CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMME IN PHYSICS

4-YEAR B.Sc. (HONOURS) (WITH RESEARCH)

(Approved by the 41st Meeting of the Board of School of Sciences)

Department of Physics

NAGALAND UNIVERSITY

2025

Major Course (Core papers)

Semester I **Total No. of Credits: 08**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-1 (T) C-1 (P)	PHYC-101	Mathematical Physics – I	03	01	04
C-2 (T) C-2 (P)	PHYC-102	Mechanics	03	01	04

Semester II **Total No. of Credits: 08**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-3 (T) C-3 (P)	PHYC-201	Digital Systems and Applications	03	01	04
C-4 (T) C-4 (P)	PHYC-202	Waves and Optics	03	01	04

Semester III **Total No. of Credits: 08**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-5 (T) C-5 (P)	PHYC-301	Mathematical Physics – II	03	01	04
C-6 (T) C-6 (P)	PHYC-302	Electricity and Magnetism	03	01	04

Semester IV **Total No. of Credits: 08**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-7 (T) C-7 (P)	PHYC-401	Analog Systems and Applications	03	01	04
C-8 (T) C-8 (P)	PHYC-402(A) OR PHYC-402(B)	Mathematical Physics – III OR Communication System	03	01	04

Semester V **Total No. of Credits: 12**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C- 9 (T) C- 9 (P)	PHYC-501	Elements of Modern Physics	03	01	04
C-10 (T) C-10 (P)	PHYC-502	Thermal Physics	03	01	04
C-11 (T) C-11 (P)	PHYC-503	Quantum Mechanics and Applications	03	01	04

Semester VI **Total No. of Credits: 16**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-12 (T) C-12 (P)	PHYC-601	Statistical Mechanics	03	01	04
C-13 (T) C-13 (P)	PHYC-602	Electromagnetic Theory	03	01	04
C-14 (T) C-14 (P)	PHYC-603	Solid State Physics	03	01	04
C-15(T) C-15(P)	PHYC-604(A) OR PHYC-604(B)	Experimental Techniques OR Physics of Devices and Communications Systems	03	01	04

Semester VII **Total No. of Credits: 16**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-16(T) C-16(P)	PHYC-701(A) OR PHYC-701(B)	Nuclear and Particle Physics OR Classical Dynamics	03	01	04
C-17(T) C-17(P)	PHYC-702(A) OR PHYC-702(B)	Astronomy and Astrophysics OR Applied Dynamics	03	01	04
C-18(T) C-18(P)	PHYC-703	Applications of Modern Optics	03	01	04
C-19(T) C-19(P)	PHYC-704	Research Methodology*	03	01	04

*This a common course for all disciplines. EachDepartment need not propose the same separately.

Semester VIII **Total No. of Credits: 16**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-20 (T)	PHYC-801	Any one OPTIONAL PAPER$$$	03	01	04
C-20 (P)					
C-21 (T)	PHYC-802				
C-21 (P)					
C-22 (T)	PHYC-803				
C-22 (P)					
C-23 (T)	PHYC-804				
C-23 (P)					
C-24	PHYC-805	Research Dissertation			12

SKILL ENHANCEMENT COURSES (3 Credit Each)

Skill Enhancement Course	Title of the paper	Total Credit 3	Proposed by Department
	Renewable Energy and Energy Harvesting	3	
	Weather Forecasting	3	
	Radiation safety	3	

The Skill Enhancement Courses (SEC) are to be selected and offered by the Physics Department of the respective colleges. Students with Major in Mathematics may opt for any SEC paper from the common pool offered by the respective college. The colleges may select the SEC paper from the common pool made by the University.

$$$ **Semester VIII** **Total No. of Credits: 16**

Paper Code	Course Code	Name of the Course	Credits		
			Theory	Practical	Total Credits
C-20 (T)	PHYC-801	Special and General Theory of Relativity	03	01	04
C-20 (P)					
C-21 (T)	PHYC-802	Advanced Quantum Mechanics	03	01	04
C-21 (P)					
C-22 (T)	PHYC-803	Band Theory of Solids	03	01	04
C-22 (P)					
C-23 (T)	PHYC-804	Physics of Nanoscale Systems	03	01	04
C-23 (P)					

CORE COURSES

Semester I

C-1(T) PHYC-101
MATHEMATICAL PHYSICS-I

(Credits: Theory-03, Practicals-01)

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

Unit - 1

Calculus:

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).

(2 Lectures)

First Order and Second Order Differential equations:

First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients.

(7 Lectures)

Unit - 2

Calculus of functions of more than one variable:

Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration.

(5 Lectures)

Introduction to Probability:

Independent random variables: Probability distribution functions; Binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

(4 Lectures)

Unit - 3

Vector Calculus:

Recapitulation of vectors:

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.

(4 Lectures)

Vector Differentiation:

Directional derivatives and normal derivative. Gradient of a scalar field. Divergence and Curl of a vector field. Del and Laplacian operators.

(5 Lectures)

Unit - 4

Vector Integration:

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.

(10 Lectures)

Unit - 5

Orthogonal Curvilinear Coordinates:

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Dirac Delta Function and its Properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(2 Lectures)

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
- 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, Mary L. Boas, Wiley-India

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PHYSICS LAB

C-1(P)   PHYC-101

MATHEMATICAL PHYSICS - I

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

- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (u)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $= \tan$; $I = I_0 \left(\frac{\sin a}{\ }\right)^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation ● Radioactive decay ● Current in RC, LC circuits with DC source ● Newton's law of cooling ● Classical equations of motion Attempt following problems using RK 4 order method: ● Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}$; $\frac{dy}{dx} = -x$ for four initial conditions $x(0) = 0,\ y(0) = -1,\ -2,\ -3,\ -4$ Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin\theta$. The pendulum is released from rest at an angular displacement *a*, i.e. $\theta(0) = a$ and $\theta'(0) = 0$. Solve the equation for *a* = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small $\theta, (\sin\theta = \theta)$

Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Press *et al*, 3rd Edn. , 2007, Cambridge University Press.
- A First Course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

C-2(T) PHYC-102

MECHANICS

(Credits: Theory-03, Practicals-01)

Unit - 1

Fundamentals of Dynamics:
Reference frames. Inertial frames. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in a uniform gravitational field. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

(5 Lectures)

Work and Energy:
Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

(4 Lectures)

Unit - 2

Collisions:
Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

(2 Lectures)

Rotational Dynamics:
Angular momentum of a particle and a system of particles. Torque. Principle of conservation of angular momentum. Kinetic energy of rotation. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.

(7 Lectures)

Unit - 3

Gravitation and Central Force Motion:
Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to a spherical shell and solid sphere.

(3 Lectures)

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).

(6 Lectures)

Unit - 4

Non-Inertial Systems:

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

(3 Lectures)

Special Theory of Relativity:

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence.

(6 Lectures)

Unit - 5

Oscillations:

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

(5 Lectures)

Elasticity:

Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

(2 Lectures)

Fluid Motion:

Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

(2 Lectures)

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.
- Introduction to Mechanics, Mahendra K Verma, Universities Press

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.

PHYSICS LAB

C-2(P) PHYC-102

MECHANICS

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

Reference Books:

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

Semester II

C-3(T) PHYC-201
DIGITAL SYSTEMS AND APPLICATIONS

(Credits: Theory-03, Practicals-01)

Unit - 1

Introduction to 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.

(3 Lectures)

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

(2 Lectures)

Digital Circuits:
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. AND, OR and NOT 6 Gates (realizations using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

(4 Lectures)

Unit - 2

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

(5 Lectures)

Data processing circuits:
Basic idea of Multiplexers, Decoders, Encoders.

(2 Lectures)

Arithmetic Circuits:

Binary Addition. Binary Subtraction. Half and Full Adders. Half & Full Subtractors

(2 Lectures)

Unit - 3

Sequential Circuits:
SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

(6 Lectures)

Timers:
IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

(3 Lectures)

Unit - 4

Shift registers:

Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

(2 Lectures)

Counters (4 bits):

Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(4 Lectures)

Introduction to Assembly Language:

1 byte, 2 byte & 3 byte instructions.

(3 Lectures)

Unit - 5

Computer Organization:

Input/output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing.

(4 lectures)

Intel 8085 Microprocessor Architecture:

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry.

(5 Lectures)

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.

PHYSICS LAB

C-3(P) PHYC-201
DIGITAL SYSTEMS AND APPLICATIONS

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

Reference Books:

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

C-4(T) PHYC-202

WAVES AND OPTICS

(Credits: Theory-03, Practicals-01)

Unit - 1

Superposition of Collinear Harmonic oscillations:

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.

(4 Lectures)

Superposition of two perpendicular Harmonic Oscillations:

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

(2 Lectures)

Wave Motion:

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave.

(3 Lectures)

Unit - 2

Velocity of Waves:

Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

(4 Lectures)

Superposition of Two Harmonic Waves:

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

(5 Lectures)

Unit - 3

Wave Optics:

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

(3 Lectures)

Interference:

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, Newton's Rings: Measurement of wavelength and refractive index.

(6 Lectures)

Unit - 4

Interferometers:

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.

(3 Lectures)

Diffraction:

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)

(2 Lectures)

Fraunhofer diffraction:

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Diffraction grating. Resolving power of grating.

(4 Lectures)

Unit - 5

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.

(6 Lectures)

Holography:

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(3 Lectures)**

Reference Books:

Waves: Berkeley Physics Course, Vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

Principles of Optics, Max Born and Emil Wolf, 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.

PHYSICS LAB

C-4(P) PHYC-202

WAVES AND OPTICS

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

Reference Books:

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

A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

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

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

Semester III

C-5(T) PHYC-301
MATHEMATICAL PHYSICS-II

(Credits: Theory-03, Practicals-01)

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

Unit - 1
Fourier Series:
Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions.

(9 Lectures)

Unit - 2
Frobenius Method and Special Functions:
Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method. Legendre, Bessel, Hermite and Laguerre Differential Equations.

(9 Lectures)

Unit - 3
Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind.

(9 Lectures)

Unit - 4
Partial Differential Equations:
Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string.

(9 Lectures)

Unit - 5
Some Special Integrals:
Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

(4 Lectures)

Theory of Errors:
Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit.

(5 Lectures)

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis, M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- 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 Methods in the Physical Sciences, Mary L. Boas, Wiley-India

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PHYSICS LAB

C-5(P) PHYC-301

MATHEMATICAL PHYSICS-II

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

Topics	**Description with Applications**
Introduction to Numerical computation software Scilab/Python	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variablepassing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohm's law to calculate R, Hooke's law to calculate Spring Constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen value problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function

Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method Partial differential equations	● First order differential equation ● Radioactive decay ● Current in RC, LC circuits with DC source ● Newton's law of cooling ● Classical equations of motion Second order Differential Equation ● Harmonic oscillator (no friction) ● Damped Harmonic oscillator ● Over damped ● Critical damped ● Oscillatory ● Forced Harmonic oscillator ● Transient and ● Steady state solution ● Apply above to LCR circuits also ● Solve $x^2 \frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$ with the boundary conditions at $x = 1,\ y = \frac{1}{2}e^2,\ \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$ in the range $1 \le x \le 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. Partial Differential Equation: ● Wave equation ● Heat equation ● Poisson equation ● Laplace equation
Using Scicos / xcos	● Generating square wave, sine wave, saw tooth wave ● Solution to harmonic oscillator ● Study of beat phenomenon ● Phase space plots

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S.J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First Course in Complex Analysis with Applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
- Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- www.scilab.in/textbook_companion/generate_book/291

C-6(T) PHYC-302
ELECTRICITY AND MAGNETISM

(Credits: Theory-03, Practicals-01)

Unit - 1

Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

(4 Lectures)

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

(5 Lectures)

Unit - 2

Electrostatics

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.

(5 Lectures)

Dielectric Properties of Matter:

Electric Field in matter. Polarization. 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.

(5 Lectures)

Unit - 3

Magnetic Field:

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) Solenoid and (2) Toroid. Properties of B: curl and divergence. Torque on a current loop in a uniform Magnetic Field.

(5 Lectures)

Magnetic Properties of Matter:

Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

(4 Lectures)

Unit - 4

Electromagnetic Induction:

Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

(6 Lectures)

Ballistic Galvanometer:

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

(3 Lectures)

Unit - 5

Electrical Circuits:

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

(4 Lectures)

Network theorems:

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.

(4 Lectures)

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

Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

PHYSICS LAB

C-6(P) PHYC-302

ELECTRICITY AND MAGNETISM

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine *dB/dx*)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. 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.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute 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

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.

Semester IV

C-7(T) PHYC-401
ANALOG SYSTEMS AND APPLICATIONS

(Credits: Theory-03, Practicals-01)

Unit - 1
Semiconductor Diodes:
P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. Barrier Formation in PN Junction Diode. Staticand Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.

(9 Lectures)

Unit - 2
Two-terminal Devices and their Applications:
(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

(5 Lectures)

Bipolar Junction transistors:
n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains a and β, Relations between a and β. Load Line analysis of Transistors. DC Load line and Q-point.

(4 Lectures)

Unit - 3
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.

(7 Lectures)

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

(2 Lectures)

Unit - 4
Feedback in Amplifiers:

Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

(4 Lectures)

Sinusoidal Oscillators
RC Phase shift oscillator, determination ofFrequency. Hartley & Colpitts oscillators.

(3 Lectures)

Conversion:
Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)

(2 Lectures)

Unit - 5

Operational Amplifiers

(Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

(4 Lectures)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Wein bridgeoscillator.

(5 Lectures)

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

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PHYSICS LAB

C-7(P) PHYC-401
ANALOG SYSTEMS AND APPLICATIONS

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal Class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741, 351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741, 351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.
21. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation.

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, 4^{th} 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

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C-8(T) PHYC-402(A)
MATHEMATICAL PHYSICS - III

(Credits: Theory-03, Practicals-01)

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

Unit - 1

Complex Analysis:

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Cauchy-Riemann Conditions.

(9 Lectures)

Unit - 2

Singular functions: poles and branch points, order of singularity, branch cuts. Integration of afunction of a complex variable. Cauchy's Inequality. Cauchy's Integral formula.

(5 Lectures)

Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem.

(4 Lectures)

Unit - 3

Integrals Transforms:

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.

(9 Lectures)

Unit - 4

Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

(5 Lectures)

Laplace Transforms:

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem.

(4 Lectures)

Unit - 5

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, Coupled differential equations of 1st order.

(9 Lectures)

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

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PHYSICS LAB

C-8(P) PHYC-402(A)

MATHEMATICAL PHYSICS - III

Scilab/C^{++} /etc. based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:
   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$
   $dy/dx + e^{-x}y = x^2$
   $d^2y/dt^2 + 2\ dy/dt = -y$
   $d^2y/dt^2 + e^{-t}dy/dt = -y$
2. Dirac Delta Function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx$ for $\sigma = 1,\ 0.1,\ 0.001$ and show it tends to 5.

3. Fourier Series:

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

   Evaluate the Fourier coefficients of a given periodic function (square wave)
4. Frobenius method and Special functions:
   $\int_{-1}^{1} P_n(\mu)P_m(\mu)\, d\mu = \delta_{n,m}$
   Plot $P_n(x)$, $j_v(x)$
   Show recursion relation
5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
8. Compute the n^{th} roots of unity for $n = 2, 3,$ and 4.
9. Find the two square roots of $-5+12j$.
10. Integral transform: FFT of e^{-x^2}
11. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
12. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Reference Books:

Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
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
A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
Scilab by Example: M. Affouf, 2012. ISBN: 978-1479203444
Scilab (A free software to Matlab): H. Ramchandran, A.S.Nair. 2011 S.Chand & Company
Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

C-8(T) PHYC-402(B)
COMMUNICATION SYSTEMS

(Credits: Theory-03, Practicals-01)

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

Unit - 1
Electronic communication:
Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

(8 Lectures)

Unit - 2
Analog Modulation:
Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

(9 Lectures)

Unit - 3
Analog Pulse Modulation:
Channel capacity, Sampling theorem, Basic Principles - PAM, PWM, PPM, Multiplexing.

(4 Lectures)

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

(6 Lectures)

Unit - 4
Introduction to Communication and Navigation systems:
Satellite Communication – Introduction, need, Geosynchronous satellite orbits, geostationary satellite, advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station.

(9 Lectures)

Unit - 5
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, 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) **(9 Lectures)**

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

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PHYSICS LAB

C-8(P) PHYC-402 (B)

COMMUNICATION SYSTEMS

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 McGra w Hill.
- Electronic Communication System, Blake, Cengage, 5th edition.

Semester V

C-9(T) PHYC-501

ELEMENTS OF MODERN PHYSICS

(Credits: Theory-03, Practicals -01)

Unit - 1

Quantum Mechanics

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them.

(10 Lectures)

Unit - 2

Position measurement

Gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets.

(3 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization.

(7 Lectures)

Unit - 3

One Dimensional Problems

One dimensional infinitely rigid box - energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension - acrossa step potential and rectangular potential barrier.

(7 Lectures)

Unit - 4

Nuclear Physics

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model, and magic numbers.

(5 Lectures)

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.

(6 Lectures)

Unit - 5

Fission and fusion

Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor. Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

(3 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.

(4 Lectures)

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw HillIntroduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
3. Physics for Scientists and Engineers with Modern Physics, Jewett and Serway, 2010,Cengage Learning.
4. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
5. 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
Quantum Mechanics, R. Eisberg and R. Resnick, John Wiley & Sons.

PHYSICS LAB

C-9(P) PHYC-501

ELEMENTS OF MODERN PHYSICS

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

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

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C-10(T) PHYC-502

THERMAL PHYSICS

(Credits: Theory-03, Practicals-01)

(Include related problems for each topic)

Unit - 1

Introduction to Thermodynamics

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 C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion coefficient.

(7 Lectures)

Unit - 2

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, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics

(7 Lectures)

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. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics.

(5 Lectures)

Unit - 3

Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their definitions, Properties and Applications. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

(5 Lectures)

Maxwell's Thermodynamic Relations

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

(5 Lectures)

Unit - 4

Kinetic Theory of Gases

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

(5 Lectures)

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.

(4 Lectures)

Unit - 5

Real Gases:

Behavior of Real Gases: Deviations from the Ideal Gas Equation. Boyle Temperature. Van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. 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.

(7 Lectures)

Reference Books:

Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

A Treatise on Heat, Meghnad Saha and B.N. Srivastava, 1958, Indian Press

Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill

Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.

Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Thermal Physics, B.K. Agrawal, Lok Bharti Publications.

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PHYSICS LAB

C-10(P) PHYC-502
THERMAL PHYSICS

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

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.

C-11(T) PHYC-503
QUANTUM MECHANICS AND APPLICATIONS
(Credits: Theory-03, Practicals-01)

Unit - 1

Time dependent Schrodinger equation:

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Normalization. Eigenvalues and Eigenfunctions. Position, momentum, and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(5 Lectures)

Time independent Schrodinger equation

Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension.

(6 Lectures)

Unit - 2

General discussion of bound states in an arbitrary potential

Continuity of wave function, application to one-dimensional problem - square well potential; Quantum mechanics of simple harmonic oscillator - energy levels and energy eigen functions using Frobenius method; Hermite polynomials; ground state.

(8 Lectures)

Unit - 3

Quantum theory of hydrogen-like atoms:

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.

(8 Lectures)

Unit - 4

Atoms in Electric & Magnetic Fields:

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

(7 Lectures)

Atoms in External Magnetic Fields:

Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

(3 Lectures)

Unit - 5

Many electron atoms:

Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Total angular momentum. Vector Model. Spin-orbit coupling in atoms - L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

(8 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P.M. Mathews and K.Venkatesan, 2^{nd} Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2^{nd} Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3^{rd} Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2^{nd} Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3^{rd} Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
- Quantum Mechanics, John L. Powell and Bernd Crasemann, Addison-Wesley Publishing Company

Additional Books for Reference

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

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PHYSICS LAB

C-11(P) PHYC-503

QUANTUM MECHANICS AND APPLICATIONS

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

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

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

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

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

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

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

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, $m = 0.511 \times 10^6$ eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3.) Solve the s-wave radial Schrodinger equation for a particle of mass *m*:

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

For the anharmonic oscillator potential

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

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

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

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

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

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

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

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

Laboratory based experiments:

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

Reference Books:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000,McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An Introduction to Computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

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Semester VI

C-12(T) PHYC-601
STATISTICAL MECHANICS

(Credits: Theory-03, Practicals-01)

Unit - 1
Classical Statistics:

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System.

(12 Lectures)

Unit - 2
Classical Theory of Radiation:

Properties of Thermal Radiation. Blackbody Radiation. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

(8 Lectures)

Unit - 3
Quantum Theory of Radiation:

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. 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.

(5 Lectures)

Unit - 4
Bose-Einstein Statistics:

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.

(10 Lectures)

Unit - 5
Fermi-Dirac Statistics:

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

(10 Lectures)

Reference Books:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2^{nd} 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

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Univ. Press

PHYSICS LAB

C-12(P) PHYC-601
STATISTICAL MECHANICS

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

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(β) 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(β), average energy <E>, energy fluctuation ΔE, 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 Rayleigh-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 . 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2^{nd} 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: Scientificand Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014Springer ISBN: 978-3319067896Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

C-13(T) PHYC-602

ELECTROMAGNETIC THEORY

(Credits: Theory-03, Practicals-01)

Unit - 1

Maxwell's Equations:

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Boundary Conditions at the 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.

(9 Lectures)

Unit - 2

EM Wave Propagation in Unbounded Media:

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 conductivityof ionized gases, plasma frequency, refractive index, skin depth.

(8 Lectures)

Unit - 3

EM Wave in Bounded Media:

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at a 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.

(**8 Lectures**)

Unit - 4

Polarization of Electromagnetic Waves:

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. 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.

(9 Lectures)

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Specific rotation. Laurent's half-shade polarimeter.

(3 Lectures)

Unit - 5

Wave Guides: Planar optical waveguides. Planar dielectric waveguide. Condition of continuity at interface. Phase shift on total reflection. Phase and group velocity of guidedwaves. Field energy and Power transmission.

(5 Lectures)

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

(3 Lectures)

Reference Books:

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

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

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PHYSICS LAB

C-13(P) PHYC-602

ELECTROMAGNETIC THEORY

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

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

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C-14(T) PHYC-603

SOLID STATE PHYSICS

(Credits: Theory-03, Practicals-01)

Unit - 1

Crystal Structure:

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

(**8 Lectures**)

Unit - 2

Elementary Lattice Dynamics:

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein, and Debye theories of specific heat of solids. T^3 law

(8 Lectures)

Unit - 3

Magnetic Properties of Matter:

Dia, Para, Ferri and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

(8 Lectures)

Unit - 4

Dielectric Properties of Materials:

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons.

(7 Lectures)

Ferroelectric Properties of Materials:

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law.

(**3 lectures**)

Unit - 5

Elementary band theory:

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) and Hall coefficient.

(**7 Lectures**)

Superconductivity:

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and Type II Superconductors, London's Equation and Penetration Depth. Idea of BCS theory (No derivation)

(**4 Lectures**)

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

PHYSICS LAB

C-14(P) PHYC-603

SOLID STATE PHYSICS

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

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 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.

C-15(T) PHYC-604(A)
EXPERIMENTAL TECHNIQUES

(Credits: Theory-03, Practicals-01)

Unit 1

Measurements:

Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square).

(4 Lectures)

Signals and Systems:

Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise.

(6 Lectures)

Unit 2

Shielding and Grounding:

Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

(3 Lectures)

Transducers & Industrial Instrumentation (working principle, efficiency, applications):

Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order, first order, second order and higher order systems.

Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers.

(6 Lectures)

Unit 3

Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Radiation Sensors: Principle of Gas filled detector, Ionization chamber, Scintillation detector.

(10 Lectures)

Unit 4

Digital Multimeter:

Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

(4 Lectures)

Impedance Bridges and Q-meter:

Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.

(3 Lectures)

Unit 5

Vacuum Systems:

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

(9 Lectures)

Reference Books:

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

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PHYSICS LAB

C-15(P) PHYC-604(A)

EXPERIMENTAL TECHNIQUES

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

Reference Books:

Electronic Circuits: Handbook of Design and Applications, U. Tietze and C. Schenk, 2008, Springer

Basic Electronics: A Text Lab Manual, P. B. Zbar, A. P. Malvino, M. A. Miller, 1990, Mc-Graw Hill

Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

C-15(T) PHYC-604(B)
PHYSICS OF DEVICES AND COMMUNICATION SYSTEMS

(Credits: Theory-03, Practicals-01)

Unit - 1
Devices:
Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. SiO_2-Si based MOS. MOSFET – their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.

(9 Lectures)

Unit - 2
Multivibrators:
Astable and Monostable Multivibrators using transistors.

(2 Lectures)

Phase Locked Loop (PLL):

Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter – Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046).

(5 Lectures)

Unit - 3
Processing of Devices:
Basic process flow for IC fabrication, electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Diffusion and implantation.

(10 Lectures)

Unit - 4
Digital Data Communication Standards:
Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.

(5 Lectures)

Power supply and Filters:
Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, short circuit protection, Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

(4 Lectures)

Unit - 5
Introduction to Communication Systems:
Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

(10 lectures)

Reference Books:

Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
Electronic Devices and Integrated Circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
Op-Amps and Linear Integrated Circuits, R.A. Gayakwad,4 Ed. 2000, PHI Learning Pvt. Ltd
Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
Electronic Communication Systems, G. Kennedy, 1999, Tata McGraw Hill.
Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.
Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
PC based instrumentation; Concepts and Practice, N.Mathivanan, 2007, Prentice-Hall of India

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PHYSICS LAB

C-15(P) PHYC-604(B)
PHYSICS OF DEVICES AND COMMUNICATION

Experiments from both Section A and Section B:

Section-A

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

Section-B:

SPICE/MULTISIM simulations for electrical networks and electronic circuits

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

Reference Books:

Basic Electronics: A Text Lab Manual, P.B. Zbar, A.P. Malvino, M.A.Miller,1994, Mc-Graw Hill

Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.

Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.

PC Based Instrumentation; Concepts and Practice, N.Mathivanan, 2007, Prentice-Hall of India

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Semester VII

C-16(T) PHYC-701(A)

NUCLEAR AND PARTICLE PHYSICS

(Credits: Theory-03, Tutorials-02)

Unit - 1

General Properties of Nuclei:

Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

(7 Lectures)

Particle physics:

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, concept of quark model.

(5 Lectures)

Unit - 2

Nuclear Models:

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

(7 Lectures)

Unit - 3

Radioactivity decay:

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

(7 Lectures)

Unit - 4

Nuclear Reactions:

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

(5 Lectures)

Interaction of Nuclear Radiation with matter:

Energy loss due to ionization (Bethe-Block formula), Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

(5 Lectures)

Unit - 5

Detectors for Nuclear Radiations:

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

(6 Lectures)

Particle Accelerators:

Accelerator facilities available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

(3 Lectures)

Reference Books:

Introductory Nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
Concepts of Nuclear Physics, Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
Introduction to the Physics of Nuclei and Particles, R.A. Dunlap. (Thomson Asia, 2004).
Introduction to 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, 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 and V.F. Weisskopf (Dover Pub.Inc., 1991)

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C-16(T)　　　　PHYC-701(B)

CLASSICAL DYNAMICS

(Credits: Theory-03, Tutorials-02)

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

Unit - 1

Classical Mechanics of Point Particles 1:

Review of Newtonian Mechanics; Application to the motion of a charged particle in external electric and magnetic fields - motion in uniform electric field, magnetic field - gyroradius and gyrofrequency, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations - one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity.

(8 Lectures)

Unit - 2

Classical Mechanics of Point Particles 2:

Canonical momenta and Hamiltonian. Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field - conservation of angular momentum and energy.

(8 Lectures)

Unit - 3

Small Amplitude Oscillations:

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.

(8 Lectures)

Unit - 4

Special Theory of Relativity:

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Relativistic kinematics.

(13 Lectures)

Unit - 5

Fluid Dynamics:

Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

(8 Lectures)

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

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C-17(T) PHYC-702(A)

ASTRONOMY AND ASTROPHYSICS

(Credits: Theory-03, Tutorials-02)

Unit - 1

Astronomical Scales:

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, Conversion of Coordinates, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar.

(9 Lectures)

Unit - 2

Basic Parameters of Stars

Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Hertzsprung-Russell Diagram.

(5 Lectures)

The Sun

Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity. Helioseismology.

The Solar System:

Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings.

(4 Lectures)

Unit - 3

Astronomical Techniques:

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.

Physical principles

Gravitation in Astrophysics, Virial Theorem, Newton versus Einstein, Systems in Thermodynamic Equilibrium.

(8 Lectures)

Unit - 4

Stellar Spectra and Classification Structure

Atomic Spectra Revisited, Stellar Spectra, Spectral Types. Black Body Approximation, H R Diagram, Luminosity Classification

(3 Lectures)

The Milky Way

Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way, Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Stars and Star Clusters of the Milky Way.

(7 Lectures)

Unit - 5

Galaxies

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies, The Intrinsic Shapes of Elliptical Stars and Gas. Spiral and Lenticular Galaxies, Bulges, Disks, Galactic Halo, The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

(4 Lectures)

Large Scale Structure & Expanding Universe:

Cosmic Distance Ladder, Distance Measurement using Cepheid Variables, Hubble's Law, Distance - Velocity Relation, Clusters of Galaxies, Virial theorem and Dark Matter.

(5 Lectures)

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

Astrophysics A Modern Perspective, K.S. Krishnasamy, Reprint, New Age International (p) Ltd, New Delhi, 2002.

An Introduction to Astrophysics, Baidyanath Basu, 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.

C-17(T)   PHYC-702(B)

APPLIED DYNAMICS

(Credits: Theory-03, Practicals-2)

Unit - 1

Introduction to Dynamical systems 1

Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems : the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Other examples of dynamical systems –

In Biology: Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics, simple genetic circuits

In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability

In Economics: Examples from game theory.

(9 Lectures)

Unit - 2

Introduction to Dynamical systems 2

Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.

Computing and visualizing trajectories on the computer using software packages.

Discrete dynamical systems. The logistic map as an example.

(8 Lectures)

Unit - 3

Introduction to Chaos and Fractals 1

Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacles. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.

Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA.

(9 Lectures)

Unit - 4

Introduction to Chaos and Fractals 2

Chaos in nonlinear finite-difference equations - Logistic map: Dynamics from time series. Parameter dependence - steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos - aperiodic, bounded, deterministic and sensitive dependence on initial conditions.

Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

(9 Lectures)

Unit - 5

Elementary Fluid Dynamics:

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

(10 Lectures)

Reference Books

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
- Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

PHYSICS LAB

C-17(P) PHYC-702(B)

APPLIED DYNAMICS

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like

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

Reference Books:

Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
Fluid Mechanics, 2nd Edn, L.D.Landau & E.M. Lifshitz, Pergamon Press, Oxford, 1987
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
Scilab by Example, M. Affouf, 2012, ISBN: 978-1479203444
Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

C-18(T)   PHYC-703

APPLICATIONS OF MODERN OPTICS

UNIT I: Quantum Optics: Quantum theory of Radiation, Second quantization, Quantum statistical description of the radiation fields, Coherent states, Photon correlations, Squeezed states and applications.
Nonlinear Optics: Basic Principles, Harmonic generation, Second harmonic generation, Phase matching, Third Harmonic generation, Optical mixing, Parametric generation of light, Parametric light oscillator, Frequency up conversion, Self-focusing of light.

UNIT II: Holography: Introduction, Basic theory of Holography, Recording and reconstruction of Hologram, Diffuse object illumination, Speckle pattern, Fourier transform Holography, Applications.
Lasers: Introduction, Directionality, Brightness, Monochromacity, Coherence, Relation between the coherence of the field and the size of the source, Absorption and emission processes, Einstein coefficients, Amplification in a medium, Laser pumping, Boltzmann's principle and the population of energy levels, Attainment of population inversion, Two level, three level and four level pumping.

UNIT III: Optical feedback: Optical resonator, Laser power and threshold condition, Confinement of beam within the resonator, Stability condition.
Laser output: Absorption and emission, Shape and width of broadening lines, Line broadening mechanisms, Natural, Collision and Doppler broadening, Ruby laser, He-Ne Laser, CO_2 laser, Semiconductor Ga-As laser, Applications.

UNIT IV: Fiber Optics: Introduction, Total internal refraction, Optical fiber modes and configurations, Fiber types, Rays and modes, Step index fiber structures, Ray optics representation, Wave representation, Mode theory for circular wave guides, Wave guide equations, Wave equations for step indexed fibers, Modal equation, Modes in step indexed fibers, Power flow in step indexed fibers, Graded indexed fiber structure, Numerical aperture and modes in graded index fibers, Signal degradation in optical fibers, Attenuation, Losses, Absorptive and radiative scattering, Core cladding, Signal distortion in optical wave guides, Information capacity determination, Group delay, Material dispersion, Wave guide dispersion, Inter modal dispersion, Pulse broadening, Preparation of different techniques of optical fibers.

Text Books & References:

1. Introduction to Electrodynamics – D.J.Griffiths, Prentice-Hall, India
2. Electromagnetics – B.B.Laud, Wiley –Eastern, New Delhi.
3. Modern Optics – Fowels
4. Laser and their applications – M.J.Beesly, Taylor and Francis, 1976.
5. Laser and Non-Linear Optics – B.B.Laud, Wiley Eastern Ltd., 1983.

6. Optics – E.Hecht, Addison Wiley, 1974.
7. Optical fibers communications – Gerel Keiser, McGraw Hill Book, 2000.
8. Introduction to Quantum Optics – Baldwin

C-19(T) PHYC-704
RESEARCH METHODOLOGY

C-20(T) PHYC-801
SPECIAL AND GENERAL THEORY OF RELATIVITY

Unit-1: Basic idea about the scalar, vectors and tensor quantities, Einstein's summation convention, Definition of covariant and contravariant tensors and their transformation rules, Tensor algebra, Basic idea about the rank of a tensor, Contraction of indices of a tensor, The quotient theorem, Lowering and raising of indices of a tensor, Concept of symmetric and antisymmetric tensors and their examples, The metric tensor and its form in various coordinate systems. **(15 Lectures)**

Unit-2: Christoffel symbols, Basic concept of geodesics, Covariant differentiation, Concept of four-vector, Four-vector potential, Covariant formulation of tensors, Lorentz gauge, Maxwell's equations in tensor form, Equation of continuity in tensor form, Formulation of electromagnetic field tensor. **(10 Lectures)**

Unit-3: Basic postulates of special theory of relativity, Concept of light cone, Lorentz transformation of electric and magnetic fields, Lorentz transformation of four-momentum, Energy-momentum relation starting from four-momentum, Concept of space-time, Proper time, Line element in space-time, Action function, Lagrangian and Hamiltonian, Euler-Lagrange equation of motion from variational principle. **(10 Lectures)**

Unit-4: Gravity as a metric phenomenon, The red shift and its experimental test, Vector fields on curves, The Riemann curvature tensor, Symmetry properties of the Riemann tensor, The Einstein field equation, The Schwarzschild solution and its consequences. **(10 Lectures)**

Reference Books:

1. *Matrices and Tensors in Physics* by A. W. Joshi (New Age International Publishers).
2. *Schaum's Outline of Tensor Calculus* by David C. Kay (McGraw-Hill Publisher).
3. *Introduction to General Relativity* by Ronald Adler, Maurice Bazin and Menahem Schiffer (McGraw-Hill Publisher).

C-21(T) PHYC-802
ADVANCED QUANTUM MECHANICS

Unit-1: Dirac's bra and ket formalism, Concept of Hilbert space, Basis states and completeness condition and its analogous connection with linear vector space, Orthonormalization condition in bracket notation, Probability density operator and its evolution, Unitary operator, Complex conjugation operator, Hermitian operator and its significance, Quantum measurements, Pauli matrices, Concept of eigenvalues and eigenvectors of an operator, Proof of Heisenberg uncertainty relation using Gaussian wavefunction. **(10 Lectures)**

Unit-2: Pauli exclusion principle, Concept of Bosons and Fermions and their properties, Symmetries in quantum mechanics, Angular momentum operator, Spin operators, Ladder operators (raising and lowering operators) and their operations: eigenvalue equations, Spin-orbit coupling (L-S coupling). **(10 Lectures)**

Unit-3: Time-independent perturbation theory and its application through various problem solving, Fermi Golden rule (qualitative discussion only), Variational principle and its applications through various problem solving, WKB approximation method. **(10 Lectures)**

Unit-4: Relativistic wave equation for spin-0 particles, The notations, The Klein-Gordon equation, The nonrelativistic limit, Free spin-0 particles, Energy-momentum tensor of the Klein-Gordon field, Lagrange density and energy-momentum tensor of the Schrödinger equation, Lorentz invariance of the Klein-Gordon equation, The Klein-Gordon equation in Schrödinger form, Charge conjugation, Relativistic wave equation for spin-1/2 particle: The Dirac equation, The α and β matrices, Representation of the Maxwell equations in the form of the Dirac equation. **(15 Lectures)**

Reference Books:

1. *Introduction to Quantum Mechanics* by David J. Griffiths (Prentice Hall Publication, New Jersey).
2. *Quantum Mechanics* by Eugen Merzbacher (John Wiley & Sons, Inc.).
3. *Quantum Mechanics* by Leonard I. Schiff (McGraw-Hill Publisher).
4. *Modern Quantum Mechanics* by J. J. Sakurai (Cambridge University Press).
5. *Principles of Quantum Mechanics* by P. A. M. Dirac (Oxford University Press).
6. *Principles of Quantum Mechanics* by R. Shankar (Springer Science).
7. *Relativistic Quantum Mechanics* by Walter Greiner (Springer-Verlag Berlin Heidelberg GmbH).
8. *Quantum Mechanics – Symmetries* by Walter Greiner (Springer-Verlag Berlin Heidelberg GmbH).

C-22(T) PHYC-803
BAND THEORY OF SOLIDS

Unit-1: Concept of real space and momentum space, The basic idea about formation of energy bands in a solid, Nearly free electron model, Band dispersion, Origin of the energy gap (band gap), Bloch theorem and its mathematical proof, Concept of effective mass, Kronig-Penney model in real space and in reciprocal space. **(15 Lectures)**

Unit-2: Concept Brillouin zone, The distinction between metals, insulators and intrinsic semiconductors, The concept of a hole, Motion of electrons in a three-dimensional lattice, The Wigner-Seitz approximation and the cohesive energy of metals, Concept of direct bandgap and indirect bandgap semiconductors. **(12 Lectures)**

Unit-3: The tight-binding approximation, Lattice models in 1D and 2D, The single-particle states, Wannier states and Bloch states, The energy dispersion relation, The Hamiltonian in second quantized form (using the creation and annihilation operators), Density of states using the Green's function formalism, Concept of Fermi surface. **(12 Lectures)**

Unit-4: Band structure of graphene lattice: Concept of zero bandgap semiconductor and Dirac cone, Basic concept of topological insulator and edge (surface) states (Qualitative discussion only). **(8 Lectures)**

Reference Books:

1. *Introduction to Solid State Physics* by Charles Kittel (John-Wiley & Sons Inc.).
2. *Solid State Physics* by A. J. Dekker (Prentice-Hall Inc., New Jersey).
3. *Solid State Physics* by N. W. Ashcroft and N. D. Mermin (Harcourt College Publishers).
4. *Principles of the Theory of Solids* by J. Ziman (Cambridge University Press).
5. *Graphene Physics: Concepts and Applications* by Stephen Brooke (Publisher: States Academic Press)
6. *Graphene: From Theory to Applications* by Tianrong Zhang (Spinger Publication).
7. *Colloquium: Topological insulators* by M. Z. Hasan and C. L. Kane, Rev. Mod. Phys. 82, 3045 (2010).

C-23(T) PHYC-804
PHYSICS OF NANSCALE SYSTEMS

Unit-1: Concept about relevant length scales for nanostructures, Size effects in nanoscale systems, Nanostructures in zero dimension (0D), one dimension (1D), two dimensions (2D), and three dimensions (3D), and their examples (quantum dots, quantum wires, nanotubes, thin films, graphene, nanocomposites etc.), Application of Schrödinger equation: Particle in a potential box – wavefunction and energy levels, Quantum confinement of particles in 1D, 2D and 3D nanostructures and its consequences. **(15 Lectures)**

Unit-2: Magnetic field effects in quantum confined systems, Aharonov-Bohm phase, Calculation of density of states (DOS) in 3D, 2D, 1D and 0D nanostructure systems, Ballistic and quasi-ballistic transport in nanostructures, Boltzmann transport equation, Landauer formula, Scattering matrix. **(10 Lectures)**

Unit-3: Particle moving in two-dimensional electron gas (2DEG) under action of a perpendicular magnetic field: Derivation of Landau levels, Cyclotron frequency, Role of the magnetic field on the degeneracy of the electron states, The integer and fractional quantum Hall effect (qualitative discussion on the basic concepts). **(10 Lectures)**

Unit-4: Characterization techniques of nanoscale systems: Bragg's law, Crystalline planes, X-Ray diffraction, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Scanning tunnelling microscopy (STM), Optical microscopy etc. **(10 Lectures)**

Reference Books:

1. *Transport in Nanostructures* by David K. Ferry, Stephen M. Goodnick, and Jonathan Bird (Cambridge University Press).
2. *Electronic Transport in Mesoscopic Systems* by Supriyo Dutta (Cambridge University Press).
3. *Electrical Transport in Nanoscale Systems* by Massimiliano Di Ventra (Cambridge University Press).
4. *Nanotechnology: Principles and Practices* by S.K. Kulkarni (Springer Publication).
5. *Introduction to Nanoscience and Nanotechnology* by K.K. Chattopadhyay and A. N. Banerjee (Publisher: Prentice Hall India (PHI) Learning Private Limited).

C-24 PHYC-805
RESEARCH DISSERTATION

SKILL ENHANCEMENT COURSES

PHYSICS – SEC-I
RENEWABLE ENERGY AND ENERGY HARVESTING

(Credits: 03)

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

Unit - 1

Fossil fuels and Alternate Sources of Energy:

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

(6 Lectures)

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

(8 Lectures)

Unit - 2

Wind Energy harvesting

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

(4 Lectures)

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

(3 Lectures)

Unit - 3

Ocean Energy

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

(4 Lectures)

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

(3 Lectures)

Unit - 4

Hydro Energy

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

(3 Lectures)

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

(6 Lectures)

Unit - 5

Electromagnetic Energy Harvesting

Linear generators, physics mathematical models, recent applications

(3 Lectures)

Carbon captured technologies, cell, batteries, power consumption

(3 Lectures)

Environmental issues and Renewable sources of energy, sustainability.

(2 Lectures)

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.
- Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, 2004, Oxford University Press, in association with The Open University.
- Solar Energy: Resource Assessment Handbook, Dr. P Jayakumar, 2009
- Photovoltaics, J.Balfour, M.Shaw and S. Jarosek, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy

PHYSICS – SEC-II

RADIATION SAFETY

(Credits: 03)

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

Unit - 1

Basics of Atomic and Nuclear Physics:

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

(9 Lectures)

Unit - 2

Interaction of Radiation with matter:

Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients,

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

Interaction of Neutrons- Collision, slowing down and Moderation.

(10 Lectures)

Unit - 3

Radiation detection and monitoring devices:

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

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

(10 Lectures)

Unit - 4

Radiation safety management

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

(8 Lectures)

Unit - 5

Application of nuclear techniques:

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

(8 Lectures)

Experiments:

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

Reference Books

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

PHYSICS – SEC-III
WEATHER FORECASTING

(Credits: 03)

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

Unit - 1

Introduction to atmosphere:

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

(13 Lectures)

Unit - 2

Measuring the weather:

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

(7 Lectures)

Unit - 3

Weather systems:

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

(7 Lectures)

Unit - 4

Climate and Climate Change:

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

(7 Lectures)

Unit - 5

Basics of weather forecasting:

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

(11 Lectures)

Demonstrations and Experiments:

1. Study of synoptic charts and weather reports, working principle of weather station.
2. Processing and analysis of weather data:
    a. To calculate the sunniest time of the year.
    b. To study the variation of rainfall amount and intensity by wind direction.
    c. To observe the sunniest/driest day of the week.
    d. To examine the maximum and minimum temperature throughout the year.
    e. To evaluate the relative humidity of the day.
    f. To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/warning (both aviation and non aviation)

Reference books:

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