

**B.Sc. with Physics (General) Syllabus**

**under CBCS**

**Nagaland University**

**PHYSICS GENERAL COURSE STRUCTURE UNDER CBCS**

Semester	Core Courses DSC	Discipline Specific Elective Courses DSE	Skill Enhancement Courses SEC
1	1. (DSC 1) Mechanics		
2	2. (DSC 2) Electricity and Magnetism		
3	3. (DSC 3) Thermal Physics and Statistical Mechanics		1. (SEC 1) Basic Instrumentation Skills 2. (SEC 2) Weather Forecasting
4	4. (DSC 4) Waves and Optics		1. (SEC 3) Physics Workshop Skills 2. (SEC 4) Renewable Energy and Energy Harvesting
5		1. (DSC 1) Digital and Analog Circuits and Instrumentation 2. (DSC 2) Quantum Mechanics 3. (DSC 3) Mathematical Physics	1. (SEC 5) Electrical Circuits and Network Skills 2. (SEC 6) Technical Drawing
6		1. (DSC 4) Elements of Modern Physics 2. (DSC 5) Solid State Physics 3. (DSC 6) Nuclear and Particle Physics 4. Dissertation	1. (SEC 7) Computational Physics Skills 2. (SEC 8) Radiology & Safety
<b>Note</b>		Only ONE in each Semester	Only ONE in each Semester

# GENERIC ELECTIVE CORE COURSES

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## Semester I

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### PHYSICS - DSC 1 MECHANICS

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **Unit - 1**

##### **Vectors**

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

**(4 Lectures)**

##### **Ordinary Differential Equations**

1<sup>st</sup>order homogeneous differential equations. 2<sup>nd</sup>order homogeneous differential equations with constant coefficients.

**(6 Lectures)**

#### **Unit - 2**

##### **Laws of Motion**

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

**(10 Lectures)**

##### **Momentum and Energy**

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

**(6 Lectures)**

#### **Unit - 3**

##### **Rotational Motion**

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

**(5 Lectures)**

##### **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)**

#### **Unit - 4**

##### **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)**

##### **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 -  $q$ ,  $\eta$  and  $\sigma$  by Searle's method.

**(8 Lectures)**

## **Unit - 5**

### **Special Theory of Relativity**

Constancy of the speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

**(7 Lectures)**

*Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate*

### **Reference Books:**

- 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, 2<sup>nd</sup> edn., 2015, Oxford University Press
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

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# **PHYSICS LAB - DSC 1**

## **MECHANICS**

### **60 Lectures**

1. Measurements of length (or diameter) using vernier caliper, 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 for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant, (b)  $g$ .

### **Reference Books:**

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> 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, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

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## Semester II

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# PHYSICS - DSC 2

## ELECTRICITY AND MAGNETISM

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

### **Unit - 1**

#### **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)**

**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)**

### **Unit - 2**

#### **Electrostatics 1**

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to a 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.

**(12 Lectures)**

### **Unit - 3**

#### **Electrostatics 2**

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.

**(10 Lectures)**

### **Unit - 4**

#### **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)**

### **Unit - 5**

#### **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)**

**Reference Books:**

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- Electricity and 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.
- Introduction to Electrodynamics, D.J.Griffiths, 3rd Edn, 1998, Benjamin Cummings.

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## **PHYSICS LAB - DSC 2**

### **ELECTRICITY AND MAGNETISM**

#### **60 Lectures**

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:
  - a. Measurement of charge and current sensitivity
  - b. Measurement of CDR
  - c. Determine a high resistance by Leakage Method
  - d. 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 and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

#### **Reference Books:**

- 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, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11<sup>th</sup> Ed.2011, Kitab Mahal
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

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## Semester III

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### PHYSICS - DSC 3

#### THERMAL PHYSICS AND STATISTICAL MECHANICS

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **Unit - 1**

##### **Laws of Thermodynamics 1**

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  $C_p$  and  $C_v$ , Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient,

**(12 Lectures)**

#### **Unit - 2**

##### **Laws of Thermodynamics 2**

Reversible and irreversible processes, Second law and Entropy, Carnot's cycle and theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

**(10 Lectures)**

#### **Unit - 3**

##### **Thermodynamical Potentials**

Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for  $(C_p - C_v)$ ,  $C_p/C_v$ ,  $TdS$  equations.

**(10 Lectures)**

#### **Unit - 4**

##### **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)**

**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.

**(6 Lectures)**

#### **Unit - 5**

##### **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)**

### **Reference Books:**

- 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.

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# **PHYSICS LAB - DSC 3**

## **THERMAL PHYSICS AND STATISTICAL MECHANICS**

### **60 Lectures**

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 coefficient 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 a 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

### **Reference Books:**

- 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, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

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## Semester IV

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### PHYSICS - DSC 4 WAVES AND OPTICS

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **Unit - 1**

##### **Superposition of Two Collinear Harmonic oscillations**

Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

**(4 Lectures)**

##### **Superposition of Two Perpendicular Harmonic Oscillations**

Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

**(2 Lectures)**

##### **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)**

#### **Unit - 2**

**Fluids:** Surface Tension: Synclastic and anticlastic surface, Excess of pressure, Application to spherical and cylindrical drops and bubbles, variation of surface tension with temperature, Jaeger's method. Viscosity, Rate flow of liquid in a capillary tube, Poiseuille's formula, Determination of coefficient of viscosity of a liquid, Variations of viscosity of liquid with temperature, lubrication.

**(6 Lectures)**

**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.

**(6 Lectures)**

#### **Unit - 3**

##### **Wave Optics**

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

**(3 Lectures)**

##### **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)**

## **Unit - 4**

### **Michelson's Interferometer**

Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.

**(3 Lectures)**

### **Polarization**

Transverse nature of light waves. Plane polarized light, production and analysis. Circular and elliptical polarization.

**(5 Lectures)**

## **Unit - 5**

### **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)**

### **Reference Books:**

- 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

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# **PHYSICS LAB - DSC 4**

## **WAVES AND OPTICS**

### **60 Lectures**

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  $\lambda^2 - T$  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.

### **Reference Books:**

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

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## DISCIPLINE SPECIFIC ELECTIVE COURSES

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### Semester V

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#### **PHYSICS - DSE 1** **DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **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.

**(4 Lectures)**

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.

**(5 Lectures)**

Binary Addition. Binary Subtraction using 2's Complement Method. Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

**(4 Lectures)**

#### **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.

**(5 Lectures)**

##### **Instrumentations 1**

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.

**(6 Lectures)**

#### **Unit - 3**

##### **Transistors**

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

**(12 Lectures)**

## **Unit - 4**

### **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.

**(13 Lectures)**

## **Unit - 5**

### **Sinusoidal Oscillators**

Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator

**(5 Lectures)**

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

**(3 Lectures)**

### **Instrumentations 2**

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

**(3 Lectures)**

### **Reference Books:**

- 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, 2<sup>nd</sup> 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, 7<sup>th</sup> Ed., 2011, Tata McGraw Hill
- Microelectronic Circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6<sup>th</sup> Edn., Oxford University Press.
- Fundamentals of Digital Circuits, A. Anand Kumar, 2<sup>nd</sup> Edition, 2009, PHI Learning Pvt. Ltd.
- OP-AMP and Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

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# **PHYSICS LAB - DSE 1**

## **DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION**

### **60 Lectures**

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.

### **Reference Books:**

- 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 and Linear Integrated Circuits, R.A. Gayakwad, 4<sup>th</sup> Edn, 2000, Prentice Hall.
- Electronic Principles, Albert Malvino, 2008, Tata Mc-Graw Hill.

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# **PHYSICS - DSE 2**

## **QUANTUM MECHANICS**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

### **Unit - 1**

#### **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)**

#### **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 wave packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

**(10 Lectures)**

### **Unit - 2**

#### **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)**

### **Unit - 3**

#### **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)**

### **Unit - 4**

#### **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)**

#### **Atoms in External Magnetic Fields**

Normal and Anomalous Zeeman Effect.

**(4 Lectures)**

## **Unit - 5**

### **Many electron atoms**

Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Vector Model. Spin-orbit coupling in atoms, L-S and J-J couplings.

**(10 Lectures)**

### **Reference Books:**

- A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2<sup>nd</sup> Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2<sup>nd</sup> Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3<sup>rd</sup> Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldas, 2<sup>nd</sup> 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 Books for Reference**

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

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# PHYSICS LAB - DSE 2

## QUANTUM MECHANICS

### 60 Lectures

*Use C/C<sup>++</sup>/Scilab for solving the following problems based on Quantum Mechanics like*

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

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

Here,  $m$  is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is  $\approx -13.6$  eV. Take  $e = 3.795$  (eVÅ)<sup>1/2</sup>,  $\hbar c = 1973$  (eVÅ) and  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>.

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

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

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

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take  $e = 3.795$  (eVÅ)<sup>1/2</sup>,  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>, and  $a = 3$  Å, 5 Å, 7 Å. In these units  $\hbar c = 1973$  (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  $m$ :

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

For the anharmonic oscillator potential

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

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<sup>2</sup>,  $k = 100$  MeV fm<sup>-2</sup>,  $b = 0, 10, 30$  MeV fm<sup>-3</sup>. In these units,  $\hbar c = 197.3$  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:

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

where  $\mu$  is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}), \quad r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take  $m = 940 \times 10^6$  eV/C<sup>2</sup>,  $D = 0.755501$  eV,  $\alpha = 1.44$ ,  $r_0 = 0.131349$  Å

### **Some laboratory based experiments:**

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

### **Reference Books:**

- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3<sup>rd</sup> Edn., 2007, Cambridge University Press.
- Elementary Numerical Analysis, K.E. Atkinson, 3<sup>rd</sup> Ed . 2007 , Wiley India Edition
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3<sup>rd</sup> 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. 2010 Betascript Publishing ISBN: 978-6133459274A
- Quantum Mechanics, Leonard I. Schiff, 3<sup>rd</sup> Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

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# **PHYSICS - DSE 3**

## **MATHEMATICAL PHYSICS**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

*The emphasis of the course is on applications in solving problems of interest to physicists. Students to be examined on the basis of problems, seen and unseen.*

### **Unit - 1**

#### **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)**

#### **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)**

### **Unit - 2**

#### **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)**

### **Unit - 3**

#### **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 and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

**(16 Lectures)**

### **Unit - 4**

#### **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)**

### **Unit - 5**

#### **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)**

**Reference Books:**

- Mathematical Methods for Physicists, Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis, 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 and Engineers, D.A. McQuarrie, 2003, Viva Books.
- Mathematical Methods in the Physical Sciences, Mary L. Boas, Wiley-India

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# PHYSICS LAB - DSE 3

## MATHEMATICAL PHYSICS

### 60 Lectures

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

- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
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 $\pi$
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, 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. $\sin \theta$ , $\cos \theta$ , $\tan \theta$ , etc.

Numerical differentiation (Forward and Backward difference 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 <ul style="list-style-type: none"> <li>• Radioactive decay</li> <li>• Current in RC, LC circuits with DC source</li> <li>• Newton's law of cooling</li> <li>• Classical equations of motion</li> </ul> Attempt following problems using RK 4 order method: <ul style="list-style-type: none"> <li>• Solve the coupled differential equations           <math display="block">\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dx} = -x</math>           for four initial conditions           <math display="block">x(0) = 0, y(0) = -1, -2, -3, -4</math>           Plot x vs y for each of the four initial conditions on the same screen for <math>0 \leq t \leq 15</math> </li> </ul> 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 $\alpha$ , i.e. $\theta(0) = \alpha$ and $\theta'(0) = 0$ . Solve the equation for $\alpha = 0.1, 0.5$ and $1.0$ and plot $\theta$ as a function of time in the range $0 \leq t \leq 8\pi$ . Also plot the analytic solution valid for small $\theta$ , ( $\sin\theta = \theta$ )

### Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5<sup>th</sup> 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. Press et al., 3<sup>rd</sup> 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, 3<sup>rd</sup> Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2<sup>nd</sup> Edn., 2006, Cambridge Univ. Press

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## Semester VI

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# PHYSICS - DSE 4

## ELEMENTS OF MODERN PHYSICS

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

### **Unit - 1**

#### **Quantum Mechanics**

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)**

#### **Bohr's Model**

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)**

### **Unit - 2**

#### **Uncertainty Principle**

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)**

#### **Wave Function**

Two slit interference experiment with photons, atoms and 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 wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

**(11 Lectures)**

### **Unit - 3**

#### **Quantum Mechanical Problems for Simple Potentials**

One dimensional infinitely rigid box, energy eigenvalues and eigenfunctions, 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)**

### **Unit - 4**

#### **Nuclear Physics**

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

**(6 Lectures)**

**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)

## **Unit - 5**

### **Radioactivity**

stability of nucleus; Law of radioactive decay; Mean life and half life  $\alpha$  decay;  $\beta$  decay, energy released, spectrum and Pauli's prediction of neutrino;  $\gamma$ -ray emission.

(11 Lectures)

### **Reference Books:**

- 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

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# **PHYSICS LAB - DSE 4**

## **ELEMENTS OF MODERN PHYSICS**

### **60 Lectures**

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.

### **Reference Books:**

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4<sup>th</sup> Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11<sup>th</sup> Edition, 2011, Kitab Mahal, New Delhi.

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# **PHYSICS - DSE 5**

## **SOLID STATE PHYSICS**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

### **Unit - 1**

#### **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)**

### **Unit - 2**

#### **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)**

### **Unit - 3**

#### **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)**

### **Unit - 4**

#### **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)**

### **Unit - 5**

#### **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)**

#### **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)**

### **Reference Books:**

- Introduction to Solid State Physics, Charles Kittel, 8<sup>th</sup> Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2<sup>nd</sup> 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
- Solid State Physics, R. K. Puri and V. K. Babbar, S. Chand & Company Ltd

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## **PHYSICS - DSE 5**

### **SOLID STATE PHYSICS**

#### **60 Lectures**

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 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

#### **Reference Books:**

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

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# PHYSICS - DSE 6

## NUCLEAR AND PARTICLE PHYSICS

**(Credits: Theory-05, Tutorials-01)**

**Theory: 75 Lectures**

*Prerequisites: Knowledge of “Elements of Modern Physics”*

### Unit - 1

#### 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 excited states.

**(10 Lectures)**

#### 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)**

### Unit - 2

#### 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)**

### Unit - 3

#### Radioactivity decay

(a) Alpha decay: basics of  $\alpha$ -decay processes, theory of  $\alpha$ -emission, Gamow factor, Geiger Nuttall law,  $\alpha$ -decay spectroscopy. (b)  $\beta$ -decay: energy kinematics for  $\beta$ - decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

**(10 Lectures)**

### Unit - 4

#### 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)**

#### 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)**

## **Unit - 5**

### **Detector for Nuclear Radiations**

Gas detectors: estimation of electric field, mobility of particle, 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)**

### **Particle Accelerators**

Accelerator facility available in India: Van-de Graaff generator, Tandem accelerator, Linear accelerator, Cyclotron, Synchrotrons.

**(5 Lectures)**

### **Reference Books:**

- Introductory Nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of Nuclear Physics, Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the Physics of Nuclei and Particles, R.A. Dunlap. (Thomson Asia, 2004)
- 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, K. Heyde (IOP-Institute of Physics Publishing, 2004).
- Radiation Detection and Measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf (Dover Pub.Inc., 1991)

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# SKILL ENHANCEMENT COURSES

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## Semester III

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### PHYSICS - SEC 1 BASIC INSTRUMENTATION SKILLS

**(Credits: 02)**

**Theory: 30 Lectures**

*This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.*

#### **Unit - 1**

##### **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)**

#### **Unit - 2**

##### **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)**

##### **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)**

#### **Unit - 3**

##### **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 and chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

**(6 Lectures)**

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)**

#### **Unit - 4**

##### **Impedance Bridges and Q-Meters:**

Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of Q-Meter. Digital LCR bridges.

**(3 Lectures)**

## **Unit - 5**

### **Digital Instruments:**

Principle and working of digital meters. Comparison of analog and digital instruments. Characteristics of digital meter. Working principles of digital voltmeter.

**(3 Lectures)**

### **Digital Multimeter:**

Block diagram and working of digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time-base stability, accuracy and resolution.

**(3 Lectures)**

### **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 equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

### **Laboratory Exercises:**

1. To observe the loading effect of a multimeter while measuring voltage across 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)

### **Reference Books:**

- 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, 3<sup>rd</sup> 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

# PHYSICS - SEC 2

## WEATHER FORECASTING

**(Credits: 02)**

**Theory: 30 Lectures**

*The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques*

### **Unit - 1**

**Introduction to atmosphere:**

Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

**(9 Lectures)**

### **Unit - 2**

**Measuring the weather:**

Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in the atmosphere; radiation laws.

**(4 Lectures)**

### **Unit - 3**

**Weather systems:**

Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

**(3 Lectures)**

### **Unit - 4**

**Climate and Climate Change:**

Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

**(6 Lectures)**

### **Unit - 5**

**Basics of weather forecasting:**

Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

**(8 Lectures)**

**Demonstrations and Experiments:**

1. Study of synoptic charts and weather reports, working principle of weather station.
2. Processing and analysis of weather data:
  - a. To calculate the sunniest time of the year.
  - b. To study the variation of rainfall amount and intensity by wind direction.
  - c. To observe the sunniest/driest day of the week.
  - d. To examine the maximum and minimum temperature throughout the year.
  - e. To evaluate the relative humidity of the day.
  - f. To examine the rainfall amount month wise.

3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/warning (both aviation and non aviation)

**Reference books:**

- Aviation Meteorology, I.C. Joshi, 3<sup>rd</sup> edition 2014, Himalayan Books
- The Weather Observer's Hand Book, Stephen Burt, 2012, Cambridge University Press.
- Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
- Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
- Why the Weather, Charles Franklin Brooks, 1924, Chapman & Hall, London.
- Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

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## Semester IV

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### PHYSICS - SEC 3

### PHYSICS WORKSHOP SKILLS

**(Credits: 02)**

**30 Lectures**

*The aim of this course is to enable the students to have familiarity and experience with various mechanical and electrical tools through hands-on mode*

#### **Unit - 1**

##### **Introduction:**

Measuring units. Conversion to SI and CGS. Familiarization with meter scale, Vernier Calliper, Screw gauge and their utility. Measurement of 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)**

#### **Unit - 2**

##### **Mechanical Skills:**

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.

**(5 Lectures)**

#### **Unit - 3**

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. Making funnel using metal sheet.

**(5 Lectures)**

#### **Unit - 4**

##### **Electrical and Electronic Skills:**

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)**

#### **Unit - 5**

##### **Introduction to prime movers:**

Mechanism, Gear system, wheel, Fixing of gears with motor axle. Lever mechanism, Lifting of heavy weight using lever. Braking systems, Pulleys, Working principle of power generation systems. Demonstration of pulley experiment.

**(6 Lectures)**

**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, 3<sup>rd</sup> Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

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# PHYSICS - SEC 4

## RENEWABLE ENERGY AND ENERGY HARVESTING

**(Credits: 02)**

**Theory: 30 Lectures**

*The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible*

### **Unit - 1**

#### **Fossil fuels and Alternate Sources of Energy:**

Fossil fuels and nuclear energy, their limitations, 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.

**(3 Lectures)**

**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 greenhouses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

**(6 Lectures)**

### **Unit - 2**

#### **Wind Energy harvesting**

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

**(3 Lectures)**

**Geothermal Energy:** Geothermal Resources, Geothermal Technologies.

**(2 Lectures)**

### **Unit - 3**

#### **Ocean Energy**

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

**(3 Lectures)**

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

**(2 Lectures)**

### **Unit - 4**

#### **Hydro Energy**

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

**(2 Lectures)**

**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.

**(4 Lectures)**

## **Unit - 5**

### **Electromagnetic Energy Harvesting**

Linear generators, physics mathematical models, recent applications

**(2 Lectures)**

Carbon captured technologies, cell, batteries, power consumption

**(2 Lectures)**

Environmental issues and Renewable sources of energy, sustainability.

**(1 Lecture)**

### **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.

### **Reference Books:**

- Non-conventional Energy Sources, G.D Rai, Khanna Publishers, New Delhi
- Solar Energy, M P Agarwal, S Chand and Co. Ltd.
- Solar Energy, Suhas P Sukhatve, Tata McGraw - Hill Publishing Company Ltd.
- Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, 2004, Oxford University Press, in association with The Open University.
- Solar Energy: Resource Assessment Handbook, Dr. P Jayakumar, 2009
- Photovoltaics, J.Balfour, M.Shaw and S. Jarosek, Lawrence J Goodrich (USA).
- [http://en.wikipedia.org/wiki/Renewable\\_energy](http://en.wikipedia.org/wiki/Renewable_energy)

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## Semester V

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# PHYSICS - SEC 5

## ELECTRICAL CIRCUITS AND NETWORK SKILLS

**(Credits: 02)**

### **Theory: 30 Lectures**

*The aim of this course is to enable the students to design and troubleshoot electrical circuits, networks and appliances through hands-on mode*

### **Unit - 1**

#### **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)**

#### **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)**

### **Unit - 2**

#### **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)**

#### **Generators and Transformers:**

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

**(3 Lectures)**

### **Unit - 3**

#### **Electric Motors:**

Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed and power of ac motor.

**(4 Lectures)**

#### **Solid-State Devices:**

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

**(3 Lectures)**

### **Unit - 4**

#### **Electrical Protection:**

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)**

## **Unit - 5**

### **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: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.

**(5 Lectures)**

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### **Reference Books:**

- 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.

## **PHYSICS - SEC 6** **TECHNICAL DRAWING**

**(Credits: 02)**

**Theory: 30 Lectures**

### **Unit - 1**

#### **Introduction:**

Drafting Instruments and their uses. lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism. 2D geometrical construction. Representation of 3D objects. Principles of projections.

**(4 Lectures)**

### **Unit - 2**

#### **Projections:**

Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.

**(6 Lectures)**

### **Unit - 3**

#### **Object Projections**

Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.

**(4 Lectures)**

### **Unit - 4**

#### **CAD Drawing:**

Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD - specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-D drawings.

**(8 Lectures)**

### **Unit - 5**

3D modeling with Auto CAD (surfaces and solids), 3D modeling with Sketch up, annotating in Auto CAD with text and hatching, layers, templates and design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.

**(8 Lectures)**

#### **Reference Books:**

- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
- AutoCAD 2014 and AutoCAD 2014, Donnie Gladfelter, Sybex, ISBN:978-1-118-57510-9
- Architectural Design with Sketchup, Alexander Schreyer, John Wiley & Sons/ISBN: 978-1-118-12309-6

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## Semester VI

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### PHYSICS - SEC 7

### COMPUTATIONAL PHYSICS SKILLS

**(Credits: 02)**

**Theory: 30 Lectures**

*The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.*

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *Course will consist of hands on training on the Problem solving on Computers.*

#### **Unit - 1**

##### **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)**

#### **Unit - 2**

##### **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)**

#### **Unit - 3**

##### **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)**

## **Unit - 4**

### **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)**

## **Unit - 5**

### **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. Plotting trajectory of a projectile projected horizontally.
6. Plotting trajectory of a projectile projected making an angle with the horizontal.
7. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen.
8. 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 a particle in a central force field and plot the output for visualization.

**(9 Lectures)**

**Reference Books:**

- Introduction to Numerical Analysis, S.S. Sastry, 5<sup>th</sup> 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 Lipshutz 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, 3<sup>rd</sup> Edn, 2007, Wiley India Edition.

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# **PHYSICS - SEC 8**

## **RADIATION SAFETY**

**(Credits: 02)**

**Theory: 30 Lectures**

*The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics*

### **Unit - 1**

#### **Basics of Atomic and Nuclear Physics:**

Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of elements, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

**(6 Lectures)**

### **Unit - 2**

#### **Interaction of Radiation with matter:**

Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources,

Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients,

Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung),

Interaction of Neutrons- Collision, slowing down and Moderation.

**(7 Lectures)**

### **Unit - 3**

#### **Radiation detection and monitoring devices:**

Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC).

Radiation detection: Basic concept and working principle of gas detectors, Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter, Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

**(7 Lectures)**

### **Unit - 4**

#### **Radiation safety management**

Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

**(5 Lectures)**

## **Unit - 5**

### **Application of nuclear techniques:**

Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

**(5 Lectures)**

### **Experiments:**

1. Study the background radiation levels using Radiation meter

#### **Characteristics of Geiger Muller (GM) Counter:**

2. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3. Study of counting statistics using background radiation using GM counter.
4. Study of radiation in various materials (e.g. KSO<sub>4</sub> etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
5. Study of absorption of beta particles in Aluminum using GM counter.
6. Detection of  $\alpha$  particles using reference source and determining its half life using spark counter
7. Gamma spectrum of Gas Light mantle (Source of Thorium)

### **Reference Books**

- Nuclear and Particle Physics , W.E. Burcham and M. Jobes, Longman (1995)
- Radiation Detection and Measurements, G.F.Knoll
- Thermoluminescence Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
- Fundamental Physics of Radiology, W.J. Meredith and J.B. Massey, John Wright and Sons, UK, 1989.
- Fundamentals of Radiation Dosimetry, J.R. Greening, Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
- Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
- An Introduction to Radiation Protection, A. Martin and S.A. Harbisor, John Willey & Sons, Inc. New York, 1981.
- NCRP, ICRP, ICRU, IAEA, AERB Publications.
- Medical Radiation Physics, W.R. Hendee, Year Book, Medical Publishers Inc. London, 1981

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## **Note to the Teacher**

In order to be in conformity with the University's system of having 5 units for each paper, some units have been shifted out of the ideal teaching sequence. Hence teachers are advised to refer to the standard sequence as given in the UGC syllabus.