FYUG(Physics) Course Curriculum Structure and syllabus for 1st Semester

Year	Semester	Major (Credit)	Minor (Credit)	MDC (Credit)	AEC (Credit)	SEC*/ Dissertation (Credit)	Experiential Learning (Credit)	VAC (Credit)	Total Credits	Additional Summer Internship
I	I	Major – 1 (4) (Level 100) MJC45PHY101(T)25: Mechanics (Credit: 03) MJC45PHY101(P)25: Mechanics (Credit: 01)	Minor – 1 (4) (Level 100) MNC45PHY101(T)25: Mechanics (Credit: 03) MNC45PHY101(P)25: Mechanics (Credit: 01)	MDC - 1 (3) MDCPHY001 / MDCPHY002 / MDCPHY003 : Introduction to Physics: (Credit:03)	AEC – 1 (Communication Skills) (4)	SEC – 1 (3) Computational Physics: SEC45PHY101(T)25-a (Credit: 02) + SEC45PHY101(P)25-a (Credit: 01) **Or** Electrical Circuits and Network Skills: SEC45PHY101(T)25-b (Credit: 02) + SEC45PHY101(P)25-b (Credit: 01)		VAC – 1 (2)	20	Additional for Bachelor's Certificate (4)

Course title: Mechanics
Credit: 04 (3+1)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course introduces the foundational theories, concepts, and principles of mechanics from a more advanced perspective. The topics covered include Newton's Laws of Motion, Rotational Dynamics, Gravitation and Central Force Motion, Non-inertial Systems, Special Theory of Relativity, etc. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to

- Understand laws of motion and their applications to various dynamical situations.
- Learn the concept of inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Explain the phenomenon of simple harmonic motion (SHM).
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.

In the practical component, the student shall perform experiments related to mechanics: compound pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), fluid dynamics, estimation of random errors in the observations, etc.

MJC45PHY101(T)25: Mechanics
Credit: 03
Theory: 45 Hours

Unit 1

Fundamentals of Dynamics: Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton's Laws of Motion. Momentum of variable mass system: motion of rocket. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D).

(5 Lectures)

Unit 2

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Work done by non-conservative forces. Law of conservation of Energy.

(4 Lectures)

Unit 3

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, theorem of parallel and perpendicular axes. Determination of moment of inertia of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D). Kinetic energy of rotation. Motion involving both translation and rotation.

(8 Lectures)

Unit 4

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. Two-body problem, its reduction to one- body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler's Laws.

(8 Lectures)

Unit 5

Oscillations: Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillations. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.

(6 Lectures)

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications**.**

(4 Lectures)

Unit 6

Special Theory of Relativity: Michelson-Morley Experiment (only qualitative description) and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, and Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle, massless particles, mass-energy equivalence and relativistic Doppler effect (transverse and longitudinal).

(10 Lectures)

MJC45PHY101(P)25: Mechanics
Credit: 01
Practical: 30 Hours

Practical: 30 Hours

Demonstration cum laboratory sessions on the construction and use of Vernier callipers, screw gauge and travelling microscope, and necessary precautions during their use.

Sessions and exercises on the least count errors, their propagation and recording in final result up to correct significant digits, linearization of data and the use of slope and intercept to determine unknown quantities.

Session on the writing of scientific laboratory reports, which may include theoretical and practical significance of the experiment performed, apparatus description, relevant theory, necessary precautions to be taken during the experiment, proper recording of observations, data analysis, estimation of the error and explanation of its sources, correct recording of the result of the experiment, and proper referencing of the material taken from other sources (books, websites, research papers, etc.)

At least 06 experiments from the following

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

References for Theory- Essential Readings:

1. An Introduction to Mechanics (2/e), Daniel Kleppner & Robert Kolenkow, 2014, Cambridge University Press.
2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education.
3. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
4. Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.
5. Analytical Mechanics, G. R. Fowles and G. L. Cassiday, 2005, Cengage Learning.

Additional Readings:

1. Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
2. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
3. University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
4. Fundamentals of Physics, Resnick, Halliday & Walker 10/e, 2013, Wiley.
5. Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
6. Physics for Scientists and Engineers, R. A. Serway, J. W. Jewett, Jr, 9/e, 2014, Cengage Learning.
7. Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.

References for Laboratory Work:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11/e, 2011, Kitab Mahal.

Course Title: Computational Physics
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objectives:

This course is designed to introduce students to the fundamental concepts of computer programming using the Python language. It aims to develop computational thinking, logical reasoning, and problem-solving abilities by engaging students in writing simple programs, understanding program flow, and working with basic data structures. The course also seeks to build confidence in coding and lay a strong foundation for further study in programming or data science.

Course learning outcomes:

By the end of this course, students will be able to understand the basic structure and syntax of Python programming, including the use of variables and fundamental data types such as strings, integers, floats, and booleans. They will be able to apply arithmetic and logical operations to solve simple problems and write Python programs using control structures like conditional statements (if, else, elif) and loops (for, while). Students will also learn to work with essential data structures such as lists, tuples, and dictionaries, and use both built-in and user-defined functions to create modular and reusable code. They will gain proficiency in handling input and output operations, debugging common errors, and developing algorithmic thinking.

Course Code: SEC45PHY101(T)25-a
Credit: 02
Theory: 30 Hours

Unit 1: Introduction

Basics of Programming Languages, Interpreter and Compiler, Algorithms and Flowcharts, History and features of Python, Python 3 vs. Python 2, Installing Python and IDEs (Anaconda, PyCharm, Jupyter Notebook etc.)

Basics of Python: Python Keywords, Identifiers and Variables, Data Types, Backslash Character Constants.

Operators and Expressions: Arithmetic Operators, Relational Operators, Logical/Boolean Operators, Assignment Operators, interactive mode and Script mode, Order of Operations, Comments in Python, Common Errors, Managing Input and Output Operations, Frequently used Formatting Specifiers.

(7 lectures)

Unit 2: Control Structures

Decision making and Branching: Conditional statements (Simple if, if-else, else-if ladder, nested-if statements), Boolean values.

Decision making and Looping: The while loop statement, The for loop statement, The range () function, Jumps in Loops, Skipping a part of a Loop, The else Clauses on Loops.

Functions: Types of Functions, Nesting of Functions, Boolean Function, Recursion Function, Default Arguments, Lambda function.

(7 lectures)

Unit 3: Data Structures

List: Definition, The in operator, Traversing in a List, Nested List, List Operations, List Slices, List Functions, List Methods, Copying Lists, Sorting Lists, Two-Dimensional Lists, Multidimensional Lists.

Dictionaries: Definition, Creating a Dictionary, Adding, Modifying, and Retrieving Values, The Dictionary Methods.

Sets : Accessing Sets with common functions**,** Subset and Superset in Sets, Relational operators in Sets, Set Operations.

Tuples : Definition, Tuple Assignment, Tuples as Return Values, The Basic Tuple operations, Relationship between Lists and Tuples, Relationships between Dictionaries and Tuples.

(7 lectures)

Unit 4: File Handling

Introduction, Text files and Binary files, Absolute and Relative filename, Opening a File, Writing Data, Some commonly used methods for File handling

Writing and Reading Numeric Data. Data visualization with matplotlib.

(4 lectures)

Unit 5: Applications to Computational Physics

What is computational physics? Oscillatory Motion (SHM), Damped pendulum dynamics, Basics of Fractals, Random Numbers in Computer Simulation, Applications of Monte Carlo Method.

(5 lectures)

Course Code: SEC45PHY101(P)25-a
Credit: 01
Practical: 30 Hours

1. Write Python programs for the following with and without recursive functions:
   A. To convert decimal numbers to binary numbers.
   B. Write a Python program to reverse the digits of an integer
   C. To find the Greatest common divisor (GCD) of two numbers
2. Write a Python program to verify a given number is prime or not.
3. Write a Python program to generate prime numbers between any two given numbers.
4. Write a Python program to organize a given set of numbers in ascending and descending orders.
5. Write a Python program to generate Fibonacci series.
6. Write a Python program to find out the Prime numbers from a sequence of Fibonacci series.
7. Write a Python program to check a given number is an Armstrong number or not.
8. Write a Python program to check a given year is a Leap year or not.
9. Write a Python program to print Pascal Triangle.

10. Write a Python program to solve the Tower of Hanoi.

References:

1. M. Shubhakanta Singh, *Programming with Python and its applications to Physical Systems,* Taylor and Francis, 2024.
2. Allen B. Downey, *Think Python*, Green Tea Press, 2014.
3. Hans Peter Langtangen, *A Primer on Scientific Programming with Python*, Springer, 2012.
4. S. Hilborn, R.C., *Chaos and Nonlinear Dynamics, An Introduction for Scientists and Engineers,* Ed. 2, Oxford University Press, USA, 2004.
5. Pang, Tao, *Introduction to Computational Physics, Ed. 2.,* Cambridge University Press, NY, 2006,
6. Landau, Rubin H., *Computational Physics: Problem solving with Computers,* John Wiley and Sons, Inc.,1997.

Course Title: Electrical circuits and Network Skills
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objectives

To develop an understanding of basic principles of electricity and its household applications. To impart basic knowledge of solid state devices and their applications, understanding of electrical wiring and installation.

Course Leaning Outcomes

At the end of this course, students will be able to

- Demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.
- Develop the capacity to analyze and evaluate schematics of power efficient electrical circuits while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.
- Gain knowledge about generators, transformers and electric motors. The knowledge would include interfacing aspects and consumer defined control of speed and power.
- Acquire capacity to work theoretically and practically with solid-state devices. Delve into practical aspects related to electrical wiring like various types of conductors and cables, wiring-Star and delta connections, voltage drop and losses.
- Measure current, voltage, power in DC and AC circuits, acquire proficiency in fabrication of regulated power supply.
- Develop capacity to identify and suggest types and sizes of solid and stranded cables, conduit lengths, cable trays, splices, crimps, terminal blocks and solder.

Course Code: SEC45PHY101(T)25-b
Credit: 02
Theory: 30 Hours

Unit 1

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

(3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(2 Lectures)

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

(3 Lectures)

Unit 2

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

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

(3 Lectures)

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

(5 Lectures)

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

(3 Lectures)

Course Code: SEC45PHY101(P)25-b
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 08 Experiments from the following

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

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References Essential Readings:

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja - S Chand & Co.
3. Performance and design of AC machines - M G Say ELBS Edn.
4. Electronic Devices and Circuits, A. Mottershead,1998, PHI Learning Pvt. Ltd.
5. Network, Lines and Fields, John D. Ryder, Pearson Ed. II, 2015.

Additional Readings:

1. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

Introduction to Physics: MDCPHY001/ MDCPHY002/ MDCPHY003
Credit:03
Theory: 45 Lectures

Course Objective

- To give an introduction to the fundamentals of Physics.
- To give introductory concepts on units and measurement, scalar and vectors, laws of motion, work, power and energy, electricity and magnetism, geometry and wave optics, gravity and planetary motion, wave and oscillation, and electronics.

Course learning Outcomes

- They will understand the basic concepts of units and measurements, motion, optics, electricity and magnetism, energy, waves and oscillation and the concept of electronics which are the fundamental parts of Physics and its application in everyday life.
- On successful completion of the course, students will be able to understand the preliminary idea of the concept of Physics and its phenomena in our daily lives.

Unit 1

Units And Measurement

Units of measurement, system of units, SI units, fundamental and derived units.

(2 lectures)

Scalar And Vectors

Vector notation, equality of vectors, vector addition, product of vectors, scalar product and vector product. Position and displacement vectors.

(4 lectures)

Unit 2

Laws Of Motion

Inertia, Newton's law of motion. law of conservation of linear momentum and its applications, impulse, friction and lubrication. Uniform circular motion: centripetal force, centrifugal force, torque, angular momentum, Law of conservation of angular momentum and its applications.

(6 lectures)

Unit 3

Work, Power and Energy

Work done by a force. Kinetic energy and potential energy, work-energy theorem, power.

(2 lectures)

Unit 4

Waves and oscillations:

Longitudinal and transverse waves (with examples), periodic motion. Simple harmonic motion (SHM), simple pendulum. Child on a swing, tuning fork, motion of a spring, damped and forced oscillations. **(5 Lectures)**

Unit 5

Gravity and Planetary Motion

Historical evolution of the concept of gravity: from Aristotle to Newton. gravitational forces in nature: everyday implications, the Universal Law of Gravitation, Kepler's Laws of planetary motion. Role of gravity in maintaining orbital motion, moon's journey around the earth- lunar cycle, tides and gravitational interactions. Satellites.

(6 Lectures)

Unit 6

Electricity and Magnetism:

Electric lines of force, electric permittivity, electric field and potential, electric flux, electrostatic shielding, Lorentz force, magnetic induction. permeability, magnetic susceptibility. brief introduction to dia-, para- and ferro-magnetic materials. electromagnetic induction, eddy current, alternating current, direct current, resistors, capacitors and inductors, electric generators, electric motor and transformer**.**

(8 lectures)

Unit 7

Geometric and Wave Optics:

Electromagnetic spectrum, dual nature of light, reflection, refraction, interference, diffraction, dispersion, scattering, structure of human eye, defects of eye (myopia, hypermetropia, presbyopia and astigmatism) and its remedy, lasers, optical fiber communication. holography, optical phenomena related to daily life (rainbow, halo, mirage, colour of sky etc.).

(8 lectures)

Unit 8

Electronics:

Diode, transistor, solar cell, IC microprocessor, concept of pixel as used in electronic displays, digital data communication (internet).

(*All qualitative only) **(4 Lectures)**

Reference Books:

1. Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited
2. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
3. Concept of Physics (I &II), H.C Verma.
4. NCERT Physics Textbooks (Class 9,10 11 &12)
5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
6. Optics, Ajay Ghatak, 6th ed., 2017, Tata McGraw Hill.
7. Electricity and Magnetism, D.C.Tayal, 1993, Himalaya Publishing House.
8. Electricity and Magnetism, J H Fewkes & J Yarwood, Oxford University Press, Calcutta, 1985
9. SWAYAM/NPTEL modules on basic physics