WEST BENGAL STATE UNIVERSITY

B.Sc. with Physics (Hons) & B.Sc. (General) with Physics

Choice Based Credit System Syllabus

First Draft

1. Scheme for CBCS Curriculum

1.1Credit Distribution across Courses

	Credits		
Course Type	Total Papers	Theory + Practical	Theory*
Core Courses	14	14*4 =56 14*2 =28	14*5 =70 14*1=14
Discipline Specific Electives	4	4*4=16 4*2=8	4*5=20 4*1=4
Generic Electives	4	4*4=16 4*2=8	4*5=20 4*1=4
Ability Enhancement Language Courses	2	2*2=4	2*2=4
Skill Enhancement Courses	2	2*2=4	2*2=4
Totals	26	140	140

*Tutorials of 1 Credit will be conducted in case there is no practical component

1.2Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course – I	English communication / Environmental Science	2
	Core course – I	Mathematical Physics-I	4
	Core course – I Practical	Mathematical Physics-I Lab	2
	Core course – II	Mechanics	4
	Core course – II Practical	Mechanics Lab	2
	Genetic Elective – 1	TBD	4

	Generic Elective – 1 Practical	TBD	2
II	Ability Enhancement Compulsory Course – II	English communication / Environmental Science	2
	Core course – III	Electricity and Magnetism	4
	Core course – III Practical	Electricity and Magnetism Lab	2
	Core course – IV	Waves and Optics	4
	Core course – IV Practical	Waves and Optics Lab	2
	Generic Elective – 2	TBD	4
	Generic Elective – 2 Practical	TBD	2
III	Core course – V	Mathematical Physics-II	4
	Core course – V Practical	Mathematical Physics-II Lab	2
	Core course – VI	Thermal Physics	4
	Core course – VI Practical	Thermal Physics Lab	2
	Core course – VII	Digital Systems and Applications	4
	Core course – VII Practical	Digital Systems & Applications Lab	2
	Skill Enhancement Course – 1	TBD	2
	Generic Elective – 3	TBD	4
	Generic Elective – 3 Practical	TBD	2
IV	Core course – VIII	Mathematical Physics III	4
	Core course – VIII Practical	Mathematical Physics-III Lab	2

	Core course – IX	Elements of Modern Physics	4
	Core course – IX Practical	Elements of Modern Physics Lab	2
	Core course – X	Analog Systems and Applications	4
	Core course – X Practical	Analog Systems & Applications Lab	2
	Skill Enhancement Course-2	TBD	2
	Generic Elective – 4	TBD	4
	Generic Elective – 4 Practical	TBD	2
V	Core course – XI	Quantum Mechanics & Applications	4
	Core course – XI Practical	Quantum Mechanics Lab	2
	Core course – XII	Solid State Physics	4
	Core course – XII Practical	Solid State Physics Lab	2
	Discipline Specific Elective – 1	TBD	4
	Discipline Specific Elective – 1 Practical	TBD	2
	Discipline Specific Elective – 2	TBD	4
	Discipline Specific Elective – 2 Practical	TBD	2
VI	Core course – XIII	Electro-magnetic Theory	4
	Core course – XIII Practical	Electro-magnetic Theory Lab	2
	Core course – XIV	Statistical Mechanics	4
	Core course – XIV Practical	Statistical Mechanics Lab	2

	Discipline Specific Elective – 3	TBD	4
	Discipline Specific Elective – 3 Practical	TBD	2
	Discipline Specific Elective – 4	TBD	4
	Discipline Specific Elective – 4 Practical	TBD	2

1.3 Choices for Discipline Specific Electives

Discipline Specific Elective – 1 to 4			
Sem V	Advanced Mathematical Physics I (4+2)	Nuclear and Particle Physics (5+1)	Advanced Dynamics (5+1)
Sem VI	Advanced Mathematical Physics II (5+1)	Astronomy and Astrophysics (5+1)	Communication Electronics (4+2)

1.4 Choices for Skill Enhancement Courses

Skill Enhancement Course-1 & Skill Enhancement Course-2		
Physics Workshop Skills	Electrical circuits & Network Skills	Renewable Energy & Energy harvesting
Computational Physics Skills	Basic Instrumentation Skills	Technical Drawing
Weather Forecasting	Radiation Safety	Applied Optics

1.5 Choices of Generic Electives (for Honours students of other disciplines)

Odd Sem	**Mechanics (4+2)**	**Thermal Physics & Statistical Mechanics (4+2)**	**Digital, Analog Circuits & Instrumentation (4+2)**	**Perspectives of Modern Physics (5+1)**
Even Sem	**Electricity & Magnetism (4+2)**	**Waves & Optics (4+2)**	**Solid State Physics (4+2)**	**Nuclear & Particle Physics (5+1)**

2. Core Subjects Syllabus

1.6Core T1 – Mathematical Physics

Mathematical Physics	
60 Lectures	**4 Credits**
Calculus	**20 Lectures**
Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). Convergence condition of Taylor series and corresponding tests. First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous and Inhomogeneous Equations with constant coefficients, particular integral. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.	
Vector Calculus	**30 Lectures**
Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities using Kronecker delta and Levi-civita symbols. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	
Introduction to probability	**10 Lectures**

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem.

Reference Books

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Spiegel
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Mathematical Physics, Goswami, 1st edition, Cengage Learning
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press
- Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

1.7Core P1 – Mathematical Physics Lab

Mathematical Physics	
60 class hours	**2 credits**

General Topics

Computer architecture and organization, memory and Input/output devices.

Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

Errors and error Analysis: Truncation and round off errors, Absolute and relative errors, Floating point computations.

Introduction to plotting graphs with QtiPlot (or equivalent)

Basic 2D and 3D graph plotting - plotting functions and datafiles, fitting data using qtiplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots.

Introduction to programming in python:

- Python as a number calculator
- algebraic calculation through python interactively
- help searching
- standard I/O statements
- program with formula crunching
- string, list, tuple and the corresponding methods
- Control structures

Programs as applications

- finite series summation
- Taylor series summation with a given precision

File handling in Python

- File I/O statements

Least square fitting

- Linear and linearised Least square fitting with supplied data

User defined functions in Python

- User defined function, default argument.

synthetic data generation and plotting

- synthetic data generation and plotting with QtiPlot (or equivalent).

Finding largest and smallest values within a dataset

- Finding largest and smallest values over a time-series data.
- Estimating largest and smallest values of a function within an interval using fixed step size.

Solution of Algebraic and Transcendental equations

- Root finding: Bisection & New Raphson Method (Initial guess to be determined by plotting) for non-linear equations.
- Applications in simple physical problems (including those of mathematical Physics)

Reference Books

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn . , 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

1.8Core T2 – Mechanics

Mechanics	
60 Lectures	**4 Credits**
Fundamentals of Dynamics	**5 Lectures**
Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.	
Work and Energy	**4 Lectures**
Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.	
Collisions	**3 Lectures**
Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.	
Rotational Dynamics	**10 Lectures**
Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Perpedicular axes theorem and parallel axes theorem and their applications in calculations of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.	
Elasticity	**6 Lectures**
Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Bending of a beam – internal bending moment..	
Fluid Motion	**4 Lectures**
Kinematics of Moving Fluids: Equation of continuity. Idea of streamiline and turbulent flow, Reynold's number. Poiseuille's Equation for Flow of a *viscous* Liquid through a Capillary Tube.	

Gravitation and Central Force Motion	9 Lectures

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

Oscillations	7 Lectures

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

Non-Inertial Systems:	4 Lectures

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.

Special Theory of Relativity	8 Lectures

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities.Relativistic Doppler effect.

Reference Books

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

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

1.9Core P2 – Mechanics Lab

Mechanics	
60 class hours	**2 Credits**

General Topic

Discussion on random errors in observations. Measurement principles of length (or diameter) using vernier caliper, screw gauge and travelling microscope. Discussion on the parts of Sextant.

List of Practical

1. To study the random error in observations of time period of some oscillation using chronometer.
2. To determine the Moment of Inertia of a regular body using another auxilary body and a cradle suspeded by a metalic wire.
3. To determine g and velocity for a freely falling body using Digital Timing Technique
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus by flexure method.
6. To determine the Modulus of Rigidity of a Wire by a torsional pendulum.
7. To determine the height of a building using a Sextant.
8. To determine the elastic Constants of a wire by Searle's method.
9. To determine the value of g using Bar Pendulum.
10. To determine the value of g using Kater's Pendulum.
11. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
- Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

1.10 Core T3 - Electricity and Magnetism

Electricity and Magnetism	
60 class hours	**4 Credits**
Electric Field and Electric Potential	**15 Lectures**
Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Charge density of a point charge – Definition of Dirac delta function. Properties of Dirac delta function. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. Potential and Electric Field of a dipole. Force and Torque on a dipole. Uniqueness theorem. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Energy stored in Electrostatic field.	
Dielectric Properties of Matter	**8 Lectures**
Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. Boudary conditions at the interface of two media.	
Magnetic Field	**10 Lectures**
Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of B: curl and divergence. . Axial vector property of B and its consequences. Vector Potential. Calculation of vector potential and magnetic induction in simple cases – straight wire, magnetic field due to small current-loop. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.	
Magnetic Properties of Matter	**5 Lectures**
Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation	

between B, H, M. Ferromagnetism. B-H curve and hysteresis. Boundary conditions at the interface of two media.

Electromagnetic Induction	**6 Lectures**
Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance, calculation in simple cases (e.g. circular loops, solenoids). Reciprocity Theorem. Energy stored in a Magnetic Field.	
Electrical Circuits	**10 Lectures**
Charge Conservation – equation of continuity. Transients in D.C.:Growth and decay of current, charging and discharging of capacitors in CR, LR & LCR circuits; oscillatory discharge; time constant; time variation of total energy in LCR cicuit. AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Phasor diagram. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit	
Network theorems	**6 Lectures**
Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits	

Reference Books

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
- Ritz-Milford
- Grant & Phillips
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

1.11 Core P3 – Electricity and Magnetism Lab

Electricity and Magnetism	
60 class hours	**2 Credits**

General topic

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances (e) Checking electrical fuses and (f) circuit continuity check**.** Demonstartion on Carey Foster's bridge, potentiometer, resistance box, inductor coil, moving coil galvanometer (in dead beat and ballistic mode), etc. Use of computers for plotting of experimental results and corresponding fitting of curves using numerical methods learnt in the last semester, are to be encouraged with evidences in laboratory notebooks

List of Practicals

1. To determine an unknown Low Resistance using Carey Foster's Bridge.
2. To verify the Thevenin and Norton theorems.
3. To verify the Superposition and Maximum power transfer theorems.
4. To determine self-inductance of a coil by Anderson's bridge.
5. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
6. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
7. To study the characteristics of a series RC Circuit.
8. To determine an unknown Low Resistance using Potentiometer.
9. To determine the resistance of a galvanometer using Thomson's method.
10. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

1.12 Core T4 - Waves and Optics

Waves and Optics	
60 Lectures	**4 Credits**
Superposition of Collinear Harmonic oscillations	**4 Lectures**
Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.	
Superposition of two perpendicular Harmonic Oscillations	**3 Lectures**
Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.	
Wave Motion	**4 Lectures**
Plane and Spherical Waves. Longitudinal and Transverse Waves. Progressive (Travelling) Wave and its differential equation. phase and group velocities for harmonic waves. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves	
Velocity of Waves	**5 Lectures**
Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.	
Superposition of Two Harmonic Waves	**7 Lectures**
Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes of wavefunction with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.	
Wave Optics	**4 Lectures**
Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Characteristics of Laser light.	

Interference	9 Lectures
Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.	
Interferometer	**4 Lectures**
Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.	
Diffraction and Holography	**20 Lectures**
Kirchhoff's Integral Theorem and Fresnel-Kirchhoff's Integral formula (Qualitative discussion only). Fraunhofer diffraction: Single slit, rectangular aperture. Resolving Power of an optical instrument – Rayleigh's criteria. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.	

Reference Books

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Hecht
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

1.13 Core P4 – Wave and Optics Lab

Wave and Optics	
60 class hours	**2 Credits**

General Topic

Discussion on the working principles of electric tuning fork, sodium and mercury vapour lamps, CRO etc. Demonstrations on adjustments of spectrometer, Fresnel biprism, Newton's ring apparatus etc. Measurement principle on the circular in a spectrometer. Use of computers for plotting of experimental results and corresponding fitting of curves using numerical methods learnt in the last semester, are to be encouraged with evidences in laboratory notebooks

List of Practical

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

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

1.14 Core T5 - Mathematical Physics-II

Mathematical Physics – II	
60 Lectures	**4 Credits**
Fourier Series	**10 Lectures**
Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Euler relation -- Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.	
Frobenius Method and Special Functions	**25 Lectures**
Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Multipole expansion in Electrostatics. Orthonormality of Hermite and Laguerre polynomials (statements only). Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x))and Orthogonality. Airy's disc for Fraunhofer diffraction through circular aperture, resolving power of a telescope.	
Some Special Integrals	**4 Lectures**
Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).	
Variational calculus in physics	**5 Lectures**
Idea of functionals. Euler-Lagrange equation from calculus of variation. Idea of constraints (holonomic only), degrees of freedom and generalised co-ordinates. Hamilton's principle and Lagrange's equation from it.	
Analytical Dynamics	**10 Lectures**

Applications of Lagrange’s equation in simple problems. Canonically cojugate momentum. Idea of cyclic co-ordinate and conservation principles from different symmetries.

Idea of Legendre transformation. Its application in mechanics and thermodynamics. Definition of Hamiltonian. Canonical equations of motion. Poisson bracket and its properties. Time variation of a dynamical variable in terms of in terms of Poisson bracket and the condition related to the constants of motion.

Partial Differential Equations	**6 Lectures**

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular symmetry. Wave equation and its solution for vibrational modes of a stretched string.

Reference Books

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books
- Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

1.15 Core P5 – Mathematical Physics II Lab

Mathematical Physics II	
60 class hours	**2 Credits**
General Topics: Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Introduction to online graph plotting using matplotlib. Use scipy to generate Legendre Polynomials and Bessel function and then plot those using matplotlib. Detailed discussion on the underlying theory of the following numerical methods including efficiency of the method in each case. Simple physical problems based on these methods are to be introduced.	
Sorting:	
• bubble sort • insertion sort	
Statistical Calculations :	
• mean, median and standard deviation for a set of discrete data points	
Interpolation:	
• Newton-Gregory forward & backward formula	
Numerical differentiation	
• Forward and Backward difference formula	
Numerical Integration	
• By trapezoidal rule. • By Simpson's 1/3 rd rule.Integration by stochastic method	
Integration by stochastic method	
• Monte Carlo random dot method	
Solution of ODE First order Differential equation	

- Euler Method

Reference Books

- ► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- ► Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- ► Numpy beginners guide, Idris Alba, 2015, Packt Publishing
- ► Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
- ► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer

1.16 Core T6 - Thermal Physics

Thermal Physics	
60 Lectures	**4 Credits**
Introduction to Thermodynamics	**25 Lectures**

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

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

Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Thermodynamic Potentials	**15 Lectures**

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization (basic principle only), First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Kinetic Theory of Gases	**20 Lectures**

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

Reference Books

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- Thermodynamics: Fermi
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

1.17 Core P6 – Thermal Physics Lab

Thermal Physics

60 class hours	**2 Credits**

General Topics:

Discussion on logscale plot to study power law dependence, decay constant etc. Discussion on the properties of PRT, thermocouple, diode sensor etc.

List of Practical

1. Verification of Stefan's law using a torch bulb.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT) using constant current source
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range by Null Method using a potentiometer.
6. To calibrate a thermocouple to measure temperature in a specified Range by direct measurement using Op-Amp differential amplifier and to determine Neutral Temperature
7. Mesuring unknown temperature using a diode sensor.
8. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
9. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
10. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

Reference Books

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

1.18 Core T7 - Digital Systems and Applications

Digital Systems and Applications	
60 Lectures	**4 Credits**
Introduction	**4 Lectures**
Electronic Components and Measuring devices (which are generally used for studying the following circuits) and their general Characteristics, Cathode-Ray Oscilloscope(CRO), Block diagram of CRO. Electron Gun. Deflection System and Time Base. Deflection Sensitivity. Applications of CRO:1)Study of waveform, 2) Measurement of Voltage , Current, Frequency and Phase difference.	
Integrated Circuits	**5 Lectures**
Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.	
Digital Circuits	**16 Lectures**
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. De Morgan's Theorems. Boolean Laws. AND, OR and NOT Gates (realization using Diodes and Transistor). Simplification of Logic Circuit using Boolean Algebra. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	
Arithmatic circuits	**5 Lectures**
Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.	
Data processing circuits	**5 Lectures**
Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.	
Sequential circuits	**6 Lectures**

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. M/S JK Flip-Flop, Combinational logic for the development of sequential circuit.	
Timers	**4 Lectures**
IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.	
Registers	**4 Lectures**
Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).	
Counters (4 bits)	**4 Lectures**
Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.	
Computer Organization	**7 Lectures**
Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.	

Reference Books

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

1.19 Core P7 – Digital Systems and Applications Lab

Digital Systems and Applications	
60 class hours	**2 Credits**

1) In the Beginning of practical course a *brief history of development of electronics* should be introduced.
2) In continuation of the previous topic, physically introduce the Valve, Transformer, Resistance, Capacitor, Potentiometer etc. and also Impotant measuring instruments (viz. digital & analog multimeter, power supply, function generator, Oscilloscope) to be used in the following experiments. Describe their characteristics with an explanation of their working principle).
3) In rest of the all practical classes: Approximately 25% of the class period should be used in introducing the perspectives and importance of the experiments to be done; details of the experiments and discussion on the observations of last class.1. a) To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.

List of Practical

1. a) To measure (i) Voltage, and (ii) Time period of a periodic waveform using CRO.

   b) To test a Diode and Transistor using a Multimeter.
2. a) To design a switch (NOT gate) using a transistor.

   b) To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. For a given truth table find logic equation, minimize and design the circuit using logic gate ICs.
4. Half Adder, Full Adder and 4-bit binary Adder.
5. To build Flip-Flop (RS, D-type and JK) circuits using NAND gates.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.

8. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
9. To build JK Master-slave flip-flop using Flip-Flop ICs
10. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
11. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

Reference Books

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

1.20 Core T8 - Mathematical Physics III

Mathematical Physics III	
60 Lectures	**4 Credits**
Complex Analysis	**20 Lectures**
Euler's formula. De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.	
Integrals Transforms	**15 Lectures**
Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.	
Boundary Value Problems	**10 Lectures**
Solutions of Laplaces equation in problems with cyldically and spherically symmetric boundary conditions. Examples from Electrostatics. Solutions of heat diffusion equation with boundary conditions of rectangular symmetry.	
Matrices	**7 Lectures**
Hermitian conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices with properties. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product of matrices.	
Eigen-values and Eigenvectors	**8 Lectures**
Eigenvalues and eigenvectors – calculation, charateristic equation. Cayley- Hamiliton Theorem. Similarity transformation with properties. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.	

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

1.21 Core P8 – Mathematical Physics III Lab

Mathematical Physics III	
60 class hours	**2 Credits**
General Topics: Detailed discussion on the underlying theory of the following numerical methods including efficiency of the method in each case. Simple physical problems based on these methods are to be introduced.	
List of Practical	

1. ODE initial value problems by RK2 & RK4
2. Solution of Linear system of equations by Gauss elimination method, determinant by Gauss Jordan method.
3. Inverse of a matrix by Gauss-Seidal iterative method.
4. Gram-Schmidt orthogonalisation method with 3 vectors.
5. Explicit calculation of largest eigenvalue calculation by power iterative method for real symmetric matrix and corresponding eigenvector
6. Eigen vectors, eigen values problems (by numpy.linalg)
7. Boudary value problems (by finite difference method with fixed grid size):
    a. Laplace eqn in 1D with Dirichlet boundary condition
    b. 1D Fourier heat equation with Dirichlet boundary condition
    c. Poisson equations
    d. Wave equation
8. Find square roots, cube roots of a complex number using two dimensional Newton-Raphson method.
9. Integral transform: FT of $\exp(-kx^2)$
10. Dirac Delta Function: Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx$, for σ=1, .1, .01 and show it tends to 5

Octave:

- Introduction of Octave with its basic features.
- Few examples of solving (a) differential equations and (b) matrix eigenvalue problems -- are to be performed using Octave

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
- https://ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

1.22 Core T9 - Elements of Modern Physics

Elements of Modern Physics	
60 Lectures	**4 Credits**
Relativistic Dynamics	**12 Lectures**
Invariance of space-time interval under Lorentz transformation. Idea of 4-vector – contravariant and contravariant components, metric. 4-scalar. Space-like, time-like and light-like separation, causality in relativity. Proper time. 4-velocity and 4-momentum. Conservation law of 4- momentum. Relativistic mass. Relativistic energy. Rest energy. Equivalence of mass & energy. Applications in two body decay of a particle, two body collisions.	
Collection of Identical Entities – Classical Approach	**6 Lectures**
Large collection of identical entities in an enclosure at thermal equilibrium. Idea of averaging over the collection, relation with bulk variables. Boltzmann weight factor. Law of equipartition of energy for single entity. Example: Cavity radiation and black body, classical theory of blackbody radiation, Rayleigh-Jeans law. Ultraviolet catastrophe.	
Emergence of Quantum Theory	**20 Lectures**
Planck's quantum postulate to avoid ultraviolet catastrophe, Planck's constant and Planck's ditribution law for	

blackbody Radiation. Photo-electric effect and Compton scattering. Light as a collection of photons; Wilson-Sommerfield quantization rule unifying Planck's quantization rule and Bohr's angular momentum quantization rule. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them.

Position measurement- gamma ray microscope thought experiment; Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables) as a consequence of wave description. Estimating minimum energy of a confined particle using uncertainty principle. Energy-time uncertainty principle- application to virtual particles and range of an interaction.

Two-Slit interference experiment with electrons and photons. Wave-particle duality, Bohr's complementarity principle. Matter waves and wave function, linear superposition principle as a consequence; Born's probabilistic interpretation of wave function bridging between wave description and particle description.

Lasers	**4 Lectures**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Nuclear Physics	**18 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, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Reference Books

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

Additional Books for Reference

- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

1.23 Core P9 – Elements of Modern Physics Lab

Elements of Modern Physics	
60 class hours	**2 Credits**

General Topics:

Discussion on properties rotational spectra of iodine, working principles of tunnel diode, vacuum diode, discharge tube.

List of Practical

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

Reference Books

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

1.24 Core T10 - Analog Systems and Applications

Analog Systems and Applications	
60 Lectures	**4 Credits**
History of the development of electronics	**3 Lectures**
Valve circuits and advantages of using semiconductor devices in modern electronic systems.	
Semiconductor Diodes	**7 Lectures**
P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.	
Two-terminal Devices and their Applications	**7 Lectures**
Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter & π- filter(qualitative, expression only), Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.	
Bipolar Junction transistors	**8 Lectures**
n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Physical Mechanism of Current Flow (unbiased).Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Active, Cutoff and Saturation Regions.	
Field Effect transistors	**3 Lectures**
Basic principle of operation of JFET, JFET parameters and CS characteristics	
Amplifiers	**8 Lectures**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.	
Coupled Amplifier	**3 Lectures**
Two stage RC-coupled amplifier and its frequency response.	
Feedback in Amplifiers	**4 Lectures**
Concept of feedback, Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.	
Sinusoidal Oscillators	**4 Lectures**
Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	
Operational Amplifiers (Black Box approach)	**4 Lectures**
Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.	
Applications of Op-Amps	**7 Lectures**
Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers.	
Conversion	**2 Lectures**
Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)	

Reference Books

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
- Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

1.25 Core P10 – Analog Systems and Applications Lab

Analog Systems and Applications	
60 class hours	**2 Credits**
General Topics: Discussion on the operational principles of the relevant circuits used in the experiments.	
List of Practical	

1. To study V-I characteristics of PN junction diode and Light emitting diode (LED) (using both current and voltage source).
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of Solar Cells and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the frequency response of voltage gain of a RC – coupled transistor amplifier.
6. To design inverting, non- inverting and buffer amplifiers using Op-amp (741/351) for dc voltage.
7. To design a Wien bridge oscillator for given frequency using a Op-Amp.
8. To add dc voltages using Op-amp in inverting and non-inverting mode.
9. a) To investigate the use of an op-amp as an Integrator.

   b) To investigate the use of an op-amp as a Differentiator.
10. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
11. To study the various biasing configurations of BJT for normal class A operation.
12. To design a Phase Shift Oscillator of given specification using Op-Amp.
13. To study the Colpitt's Oscillator.
14. To design a digital to analog converter (DAC) of given specifications.

15. To study the analog to digital converter (ADC) IC.

16. To design a precision Differential amplifier of given I/O specification using Op-Amp.

17. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation.

18. To design inverting amplifier using Op-amp (741/351) and study its frequency response

19. To design non-inverting amplifier using Op-amp (741/351) & study its frequency response

20. To study the zero – crossing detector and comparator.

21. Using Schmitt trigger and associated circuit (with OPAMP) generate different wave forms.

Reference Books

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
- Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

1.26 Core T11 - Quantum Mechanics and Applications

Quantum Mechanics and Applications	
60 Lectures	**4 Credits**

Basic Formalism	**12 Lectures**

Departure from matter wave description. Quantum mechanics as a new framework to describe the rules of the microscopic world. Postulates of quantum mechanics: State as a vector in a complex vector space, inner product, its properties using Dirac bra-ket notation. Physical observables as Hermitian operators on state space – eigenvalues, eigenvectors and completeness property of the eigenvectors – matrix representation. Measurement statistics. Unitary time-evolution. Demonstration of the rules in 2-level systems.

Wave-function as the probability amplitude distribution of a state for the observables with continuous eigenvalues. Position representation and momentum representation of wave-functions and operators. Position, momentum and Hamiltonian operators. Non-commuting observables and incompatible measurement, uncertainty relation. Position-momentum uncertainty principle as an example.

Commuting observables and degeneracy; complete set of commuting observables.

Schrodinger Equation	**12 Lectures**

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 and Linear Superposition Principles of the solutions of Schoedinger equation. Wave Function of a Free Particle. Explanation of wave-particle duality in two slit experiment with microscopic particles from the above formalism.

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 spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave-function; consistency with position-momentum uncertainty principle.

Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. Tunnelling effect in the case of alpha decay and in scanning tunnel microscopes (qualitative discussion only).

Bound states in an arbitrary potential	**8 Lectures**

Bound states – continuity of wave function, boundary condition and emergence of discrete energy levels.

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; generalisation for three dimension and degeneracy of energy levels. Quantum dot as example.

Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions; Hermite polynomials; ground state, zero point energy & uncertainty principle. Raising-lowering operator and their applications.

Quantum theory of hydrogen-like atoms	**10 Lectures**

Time independent Schrodinger equation in spherical polar coordinates with spherically symmetric potential; separation of variables for second order partial differential equation; angular momentum operators, commutation relations, ladder operators & quantum numbers; spherical co-ordinate representation of angular momentum operators. Radial wavefunctions for Coulomb potential; shapes of the probability densities for ground & first excited states. Commuting observables and degeneracy of energy levels. Orbital angular momentum quantum numbers l and m; s, p, d,shells-subshells. Applications for Hydrogen atom, He^+ ion, positronium and alikes.

Applications of Quantization Rules in Atomic Physics	**18 Lectures**

Absence of exact stationary state solutions for relativistic effects and for multi-electron atoms. Approximate description by semi-classical vector model of atoms.

Electron angular momentum quantization rules. Space quantization. Orbital Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr magneton. Electron Spin as relativistic quantum effect (qualitative discussion only), Spin Angular Momentum. Spin Magnetic Moment. Stern-Gerlach Experiment. Larmor Precession.

Multi-electron atoms. Pauli's Exclusion Principle (statement only). Spectral Notations for atomic States. Aufbau principle, $n+l$ rule (qualitative discussion only). Periodic table.

Spin orbit interaction. Addition of angular momentum (statement only). Total angular momentum of electron. Total energy level correction due to relativistic effects and spin-orbit interaction (statement only). Fine structure splitting.

Normal and Anomalous Zeeman Effect, Lande g factor, Paschen Back effect. Stark Effect (Qualitative Discussion only).

Spin-orbit coupling in atoms – L-S and J-J coupling schemes. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.). Mosley's law and its explanation from Bohr theory.

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

Additional Books for Reference

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

1.27 Core P11 – Quantum Mechanics and Applications Lab

Quantum Mechanics and Applications	
60 class hours	**2 Credits**

General Topics: Detailed discussion on the underlying theory of the following numerical methods including efficiency of the method in each case.

List of Practical

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

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

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

   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

   Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511x106 eV/c2, 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:

   For the anharmonic oscillator potential

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

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

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

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 = 940x106eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Reference Books

- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ.Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.

1.28 Core T12 - Solid State Physics

Solid State Physics	
60 Lectures	**4 Credits**
Crystal Structure	**12 Lectures**
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. Laue's condition and Bragg's Law. Structure Factor.	
Elementary Lattice Dynamics	**10 Lectures**
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, its limitations. Einstein's theories of specific heat of solids, its limitations.	
Magnetic Properties of Matter	**8 Lectures**
Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.	
Dielectric Properties of Materials	**8 Lectures**
Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena.	
Ferroelectric Properties of Materials	**6 Lectures**
Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	
Drude's theory	**6 Lectures**
Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory	

Elementary band theory	10 Lectures
Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.	
Superconductivity	**6 Lectures**
Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.	

Reference Books

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

1.29 Core P12 – Solid State Physics Lab

Solid State Physics	
60 class hours	**2 Credits**

General Topics: Discussion on the operation of the relevant circuits used for the different studies in the following experiments.

List of Practical

1. To determine the Coupling Coefficient of a Piezoelectric crystal.
2. To measure the Dielectric Constant of a dielectric Materials with frequency
3. To study the characteristics of a Ferroelectric Crystal.
4. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
5. To measure the resistivity of a semiconductor (Ge) with temperature by reverse bias characteristics of Ge diode (room temperature to 80 oC) and to determine its band gap.
6. To determine the Hall coefficient of a semiconductor sample.
7. To study temperature coefficient of a semiconductor (NTC thermistor)
8. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
9. To measure the Magnetic susceptibility of Solids.
10. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
11. To determine the refractive index of a dielectric layer using SPR

Reference Books

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

1.30 Core T13 - Electromagnetic Theory

Electromagnetic Theory	
60 Lectures	**4 Credits**
Maxwell Equations	**12 Lectures**
Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density (statement only).	
EM Wave Propagation in Unbounded Media	**10 Lectures**
Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	
EM Wave in Bounded Media	**10 Lectures**
Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).	
Polarization of Electromagnetic Waves	**17 Lectures**
Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation.	

Laurent’s half-shade polarimeter.

Wave guides	**8 Lectures**

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

Optical Fibres	**3 Lectures**

Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Reference Books

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Optics, E. Hecht, 2016, Pearson.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press

1.31 Core P13 – Electromagnetic Theory Lab

Electromagnetic Theory	
60 class hours	**2 Credits**
General Topics: Discussion on the working principles of polaroids, polarimeter, photometers etc.	
List of Practical	

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
4. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
5. To verify Fresnel's formula for reflection of polarized light incident on a dielectric interface
6. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
7. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To study the reflection, refraction of microwaves
10. To study Polarization and double slit interference in microwaves.
11. To analyze elliptically polarized Light by using a Babinet's compensator.
12. To study dependence of radiation on angle for a simple Dipole antenna.
13. To verify the Stefan`s law of radiation and to determine Stefan's constant.

Reference Books

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

1.32 Core T14 – Statistical Mechanics

Statistical Mechanics	
60 Lectures	**4 Credits**
Classical Statistical Mechanics	**20 Lectures**
Macrostate & Microstate, concept of time averaging in a macroscopic measurement. Ergodic hypothesis (statement only). Elementary Concept of Ensemble, Liouville's theorem. Microcanonical ensemble, Phase Space, postulate of equal a priori probability, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Density of states: for ideal gas, for standing waves in a cavity. Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential. Equivalence of microcanonical, canonical and grand canonical ensemble for large systems (qualitative discussion only).	
Chemical Equilibrium	**5 Lectures**
Chemical potential and chemical reaction. Law of chemical equilibrium. Chemical potential for ideal gas, for photon gas. Ionisation potential. Saha's Ionization Formula.	
Theory of Blackbody Radiation	**6 Lectures**
Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Recapitulation of Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	
System of identical particles	**6 Lectures**
Collection of non-interacting identical particles. Classical approach and quantum approach: Distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only). Bosons and	

Fermions. Spin statistics theorem (statement only). Pauli exclusion principle for Fermions.

Bose-Einstein Statistics:	**12 Lectures**

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. Phonon gas. Debye theory of specific heat of solids. T3 law

Fermi-Dirac Statistics:	**11 Lectures**

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Fermi temperature, Fermi momentum, Sommerfield correction to free electron theory in a Metal. Specific Heat of Metals, Wiedemann-Franz law,

Reference Books

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
- Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press

1.33 Core P14 – Statistical Mechanics Lab

Statistical Mechanics	
60 Class Hours	**2 Credits**

General Topics: Detailed discussion on the underlying theory of the following numerical methods including efficiency of the method in each case.

List of Practical

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

   b) Study of transient behavior of the system (approach to equilibrium)

   c) Relationship of large N and the arrow of time

   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution

   e) Computation and study of mean molecular speed and its dependence on particle mass

   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function Z(□) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics:

   a) Study of how Z(□), average energy <E>, energy fluctuation □E, specific heat at constant volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.

   b) Ratios of occupation numbers of various states for the systems considered above

   c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two

cases.

5. Plot the following functions with energy at different temperatures

   a) Maxwell-Boltzmann distribution

   b) Fermi-Dirac distribution

   c) Bose-Einstein distribution

Reference Books

- Elementary Numerical Analysis, K.E.Atkinson, 3 rd Edn . 20 07 , Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

3. Department Specific Electives Subjects Syllabus

1.34 DSE T1 - Advanced Mathematical Physics I

Advanced Mathematical Physics	
60 Lectures	**4 Credits**
Laplace Transform	
Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	
Linear Vector Spaces	
Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. Inner products. Gram-Schmidt orthogonalization. Orthogonal and unitary transformations and their matrix representations.	
Cartesian Tensors	
Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors.	

Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

General Tensors

Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

Reference Books

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press

1.35 DSE P1 – Advanced Mathematical Physics I Lab

Advanced Mathematical Physics I	
60 Class Hours	**2 Credits**

List of Practical

1. Linear algebra:
   a. Multiplication of two 3 x 3 matrices.
   b. Eigenvalue and eigenvectors of

   $\alpha = \tan\alpha$; $I = I_0 \left\{\frac{\sin\alpha}{\alpha}\right\}^2$;

2. Orthogonal polynomials as eigen functions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Reference Books

► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

1.36 DSE T2 - Advanced Mathematical Physics II

Advanced Mathematical Physics II	
75 Lectures	**6 Credits**
Partial Differential Equations:	**20 Lectures**
Existence and uniqueness theorem for soutions of partial differential equations (PDE). Categorisation of PDE's. Solution method for one homogeneous example of each type. Inhomogeneous PDE. Green's function. General solution in terms of Green's function. Solution of Poisson's equation by Green's function method.	
Group Theory	**30 Lectures**
Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses. Application to small vibrations. Continuous goups: Generator of Lie group. Rotation group and angular momentum as its generator. Homomorphism between SO(3) and SU(2).	
Advanced Probability Theory:	**25 Lectures**
Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.	

Reference Books

- Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
- Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
- Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
- Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover

- Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
- Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

1.37 DSE T3 – Advanced Dynamics

Advanced Dynamics	
75 Lectures	**6 Credits**
Lagrangian & Hamiltonian Dynamics	**15 Lectures**
Lagrange's equation for the cases with semi-holonomic constraints. Evaluation of constraint forces in general. Simple problems with both time-dependent and time independent constraints. Idea of canonical transformations. Generating functions. Properties of canonical transformation. Invariance of Poisson bracket. Use of canonical transformations in solving Hamilton's equations; harmonic oscillator problem as test case.	
Rigid Body Mechanics	**10 Lectures**
Definition of rigid body. General motion as combination of translation and rotation. Rotation of rigid body and the relation between its angular momentum and angular velocity. Moment of inertia and product of inertia. Kinetic energy of rotation. Principal axis transformation and principal moments of inertia, application in simple cases. Euler equations for free top and their solutions describing the motion of symmetric bodies.	
Small Amplitude Oscillations	**10 Lectures**
Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.	
Dynamical Systems	**25 Lectures**
Definition of a continuous dynamical system. The idea of phase space, flows and trajectories. Autonomous and non-autonomous systems, dimensionality. Linear stability analysis to study the behaviour of an 1-dimensional autonomous system. Illustration of the method using the single particle system described by v=f(x) and comparing it with the exact analytical solution. Extension of the method for simple mechanical	

systems as 2-dimensional dynamical systems, categorisation of equilibrium/fixed points : illustrations for the free particle, particle under uniform gravity, simple and damped harmonic oscillator (both under-damped and over-damped). Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition. Study on the behaviour of the quartic oscillator with an attractive or repulsive quadratic term in the potential; idea of bifurcation. Phase space diagram for the general motion of a pendulum and its behaviour. Oscillator with non-linear damping, Van-der-Pol oscillator as the example, behaviour in large dqamping limit, idea of limit cycle.

Discrete time dynamical systems, examples. Description by iterative map. Logistic map: Dynamics from time series. Cobweb iteration (using calculator or simple programs only). Fixed points. Parameter dependence- steady, periodic and chaos states. Idea of chaos and Lyapunov exponent.

Fluid Dynamics	**15 Lectures**

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 & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows. Euler equation and Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

Reference Books

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
- Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
- Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

1.38 DSE T4 - Nuclear and Particle Physics

Nuclear and Particle Physics	
75 Lectures	**6 Credits**
General Properties of Nuclei	**10 Lectures**
Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.	
Nuclear Models	**12 Lectures**
Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	
Radioactivity decay	**10 Lectures**
(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) □-decay: energy kinematics for □-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.	
Nuclear Reactions	**8 Lectures**
Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	
Interaction of Nuclear Radiation with matter	**8 Lectures**
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.	
Detector for Nuclear Radiations	**8 Lectures**
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.	
Particle Accelerators	**5 Lectures**
Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	
Particle physics	**14 Lectures**
Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.	

Reference Books

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by
- K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

1.39 DSE T6 - Astronomy and Astrophysics

Astronomy and Astrophysics

75 Lectures	**6 Credits**
Astronomical Scales	**24 Lectures**
Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.	
Astronomical techniques	**5 Lectures**
Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes)	
Physical principles	**4 Lectures**
Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.	
The sun and solar family	**11 Lectures**
The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification). Main sequence, red giants and white dwarfs, Chandrashekhar mass limit.	
The milky way	**14 Lectures**
Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral	

Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.	
Galaxies	**7 Lectures**
Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms	
Large scale structure & expanding universe	**10 Lectures**
Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).	

Reference Books

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory,4th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi, 2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication

1.40 DSE T11 - Communication Electronics

Communication Electronics	
60 Lectures	**4 Credits**
Electronic communication	**8 Lectures**
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. Concept of Noise, signal-to-noise (S/N) ratio.	
Analog Modulation	**12 Lectures**
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	
Analog Pulse Modulation	**10 Lectures**
Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.	
Digital Pulse Modulation	**10 Lectures**
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).	
Introduction to Communication and Navigation systems:	**10 Lectures**
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.	
Mobile Telephony System:	**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)

Reference Books

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
- 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

1.41 DSE P11 – Communication Electronics Lab

Communication Electronics Lab	
60 Class Hours	**2 Credits**
List of Practical	

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.

2 Skill Enhancement Course

2.1SEC T1 – Physics Workshop Skill

Physics Workshop Skill	
30 class hours	**2 Credits**
Introduction	
Measuring units: conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.	
Mechanical Skill	
Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.	
Electrical and Electronic Skill	
Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.	
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.	
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]

2.2SEC T2 - Computational Physics

Computational Physics	
30 class hours	**2 Credits**
Introduction	
Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.	
Scientific Programming	
Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN/ C++, Basic elements of FORTRAN 90/95 or C++: 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 90/95 or C++ Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.	
Control Statements	
Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements, 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 90/95 or C++ 2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN 90/95 or C++.	

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

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.

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.

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, et al. New Age International Publishers, New Delhi(1999)
- A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.

2.3SEC T3 – Electrical Circuits and Network Skills

Electrical Circuits and Network Skills	
30 class hours	**2 Credits**
Basic Electricity Principles	
Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.	
Understanding Electrical Circuits	
Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.	
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.	
Generators and Transformers	
DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.	
Electric Motors	
Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor	
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	
Electrical Protection	

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

Electrical Wiring

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

Reference Books

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

2.4SEC T4 - Basic Instrumentation Skills

Basic of Measurement	
30 class hours	**2 Credits**
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.	
Electronic Voltmeter	
Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.	
Cathode Ray Oscilloscope	
Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.	
Signal Generators and Analysis Instruments	
Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.	
Impedance Bridges & Q-Meters	
Block diagram of bridge: working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.	

Digital Instruments

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

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.

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

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises

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

Open Ended Experiments

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

Reference Books

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

2.5SEC T5 – Renewable Energy and Energy Harvesting

Renewable Energy and Energy Harvesting	
30 class hours	**2 Credits**
Fossil fuels and Alternate Sources of energy	
Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.	
Solar energy	
Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	
Wind Energy harvesting	
Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.	
Ocean Energy	
Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.	
Geothermal Energy	
Geothermal Resources, Geothermal Technologies	
Hydro Energy	
Hydropower resources, hydropower technologies, environmental impact of hydro power sources.	

Piezoelectric Energy harvesting

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

Electromagnetic Energy Harvesting

1. Linear generators, physics mathematical models, recent applications
2. Carbon captured technologies, cell, batteries, power consumption
3. Environmental issues and Renewable sources of energy, sustainability.

Demonstrations and Experiments

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

Reference Books

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

2.6SEC T6 - Technical Drawing

Technical Drawing	
30 class hours	**2 Credits**
Introduction	
Drafting Instruments and their uses. Lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism.2D geometrical construction. Representation of 3D objects. Principles of projections.	
Projections	
Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.	
Object Projections	
Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids	
CAD Drawing	
Introduction to CAD and Auto CAD or equivalent, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-Ddrawings. 3D modeling with Auto CAD or equivalent (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD (or equivalent) with text and hatching, layers, templates & design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.	
Reference Books	
► K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International ► AutoCAD 2014 & AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9 ► Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN: 978-1-118-12309-6	

2.7SEC T7 – Radiation Safety

Radiation Safety	
30 class hours	**2 Credits**
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.	
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.	
Radiation detection and monitoring devices: Radiation Quantities and Units	
Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.	
Radiation safety management	
Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.	

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, Sterization, Food preservation.

Experiments

1. Study the background radiation levels using Radiation meter
2. Characteristics of Geiger Muller (GM) Counter:
3. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
4. Study of counting statistics using background radiation using GM counter.
5. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
6. Study of absorption of beta particles in Aluminum using GM counter.
7. Detection of α particles using reference source & determining its half-life using spark counter
8. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books

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

2.8SEC T8 - Applied Optics

Applied Optics	
30 class hours	**2 Credits**

Sources and Detectors

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

Experiments on Lasers:

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

Experiments on Semiconductor Sources and Detectors

1. V-I characteristics of LED
2. Study the characteristics of solid state laser
3. Study the characteristics of LDR
4. Photovoltaic Cell
5. Characteristics of IR sensor

Fourier Optics

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

Experiments on Fourier Optics:

1. Fourier optic and image processing
    a. Optical image addition/subtraction
    b. Optical image differentiation
    c. Fourier optical filtering

d. Construction of an optical 4f system

2. 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:

1. 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.

Holography

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

Photonics: Fibre Optics

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

Experiments on Photonics: Fibre Optics

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

Reference Books

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

2.9 SEC T9 – Weather Forecasting

Weather Forecasting	
30 class hours	**2 Credits**

Introduction to atmosphere

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

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

Weather systems

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

Climate and Climate Change

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

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.

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 by wind direction.
    c. To observe the sunniest/driest day of the week.
    d. To examine the maximum and minimum temperature throughout the year.
    e. To evaluate the relative humidity of the day.
    f. To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation)

Reference Books

- Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
- The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
- Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
- Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
- Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.
- Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.