CHOICE BASED CREDIT SYSTEM

B. SC. PROGRAM WITH PHYSICS

<u>Details of Courses Under CBCS for B.Sc. Program with Physics as one subject</u>

Course	***Credits**	
	Theory+ Practical	Theory+Tutorials
<u>I. Core Course</u> **(12 Papers)** 04 Courses from each of the 03 disciplines of choice	12X4= 48	12X5=60
Core Course Practical / Tutorial* **(12 Practical/ Tutorials*)** 04 Courses from each of the 03 Disciplines of choice	12X2=24	12X1=12
<u>II. Elective Course</u> **(6 Papers)** Two papers from each discipline of choice including paper of interdisciplinary nature.	6x4=24	6X5=30
Elective Course Practical / Tutorials* **(6 Practical / Tutorials*)** Two Papers from each discipline of choice including paper of interdisciplinary nature	6 X 2=12	6X1=6
Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester		
<u>III. Ability Enhancement Courses</u>		
1**. Ability Enhancement Compulsory** **(2 Papers of 2 credits each)** **Environmental Science** **English/MIL Communication**	2 X 2=4	2X2=4
2**. Skill Enhancement Course** **(Skill Based)** **(4 Papers of 2 credits each)**	4 X 2=8	4 X 2=8
	Total credit= 120	**Total credit= 120**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/ NCC/NSS/related courses on its own.

***Wherever there is a practical there will be no tutorial & vice-versa. The size of group for practical papers is recommended to be maximum of 12 to 15 students.**

Proposed scheme for CBCS in B. Sc. Program with Physics as one subject

Semester	**CORE COURSE (12)**	**Ability Enhancement Compulsory Course (AECC) (2)**	**Skill Enhancement Course (SEC)(2)**	**Discipline Specific Elective DSE (6)**
I	Mechanics	(English/MIL Communication)/ Environmental Sc.		
	DSC- 2 A			
	DSC- 3 A			
II	Electricity, Magnetism & EMT	Environmental Science /(English/MIL Communication)		
	DSC- 2 B			
	DSC- 3 B			
III	Thermal Physics and Statistical Mechanics		SEC-1	
	DSC- 2 C			
	DSC- 3 C			
IV	Waves and Optics		SEC -2	
	DSC- 2 D			
	DSC- 3 D			
V			SEC -3	DSE-1 A
				DSE-2 A
				DSE-3 A
VI			SEC -4	DSE-1 B
				DSE-2 B
				DSE-3 B

B. Sc. Program with Physics as one subject

Semester	COURSE OPTED	COURSE NAME	Credits
I	**Ability Enhancement Compulsory Course-I**	**English communications/ Environmental Science**	**2**
	Core course-I	**Mechanics**	**4**
	Core Course-I Practical/Tutorial*	**Mechanics Lab**	**2**
	Core course-II	**DSC 2A**	**6**
	Core Course-III	**DSC 3A**	**6**
II	**Ability Enhancement Compulsory Course-II**	**English communications/ Environmental Science**	**2**
	Core course-IV	**Electricity, Magnetism and EMT**	**4**
	Core Course-IV Practical/Tutorial*	**Electricity, Magnetism & EMT Lab**	**2**
	Core course-V	**DSC 2B**	**6**
	Core Course-VI	**DSC 3B**	**6**
III	**Core course-VII**	**Thermal Physics & Statistical Mechanics**	**4**

	Core Course-VII Practical/Tutorial	**Thermal Physics and Statistical Mechanics Lab**	**2**
	Core course-VIII	**DSC 2C**	**6**
	Core Course-IX	**DSC 3C**	**6**
	Skill Enhancement Course -1	**SEC-1**	**2**
IV	**Core course-X**	**Waves and Optics**	**4**
	Course-X Practical/Tutorial	**Waves and Optics Lab**	**2**
	Core course-XI	**DSC 2D**	**6**
	Core course-XII	**DSC 3D**	**6**
	Skill Enhancement Course -2	**SEC -2**	**2**
V	**Skill Enhancement Course -3**	**SEC -3**	**2**
	Discipline Specific Elective -1	**DSE-1A (Subject 1: Physics)**	**6**
	Discipline Specific Elective -2	**DSE-2A (Subject 2)**	**6**
	Discipline Specific Elective -3	**DSE-3A (Subject 3)**	**6**
VI	**Skill Enhancement Course -4**	**SEC -4**	**2**
	Discipline Specific Elective -4	**DSE-1B (Subject 1: Physics)**	**6**
	Discipline Specific Elective -5	**DSE-2B (Subject 2)**	**6**
	Discipline Specific Elective-6	**DSE-3B (Subject 3)**	**6**
Total Credits			**120**

***Wherever there is a practical there will be no tutorial and vice-versa. The size of group for practical papers is recommended to be maximum of 12 to 15 students.**

B.Sc. Program with Physics as one subject

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

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

Discipline Specific (Physics) Elective papers (Credit: 06 each)

(DSE 1, DSE 2): Choose 2 (one for each semester)

Odd Semester: (Choose any one)

1. Digital, Analog and Instrumentation(4) + Lab (4)
2. Elements of Modern Physics (4) + Lab (4)
3. Mathematical Physics(4) + Lab (4)
4. Nano Materials and Applications(4) + Lab (4)
5. Communication System (4) + Lab (4)
6. Verilog and FPGA based system design (4) + Lab (4)
7. Medical Physics (4) + Lab (4)
8. Applied Dynamics (4) + Lab (4)

Even Semester: (Choose any one)

9. Solid State Physics (4) + Lab (4)
10. Embedded System: Introduction to microcontroller(4) + Lab (4)
11. Nuclear and Particle Physics (5) + Tut (1)
12. Quantum Mechanics (4) + Lab (4)
13. Digital Signal processing (4) + Lab (4)

14. Astronomy and Astrophysics (5) + Tutorials (1)
15. Atmospheric Physics (4) + Lab (4)
16. Physics of the Earth (5) + Tutorials (1)
17. Biological physics (5) + Tutorials (1)
18. Dissertation

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

1. Physics Workshop Skills
2. Computational Physics Skills
3. Electrical circuit network Skills
4. Basic Instrumentation Skills
5. Renewable Energy and Energy harvesting
6. Engineering design and prototyping
7. Radiation Safety
8. Applied Optics
9. Weather Forecasting

Semester I

PHYSICS-DSC 1 A: MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in vectors, differential equations and mechanics.

Vectors: Vector algebra. Derivatives of a vector with respect to a parameter. Scalar and vector products of two, three and four vectors. Gradient, divergence and curl of vectors fields. Polar and Axial vectors. **(5 Lectures)**

Ordinary Differential Equations: 1st order homogeneous differential equations, exact and non-exact differential equations, 2nd order homogeneous and non-homogenous differential equations with constant coefficients (Operator Method Only). **(9 Lectures)**

Laws of Motion: Review of Newton's Laws of motion. Dynamics of a system of particles. Concept of Centre of Mass, determination of center of mass for discrete and continuous systems having cylindrical and spherical symmetry (1-D, 2-D, 3-D objects). **(6 Lectures)**

Work and Energy: Motion of rocket. Work-Energy theorem for conservative forces. Force as a gradient of Potential Energy. Conservation of momentum and energy. Elastic and in-elastic Collisions. **(4 Lectures)**

Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia. Theorem of parallel and perpendicular axes (statements only). Calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D). Kinetic energy of rotation. Motion involving both translation and rotation. **(8 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 (statements only). Satellite in circular orbit and applications. Geosynchronous orbits. **(4 Lectures)**

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Compound pendulum. Differential equations of damped oscillations and forced oscillations and their solution. **(10 Lectures)**

Special Theory of Relativity: Frames of reference. Gallilean Transformations. Inertial and Non-inertial frames. Outcomes of Michelson Morley's Experiment. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic transformation of velocity. Relativistic variation of mass. Mass-energy equivalence. Transformation of Energy and Momentum. **(14 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. FW Sears, MW Zemansky & HD Young 13/e, 1986.Addison-Wesley
- Mechanics Berkeley Physics course, v.1:Charles Kittel, et.al. 2007, Tata McGraw-Hill
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2^{nd} edn., 2015, Oxford University Press
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHYSICS LAB: DSC 1 LAB: MECHANICS

60 Lectures

At least 06 experiments from the following:

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

Reference Books:

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

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

Semester II

PHYSICS-DSC 2: ELECTRICITY AND MAGNETISM
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This course begins with elementary vector analysis, an essential mathematical tool for understanding static electric and magnetic field. By the end of the course student should appreciate Maxwell's equations.

Vector Analysis: Review of vector algebra (Scalar and Vector product), Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(10 Lectures)**

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.
(24 Lectures)

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)**

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)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Wave equation in free space **(10 Lectures)**

Reference Books:

- Vector analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.
- 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 LAB- DSC 2 LAB: ELECTRICITY AND MAGNETISM 60 Lectures

At least 06 experiments from the following:

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 & 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 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 theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

Reference Books

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

Semester III

PHYSICS-DSC 3: THERMAL PHYSICS & STATISTICAL MECHANICS (Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. The primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical systems and processes. This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecues through statistical mechanics.

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 C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot's cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(22 Lectures)**

Thermodynamic 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)**

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)**

Statistical Mechanics: Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law, distribution of velocity, Quantum statistics, Fermi-Dirac distribution law, Bose-Einstein distribution law, 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.
- 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 LAB-DSC 3 LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

60 Lectures

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

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

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

Semester IV

PHYSICS-DSC 4: WAVES AND OPTICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

The physics and mathematics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a violin string, etc. can all be described in a similar way. Light too, often displays properties that are wave-like.
The course is aimed at equipping the students with the general treatment of waves. This begins with explaining ideas of oscillations and simple harmonic motion and go on to look at the physics of travelling and standing waves. This understanding applies to have a more elaborate analysis for sound waves and this further considers a number of phenomena in which the wave properties of light are important such as interference, diffraction, and polarization with emphasis of examples as seen in daily life.

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **(6 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) 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. **(8 Lectures)**

Sound: Sound waves, production and properties. Intensity and loudness of sound. Decibels. Intensity levels. musical notes. musical scale. Acoustics of buildings (General idea). **(6 Lectures)**

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 & 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 **(12 Lectures)**

Michelson's Interferometer: Construction and working. Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. **(4 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & 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)**

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

Reference Books:

- Vibrations and Waves, A.P. French, 1st Edn., 2003, CRC press.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- 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, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications
- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

PHYSICS LAB-DSC 4 LAB: WAVES AND OPTICS

60 Lectures

AT LEAST 08 EXPERIMENTS FROM THE FOLLOWING

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 Refractive Index of the Material of given Prism using Na Light.
6. To determine Dispersive Power of the Material of a given Prism using Hg Light
7. To determine the value of Cauchy Constants of a material of a prism.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using diffraction of single slit.
12. To determine wavelength of (1) Sodium and (2) Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To determine the wavelength of Laser light using Diffraction grating

Reference Books:

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

Discipline Specific (Physics) Elective

Select two papers

ODD SEMESTER (Choose one paper)

PHYSICS- DSE: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This paper aims to cover the basic digital and analog electronic systems. The concept of Boolean algebra is discussed in detail and arithmetic circuits are described. Students will learn the physics of semiconductor devices such as p-n junction, rectifier diodes and bipolar junction transistors. By the end of the syllabus, students will also have an understanding of operational amplifiers and instrumentation including CRO, power supply etc.

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. NAND and NOR. Gates as Universal Gates. XOR and XNOR Gates. **(5 Lectures)**

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuitusing Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of aTruth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(6 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. PN junction and its characteristics. Static and dynamic Resistance. (**2 Lectures)**

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 of transistor. Analysis of single-stage CE amplifier using hybrid Model. Input and output Impedance. Current and Voltage gains. **(12 Lectures)**

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. **(14 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Phase-shift Oscillator. **(5 Lectures)**

UNIT-4: Instrumentations:

Introduction to CRO: Block diagram of CRO. Applications of CRO: (!) Study of waveform, (2) Measurement of voltage, current, frequency, and phase difference.

(3 Lectures)

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)**

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. **(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, 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.
- OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

PRACTICALS - DSE LAB: DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTS

60 Lectures

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using a CRO
2. To minimize a given (a) logic circuit and (b) Boolean equation.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of (a) PN diode, (b) Zener diode and (c) LED
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.
9. (a) To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.

(b) To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.

10. To study a precision Differential Amplifier of given I/O specification using Op-amp.
11. To investigate the use of an op-amp as a Differentiator
12. 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 Circuit, R.A. Gayakwad, 4th edn., 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

PHYSICS- DSE: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This course introduces modern development in physics. Starting from Planck's Law it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. It also introduces basic concepts of Nuclear Physics.

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)**

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. **(6 Lectures)**

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. **(6 Lectures)**

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; 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)**

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)**

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 & binding energy.

(6 Lectures)

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)**

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, John R.Taylor, Chris D.Zafiratos, M.A.Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics:Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill
- Quantum Physics, Berkeley Physics Course,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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PRACTICALS -DSE-1 LAB: ELEMENTS OF MODERN PHYSICS

60 Lectures

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
1. To determine work function of material of filament of directly heated vacuum diode
2. To determine value of Planck’s constant using LEDs of at least 4 different colours.
3. To determine the ionization potential of mercury.
4. To determine the wavelength of H-alpha emission line of Hydrogen atom.
5. To determine the absorption lines in the rotational spectrum of Iodine vapour.
6. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.

7. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
8. To determine the value of e/m by magnetic focusing.

Reference Books:

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

PHYSICS-DSE: 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. The students are to be examined entirely on the basis of problems, seen and unseen.

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)**

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. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.

(10 Lectures)

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 Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

(16 Lectures)

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

(4 Lectures)

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of 1D wave equation. **(10 Lectures)**

Complex Analysis: Brief revision of Complex numbers & 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. Integration of a function of a complex variable. Cauchy's Integral formula. **(14 Lectures)**

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Essential Mathematical Methods, K.F. Riley and M.P. Hobson, 2011, Cambridge University Press

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PRACTICALS -DSE LAB: 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*
- *At least two programs must be attempted from each programming section.*

Topics	**Descriptions 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 and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and roundoff errors, Absolute and relative errors, Floating point computations
	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O

Review of C & C++ Programming fundamentals	statements, scanf and printf, cin and cout ,Manupulators for data formatting, Control statements (decision making and looping statements) *(if-statement, if-else statement, nested if statement, else-if statement, ternary operator, goto statement, switch statement, unconditional and conditional looping, while and do while loop, for loop,nested loops, break and continue statements*). Arrays (1D and 2D)and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs: using C/C++ language	Sum and 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 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. $sin\theta$, $cos\theta$, $tan\theta$ etc
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data calculate velocity and acceleration and vice versa. Find the area of BH 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 $0 \leq t \leq 15$ • The differential equation describing the motion of a pendulum is $\frac{d^2\vartheta}{dt^2} = -\sin(\vartheta)$. The pendulum is released from rest at an angular displacement α, i. e. $\vartheta(0) = \alpha \ and\ \vartheta'(0) = 0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small ϑ $(\sin(\vartheta) = \vartheta$

Referred Books:

- 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. Press et.al., 2nd Edn., 2013, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- An Introduction to computational Physics,T.Pang,2nd Edn., 2006,CambridgeUniv. Press

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PHYSICS-DSE: Nano Materials and Applications
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of the module students should also be able to understand the optical properties and electron transport phenomenon in nanostructures. It also covers few important applications of nano materials used in this technological era.

NANOSCALE SYSTEMS: Density of states (1-D,2-D,3-D). Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

(10 Lectures)

SYNTHESIS OF NANOSTRUCTURE MATERIALS: Metals, Metal Oxide, Carbon based nanomaterials CNT, C_{60}, graphene. Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Chemical vapor deposition (CVD).Sol-Gel. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots. **(8 Lectures)**

CHARACTERIZATION: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy.Scanning Tunneling Microscopy. **(8 Lectures)**

OPTICAL PROPERTIES: Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. **(14 Lectures)**

ELECTRON TRANSPORT: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. **(6 Lectures)**

APPLICATIONS: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). **(14 Lectures)**

Reference books:

- C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PRACTICALS-DSE LAB: Nano Materials and Applications
60 Lectures

At least 04 experiments from the following:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.

7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books:

- C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
- K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PHYSICS- DSE: COMMUNICATION SYSTEM
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This paper aims to describe the concepts of electronics in communication. Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail. Communication and Navigation systems such as GPS and mobile telephony system are introduced.

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. **(4 Lectures)**

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. **(12 Lectures)**

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

(9 Lectures)

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). **(10 Lectures)**

Introduction to Communication and Navigation systems:Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. **(10 Lectures)**

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only). **(15 Lectures)**

Reference Books:

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
- Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
- Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
- Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

PHYSICSS LAB-DSE LAB: COMMUNICATION SYSTEM LAB 60 Lectures

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)

8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Reference Books:

- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Electronic Communication system, Blake, Cengage, 5th edition.

PHYSICS-DSE: VERILOG AND FPGA BASED SYSTEM DESIGN
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained. At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices. (**20 Lectures**)

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan. (**20 Lectures**)

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog.
(**20 lectures**)

Reference Books:

- LizyKurien and Charles Roth. *Principles of Digital Systems Design and VHDL.*Cengage Publishing. ISBN-13: 978-8131505748
- Palnitkar, Samir, *Verilog HDL.* Pearson Education; Second edition (2003).
- Ming-Bo Lin. *Digital System Designs and Practices: Using Verilog HDL and FPGAs.* Wiley India Pvt Ltd. ISBN-13: 978-8126536948
- Zainalabedin Navabi. *Verilog Digital System Design.* TMH; 2ndedition. ISBN-13: 978-0070252219

- S. K. Mitra, Digital Signal processing, McGraw Hill, 1998
- VLSI design, Debaprasad Das, 2nd Edition, 2015, Oxford University Press.
- D.J. Laja and S. Sapatnekar, Designing Digital Computer Systems with Verilog, Cambridge University Press, 2015.

PRACTICALS-DSE LAB: VERILOG AND FPGA LAB
60 Lectures

AT LEAST 08 EXPERIMENTS FROM FOLLOWING.

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

Reference Books

- W.Wolf, FPGA- based System Design, Pearson, 2004
- U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
- S. Palnitkar, Verilog HDL– A Guide to Digital Design & Synthesis, Pearson, 2003
- Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

PHYSICS-DSE: Medical Physics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

The last few years have witnessed a tremendous growth in the applications of Physics to the field of medicine. Beginning with the use of Imaging in Diagnostics to Radiation therapy for Cancer, everything involves Physics. Hence, there is a big need for medical physicists. This course introduces a student to the basics of Medical Physics. Today with the changing life styles it is also necessary for one to have a better understanding of the human body from the perspective of Physics. This course seeks to fulfil both these needs.

PHYSICS OF THE BODY-I

Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal.

Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement. Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. **Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation. **Pressure system of body:** Physics of breathing, Physics of cardiovascular system. Basics of CPR. **(8 Lectures)**

PHYSICS OF THE BODY-II

Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. **Optical system of the body:** Physics of the eye. **Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer. **(10 Lectures)**

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I

X-RAYS: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. **X-ray tubes & types**: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit, types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables, HT generation. **(7 Lectures)**

RADIATION PHYSICS: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, Rem & Sievert, linear attenuation coefficient. **Radiation Detectors**: Thimble chamber, condenser chambers, Geiger Muller counter, Scintillation counters and Solid State detectors, ionization chamber, Dosimeters, survey methods, area monitors, TLD,Semiconductor detectors. **(7 Lectures)**

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI

Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. **Computed tomography scanner**- principle & function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). **(9 Lectures)**

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy-LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines ,Medical linear accelerator. Basics of Teletherapy units, deep x-ray, Telecobalt units, medical linear accelerator, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume. **(9 Lectures)**

RADIATION AND RADIATION PROTECTION: Principles of radiation protection ,protective materials-radiation effects , somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge , pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors**.** Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose. **(5 Lectures)**

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II

Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography.

Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment.

Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes. **(5 Lectures)**

Reference Books:

- Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
- Basic Radiological Physics Dr. K.Thayalan- Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- Physics of the human body, Irving P. Herman, Springer (2007).
- Physics of Radiation Therapy: F M Khan - Williams and Wilkins, 3rd edition (2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.

- The Physics of Radiology-H E Johns and Cunningham.

PHYSICS-DSE LAB: Medical Physics

60 Lectures

At least 05 experiments from the following:

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.
2. Basic Process of doing CPR
3. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.
4. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
5. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.
6. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.
7. Familiarization with Geiger-Muller (GM) Counter & to measure background radiation
8. Familiarization with Radiation meter and to measure background radiation.
9. Familiarization with the Use of a Vascular Doppler.

Reference Books:

- Basic Radiological Physics, Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rdedition (2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
- Handbook of Physics in Diagnostic Imaging: Roshan S. Livingstone: B. I. Publications Pvt Ltd.

PHYSICS-DSE: APPLIED DYNAMICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in applied dynamics.

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems.
Examples of dynamical systems –
Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bistability

(22 Lectures)

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states.Cobweb iteration.Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.
Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.
Nonlinear time series analysis and chaos characterization: Detecting chaos from Return map, Power spectrum, Autocorrelation, Lyapunov exponent, Correlation dimension.

(22 Lectures)

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streaklines. **(16 Lectures)**

Reference Books

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.

- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

PHYSICS PRACTICAL-DSE LAB: APPLIED DYNAMICS
60 Lectures

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

Reference Books

- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

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EVEN SEMESTER (CHOOSE ONE PAPER)

PHYSICS-DSE: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This syllabus gives an introduction to the basic phenomena in Solid State Physics. This aims to provide a general introduction to theoretical and experimental topics in solid state physics. On successful completion of the module students should be able to elucidate the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, describe the main features of the physics of electrons in solids; explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law.

(12 Lectures)

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 (qualitative only). T^3 law **(10 Lectures)**

Free electron theory: Electrons in metals- Drude Model, 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)**

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)

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.

(11 Lectures)

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors. **(5 Lectures)**

Reference Books:

- 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, Neil W. Ashcroft and N. David Mermin, 1976, Cengage Learning
- Solid State Physics, Rita John, 2014, McGraw Hill

- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PRACTICALS-DSE LAB: SOLID STATE PHYSICS

60 Lectures

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

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) technique.
6. To determine the refractive index of a dielectric layer using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o}C) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. To measure the resistivity of a semiconductor (Ge) with temperature by two-probe method and to determine its band gap.
12. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
13. Measurement of change in resistance of a semiconductor with magnetic field.

Reference Books

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

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PHYSICS-DSE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper gives a review of microprocessor and introduces microcontroller 8051. Here, students will learn about the 8051 I/O port programming, various addressing modes, Timer and counter programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals.

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded system, operational & non-operational quality attributes of embedded system, elemental description of embedded processors and microcontrollers.
(6 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085μp pin diagram and architecture, Data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **(4 Lectures)**

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. **(12 Lectures)**

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using Assembly Language), I/O programming: Bit manipulation. **(4 Lectures)**

Programming of 8051: 8051addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming: for time delay and I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.
(12 Lectures)

Timer and counter programming: Programming 8051 timers, counter programming.
(3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. **(6 Lectures)**

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. **(2 Lectures)**

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **(3 Lectures)**

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. **(8 Lectures)**

Reference Books:

- Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, 2nd Edition, 2007, Pearson Education
- Embedded Systems and Robots, Subrata Ghoshal, 2009, Cengage Learning
- Introduction to embedded system, K.V. Shibu, 1st Edition, 2009, McGraw Hill
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

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PRACTICALS- DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
60 Lectures

Following experiments (at least 060 using 8051:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow first four LED then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Reference Books:

- Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education
- Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
- Embedded Microcomputer systems:Real time interfacing, J.W. Valvano 2011, Cengage Learning.

PHYSICS-DSE: Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

Objective: The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application. The course will focus on the developments of problem based skills.

Outcomes : The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density (experimental determination of each), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments.

(10 Lectures)

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model. **(11 Lectures)**

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. **(10 Lectures)**

Nuclear Reactions: Types of Reactions, units of related physical quantities, 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. **(9 Lectures)**

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. **(9 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

(7 Lectures)

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

(11 Lectures)

Reference Book :

- Basic Ideas and concepts in Nuclear Physics : An introductory Approach by K Heyde, Third edition, IOP Publication, 1999.
- Nuclear Physics by S. N. Ghoshal, First edition, S. Chand Publication, 2010.
- Concepts of Nuclear Physics by Bernard L Cohen, Tata McGraw Hill Publication, 1974.
- Introductory Nuclear Physics by Kenneth S, Krane, Wiley-India Publication, 2008
- Nuclear Physics : principles and applications by John Lilley, Wiley Publication, 2006.
- Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.
- Radiation detection and measurement, G.F. Knoll, John Wiley & Sons, 2010.
- Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.
- Introduction to Modern Physics by Mani & Mehta, Affiliated East-West Press, 1990.
- Introduction to elementary particles by David J Griffiths, Wiley, 2008.
- Modern Physics by Serway, Moses and Moyer, CENGAGE LEARNING, 2012.
- Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.
- Numerical Books : Schaum's Outline of Modern Physics, McGraw-Hill Education, 1999 and Modern

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DSE: QUANTUM MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Prerequisites: Knowledge of (1) "Mathematical Physics" and (2) "Elements of Modern Physics"

In continuation with modern physics this course is an application of Schrodinger equation to various quantum mechanical problems. This gives fair idea of formulation of eigenvalues and eigen functions.

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 & momentum. Wave Function of a Free Particle. **(10 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 wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.
(12 Lectures)

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.
(10 Lectures)

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)**

Atoms in Electric and Magnetic Fields:- Electron Angular Momentum. Angular momentum Quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy. **(8 Lectures)**

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Antisymmetric

Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Spin-orbit coupling in atoms-L-S and J-J couplings.

(10 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rdEdn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2ndEdn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4thEdn., 2001, Springer

DSE LAB: QUANTUM MECHANICS

60 Lectures

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

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

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

Here, m is the reduced mass of electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Note that the ground state energy of hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(\text{eVÅ})^{1/2}$, ħc = 1973 (eVÅ) and m = $0.511\text{x}10^6$ 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

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

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 $(\text{eVÅ})^{1/2}$, m = $0.511\text{x}10^6$ 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 the 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

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

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

Some laboratory based experiments: (optional)

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

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., 3rd Edn., 2007, Cambridge University Press.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed. 2007,Wiley India Edition
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández.2014 Springer
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

ELECTRONICS-DSE: DIGITAL SIGNAL PROCESSING
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals. This paper also highlights the concept of filters and realization of Digital Filters. At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to

Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. **(10 Lectures)**

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The *z*-Transform:** Bilateral (Two-Sided) *z*-Transform, Inverse *z*-Transform, Relationship Between *z*-Transform and Discrete-Time Fourier Transform, *z*-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the *z*-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations. **(15 Lectures)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. **(5 Lectures)**

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. **(10 Lectures)**

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (*WN*), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. **(5 Lectures)**

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. **(15 Lectures)**

Reference Books:

- Digital Signal Processing, Tarun Kumar Rawat,2015,Oxford University Press, India
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
- Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

PRACTICAL-DSE LAB: DIGITAL SIGNAL PROCESSING LAB

60 Lectures

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \leq n \leq 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation

$$y(n) = 0.8y(n-1) + x(n)$$

(a) Determine $H(e^{jw})$

(b) Calculate and plot the steady state response $y_{ss}(n)$ to

$$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system

$$y(n) = 0.9y(n-1) + x(n)$$

(a) Find $H(z)$ and sketch its pole-zero plot

(b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t.$ The sampling frequency is $f_s = 500\ Hz.$ Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let $x(n)$ be a 4-point sequence:

$$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

Compute the DTFT $X(e^{jw})$ and plot its magnitude

(a) Compute and plot the 4 point DFT of $x(n)$

(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,

$$x(n) = \underset{\uparrow}{\{1,2,2,1\}}$$

$$h(n) = \underset{\uparrow}{\{1,-1,-1,1\}}$$

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:
passband edge $F_p = 2\ KHz$
stopband edge $F_s = 5\ KHz$
Passband attenuation $A_p = 2\ dB$
Stopband attenuation $A_s = 42\ dB$
Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} \qquad |w| \le \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:

- Digital Signal Processing, Tarun Kumar Rawat,Oxford University Press, India
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

PHYSICS-DSE: Astronomy and Astrophysics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

The syllabus of "Astronomy and Astrophysics" has been designed in a manner that provides excellent platform for understanding the origin and evolution of the Universe. It gives a comprehensive introduction on the measurement of basic astronomical parameters such as astronomical scales, luminosity and astronomical quantities. This course gives an overview on key developments in observational astrophysics. This primarily includes the telescope optics, instrument detectors and the choice of observation sites. The syllabus also reviews the formation of planetary system and its evolution with time. This course nicely covers the physical properties of Sun and the components of the solar system; and stellar and interstellar components of our Milky Way galaxy. It emphasizes on the physical laws that enable us to understand the origin and evolution of galaxies, presence of dark matter and large scale structures of the Universe.

Basic Astronomical Parameters: Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars).
Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.
Stellar spectra: Spectral types and their temperature dependence, Hertzsprung-Russell Diagram. **(24 Lectures)**
Astronomical telescopes and techniques: Atmospheric Windows, Optical telescopes, Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST) **(8 Lectures)**

Stellar structure: Derivation of Virial Theorem for N bodies, Basic Equations of stellar structure, simple stellar models (Polytropic model, Derivation of the Lane-Emden equation, analytical solutions of the Lane-Emden equation) **(14 Lectures)**

The Sun and the Solar System: Solar Atmosphere, Solar Photosphere, Chromosphere, Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics, Origin of the Solar System (The Nebular Model, Tidal Forces, Planetary Rings and their formation); Extra-Solar Planets. **(8 Lectures)**

The Milky Way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stellar Clusters, Morphological classification of the Galaxies **(12 Lectures)**

Large Scale Structure and Expanding Universe: Main sequence fitting, Standard candles (Cepheid variables, Supernovae), Cosmic Distance Ladder, Clusters of Galaxies (Virial theorem and Dark Matter), Hubble's Law **(9 Lectures)**

Reference Books:

- An Introduction to Modern Astrophysics and Cosmology (Second Edition), B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co., 2006.
- Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory, Saunders College Publishing, 1998.
- Fundamental of Astronomy (Fifth Edition), H. Karttunen et al. Springer, 2007.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Publication, 2001.
- The Cosmic Perspective (Eighth Edition), J. O. Bennet, M. Donahue, N. Schneider & M. Voit, Pearson Publications, 2017.
- The Physical Universe: An Introduction to Astronomy, Frank Shu, Oxford University Press, 1985.
- Astrophysics: Stars and Galaxies, K. D. Abhyankar, Universities Press, 2001.

PHYSICS-DSE: Atmospheric Physics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This paper aims to describe the characteristics of earth's atmosphere and also its dynamics. Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms. **(12 Lectures)**

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

(12 Lectures)

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration

(12 Lectures)

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. **(12 Lectures)**

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. **(12 Lectures)**

Reference Books:

- Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PRACTICALS-DSE LAB: Atmospheric Physics

60 Periods

Scilab/C++/ Fortran/ Matlab based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   (a) Atmospheric gravity waves (AGW)
   (b) Kelvin waves
   (c) Rossby waves and mountain waves

2. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar

3. Offline and online processing of LIDAR data

4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.

5. Handling of satellite data and plotting of atmospheric parameters using different techniques such as radio occultation technique

6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

7. PM 2.5 measurement using compact instruments

8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

Reference Books:

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
- The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3rd edn. 2002.
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
- Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PHYSICS-DSE: Physics of Earth
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

1. **The Earth and the Universe**: **(17 Lectures)**

(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.

(b) General characteristics and origin of the Universe. The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way galaxy, Nebular Theory, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteoroids, Meteors and Meteorites. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.

(c) Energy and particle fluxes incident on the Earth.

(d) The Cosmic Microwave Background.

2. **Structure**: (**18 Lectures)**

(a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?

(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.

(c) The Atmosphere: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation.

(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

3. **Dynamical Processes**: **(18 Lectures)**

(a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics, types of plate movements, hotspots, sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belt, Seismic waves, Richter scale, geophones. Volcanoes: types products and distribution.

(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of Coriolis forces. Concepts of eustasy, tend – air-sea interaction. Tides. Tsunamis.

(c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones.

Climate:

i. Earth's temperature and greenhouse effect.
ii. Paleoclimate and recent climate changes.
iii. The Indian monsoon system.

(d) Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

4. **Evolution:** **(18 Lectures)**

Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Time line of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of Uniformitarianism, Catastrophism and Neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth

Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

5. **Disturbing the Earth – Contemporary dilemmas** **(4 Lectures)**
   (a) Human population growth.
   (b) Atmosphere: Greenhouse gas emissions, climate change, air pollution.
   (c) Hydrosphere: Fresh water depletion.
   (d) Geosphere: Chemical effluents, nuclear waste.
   (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Reference Books:

- Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
- Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books.
- Holme's Principles of Physical Geology, 1992, Chapman & Hall.
- Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
- The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.
- Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
- Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
- The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
- The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
- Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
- Climate Change: A Very Short Introduction, Mark Maslin, 3rd Edition, 2014, Oxford University Press.
- The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.
- IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

PHYSICS-DSE: Biological Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

The Biological Physics course introduces the emerging inter-disciplinary field on the interface of Physics and Biology. It makes use of concepts from Physics and discusses their application in Biology. This course helps the students to develop a system level perspective of Biology and equips them with the required mathematical and computational skills.

Overview: (**9 Lectures**)

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

Molecules of life: (**22 Lectures**)

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.

Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

The complexity of life: (**30 Lectures**)

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.

Evolution: (**14 Lectures**)

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Reference Books:

- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
- Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)
- Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
- An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
- Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Skill Enhancement Course(any four) (Credit: 02 each)- SEC1 to SEC4

PHYSICS WORKSHOP SKILL

(Credits: 02)

30 Lectures

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

Introduction: Measuring devices: Vernier calliper, Screw gauge and travelling microscope. 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. **(6 lecture)**

Mechanical Skill: Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. 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. **(14 Lecture)**

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. **(10 Lectures)**

Practical

Main emphasis is on taking observations, calculations, graph and result. Perform at least three practical.

1. Comparison of diameter of a thin wire using screw gauge and travelling microscope.
2. Drilling of Hole in metal, wood and plastic.
3. Cutting of metal sheet.
4. Cutting of glass sheet
5. Lifting of heavy weights using simple pulley/lever arrangement.

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]

COMPUTATIONAL PHYSICS
(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 and Science.

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

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linuxas 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)**

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)

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)**

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)**

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)

Reference Books:

- 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, etal. New Age International Publishers, New Delhi(1999)
- Elementary Numerical Analysis, K.E.Atkinson,3rd Edn., 2007, Wiley India Edition.

ELECTRICAL CIRCUIT NETWORK SKILLS
(Credits: 02)
Theory: 30 Lectures

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

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

Electrical Circuits: Basic 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)**

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. **(2 Lectures)**

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor **(3 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)**

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device. **(3 Lectures)**

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, and solder. Preparation of extension board. **(5 Lectures)**

Network Theorems: (1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem. **(3 Lectures)**

Laboratory exercises:

AT LEAST 08 EXPERIMENTS FROM THE FOLLOWING

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

Reference Books:

- Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
- 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.

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.

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)**

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. Block diagram ac millivoltmeter**,** specifications and their significance. **(4 Lectures)**

Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance. **(6 Lectures)**

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

Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(4 Lectures)**

Impedance Bridges: 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)**

Digital Instruments: Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **(3 Lectures)**

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. **(3 Lectures)**

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

1. Use of an oscilloscope.
2. Oscilloscope 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 using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a Oscilloscope.
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:

- 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

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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

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. **(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 green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. **(6 Lectures)**

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)**

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)**

Geothermal Energy: Geothermal Resources, Geothermal Technologies.**(2 Lectures)**

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)**

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 voltageusing thermoelectric modules.

Reference Books:

- Non-conventional energy sources, B.H. Khan, McGraw Hill
- Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
- Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.
- Renewable Energy, 3rd Edition,
- Solar Energy: Resource Assesment Handbook, P Jayakumar, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy

ENGINEERING DESIGN AND PROTOTYPING
(Credits: 02)
Theory: 30 Lectures

"How I See is How I Understand"
Drawings and pictorial representations are simple but effective tools in engineering crafts and one of the best ways to communicate ideas, learnings, and concepts. The purpose of this SEC is to empower the learners to think computationally and communicate pictorially.

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral. **(4 Lectures)**

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids. **(10 Lectures)**

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 of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale. **(10 Lectures)**

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.

(6 Lectures)

References:

- Engineering Drawing, N.S. Parthasarathy and Vele Murali, 1st Edition, 2015, Oxford University Press
- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
- Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
- AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
- Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
- Norton, Robert L. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.
- James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.

RADIATION SAFETY
(Credits: 02)
Theory: 30 Lectures
Objective: It is a course focus on the applications of nuclear techniques and radiation protection. It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure.

Outcomes: This will prepare the work force for jobs in industry and medical fields..

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 element, 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)

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)

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 Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry. **(7 Lectures)**

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, limitations, 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)**

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: Minimum four experiments need to be perform from the following,

1. Estimate the energy loss of different ions in Water and carbon, using SRIM/TRIM etc simulation software.

2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H-ion.

3. Comparison of interaction of H like ions in a given medium (Carbon/Water) using simulation software (SRIM etc).

4. Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics, University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/)

5. Study the background radiation levels using Radiation meter.

6. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).

7. Study of counting statistics using background radiation using GM counter.

8. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.

9. Study of absorption of beta particles in Aluminum using GM counter.

10. Detection of α particles using reference source & determining its half-life using spark counter

11. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books:

1. Nuclear and Particle Physics by W. E. Burcham and M. Jobes, Harlow Longman Group, 1995.

2. G. F. Knoll, Radiation detection and measurement, 4^{th} Edition, Wiley Publications, 2010.

3. Thermoluminescence dosimetry by A. F. Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5)

4. Fundamental Physics of Radiology by W .J. Meredith and J.B. Massey, John Wright and Sons, UK, 1989.

5. An Introduction to Radiation Protection by A. Martin and S. A. Harbisor, John Willey & Sons, Inc. New York, 1981.

6. Medical Radiation Physics by W. R. Hendee, Year book Medical Publishers, Inc., London, 1981.

7 Nuclear Physics: Principles and Applications by John Lilley, Wiley Publication, 2006.

8 Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, Academic Press Elsevier, 2007.

9 Technique for Nuclear and Particle Physics experiments by William R Leo, Springer, 1994.

10. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

11. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011

12. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources. , 2007

APPLIED OPTICS
(Credits: 02)
THEORY: 30 Lectures

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

(i) Sources and Detectors (9 Periods)

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:

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

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor

(ii) Fourier Optics (6 Periods)

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 simulation can also be done.

(iii) Holography (6 Periods)

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 Periods)

Optical fibres and their properties, Principal of light propagation through a fibre, Thenumerical 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

Reference Books:

- 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
- Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

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

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 **(9 Periods)**

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 atmosphere; radiation laws. **(4 Periods)**

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes. **(3 Periods)**

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion **(6 Periods)**

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 Periods)**

Demonstrations and Experiments:

1. Study of synoptic charts & 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.
   (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).

5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

Reference books:

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agro meteorology, S.R. Ghadekar, 2005,Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.
