

## Detailed Syllabi of Physics Hons. of WBSU Under NEP 2020

### Semester I

#### DS-1

### Mathematical Methods-I (Theory)

**3 Credit**

**45 lectures.**

#### Calculus

**18 Lectures**

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). Convergence condition of Taylor series and corresponding tests. First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous and Inhomogeneous second order differential equations with constant coefficients, particular integral. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration

#### Vector Calculus

**27 Lectures**

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities using Kronecker delta and Levi-civita symbols. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

#### Reference Books

- ▶ Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.
- ▶ Vector Analysis with an Intro. to Tensor Analysis: Schaum's Outline Series. M.R. Spiegel, 1981, McGraw Hill.
- ▶ Introduction to Mathematical Physics. C. Harper, 1989, PHI.
- ▶ Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- ▶ Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- ▶ Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press

## DS1-Lab

### Mathematical Method -I (Lab)

#### 2 Credit

##### 1. Introduction to plotting graphs with QtiPlot (or equivalent)

a) Basic 2D and 3D graph plotting - plotting functions, modifying the appearance of graphs, polar and parametric plots, Surface and contour plots, exporting plots.

Importing multicolumn data. Plotting and fitting data using qtiplot's fit function.

##### 2. Introduction to programming in python:

- Python as a number calculator
- algebraic calculation through python interactively
- help searching of functions (from built-ins, idea of default argument)
- importing modules like math, cmath modules and)
- standard I/O statements (input, raw\_input, print)
- string, list, tuple and the corresponding methods. (In the interactive mode. Slicing. Help searching for methods.)
- program with formula crunching.  
Control structures (use of simple programs to learn the use of if, if-elif-else, for, while, try-except.

##### 3. Programs as applications

- finite series summation [Example: AP, GP, power series, trigonometric series, etc.
- Taylor series summation with a given precision [for different  $f(x)$  about  $x=0$  or about some non-zero value and comparison with library functions, where available.

##### 4. File handling in Python

- File I/O statements: Example programs like
1. File I/O : Create a three column data (x,y,z) file using a text editor. Read it from python. Find the sum and standard deviation of y and z .
  2. File I/O: Create a single column data containing repetitive integers of at least 20 entries. Read the file. Find the frequency table of the distinct elements. Output that in another file.

##### 5. Least square fitting

Linear and linearisable Least square fitting with supplied data. The final fit should be displayed through Qtiplot or a similar software. Use data recorded from the suitable experiments in Mechanics paper.

##### 6. User defined functions in Python

- User defined function, default argument, global  
Example: Write functions for
  - i)  $f(x)=x !!$
  - ii)  $f(n)=n$ -th element of the Fibonacci sequence
  - iii) linspace (start, stop, number), the third being a default argument  
Write function  $(a, x)=\exp(-ax)\sin(x)$  :  $a$  being a global arguments

## 7. Solution of Algebraic and Transcendental equations by Bisection Method

- Root finding: Bisection (Initial guess to be determined by plotting) for non-linear equations.
- Determination of time of journey for a moving particle obeying  $x=f(t)$  or similar problems are to be worked out.

## 8. Solution of Algebraic and Transcendental equations by Newton -Raphson Method

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

### Reference Books:

1. [The Python Tutorial](#)
2. [PYTHON PROGRAMMING FOR PHYSICISTS](#)
3. Scientific Computing in Python, Abhijit Kar Gupta, 2021, Techno World.

## Semester 2

### DS-2

#### Mechanics I (Theory)

**3 Credit**

**45 Lectures**

#### **Fundamentals of Dynamics**

**5 Lectures**

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

#### **Work and Energy**

**4 Lectures**

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by nonconservative forces. Law of conservation of Energy.

#### **Collisions**

**3 Lectures**

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

#### **Rotational Dynamics**

**8 Lectures**

Recapitulation: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Perpendicular axes theorem and parallel axes theorem and their applications in calculations of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

#### **Elasticity**

**6 Lectures**

Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Bending of a beam – internal bending moment.

#### **Fluid Motion**

**4 Lectures**

Kinematics of Moving Fluids: Equation of continuity. Idea of streamline and turbulent flow, Reynold's number. Poiseuille's Equation for Flow of a viscous Liquid through a Capillary Tube.

#### **Gravitation and Central Force Motion**

**8 Lectures**

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

#### **Oscillations**

**7 Lectures**

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

#### **Reference Books**

- ▶ An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- ▶ Classical Dynamics of Particles and Systems. S.T. Thornton and J. B. Marion, 2009, Brooks/Cole.
- ▶ Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

- ▶ Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- ▶ Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.
- ▶ General Properties of Matter. F.H. Newman and V.H.L. Searle, 1957, Hodder and Stoughton.
- ▶ General Properties of Matter. B. Brown, 1969, Springer Science.
- ▶ Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
- ▶ Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- ▶ Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, 1979, Tata McGraw-Hill▶ Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, 1979, Tata McGraw-Hill
- ▶ Mechanics, K. R. Symon, 3<sup>rd</sup> ed., 1971, Addison-Wesley
- ▶ Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited

**DS-2 (Lab)**  
**Mechanics -1 Lab**

2 Credits

List of Experiments:

1. To determine the Moment of Inertia of a regular body using another auxiliary body and a cradle suspended by a metallic wire.
2. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique
3. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4. To determine the Young's Modulus by flexure method.
5. To determine the Modulus of Rigidity of a wire by a torsional pendulum.
6. To determine the value of  $g$  using Bar Pendulum.
7. To determine the value of  $g$  using Kater's Pendulum.

**Reference Books**

- ▶ Advanced Practical Physics for Students, B. I. Worsnop and H. T. Flint, 1957, Methuen & Co.
- ▶ An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 8<sup>th</sup> ed., 2007, New Central Book Agency
- ▶ Advanced Practical Physics, vol 1, B. Ghosh & K. G. Mazumdar, 7<sup>th</sup> ed., Sreedhar Publishers, 2006

# Minor Courses

## Semester 1

(Minor 1)

### Mechanics Theory

**45 Lectures**

**3 Credits**

#### Vectors

Vector algebra, Scalar and vector products, derivatives of a vector wrt a parameter, ordinary differential equations: 1<sup>st</sup> order homogeneous differential equations, 2<sup>nd</sup> order homogeneous and inhomogeneous differential equations with constant coefficients.

#### Particle Dynamics

**14 Lectures**

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.

#### Gravitation

**7 Lectures**

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

#### Oscillations

**6 Lectures**

Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Forced harmonic oscillations, resonance.

#### Elasticity

**8 Lectures**

Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants – Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum.- Bending of beam.

#### Reference Books

- ▶ Introduction to Mathematical Physics. C. Harper, 1989, PHI.
- ▶ An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- ▶ Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- ▶ Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.
- ▶ Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
- ▶ Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, 1979, Tata McGraw-Hill
- ▶ Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited

## Mechanics (Minor 1) Lab

Credit 2

1. To determine the Moment of Inertia of a regular body using another auxiliary body and a cradle suspended by a metallic wire.
2. To determine  $g$  and velocity for a freely falling body using Digital Timing Technique
3. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4. To determine the Young's Modulus by flexure method.
5. To determine the Modulus of Rigidity of a wire by a torsional pendulum.
6. To determine the value of  $g$  using Bar Pendulum.
7. To determine the value of  $g$  using Kater's Pendulum.

### Reference Books

- ▶ An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 8<sup>th</sup> ed., 2007, New Central Book Agency
- ▶ Advanced Practical Physics, vol 1, B. Ghosh & K. G. Mazumdar, 7<sup>th</sup> ed., Sreedhar Publishers, 2006



## Semester 2

(Minor -2)

### Electricity and Magnetism Theory

45 Lectures

3 Credits

#### Vector Analysis

10 Lectures

Gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

#### Electrostatics

16 Lectures

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field. Electric potential due to an electric dipole. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

#### Magnetism

9 Lectures

Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

#### Electromagnetic Induction

5 Lectures

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

#### Linear Network

5 Lectures

Impedance of L, C, R and their combinations. Thevenin & Norton's Theorem. Maximum power transfer theorem and superposition theorem. Anderson's bridge.

#### Reference Books

- ▶ Vector Analysis with an Intro. to Tensor Analysis: Schaum's Outline Series. M.R. Spiegel, McGraw Hill.
- ▶ Foundations of Electromagnetic Theory. J.R. Reitz, F.J. Milford and R.W. Christy, 2010, Pearson.
- ▶ Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- ▶ Electricity and Magnetism, vol. 1, J. H. Fewkes and J. Yarwood, 2<sup>nd</sup>. ed., 1965, Oxford University Press
- ▶ Electromagnetism. I.S. Grant and W.R. Phillips, 2013, Wiley.
- ▶ Classical Electromagnetism. J. Franklin, 2008, Pearson Education.
- ▶ Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- ▶ Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill.
- ▶ A text book in Electrical Technology, B L Theraja, S Chand and Co.

## **Electricity and Magnetism (Minor-2) Lab**

Credit 2

1. To determine an unknown Low Resistance using Carey Foster's Bridge.
2. To verify the Thevenin and Norton theorems.
3. To verify the Superposition and Maximum Power Transfer theorems.
4. To determine self-inductance of a coil by Anderson's bridge.
5. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
6. To determine an unknown Low Resistance using Potentiometer.
7. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

### **Reference Books**

- ▶ An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 8<sup>th</sup> ed., 2007, New Central Book Agency
- ▶ Advanced Practical Physics, vol 1, B. Ghosh & K. G. Mazumdar, 7<sup>th</sup> ed., Sreedhar Publishers, 2006
- ▶ Advanced Practical Physics, vol 2, B. Ghosh, 2<sup>nd</sup> ed., Sreedhar Publishers, 2005

**Skill Enhancement Courses**  
**Physics**

**Semester 1**

**SEC (Physics) 1**

**Basic Instrumentation Skills**

**Credit 3**

**Lecture 45**

**1. Basic of Measurement**

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

**2. Electronic Voltmeter**

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

**3. Cathode Ray Oscilloscope**

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

**4. Signal Generators and Analysis Instruments**

Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

**5. Digital Instruments**

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

**6. Digital Multimeter**

Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

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

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

• **Laboratory Exercises**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. Measurement of voltage, frequency, time period and phase angle using CRO.
4. Measurement of time period, frequency, average period using universal counter/ frequency counter.
5. Measurement of rise, fall and delay times using a CRO.
6. Measurement of distortion of a RF signal generator using distortion factor meter.

**Reference Books**

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

**Semester 2**  
**SEC (Physics) 2**  
**Computational Physics Skills**

**Credit 3**

**Lecture 45**

**Introduction**

Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of  $\sin(x)$  as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

**Scientific Programming**

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN/ C++, Basic elements of FORTRAN 90/95 or C++: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran 90/95 or C++ Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

**Control Statements**

Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements, Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

**Programming**

1. Exercises on syntax on usage of FORTRAN 90/95 or C++
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN 90/95 or C++.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using  $\exp(x)$  series evaluated at  $x=1$

**Scientific word processing: Introduction to LaTeX**

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining

LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

### **Visualization**

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

### **Hands on exercises**

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

### **Reference Books**

1. Computer Programming in Fortran 90 and 95. V. Rajaraman, 1997 (Publisher: PHI).
2. Object Oriented Programming with C++. E. Balaguruswamy, 2017. McGraw Hill, India.
3. LaTeX—A Document Preparation System, Leslie Lamport (Second Edition, Addison- Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)

# MDC (Physics)

## Current perspectives of Physics

**3 credit**

**45 lectures**

**Course objective:** To give an overview of some basic physical ideas at a semi-popular level – with minimal use of mathematics.

**Course Pre-requisites:** High school level exposure of physical science, algebra and geometry.

### Module 1

#### 1(a) Introduction :

**2 lectures**

Qualitative idea of Systems, Observers, Reference frames and Forces originating from the fundamental Interactions of nature, long-range (gravity and electromagnetic) and short-range (strong and weak forces).

#### 1(b) How Physics works:

**12 lectures**

Examples of how observations lead to discovery of Laws of nature, how theories are constructed around these laws, how experiments verify theoretical predictions and theories are modified to suit the experimental findings.

#### Examples:

- Galilean and Newtonian Dynamics giving Laws of motion, Kepler's laws of Planetary motion explained by Newton's theory of gravity, Discovery of Neptune as a verification of Newton's gravity theory, Newton's gravitational constant. [3 lectures]
- Different empirical laws of Electromagnetism (Coulomb's law, Faraday's law, Ampere's law etc) connected by Maxwell's theory, Prediction of electromagnetic wave and its speed of propagation as a Universal constant. Inconsistency with laws of Galilean Relativity leading to discovery of Special Relativity. [4 lectures]
- Observation of atomic spectra and Black-body radiation leading to Planck's quantum theory and Einstein's explanation of Photoelectric effect introducing Photon as a "quanta of energy"(Details to be covered in Module 3). Discovery of Bohr model of atom. Development of quantum mechanics, Planck's constant – a fundamental constant of nature. [5 lectures]

### Module 2

#### The grand scheme of Physics:

**13 lectures**

The three fundamental constants of nature,  $c$ ,  $G$  and  $\hbar$ .

- |                                    |   |              |
|------------------------------------|---|--------------|
| $(c^{-1} = 0, G = 0, \hbar = 0) :$ | Classical non-relativistic mechanics: the starting point.   |              |
| $(c^{-1} = 1, G = 0, \hbar = 0) :$ | Classical relativistic mechanics, SR, Electrodynamics<br>(mention basic technologies like, cars, electricity, energy industry)  | [1 lecture]  |
| $(c^{-1} = 0, G = 1, \hbar = 0) :$ | Classical Newtonian gravity, falling bodies, Structure of solar system, Galaxies.   | [1 lecture]  |
| $(c^{-1} = 0, G = 0, \hbar = 1) :$ | Non-relativistic quantum mechanics, basic structure of atoms, molecules, solid state physics. (Qualitative)<br>(mention modern application in electronic and data storage devices, e.g., computers, mobiles). | [4 lectures] |

- ( $c^{-1} = 1, G = 1, \hbar = 0$ ) : Classical General relativity, curved spacetime, fine-tuning of planetary motion, perihelion precession of Mercury, deflection of light by the Sun, recent observational evidence of Black-holes and Gravitational waves as predicted by theory.  
(*modern applications in communication, e.g. GPS, astronomical telescopes giving information about the cosmological structure of the Universe*). [5 lectures]
- ( $c^{-1} = 1, G = 0, \hbar = 1$ ) : Relativistic quantum mechanics, it's inconsistencies leading to Quantum field theory which explains sub-atomic structures, fundamental particles, standard model (LHC).
- ( $c^{-1} = 1, G = 1, \hbar = 1$ ) : Theory of Quantum Gravity, yet to be formalised. [2 lectures]

### Module 3

#### 3(a) Light and it's dual nature: 10 lectures

Corpuscular and wave theories of light- a historical overview; merits and demerits of the two theories; simple experiments demonstrating dispersion of light using prism, diffraction of light with laser source, demonstration of Newton's rings and its qualitative explanation; naïve idea of black body radiation, Planck's proposal of energy quanta, photoelectric effect and particle nature of light; Scattering of light, Raman effect (qualitative).

#### 3(b) The Electromagnetic Spectrum: 8 lectures

Introduction to the entire electromagnetic spectrum; Light as an electromagnetic wave (mention Maxwell's theory, Hertz's experiment); usage of different parts of the electromagnetic spectrum - with examples from everyday life including x-rays and gamma-rays in medical science, microwaves and radio waves (mentioning India's Radio telescope site at GMRT), preliminary concepts of LASER, Holography and Fibre optics.

### Reference Books

1. Perspectives of Modern Physics, Arthur Beiser, McGraw-Hill Inc.,US, 1969.
2. The Feynman Lectures on Physics - Vol. I, II & III, Pearson Education; Combo edition, 2012.
3. At the root of Things, The subatomic world, Palash B. Paul, CRC Press, 2014.
4. কী কী সমস্যা সমাধানের গুণ, পলাশ বরন পাল, পিওমবস ক পাবলিশিং, ২য় সংস্করণ, ১৯৯৭।  
রাজ্য পত্র
5. Seven Brief Lessons On Physics, Carlo Rovelli, Penguin Random House, UK, 2014.