Semester III

Curriculum and Credit Framework for Undergraduate Programme of Physics Hons. (single Major) *w.e.f. 2024 (NEP 2020)*

Course	Course Code	Name of the Paper	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				Th	Pr	T		
CC- 3	**PHSUMCC303**	Electricity and Magnetism	Theory	4	0	0	4	50 (ESE-40, CA-7,IA-3)
CC- 4	**PHSUMCC304**	Waves and Optics	Theory	4	0	0	4	50 (ESE-40, CA-7,IA-3)
SEC3	**PHSUSEC303**	Digital and Analog applications skill	Practical	0	6		3	50 CIA=30 ESE=20 (Expt=15, Viva=5)
MDC3	**PHSUMDC307**	The idea of our Universe	Theory	3			3	50 (ESE-40, CA-7,IA-3)
GE1B (MIC)	**PHSUMIC302**	Mathematical Physics-I and Mechanics	Practical		8		4	50 CIA=30 ESE=20 (Expt=15, Viva=5)

Th= Lecture, **T=** Tutorial, **Pr =** Practical, **CC -** Core Course, SEC=Skill enhancement course, MDC=Multi-disciplinary Course, IA= Internal Assessment, CA= Class attendance.
CIA=Continuous Internal assessment, ESE=End semester examination, Expt.=Experiment

CC 3: ELECTRICITY AND MAGNETISM

(Credits: 04, Lectures 60)

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. **(6 Lectures)**

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. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

(10 Lectures)

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability.

(10 Lectures)

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. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(9 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. **(4Lectures)**

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**)

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. **(4Lectures)**

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)**

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. (3 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.

CC 4: WAVES AND OPTICS

(Credits: 04, Lectures 60)

In this course, students learn about the basic concepts over the physical properties of light waves. In laboratory, they get to study various optical phenomena.

Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(5 Lectures)**

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an 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. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(4 Lectures)**

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. **(6 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. 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. Open and Closed Pipes. Superposition of N Harmonic Waves. **(7 Lectures)**

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: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(4 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. Multiple slits. Diffraction grating. Resolving power of grating. **(8 Lectures)**

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.
(7 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.

SEC3 (LAB): Digital and Analog Applications Skills

(Credits: 3)

Group-A
(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.

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, PHI Learning.

Group-B
(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. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To study the Colpitt`s oscillator.
10. To design a digital to analog converter (DAC) of given specifications.
11. To study the analog to digital convertor (ADC) IC.
12. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
13. To design inverting amplifier using Op-amp (741,351) and study its frequency response
14. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
15. To study the zero-crossing detector and comparator
16. To add two dc voltages using Op-amp in inverting and non-inverting mode
17. To design a precision Differential amplifier of given I/O specification using Op-amp.
18. To investigate the use of an op-amp as an Integrator.
19. To investigate the use of an op-amp as a Differentiator.
20. To design a circuit to simulate the solution of a 1st/2nd 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, 4th edition, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

MDC-3

The Idea of our Universe

(3 Credits, 45 Lectures)

The Astronomer's Universe: Astronomy and Physics, The olbers paradox (5 lectures)

The life of a star: The classification of stars, The Herzsprung-Russel diagram, The birth of a star, The main sequence, the red giant stars, white dwarfs, neutron stars, and black holes, super nova. A star as a thermonuclear reactor, Planetary systems. (8 lectures)

Our Galaxy and Beyond: Our Galaxy, External Galaxies, Quasi Tailors objects (QSO), High energy astro physics. (5 Lectures)

Theories of the Universe: Newtonian Cosmology, The expanding universe, Cosmological postulates, element synthesis in the "hot bigbang", The steady state theory. Other cosmological model (T LECTURES) (8 Lectures)

Gravitation: Newtonian gravitation, General theory of relativity, Mach's Principal, Is the gravitational Changing? (5 Lectures)

Universe the arrow of time: Reversible phenomenon, Thermodynamics and cosmology, the electromagnetic arrow of time, Why and arrow of time. (6 Lectures)

Nature of the universe: A confrontation between theory and observations, Test of Model of the universe by consistency, Test of models of the universe best on the distant parts of the universe. Observation from the nearby universe. The nature of QSO Shifts and unsolved problems. (8 Lectures)

Reference Book :

1. The structure of the universe-Joyanta Bishnu, Narliker, Oxford University Press.

GE1B(MIC) LAB: Mathematical Physics-I and Mechanics:
Credit:4

Group-A
(Mathematical Physics-I)

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.
Fundamentals of PYTHON programming
Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, Data formatting, handling, List, String, Dictionary, Tuple, Set. 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*), user defined functions, 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 (π)
Solution of Algebraic and Transcendental equations by Bisection, Newton-Raphson and Secant methods
Solution of linear and quadratic equations, solving $\alpha = \tan\alpha$, $I = I_0 \left(\frac{\sin\alpha}{\alpha}\right)^2$ for example

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 $x = 0$, $y = -1, -2 - 3, -4$

Plot x vs. y for each of the four initial conditions on the same screen.

The differential equation describing the motion of a pendulum is $\frac{d^2(\theta)}{d^2} = -\sin\theta$.The pendulum is released from rest at a given angular displacement. Solve the equation and plot the analytic solution valid for small displacement.

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly
- A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn . , 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T. Pang, 2nd Edn., 2006,Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd
- Scientific Computing in Python, 1st edn, (2018), Abhijit Kar Gupta, Techno World Pub.

Group-B
(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 study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine **g** and velocity for a freely falling body using Digital Timing Technique
6. To determine Young's Modulus of the material of a beam by the method of Flexure.
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 Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
- Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

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