Instruments”, 3rd Edition, Sir
- Issac Pitman and Sons, 1960.

- Buckingham, H. and Price, E.N., “Principles of Electrical Measurements”, 1961.

Course Code	Subject Name	L T P	Cr.
BPH-309	**Nuclear & Particle Physics**	**4-0-0**	**4**

Objectives: Introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems. Provide students with opportunities to develop basic knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts, theories, scientific vocabulary, terminology, conventions, scientific quantities and their determination.

Unit I: Structure of Nuclei and Radioactivity **(12 Lectures)**

Basic Properties of Nuclei: (1) Mass, (2) Radii, (3) Charge, (4) Angular Momentum, (5) Spin, (5) Magnetic Moment (μ), (6) Stability and (7) Binding Energy. Radioactivity: Law of Radioactive Decay. Half-life, Theory of Successive Radioactive Transformations. Radioactive Series, Binding Energy, Mass Formula. α-decay :- Range of α-particles, Geiger-Nuttal law and α-particle Spectra. Gamow Theory of Alpha Decay, β-decay. Energy Spectra and Neutrino Hypothesis, γ-decay :- Origin of γ-rays, Nuclear Isomerism, and Internal Conversion.

Unit II: Nuclear Reactions **(10 Lectures)**

Types of Reactions and Conservation Laws. Concept of Compound and Direct Reaction. Compound Nucleus. Scattering Problem in One Dimension : Reflection and Transmission by a Finite Potential Step. Stationary Solutions, Attractive and Repulsive Potential Barriers, Scattering Cross-section. Reaction Rate. Q-value of Reaction. Fission and Fusion.

Unit III: Nuclear Models and Accelerators **(8 Lectures)**

Liquid Drop Model. Mass formula. Shell Model. Meson Theory of Nuclear Forces and Discovery of Pion. Van de Graaff Generator, Linear Accelerator, Cyclotron, Betatron.

Unit IV: Detectors of Nuclear Radiations **(8 Lectures)**

Interaction of Energetic particles with matter. Ionization chamber. GM Counter. Cloud Chambers. Wilson Cloud Chamber. Bubble Chamber. Scintillation Detectors. Semiconductor Detectors (Qualitative Discussion Only).

Unit V: Elementary Particles **(12 Lectures)**

Cosmic Rays: Nature and Properties, Fundamental Interactions, Classification of Elementary Particles. Particles and Antiparticles. Baryons, Hyperons, Leptons, and Mesons. Elementary Particle Quantum Numbers: Baryon Number, Lepton Number, Strangeness, Electric Charge, Hypercharge and Isospin0. Conservation Laws and Symmetry. Different Types of Quarks and Quark Contents of Spin ½ Baryons. Photons.

Reference Books:

- Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987)
- Concepts of nuclear physics by Bernard L.Cohen.(New Delhi: Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei and particles by R.A. Dunlap. (Singapore: Thomson Asia, 2004).
- Nuclear physics by Irving Kaplan. (Oxford & IBH, 1962).
- Introductory nuclear physics by Kenneth S. Krane. (John Wiley & Sons, 1988)

Course Code	Subject Name	L T P	Cr.
BPH-351	Mathematical Physics-III Lab	0-0-4	2

Objectives: The aim of this lab is to familiarize students with mathematical physics tools along with programming skills.

Experiments: Scilab/C++ based simulations experiments based on Mathematical Physics problems like

Solve differential equations:

$$dy/dx = e^{-x} \text{ with } y = 0 \text{ for } x = 0$$
$$dy/dx + e^{-x}y = x^2$$
$$d^2y/dt^2 + 2\,dy/dt = -y$$
$$d^2y/dt^2 + e^{-t}dy/dt = -y$$

Dirac Delta Function, Evaluate

$$\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx, \quad \text{for } \sigma = 1,\ 0.1,\ 0.01$$

and show it tends to 5.

3. Fourier Series:

Program to sum $\sum_{n=1}^{\infty}(0.2)^n$

Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

$$\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$$

Plot $P_n(x), j_\nu(x)$

Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. *sinθ,* Given Bessel's function at N

points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

8. Compute the n^{th} roots of unity for n = 2, 3, and 4.

Course Code	Subject Name	L T P	Cr.
BPH-353	Quantum Mechanics & Applications Lab	0-0-4	2

Objective: Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

2. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{h^2}V(r) - E \text{ where } V(r) = \frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x106 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r)= \frac{2m}{h^2}V(r) - E$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential.

$$aV(r)= \frac{e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511x106 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass

$$m\frac{d^2y}{dx^2} = A(r)u(r), A(r) = \frac{2m}{h^2}V(r) - E$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 33 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3} .In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen

$$\frac{d^2y}{dx^2} = A(r)u(r), \qquad A(r) = \frac{2m}{h^2}V(r) - E$$

Where m is the reduced mass of the two-atom system for the Morse potential.

$$V(r) = D\left(e^{-2r} - e^{-r}\right), r = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: m = 940x106 eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Laboratory based experiments:

8. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
9. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
10. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs.

NOTE: Each student is required to perform at least five experiments.

Reference Books:

- Schaum's outline of Programming with C++.J. Hubbard, 2000, McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.

Course Code	Subject Name	L T P	Cr.
BPH-355	Solid State Physics Lab	0-0-4	2

Objectives: The aim of this course is to give you an extended practical knowledge of the principles and techniques of solid-state physics. The course covers the physical understanding of matter from an atomic viewpoint.

11. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
12. To measure the Magnetic susceptibility of Solids.
13. To determine the Coupling Coefficient of a Piezoelectric crystal.
14. To measure the Dielectric Constant of a dielectric Materials with frequency
15. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
16. To determine the refractive index of a dielectric layer using SPR
17. To study the PE Hysteresis loop of a Ferroelectric Crystal.
18. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
19. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{0}C) and to determine its band gap.

20. To determine the Hall coefficient of a semiconductor sample.

Note: Each student is required to perform at least five experiments.

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Textbook of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Course Code	Subject Name	L T P	Cr.
BPH-322	Physics of Devices and Communication Lab	0-0-4	2

Experiments from both Section A and Section B:

Section-A

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.

11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Section-B:

SPICE/MULTISIM simulations for electrical networks and electronic circuits

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of given cutoff frequency
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

Reference Books:

- Basic Electronics:A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller,1994, Mc-Graw Hill
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics : Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.
- Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
- PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

SEMESTER-VI

Course Code	Subject Name	L T P	Cr.
BPH-302	Electro-Magnetic Theory	4-0-0	4

OBJECTIVE: Main objective to study this course is to have a clean understanding of electromagnetic theory.

Unit-I: Maxwell Equations **(12 Lectures)**

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density

Unit-II: EM Wave Propagation in Unbounded Media **(10 Lectures)**

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

Unit-III: EM Wave in Bounded Media **(10 Lectures)**
Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).

Unit-IV: Polarization of Electromagnetic Waves **(10 Lectures)**

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light. Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

Unit-V: Wave Guides & Optical Fibres **(10 Lectures)**

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Reference Books:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning.
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill.
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning.
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.

Course Code	Subject Name	L T P	Cr.
BPH-304	Experimental techniques	4-0-0	4

Objective: Main objective to study this course is to have a clean understanding of experimental techniques.

Unit-I
Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. **(5 Lectures)**

Unit-II
Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise.
Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. **(6 Lectures)**

Unit-III
Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. **(7 Lectures)**

Unit-IV
Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. Impedance Bridges and Q-meter**:** Block diagram and working principles of RLC bridge.

Q-meter and its working operation. Digital LCR bridge. **(4 Lectures)**

Unit-V

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization). **(4 Lectures)**

Reference Books:

- Measurement, Instrumentation and Experiment Design in Physics and Engineering,
- M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI
- Learning Pvt. Ltd.
- Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
- Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata
- McGraw Hill
- Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

Course Code	Subject Name	L T P	Cr.
BPH-306	Nano-Materials and Applications	4-0-0	4

OBJECTIVE: Main objective to study this course is to have a clean understanding of nano-materials and technology.

Unit I: Nanomaterials and Nanotechnology **(10 lectures)**

Basic concepts of Nano science and technology – Quantum wire – Quantum well – Quantum dot – Properties and technological advantages of Nanomaterials– Carbon Nanotubes and applications – Material processing by Sol – Gel method, Chemical Vapour deposition and Physical Vapour deposition – Microwave Synthesis of materials – Principles of SEM, TEM and AFM.

Unit II: Nanostructures **(10 lectures)**

Electronic Structure of Nanoparticles- Kinetics in Nanostructured Materials- Zero dimensional, one-dimensional and two-dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanostructured beams, and nanocomposites-artificial atomic clusters-Size dependent properties-size dependent absorption spectra-phonons in nanostructures.

Unit III: Physical Properties of Nanomaterials **(10 lectures)**

Melting point and phase transition processes- quantum-size-effect (QSE). Size-induced metal-insulator-transition (SIMIT)- nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials chemical physics of atomic and molecular clusters.

Unit IV: Surface and Micro-structural Properties of Nanomaterials **(10 lectures)**

Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization-surface charge density-electric potential at the proximity of solid surface-Van der Waals attraction potential. Micro-structural Properties: Properties slightly dependent on temperature and grain size; properties strongly dependent on temperature and grain size; strengthening mechanisms; enhancement of available plasticity; grain size evolution and grain size control; Hall Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials.

Unit V: Applications of Nanomaterials **(10 lectures)**

Solar energy conversion and catalysis, Molecular electronics and printed electronics Nanoelectronics, Polymers with a special architecture, Liquid crystalline systems, Linear and nonlinear optical and electrooptical properties, Applications in displays and other devices, Advanced organic materials for data storage, Photonics, Plasmonics ,Chemical and biosensors, Nanomedicine and Nanobiotechnology.

Reference Books:

- Joel I. Gersten, "The Physics and Chemistry of Materials", Wiley, 2001.
- A. S. Edelstein and R. C. Cammarata, "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Pub., 1998.
- Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002
- S.Yang and P.Shen: "Physics and Chemistry of Nanostructured Materials", Taylor & Francis, 2000.

Course Code	Subject Name	L T P	Cr.
BPH-352	Electro-Magnetic Theory Lab	0-0-4	2

OBJECTIVE: Main objective to study this course is to have a clean understanding of electromagnetic theory.

Experiments:

1. To verify the law of Malus for plane polarized light.

2. To determine the specific rotation of sugar solution using Polarimeter.

3. To analyze elliptically polarized Light by using a Babinet's compensator.

4. To study dependence of radiation on angle for a simple Dipole antenna.

5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

6. To study the reflection, refraction of microwaves

7. To study Polarization and double slit interference in microwaves.

8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

11. To verify the Stefan`s law of radiation and to determine Stefan's constant.

12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Note: Each student is required to perform at least seven experiments.

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia, Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Course Code	Subject Name	L T P	Cr.
BPH-354	Experimental techniques Lab	0-0-4	2

OBJECTIVE: Main objective to experimental knowledge of synthesis and characterization of various experimental techniques in physics.

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.

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5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter.

Course Code	Subject Name	L T P	Cr.
BPH-356	**Nano-Materials and Applications Lab**	**0-0-4**	**2**

OBJECTIVE: Main objective to experimental knowledge of synthesis and characterization of nano-materials.

1. Synthesis of Silver Nanoparticles by Chemical reduction method and their UV-VIS absorption studies.
2. Synthesis of Gold Nanoparticles with different morphology by Chemical reduction method and UV-Vis absorption studies.
3. Synthesis of Iron Oxide Nanoparticles by Polyol method and their UV-VIS absorption studies.
4. Synthesis of Gold Nanoparticles by Polyol method and their SPR studies.
5. Synthesis of TiO_2 Nanoparticles by Sol-Gel Method and Characterize using XRD and SEM analysis.
6. Synthesis of Ceria Nanoparticles and Characterize using XRD and SEM analysis.
7. X-ray diffraction studies of synthesised of TiO_2 nanoparticles and measuring the crystallite size.
8. Synthesis of ZnSe Nanoparticles by Co-Precipitation Method.
9. SERS studies of Gold nanoparticles
10. Synthesis of Quantum dots and Photoluminescence studies.
11. Nanofluids preparation and characterization
12. $Al2O_3$ Nanotemplate by anodization method and Tubes fabrication
13. Fabrication of thin films by Sputtering, Electron beam and Spray pyrolysis methods.
14. Fabrication of TiO2 nanofibers on ITO glass substrate by Electro-spinning technique. Synthesis of CNTs by CVD method.
15. Nanocrystalline thin film by spin coating.
16. Chemical bath deposition by dip coating.

Reference Books:

- Joel I. Gersten, "The Physics and Chemistry of Materials", Wiley, 2001.
- A. S. Edelstein and R. C. Cammarata, "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Pub., 1998.
- Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002
- S.Yang and P.Shen: "Physics and Chemistry of Nanostructured Materials", Taylor & Francis, 2000.

Course Code	Subject Name	L T P	Cr.
BPH-358	Dissertation/ Project	0-0-12	6

OBJECTIVE: Main objective to study this course is to have a clean understanding of writing project.

1. Identification of a research Topic, reading of relevant literature, Summary of National and International Scenario of course taught.
2. Understanding of the unsolved and unresolved problems in the literature, framing of objectives for dissertation.
3. Assessment about the feasibility of identified objectives within available resources, and fine tuning of objectives for future work.
4. Experimental / computational analysis, data analysis and writing of report.
5. Writing of manuscript and Poster making for presentation in scientific conferences or publication in Journal based on above work.