Semester II

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

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credits	Marks
				Th	Pr	T		
CC- 2 (Practical)	PHSUMCC 202	Mathematical Physics -I and Mechanics	Practical	0	8	0	4	50 CIA=30 (GrA-15 Gr.B-15) ESE=20 (Expt=15, Viva=5)
SEC-2		Analog Systems and Applications	Theory	3	0	0	3	50
MDC-2		The Idea of our Universe	Theory	3	0	0	3	50
GE2A (MIC)	MIC201	Mathematical Physics-I and Mechanics	Theory	4	0	0	4	50

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

CC2 (Mathematical Physics -I and Mechanics)

Gr.A

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 $\alpha = \tan\alpha$, $I = I_0 (\frac{\sin\alpha}{\alpha})^2$ 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:

- Python Computing -A. Kargupta.
- 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.

Gr. B (Mechanics)

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

Reference Books:

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

SEC-2: Analog System and Applications Skill

(Credits: 03, Lectures 45)

Aim of the course is to enable the students to know the basic of digital circuit and helps to design the electrical circuit, networks and appliances through hand on mode

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current flow Mechanism in Forward and Reverse Biased Diode. **(5 Lectures)**

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. **(5 Lectures)**

Bipolar Junction transistors: Formation of current component n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(6 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(8 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(4 Lectures)**

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) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. **(9 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.

MDC-2 : 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 big-bang", The steady state theory. Other cosmological model (8 Lecture)

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 (5 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 near by universe. The nature of QSO Shifts and unsolved problems. (9 Lecture)

Reference Book

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

GE2A(MIC): Mathematical Physics-I and Mechanics
(Credits: 04, Lectures 60)

The emphasis of this course is on application in solving problems of different physical systems of interest. The students are to be examined entirely on the basis of problems, seen and unseen.

Group-A (Mathematical Physics-I) Lectures 30

First Order and Second Order Differential equations:

First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronski an and general solution. Statement of existence and Uniqueness Theorem for

Initial Value Problems. Particular Integral. **(7 Lectures)**

Vector Calculus:

***Recapitulation of vectors*:** Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. (**5 Lectures**)

***Vector Differentiation*:** Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **(6 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vectorfields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(6 Lectures)**

Orthogonal Curvilinear Coordinates:

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E.Harris.
- 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
- Mathematical Physics-H.K.Dass
- Vector Analysis-Spigel
- Mathematical Physics-A Ghatak, Guha
- Mathematical Physics-A. B. Gupta

Group-B (Mechanics, Lectures 30)

The aim of this course is to study various classical dynamics systems. Students will learn different key concepts involving the description of a mechanical system by go through problem solving**.**

Fundamentals of Dynamics: Reference frames, Inertial frames; Review of Newton's Laws of Motion, Galilean transformations; Galilean invariance. Momentum of variable mass system: motion of rocket. Motion of a projectile in uniform gravitational field, Dynamics of a system ofparticles, 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. **(2 Lectures)**

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

translation and rotation. **(5 Lectures)**

Elasticity: Stress and strain. Stress-strain curve. Hook's law and elastic moduli and the relations between them. Twisting torque on a cylinder or wire. Torsional rigidity. Bending of beam. Shearing force and the torque. Internal bending moment. Geometrical moment of inertia. Depression of horizontal beam. Cantilever. Beam supported on knife edges at the two ends and loaded at the middle. Depression due to shear. (**4 Lectures**)

Fluid Motion: Kinematics of Moving Fluids: critical velocity and Reynold's number. Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. Corrections to Poiseuille's equation. Flow through capillaries in series and in parallel. **(2 Lectures)**

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

Motion of a particle under a central force field, Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(5 Lectures)**

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: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(4 Lectures)**

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. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(3Lectures)**

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, PearsonEducation
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- General Properties of matter, Sengupta and Chatterjee.
- Classical Mechanics and General Properties of Matter-D.P. Roychowdhury and S.N. Maity
- Classical Mechanics, A.B. Gupta
- 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.

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