DEPARTMENT OF PHYSICS
DIBRUGARH UNIVERSITY

SYLLABUS FOR

B.Sc. IN PHYSICS

WITHOUT MAJOR IN ANY DISCIPLINE

Approved by the Board of Studies in Physics

held on March 13 and 28, 2017

Course Structure (Physics-Without Major)

Details of courses under B.Sc. (Without Major)

Course	Credits	
	Theory + Practicals	**Theory+ Tutorial**
1. Core course (12 Papers)		
04 courses from each of 03 discipline of choices	12X4= 48	12X5= 60
Core courses Practical/Tutorial * (12 Practicals/Tutorials)	12X2= 24	12X1= 12
II. Elective Course (6 Papers)		
Two papers from each discipline of choice including paper of interdisciplinary nature	6X4= 24	6X5= 30
Elective Core course Practical/Tutorial * (6 practical/Tutorial *)	6X2= 12	6X1= 6
III. Ability enhancement Courses		
1. Ability enhancement Compulsory (3 Papers of 2 credit each)	3X2= 6	3X2= 6
2. Skill Enhancement Courses (4 Papers of 2 credit each)	4X2= 8	4X2= 8
	Total credit= 122	Total credit= 122

- ❖ **Optional dissertation or project work in place of one Discipline elective paper (6 credit) in 6th semester**
- ❖ **Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.**

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN BSc without Major

Semester	**CORE COURSES (12)**	**Ability Enhancement Compulsory Course (AECC)(3)**	**Skill Enhancement Courses (SEC) (2)**	**Discipline specific electives (DSE) (6)**
I	Mechanics	AECC-1 Communicative English		
	DSC-2A	AECC-2 MIL/ Communicative Hindi/Alternative English		
	DSC-3A			
II	Electricity and Magnetism	AECC-3 Environmental Science		
	DSC-2B			
	DSC-3B			
III	Thermal Physics and Statistical Mechanics		SEC-1: Electrical circuits and Network skills	
	DSC-2C			
	DSC-3C			
IV	Waves and optics		SEC-2: Applied Optics	
	DSC-2D			
	DSC-3D			
V			SEC-3: Basic Instrumentation Skills/Computational Physics Skills	DSE-1A: Digital and Analog Circuits and Instrumentation + Lab / Mathematical Physics + Lab / Nuclear and Particle Physics + Tutorial
				DSE-2A
				DSE-3A
VI			SEC-4: Renewable energy and energy harvesting / Physics Workshop Skills	DSE-1B: Elements of Modern Physics + Lab / Solid State Physics + Lab / Quantum Mechanics + Lab / Dissertation
				DSE-2B
				DSE-3B

- *** Wherever there is a practical there will be no tutorial and vice-versa.**

SEMESTER	COURSE OPTED	COURSE NAME	CREDITS
I	Ability Enhancement compulsory course- I	Communicative English	2
	Ability Enhancement compulsory course- II	MIL/ Communicative Hindi/Alternative English	2
	Discipline Specific Core -1A	Mechanics	4
	Discipline Specific Core -1A Practical/ Tutorial	Mechanics Lab	2
	Discipline Specific Core -2A	DSC-2A	6
	Discipline Specific Core -3A	DSC-3A	6
II	Ability Enhancement compulsory course- III	Environmental Science	2
	Discipline Specific Core -1B	Electricity and Magnetism	4
	Discipline Specific Core -1B Practical/ Tutorial	Electricity and Magnetism Lab	2
	Discipline Specific Core	DSC- 2B	6
	Discipline Specific Core	DSC- 3B	6
III	Discipline Specific Core -1C	Thermal Physics and Statistical Mechanics	4
	Discipline Specific Core -1C Practical/ Tutorial	Thermal Physics and Statistical Mechanics Lab	2
	Discipline Specific Core- 2C	DSC- 2C	6
	Discipline Specific Core -3C	DSC- 3C	6
	Skill Enhancement Course-1	SEC-1	2
IV	Discipline Specific Core -1D	Waves and Optics	4
	Discipline Specific Core -1D Practical/ Tutorial	Waves and Optics Lab	2
	Discipline Specific Core -2D	DSC-2D	6
	Discipline Specific Core -3D	DSC-3D	6
	Skill Enhancement Course-2	SEC-2	2

SEMESTER	COURSE OPTED	COURSE NAME	CREDITS
V	**Skill Enhancement Course-3**	**SEC-3**	**2**
	Discipline Specific Elective- 1	**DSE-1A**	**6**
	Discipline Specific Elective- 2	**DSE-2A**	**6**
	Discipline Specific Elective- 3	**DSE-3A**	**6**
VI	**Skill Enhancement Course-4**	**SEC-4**	**2**
	Discipline Specific Elective- 4	**DSE-1B**	**6**
	Discipline Specific Elective- 5	**DSE-2B**	**6**
	Discipline Specific Elective- 6	**DSE-3B**	**6**
TOTAL CREDITS			**122**

B.Sc. Physical Science

Core papers Physics (Credit: 06 each) (DSC 1-4):

1. Mechanics + Lab
2. Electricity and Magnetism + Lab
3. Thermal Physics and Statistical Mechanics + Lab
4. Waves and Optics + Lab

Discipline Specific Elective papers (Credit: 06 each) (DSE 1, DSE 2):

DSE 1A: Digital and Analog Circuits and Instrumentation + Lab

Mathematical Physics + Lab

Nuclear and Particle Physics + Tut

DSE 1B: Elements of Modern Physics + Lab

Solid State Physics + Lab

Quantum Mechanics + Lab

Dissertation

Skill Enhancement Course (any four) (Credit: 02 each) - SEC 1 to SEC 4

SEC-1: Electrical circuits and Network Skills

SEC-2: Applied Optics

SEC-3: Basic Instrumentation Skills / Computational Physics Skills

SEC-4: Renewable Energy and Energy harvesting / Physics Workshop Skills

Important:

The size of the practical group for practical papers is recommended to be 12-15 students.

Semester I

Course Code: PHYSICS-DSC-1A
Course Title: MECHANICS
Nature of the Course: CORE
Total credits assigned: 06
Distribution of credits: Theory – 04, Practicals-02

Objective of the course: At the completion of this course, a student will be able to

1. Understand the basic components of mechanics- e.g. motion, force and torque, mass and moment of inertia, linear and angular momenta, kinetic energy and potential energy etc. by parallel studies of linear dynamics and rotational dynamics.
2. Understand the basic conservation laws by studying them in various mechanical systems including collisions, oscillations, gravitational systems etc.
3. Detailed analysis of simple harmonic oscillator.
4. Study planetary motions as a central force problem.
5. Understand the concept of frame of reference, importance of relative transformations and invariance of laws of physics.
6. Realize the consequences of non-inertial frame in our real physical world.
7. Know about the peculiar phenomena of special relativity which are not seen in Newtonian relativity and to understand the concept of space-time.

PHYSICS-DSC-1A -: MECHANICS (THEORY)
60 Lectures, 60 Marks

Vectors:
Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(3 Lectures, 3 Marks)**
Ordinary Differential Equations:
1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(7 Lectures, 7 Marks)**

Laws of Motion:
Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(10 Lectures, 10 Marks)**

Momentum and Energy:
Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(6 Lectures, 6 Marks)**

Rotational Motion:
Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(5 Lectures, 5 Marks)**

Gravitation:

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.**(8 Lectures, 8 Marks)**

Oscillations:
Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures, 6 Marks)**

Elasticity:
Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method. **(8 Lectures, 8 Marks)**

Special Theory of Relativity:
Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(7 Lectures, 7 Marks)**

Recommended readings:

- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
- Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHYSICS-DSC- 1A : MECHANICS (LAB)
60 Lectures , 20 Marks

1. Measurements of length (or diameter) using vernier calipers, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To determine g and velocity of a freely falling body using a digital Timing Technique.
10. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Recommended readings:

- 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.
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Mode of Assessment/ Assessment Tools (%)

Internal: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): 80
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to

1. Understand the basic concepts of mechanics.
2. Understand classical mechanics and quantum mechanics smoothly.
3. Understand conservation laws as they are the fundamental laws of nature and will help them in realizing a crucial phenomenon of nature- symmetry.
4. Understand simple harmonic oscillator as it is a unique mechanical problem and will help them to understand the advanced treatment in quantum mechanics and modern Physics.
5. Develop knowledge of special relativity to understand relativistic formulation of modern theories.
6. Develop knowledge of mechanics which will help students in their everyday life.

Semester II

Course Code : PHYSICS-DSC-2A
Course Title : ELECTRICITY AND MAGNETISM
Nature of the Course : CORE
Total Credits assigned : 06
Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the completion of this course, a student will be able to :

1. Understand basic knowledge of electricity and magnetism.
2. Understand basic knowledge of electrical and magnetic properties of matter in brief.
3. Understand the basic knowledge of the effect of electric field on magnetic field and the effect of magnetic field on current.
4. Understand the basic principle of the electrical circuit (AC) circuit and electrical networking.
5. Develop the basic theoretical as well as experimental skill on electrical networking.

PHYSICS-DSC-2A: ELECTRICITY AND MAGNETISM (THEORY)
60 Lectures, 60 Marks

Vector Analysis:
Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

(12 Lectures, 12 Marks)

Electrostatics:
Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(22 Lectures, 22 Marks)**

Magnetism:
Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro-magnetic materials. **(10 Lectures, 10 Marks)**

Electromagnetic Induction:

Faraday's laws of electromagnetic induction**.** Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures, 6 Marks)**

Maxwell`s equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

(10 Lectures, 10 Marks)

Recommended readings:

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

PHYSICS-DSC- 2A: ELECTRICITY AND MAGNETISM (LAB)

60 Lectures, 20 Marks

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages,
   (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii)Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and
   (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin's and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

Recommended readings:

- Advanced Practical Physics for students, B.L.Flint & 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
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

Mode of Assessment/ Assessment Tools (%)

Internal: **20** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): **80**
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected Learner outcome: This course will enable the students to :

1. Perform quantitative analyses of basic problems in Electrostatics and Magnetodynamics.
2. Apply Gauss's Law, Ampere's Law, and Biot-Savart Law to solving practical problems in electricity and magnetism.
3. Apply the fundamental laws of electromagnetism to solve problems of electrostatics, magnetostatics, and electromagnetic induction
4. Explain and analyze the behaviour of alternating currents in LCR circuits.
5. Perform and interpret the results of simple experiments and demonstrations of physical principles.
6. Solve problems relevant to interfaces between media with defined boundary conditions.

Semester III

Course Code : PHYSICS-DSC-3A
Course Title : THERMAL PHYSICS AND STATISTICAL MECHANICS
Nature of the Course : CORE
Total credits assigned : 06
Distribution of credits: Theory – 04, Practicals-02

Course objectives: At the completion of this course, a student will be able to

1. Develop the working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics.

2. Provide insight to the postulates of Statistical Mechanics and statistical interpretation of thermodynamics
3. Understand the laws of radiation and acquire knowledge for their applications in various disciplines in Physics, Chemistry, Biology, Earth and Atmospheric Sciences.
4. Develop application oriented knowledge on laws of statistical mechanics in selected problems
5. Use the methodologies, conventions and tools of thermal and statistical physics to test and communicate ideas and explanation

PHYSICS-DSC-3A: THERMAL PHYSICS AND STATISTICAL MECHANICS (THEORY)
60 Lectures, 60 Marks

Laws of Thermodynamics:
Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(22 Lectures, 22 Marks)**

Thermodynamic Potentials:
Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(10 Lectures, 10 Marks)**

Kinetic Theory of Gases:
Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.**(10 Lectures, 10 Marks)**

Theory of Radiation:
Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.**(6Lectures, 6 Marks)**

Statistical Mechanics:
Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures, 12 Marks)**

Recommended readings:

- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

PHYSICS-DSC-3A: THERMAL PHYSICS AND STATISTICAL MECHANICS (LAB)
60 Lectures, 20 Marks

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off- Balance Bridge

Recommended readings:

- Advanced Practical Physics for students, B.L.Flint & 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, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

- A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Mode of Assessment/ Assessment Tools (%)

Internal: 20
Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): 80
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected learner Outcomes: This course will enable the students to :

1. Apply laws of thermodynamics and statistical mechanics to a range of situations in real world
2. Conduct scientific problems and experiments on thermodynamics and allied disciplines
3. Demonstrate a working knowledge of the physical principles describing the thermal physics.
4. Explain thermal physics as logical consequences of the postulates of statistical mechanics.

Semester IV

Course Code : PHYSICS-DSC-4A
Course Title : WAVE AND OPTICS
Nature of the Course : CORE
Total credits assigned : 06
Distribution of credits: Theory – 04, Practicals-02

Course objectives: At the completion of this course, a student will be able to :

1. Develop basic idea of the behaviour of light on the principle of wave theory of light.
2. Develop the knowledge of the different phenomena due to the interaction of light among them and with mater.
3. Enhance knowledge about some fundamental principles of light which is used in different optical instrument which very essential for Physics student.

PHYSICS-DS-4A: WAVES AND OPTICS (THEORY)
60 Lectures, 60 Marks

Superposition of Two Collinear Harmonic oscillations:
Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations:
Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.
(6 Lectures, 6 Marks)

Waves Motion- General:
Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.,
(7 Lectures, 7 Marks)

Sound:
Simple harmonic motion - forced vibrations and resonance - Fourier’s Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient -

Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.
(10 Lectures, 10 Marks)

Wave Optics:
Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.
(3 Lectures, 3 Marks)

Interference:
Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **(10 Lectures, 10 Marks)**

Michelson's Interferometer:
Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. **(5 Lectures, 5 Marks)**

Diffraction:
Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(14 Lectures, 14 Marks)**

Polarization:
Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(5 Lectures, 5 Marks)**

Recommended readings:

- Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

PHYSICS-DSC- 4A : WAVES AND OPTICS (LAB)
60 Lectures, 20 Marks

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's

method).

6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Recommended readings:

- 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, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Mode of Assessment/ Assessment Tools (%)

Internal: **20** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): **80**
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected learner Outcomes: This course will enable the students to

1. Justify different phenomena due to light and the interaction of light among them and with matter.
2. Use different optical instruments.
3. Produce different natural phenomena using different apparatus in the laboratory.

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code : PHYSICS-DSE-1A
Course Title : DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION
Nature of the Course : DSE
Total credits assigned : 06

Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the completion of this course, a student will be able to :

1. Learn about digital circuits, Boolean algebra, logic gates and binary numbers systems.
2. Learn about semiconductor devices like PN junction, bipolar junction transistor and its application to different circuits.
3. Gain knowledge of operational amplifier, its applications and analysis.
4. Use and handle different instruments like power supply, Oscilloscope etc.

PHYSICS-DSE-1A: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION (THEORY)
60 Lectures, 60 Marks

UNIT-1: Digital Circuits
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR gates

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor. **(13 Lectures, 13 Marks)**

UNIT-2: Semiconductor Devices and Amplifiers:
Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers. **(17Lectures, 17Marks)**

UNIT-3: Operational Amplifiers (Black Box approach):
Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator,
(5) Integrator, (6) Zero crossing detector.

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator **(18 Lectures, 18 Marks)**

UNIT-4: Instrumentations:

Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. **(12 Lectures, 12 Marks)**

Recommended readings:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
- Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.
- OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

PHYSICS-DSE-1A : DIGITAL, ANALOG CIRCUITS AND INSTRUMENTS (LAB)
60 Lectures, 20 Marks

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder, Full adder and 4-bit Binary Adder.
5. Adder-Subtractor using Full Adder I.C.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To study IV characteristics of PN diode, Zener and Light emitting diode
9. To study the characteristics of a Transistor in CE configuration
10. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
11. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
12. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.

13. To study Differential Amplifier of given I/O specification using Op-amp.
14. To investigate a differentiator made using op-amp.
15. To design a Wien Bridge Oscillator using an op-amp.

Recommended readings:

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4^{th} Edn, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

Mode of Assessment/ Assessment Tools (%)

Internal: 20

Assignment /Presentation/ attendance/ Class room interaction/quiz etc: 10

Written Test for theory and/or Viva Voce for Laboratory: 10

Final (End Semester): 80

Written Test for theory and/or Laboratory experiments: 80

(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to

1. Have the knowledge about different digital circuits, Boolean algebra, binary number system, logic gates etc.
2. Be able to design logic gates, adder and subtractor circuit etc. And verify them.
3. Be able to develop the knowledge of semiconductor device like PN junction, solar cell photodiode, bipolar junction transistor etc. The students will also be able to analyse various electronic circuits containing transistors and operational amplifiers.
4. Use and apply CRO for various measurement purposes.

Course Code: PHYSICS-DSE-1A
Course Title: MATHEMATICAL PHYSICS
Nature of the Course: CORE
Total credits assigned: 06
Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the completion of this course, a student will be able to

1. Write a problem in elementary Physics in the language of Mathematics.
2. Identify a range of diverse mathematical techniques/ideas to formulate, simplify and solve some problems in Physics.

3. Analyse some of the useful mathematical ideas and techniques.
4. Apply the knowledge and understanding of these mathematical methods to solve problems in a number of fundamental topics in physics.
5. Learn computer programming and numerical analysis and know its role in solving problems in Physics
6. Construct a problem in Physics computationally.

PHYSICS-DSE-1A: MATHEMATICAL PHYSICS (THEORY)
60 Lectures, 60 Marks

Calculus of functions of more than one variable:
Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

(6 Lectures, 6 Marks)

Fourier Series:
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. **(10 Lectures, 10 Marks)**

Frobenius Method and Special Functions:
Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite & Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

(16 Lectures, 16 Marks)

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

(4 Lectures, 4 Marks)

Partial Differential Equations:
Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry.

(10 Lectures, 10 Marks)

Complex Analysis:
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. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy’s Integral formula. **(14 Lectures, 14 Marks)**

Recommended readings:

- 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.
- An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.

PHYSICS- DSE-1A: MATHEMATICAL PHYSICS (LAB)
60 Lectures, 20 Marks

The course will consist of lectures (both theory and practical) in the Lab Evaluation is to be done not on the programming but on the basis of formulating the problem.. Students can use any one operating system Linux or Microsoft Window

Topics	Description and application
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

Review of C & C++ Programming Fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs using C/C++ language	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
Random number generation	Area of circle, area of square, volume of sphere, value of Pi (π)
Solution of algebraic and transcendental equation by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = tan\alpha$ $I = I_0 \left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc*
Numerical differentiation (Forward and backward interpolation formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion Attempt following problems using RK 4 order method: • Solve the coupled differential equations $$\frac{dx}{dt} = y + x - \frac{x^3}{3}\ ;\ \frac{dy}{dx} = -x$$ for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4 Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$ The differential equation describing the motion of a pendulum is: — $$\frac{d^2\theta}{dt^2} = -sin\theta$$ The pendulum is released from rest at an angular displacement α, i.e. θ(0) = α and $\theta^{/}(0) = 0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small θ (sin(θ)) = θ

Recommended readings:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C++: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- 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

Mode of Assessment/ Assessment Tools (%)

Internal: 20 Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): 80
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected Learner Outcomes: This course will enable a student to

1. Develop requisite mathematical skills to understand some of the fundamental concepts in physics.
2. Develop the ability to critically analyse a topic.
3. Understand the use and importance of computational/numerical methods in physics and to construct a physics problem computationally.

Course Code: PHYSICS-DSE-1A
Course Title: NUCLEAR AND PARTICLE PHYSICS
Nature of the Course: DSE
Total credits assigned: 06
Distribution of credits: Theory – 05, Tutorials-01

Course objective: At the completion of this course, a student will be able to :

1. Learn various concepts in nuclear physics.
2. Emphasize the existing connections with other domains of physics, in particular quantum mechanics, mathematical physics and particle physics.

PHYSICS-DSE-1A: NUCLEAR AND PARTICLE PHYSICS (THEORY)
Theory: 75 Lectures, 80 Marks

General Properties of Nuclei:
Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures, 10 Marks)**

Nuclear Models:
Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of

nuclear force. **(12 Lectures, 14 Marks)**

Radioactivity decay:
(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) α-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.
(**10 Lectures, 10 Marks)**

Nuclear Reactions:
Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures, 8 Marks)**

Interaction of Nuclear Radiation with matter:
Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.
(8 Lectures, 8 Marks)

Detector for Nuclear Radiations:

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(8 Lectures, 10 Marks)**

Particle Accelerators:
Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(5 Lectures, 5 Marks)**

Particle physics:
Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. **(14 Lectures, 15 Marks)**

Recommended readings:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press

- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Mode of Assessment/ Assessment Tools (%)

Internal: 20 Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): 80
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to :

1. Develop knowledge regarding nuclear and elementary particle as well as properties and phenomena related to them.
2. Successfully apply the same knowledge in solving problems in the field of nuclear and particle physics.

Course Code: PHYSICS-DSE-1B
Course Title: ELEMENTS OF MODERN PHYSICS
Nature of the Course: DSE
Total credits assigned: 06
Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the end of this course the students will be able to

1. Apply concepts of 20^{th} century Modern Physics to deduce the structure of atoms.
2. Explain the wave-particle duality of the photon.
3. Analyse the structure of matter at its most fundamental.
4. Develop an insight into the key principles and applications of Nuclear Physics.

PHYSICS-DSE-1B: ELEMENTS OF MODERN PHYSICS (THEORY)

60 Lectures, 60 Marks

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. **(8 Lectures, 8 Marks)**

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. **(4 Lectures, 4 Marks)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(4 Lectures, 4 Marks)**

Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(11 Lectures, 11 Marks)**

One dimensional infinitely rigid box- energy eigenvalues and eigen functions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. **(12 Lectures, 12 Marks)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy **(6 Lectures, 6 Marks)**

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. **(11 Lectures, 11 Marks)**

Fission and fusion - 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. **(4 Lectures, 4 Marks)**

Recommended readings:

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw

Hill
- Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning
- Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

---

PHYSICS-DSE-1B : ELEMENTS OF MODERN PHYSICS (LAB)
60 Lectures, 20 Marks

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of 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 absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Recommended readings:

- 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, Indu Prakash and Ramakrishna, 11th
- Edition, 2011, Kitab Mahal, New Delhi.

Mode of Assessment/ Assessment Tools (%)

Internal: **20** Assignment /Presentation/ attendance/ Class room interaction/quiz etc: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): **80**
Written Test for theory and/or Laboratory experiments: 80
(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to :

1. Have a good understanding and appreciation of the theory.
2. Apply it in solving simple problems in Quantum Mechanics (QM), structure of atoms, and Nuclear Physics.

Course Code : PHYSICS-DSE-1B
Course Title : SOLID STATE PHYSICS
Nature of the Course : DSE
Total credits assigned : 06
Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the completion of this course, a student will be able to :

1. Learn the fundamentals of solid state physics.
2. Understand the structural, electronic and lattice vibration dependent behaviour of solids.
3. Learn the basic concepts in hands on mode through laboratory experiments associated to the course.

PHYSICS-DSE-1B: SOLID STATE PHYSICS (THEORY)
60 Lectures, 60 Marks

Crystal Structure:
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. **(12 Lectures, 12 Marks)**

Elementary Lattice Dynamics:
Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 Lectures, 10 Marks)**

Magnetic Properties of Matter:
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. **(12 Lectures, 12 Marks)**

Dielectric Properties of Materials:
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 . **(10 Lectures, 10 Marks)**

Elementary Band Theory:

Kronig Penny model, Band gaps, conductors Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **(10 Lectures, 10 Marks)**

Superconductivity:

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. **(6 Lectures, 6 Marks)**

Recommended readings:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, 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, Rita John, 2014, McGraw Hill
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PHYSICS-DSE-1B: SOLID STATE PHYSICS (LAB)

60 Lectures, 20 Marks

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 study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Recommended readings:

- 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, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11^{th} Edn., 2011, Kitab Mahal
- Elements of Solid State Physics, J.P. Srivastava, 2^{nd} Ed., 2006, Prentice-Hall of India

Mode of Assessment/ Assessment Tools (%)

Internal: **20** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10

Written Test for theory and/or Viva Voce for Laboratory: 10

Final (End Semester): **80**

Written Test for theory and/or Laboratory experiments: 80

(Equal weightage to be assigned to each credit)

Expected Learner Outcome: The course will

1. Equip a student with basic concepts of solid state physics so that the knowledge can be applied for further development of the subject.
2. Enable a student to work in both theoretical and experimental aspects of solid state physics.
3. Help the students in thorough learning of the concepts associated to the course through the laboratory experiments.

Course Code: PHYSICS-DSE-1B
Course Title: QUANTUM MECHANICS
Nature of the Course: DSE
Total credits assigned: 06
Distribution of credits: Theory – 04, Practicals-02

Course Objectives: At the completion of this course, a student will be able to

1. Know about the development of modern physics and the theoretical formulation of quantum mechanics.
2. Know the applications of quantum mechanics in solving physical problems.

PHYSICS-DSE-1B: QUANTUM MECHANICS (THEORY)

60 Lectures, 60 Marks

Time dependent Schrodinger equation :

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 & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures, 6 Marks)**

Time independent Schrodinger equation-

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 the spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures, 10 Marks)

General discussion of bound states in an arbitrary potential-

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.

(12 Lectures, 12 Marks)

Quantum theory of hydrogen-like atoms:

time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells (idea only) **(10 Lectures, 10 Marks)**

Atoms in Electric and Magnetic Fields:-

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 & Magnetic Energy, Gyromagnetic Ratio & Bohr Magneton. **(8 Lectures, 8 Marks)**

Atoms in External Magnetic Fields:

Normal and Anomalous Zeeman Effect. **(4 Lectures, 4 Marks)**

Many electron atoms:

Pauli’s Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral notations of atomic states, Total angular momentum, vector model, spin orbit couplingin atoms-L-S and J-J couplings.

(10 Lectures, 10 Marks)

Recommended readings:

- A Text book of Quantum Mechanics, P.M. Mathews & 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 for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional recommended readings:

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.

PHYSIC-DS-1B : QUANTUMMECHANICS (LAB)
60 Lectures, 20 Marks
Use C/C++/Scilab for solving the following problems based on Quantum Mechanics

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

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

Here, m is the reduced mass of the electron. Obtain the energy eigen values and plot the corresponding wave functions. 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 = 0.511×10^6 eV/c^2.

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

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

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.

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 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:

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

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 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 molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$$

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

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

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 = 940×10^6eV/c^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Some laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Recommended readings:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Ed. 2007, Wiley India Edition
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand and Company, New Delhi ISBN: 978-8121939706
- Scilab Image Processing: Lambert M. Surhone. 2010Betascript Publishing ISBN: 978-6133459274A
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

Mode of Assessment/ Assessment Tools (%)

Internal: **20** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 10
Written Test for theory and/or Viva Voce for Laboratory: 10
Final (End Semester): 80
Written Test for theory and/or Laboratory experiments: 80

Expected learner Outcomes: This course will enable the students to

1. Learn how to apply quantum mechanics to solve physical systems in different areas of science.
2. Know about the physical behaviour of materials.
3. Learn how the scientific behaviour of materials can be used for human applications.

SKILL ENHANCEMENT COURSES (SEC)

Course Code: PHYSICS-SEC-1
Course Title: ELECTRICAL CIRCUITS AND NETWORK SKILLS
Nature of the Course: SEC
Total Credits assigned: 02

Course Objectives: At the completion of this course, a student will be able to :

1. Design and trouble shoots the electrical circuits, networks and appliances through hands on mode.
2. Build the basic foundation for learning electrical wirings and repairing of other house hold equipments.

PHYSICS- SEC-1: ELECTRICAL CIRCUITS AND NETWORK SKILLS (THEORY)
30 Lectures, 40 Marks

Basic Electricity Principles:
Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.
(3 Lectures, 4 Marks)

Understanding Electrical Circuits:
Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(4 Lectures, 6 Marks)**

Electrical Drawing and Symbols:
Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.
(4 Lectures, 5 Marks)

Generators and Transformers:
DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **(3 lectures, 3 Marks)**

Electric Motors:
Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heater and motors, speed and power of ac motor **(4 lectures, 5 Marks)**

Solid state devices:

resistors , inductors and capacitors , Diode and rectifiers, Components in series or in shunt, Response of Inductors and capacitors with AC or DC sources.

(3 lectures, 3 Marks)

Electrical Protections:

Relays , fuses and disconnect switches, Circuit breakers, Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

(4 Lectures, 7 Marks)

Electrical Wiring:

Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(5 Lectures, 7 Marks)**

Recommended readings:

- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBS Edn

Mode of Assessment/ Assessment Tools

Internal: **10**

Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 5

Written Test for theory and/or Viva Voce for Laboratory: 5

Final (End Semester): **40**

Written Test for theory and/or Laboratory experiments: 40

(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to

1. Design and troubleshoot certain electrical circuits and domestic appliances along with the understanding of the working of those appliances.
2. Do electrical wiring and repairing.
3. Develop the skill for various electrical repairing and servicing purposes.

Course Code: PHYSICS-SEC-2
Course Title: APPLIED OPTICS
Nature of the Course: SEC
Total credits assigned: 02

Course Objectives: At the completion of this course, a student will be able to

1. Learn about various optical devices, components and systems.
2. Do experiments related to optoelectronic devices.
3. Learn about Fourier transform spectroscopy, holography and various aspects of fibre optics.

PHYSICS-SEC-2: APPLIED OPTICS (THEORY)
30 Lectures, 40 Marks.

(i) Sources and Detectors **(9 Lectures, 12 Marks)**

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

Experiments on Lasers:

1. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
3. To find the polarization angle of laser light using polarizer and analyzer
4. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors:

a) V-I characteristics of LED
b) Study the characteristic of solid stste laser
c) Study the characteristics of LDR
d) Photovoltaic cell
e) Characteristic of IR sensor

(ii) Fourier optics **(6 Lectures, 8 Marks)**

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

a. Fourier optic and image processing

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer stimulation can also be done.

(iii) Holography **(6 Lectures, 8 Marks)**

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

(iv) Photonics : Fibre optics **(9 Lectures, 12 Marks)**

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

a) To measure the numerical aperture of an optical fibre
b) To study the variation of the bending loss in a multimode fibre
c) To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d) To measure the near field intensity profile of a fibre and study its refractive index profile
e) To determine the power loss at a splice between two multimode fibre

Mode of Assessment/ Assessment Tools

Internal: 10 Assignment /Presentation/ attendance/ Class room interaction/quiz etc: 5
Written Test for theory and/or Viva Voce for Laboratory: 5
Final (End Semester): 40
Written Test for theory and/or Laboratory experiments: 40
(Equal weightage to be assigned to each credit)

Recommended readings:

- Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
- LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
- Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
- Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4^{th} Edn., 1996, Cambridge Univ. Press

---

Expected Learners outcome: This course will enable the students to

1. Acquire knowledge about various optoelectronic devices and their applications.
2. Understand the basics of Laser and their uses.
3. Understand about Fourier transform spectroscopy and will learn to use this technique for various purposes.
4. Learn the use of optical fibres and related information.

Course Code: PHYSICS-SEC-3
Course Title: COMPUTATIONAL PHYSICS SKILLS
Nature of the Course: SEC
Total Credits assigned: 02

Course objective: At the completion of this course, a student will be able to :

1. Learn computer programming and numerical analysis but to emphasize its role in solving problems in Physics and Science.
2. Have hands on training on the problem solving on computers applying FORTRAN language and computational methods to solve physical problems in LINUX operating system.
3. Acquire practical experience on scientific word processing with LaTeX, graphical analysis and visualization of computational data with Gnuplot.

PHYSICS- SEC-3: COMPUTATIONAL PHYSICS SKILLS (THEORY)

30 Lectures, 40 Marks

.

Introduction:

Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots

of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **(4 Lectures, 5 Marks)**

Scientific Programming:

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

(5 Lectures, 7 Marks)

Control Statements:

Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

(6 Lectures, 8 Marks)

Scientific word processing: Introduction to LaTeX:

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. **Equation**

representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

(6 Lectures, 8 Marks)

Visualization:

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

(9 Lectures, 12 Marks)

Recommended readings:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
- Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
- A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

Mode of Assessment/ Assessment Tools

Internal: **10** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 5
Written Test for theory and/or Viva Voce for Laboratory: 5
Final (End Semester): **40**
Written Test for theory and/or Laboratory experiments: 40

(Equal weightage to be assigned to each credit)

Expected learner outcome: This course will enable the students to :

1. Apply their knowledge on computer programming and numerical analysis in solving real physical problems.
2. Develop basic knowledge of FORTRAN programming language and LINUX operating system will make them enabled dealing scientific computing in different areas of Physics.

Course Code: PHYSICS-SEC-3
Course Title: BASIC INSTRUMENTATION SKILLS
Nature of the Course: SEC
Credits: 02

Course Objectives:

In modern measurement processes, the parameter to be measured is sensed and converted to an electrical signal for processing and display. The apparatus and methods used to perform this task include the use of a wide range of transducers and conditioning circuits that are usually interface to computers for final signal processing and display. After completing this course students will be able to

1. Understand measurement process, the design, and operation of the electronic circuit and systems that enable it.
2. Analyse the physics of the operation of sensors and their interfaces to analogue and digital electronic circuits.

PHYSICS SEC-3 : BASIC INSTRUMENTATION SKILLS (THEORY)
30 Lectures, 40 Marks

Basic of Measurement:
Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **(4 Lectures, 5 Marks)**

Electronic Voltmeter:

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier-rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance. **(4 Lectures, 5 Marks)**

Cathode Ray Oscilloscope:

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. **(6 Lectures, 8 Marks)**

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(3 Lectures, 4 Marks)**

Signal Generators and Analysis Instruments:

Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(4 Lectures, 6 Marks)**

Impedance Bridges & Q-Meters:

Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges. **(3 Lectures, 4 Marks)**

Digital Instruments:

Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **(2 Lectures, 3 Marks)**

Digital Multimeter:

Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. **(4 Lectures, 5 Marks)**

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipments.
4. Use of digital multimeter/VTVM for measuring voltages.
5. Circuit tracing of laboratory electronic equipments.
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.

8. Troubleshooting a circuit.
9. Balancing of bridges.

Laboratory exercises:

1. To measure the loading effect of a multimeter while measuring voltageaccross a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Recommended readings:

- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India -

Mode of Assessment/ Assessment Tools

Internal: **10** Assignment /Presentation/ attendance/ Class room interaction/quiz etc: 5
Written Test for theory and/or Viva Voce for Laboratory: 5
Final (End Semester): **40**
Written Test for theory and/or Laboratory experiments: 40
(Equal weightage to be assigned to each credit)

Expected Learner outcome:

This course will enable the students to

1. Design and analyse electronic instrumentation system to interface with standard industrial sensors/transducers.

2. Effectively design instrumentation systems that conform to industrial regulations.
3. Analyse and specify component and system requirements for installation of instrumentation systems.
4. Calculate electrical noises in measurement systems.
5. Implement techniques to reduce electrical noises in measurement circuits.
6. Select sensors for applications to specific measurement tasks.
7. Explain the precision and accuracy of a measure as it pertains to international standards.
8. Design AC and DC Null circuits for application to a wide range of measurements.

Course Code: PHYSICS-SEC-4
Course Title: RENEWABLE ENERGY AND ENERGY HARVESTING
Nature of the Course: SEC
Total Credits assigned: 02

Course Objectives: At the completion of this course, a student will be able to :

1. Learn about the viable, sustainable and renewable source of energy.
2. Understand the basics of renewable energy, its importance, utility and conversion into various forms.
3. Develop his/her knowledge about the important role that renewable energy has and will have.
4. Analyze various technologies involved in the energy harvesting processes, their applications, limitations and importance in the everyday world.

PHYSICS- SEC- 4: RENEWABLE ENERGY AND ENERGY HARVESTING (THEORY)
30 Lectures, 40 Marks

Unit I

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

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.

(8 Lectures, 11 Marks)

Unit II

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Ocean Energy: 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.

(8 Lectures, 11 Marks)

Unit III

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

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

(8 Lectures, 10 Marks)

Unit IV

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, Recent applications.

Carbon captured technologies, cell, batteries, power consumptions

Environmental issues and renewable sources of energy, sustainability.

(6 Lectures, 8 Marks)

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Recommended readings:

- 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

Mode of Assessment/ Assessment Tools

Internal: **10** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 5
Written Test for theory and/or Viva Voce for Laboratory: 5
Final (End Semester): **40**
Written Test for theory and/or Laboratory experiments: 40
(Equal weightage to be assigned to each credit)

Expected learner Outcome: This course will enable the students to :

1. Learn in depth the application of heat transfer processes and thermodynamic cycles to various energy harvesting systems.
2. Pull together the background knowledge in real life examples and equip them to design and evaluate various energy based models with efficient applications.
3. Pursue a career in energy technology.

Course Code : PHYSICS-SEC-4
Course Title : PHYSICS WORKSHOP SKILL
Nature of the Course : SEC
Total Credits assigned : 02

Course Objectives: At the completion of this course, a student will be able to :

1. Use various mechanical and electrical tools through hands on work.
2. Enhance the mechanical, electrical and electronic skill.

PHYSICS SEC 4: PHYSICS WORKSHOP SKILLS (THEORY)
30 Lectures, 40 Marks

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

(4 Lectures, 5 Marks)

Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet. **(10 Lectures, 13 Marks)**

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay. **(10 Lectures, 13 Marks)**

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment. **(6 Lectures, 9 Marks)**

Reference Books:

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

Mode of Assessment/ Assessment Tools

Internal: **10** Assignment /Presentation/ attendance/ Class room interaction/quiz etc.: 5

Written Test for theory and/or Viva Voce for Laboratory: 5

Final (End Semester): **40**

Written Test for theory and/or Laboratory experiments: 40

(Equal weightage to be assigned to each credit)

Expected learner Outcome: This course will enable the students to

1. Develop the theoretical as well as experimental knowledge on different instruments and instrumentation.
2. Develop the knowledge of some measurement techniques and data and error analysis technique, which is very essential for physics student.
3. Handle different electrical network based instruments.