Physics: General Course Curriculum & Credit Framework (NEP 2020)

Sem I and II

Teaching Plan

Name of Teacher: Dr. Sandip Majumdar

THREE YEARS MULTIDISCIPLINARY U.G PHYSICS PROGRAMME UNDER THE UNIVERSITY OF CALCUTTA

STRUCTURE OF THE COURSE

1st Semester:	***2nd Semester:***
A) MDC-1 (Level-100) for students choosing Physics as one of their core papers **B) SEC – 1**: Introduction to Graph plotting & Programming **C) Interdisciplinary Course (IDC)** will be offered for students of other disciplines who do not have Physics as a major or minor subject, in any one of the first three semesters.	**A) MDC-2 (Level-100) for students choosing Physics as one of their core papers.** **B) SEC – 1**: Introduction to Graph plotting & Programming **C) Interdisciplinary Course (IDC)** will be offered for students of other disciplines who do not have Physics as a major or minor subject, in any one of the first three semesters.
3rd Semester:	***4th Semester:***
A) MDC-3 (Level-200) for students choosing Physics as one of their core papers. **B) SEC – 1**: Introduction to Graph plotting & Programming. **C) Interdisciplinary Course (IDC)** will be offered for students of other disciplines who do not have Physics as a major or minor subject, in any one of the first three semesters. **D) MDC Minor 1: for students choosing Physics as minor subject.**	**A) MDC-4 & MDC -5 (Level-200) for students choosing Physics as one of their core papers.** **B) MDC Minor 2: for students choosing Physics as minor subject.**
5th Semester:	6***th Semester:***
A) MDC-6 & MDC -7 (Level-200) for students choosing Physics as CC1. **B) MDC Minor 3 & 4: for students choosing Physics as minor subject.** **If the students choose to study Physics as CC2, he/she shall study only MDC-6 paper.**	**A) MDC-8 & MDC -9 (Level-200) for students choosing Physics as CC2.** **B) MDC Minor 5 & 6: for students choosing Physics as minor subject.** **If the students choose to study Physics as CC1, he/she shall study only MDC-8 paper.**

- **SEC course can be studied in any one of the Semesters 1, 2 and 3.**

CURRICULUM STRUCTURE

ODD SEMESTERS (JULY TO DECEMBER)			
SEMESTER-I		***CREDITS***	***MARKS***
MDC-1	Basic Physics-I (Level-100)	3T+1L=4	100
SEC-1	Introduction to Graph plotting & Programming	0T+4L=4	100
IDC	Frontiers of Physics	2T+1Tu	75
SEMESTER-III		***CREDITS***	***MARKS***
MDC-3	Waves & Optics (Level-200)	3T+1L=4	100
SEC-1	Introduction to Graph plotting & Programming	0T+4L=4	100
MDC Minor 1	Basic Physics-I (Level-100)	3T+1L=4	100
IDC	Frontiers of Physics	2T+1Tu	75
SEMESTER-V		***CREDITS***	***MARKS***
MDC 6	Analog Electronics (Level-200)	3T+1L=4	100
MDC 7	Nuclear & Particle Physics (Level-200)	3T+1Tu=4	100
MDC Minor 3	Waves & Optics (Level-200) Same as MDC 3		
MDC Minor 4	Mathematical Physics – I (Level-200)		

EVEN SEMESTERS (JANUARY TO JUNE)			
SEMESTER-II		***CREDITS***	***MARKS***
MDC-2	Basic Physics-II (Level-100)	3T+1L=4	100
SEC-1	Introduction to Graph plotting & Programming	0T+4L=4	100
IDC	Frontiers of Physics	2T+1Tu	75
SEMESTER-IV		***CREDITS***	***MARKS***
MDC 4	Modern Physics (Level-200)	3T+1L=4	100
MDC 5	Electromagnetism (Level-200)	3T+1L=4	100
MDC Minor 2	Basic Physics-II (Level-100)	3T+1L=4	100
SEMESTER-VI		***CREDITS***	***MARKS***
MDC 8	Digital Electronics (Level-200)	3T+1L=4	100
MDC-9	Instrumentation (Level-200)	3T+1L=4	100
MDC Minor 5	Modern Physics (Level-200) Same as MDC 4		
MDC Minor 6	Electromagnetism (Level-200) Same as MDC 5		

PAPER: MDC-1/MDC Minor-1: BASIC PHYSICS-I

THEORY [3 Credits, 50 Lecture Periods]

(A) Mathematical Physics: [20 Lecture Periods (LP)]

1. Preliminaries: SI system of units, dimensional analysis. Plotting of functions (both cartesian and polar), Limits, Intuitive ideas about continuity and differentiability of a function. Taylor series of one variable and binomial series (statements only); Maxima and minima for functions of one variable. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. [5 LP]

2. Ordinary Differential Equations: First order linear differential equations and integrating factor. Linear second order homogeneous equations with constant coefficients. Simple harmonic motion as an example. [2 LP]

3. Vectors: Dot, cross, scalar triple and vector triple products of cartesian vectors. Vector differentiation. Scalar and vector fields --- gradient, divergence, curl and Laplacian (for Cartesian coordinates), solenoidal and irrotational vector field. Statement of Divergence theoremand Stokes' theorem; application to simple cases. [7 LP]

4. Curvilinear coordinates: Plane polar, spherical polar and cylindrical polar coordinates: their unit vectors, role of unit vectors as basis vectors. Surface and volume element (from geometry). Line, surface and volume integrals. Form of the gradient operator in curvilinear coordinates. Velocity and acceleration of point particle in Cartesian, plane polar, spherical polar, cylindrical polar coordinates. [6 LP]

(B) Classical Mechanics: [30 Lecture Periods]

1. Review of Newton's Laws: Concepts of Inertial frames; force and mass. Galilean transformations and Galilean invariance; Newton's laws of motion, principle of conservation of linear momentum, Simple problems involving motion under resistive forces. Rotational motion: Angular velocity, angular acceleration, angular momentum, torque, principle of conservation of angular momentum. [6 LP]

2. Work Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field. Concept of potential and potential energy. Other equivalent definitions of a conservative force. Conservation of energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and unstable equilibrium. [4 LP]

3. Dynamics of a system of particles: The problem of solving equation of motion; Action- reaction kind of forces and the two body problem; Reduced mass & centre of mass; Properties ofthe centre of mass; Effect of torque; Linear momentum, angular momentum & total energy of a system of particles. [4 LP]

4. Central force: Newton's Law of Gravitation; Kepler's Laws; Conservation of angular momentum, Gauss's law for Gravitation (integral form); Gravitational potential and intensity due

to uniform spherical shell , solid sphere of uniform density and infinite flat sheet. Differential equation for the path in a central force field. Motion under an inverse square force, calculation of orbits. [8 LP]

6. Scattering: Two body collision and scattering [2 LP]

7. Mechanics of Continuum: Kinematics of Moving Fluids: Idea of compressible and incompressible fluids, Equation of continuity; streamline and turbulent flow, Reynold's number. Stokes' law from dimensional analysis; Euler's Equation and the special case of fluid statics. Simple applications (e.g: Pascal's law and Archimedes principle). Bernoulli's Theorem. [6 LP]

Recommended Texts for Theory:

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(For Mathematical Preliminaries portion)

1. Mathematical Methods in the Physical Sciences, M. L. Boas, 2005, Wiley
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier
3. Essential Mathematical Methods, K.F.Riley and M.P.Hobson, 2011, Cambridge Univ. Press
4. Vector Analysis and an introduction to Tensor Analysis, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outline Series, Tata Mc Graw Hill Education Private Limited, edition 2009

(For Mechanics portion)

1. An Introduction to Mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw- Hill
2. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
3. Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
4. Introduction to Classical Mechanics, R. G. Takwale and P.S.Puranik, Tata McGraw-Hill Publishing Company Ltd.
5. Theory and Problems of Theoretical Mechanics, M. R. Spiegel, McGraw Hill Education
8. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill. Physics
9. Mechanics, Resnick, Halliday and Walker 8/e. 2008, Wiley
10. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
11. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
12. Classical Mechanics, J C Upadhyay, Himalaya Publishing.

PRACTICAL [1 Credit, 30 Laboratory Periods]

Pre-requisites: Measurements using slide calipers, screw gauge & travelling microscope; Ideas about rounding off experimental data in conformity with the least count of the measuring instrument; Idea of systematic & random errors introduced in different instruments. It is expected that the necessary theory for each of the experiments, for this and the subsequent semesters, will be discussed in brief in the laboratory itself.

1. Measurement of the diameter of a wire using screw gauge a number of times and to determine the mean, median, mode & standard deviation for study of random error in observation.

2. Measurement of a suitable vertical height using Sextant.

3. Determination of the Moment of Inertia of a metallic cylinder / rectangular rod about an axis passing through its centre of gravity

4. Determination of modulus of rigidity of the material of a suspension wire by dynamical method.

5. To determine the coefficient of viscosity of water by Poiseuille's method.

Recommended Texts for Practical:

1. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
2. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
3. Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication
4. Advanced Practical Physics Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publisher
5. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
6. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
7. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd

PAPER: SEC-1: INTRODUCTION TO COMPUTER PROGRAMMING AND GRAPH PLOTTING

PRACTICAL [4 Credits, 60 Laboratory Periods]

1. Introduction to Graph Plotting (2D only, using GNUPLOT)

(a) **Plotting 2D graphs:** both functions and data files. Changing plot range and plot styles: the options- with points (w p), with dots (w d), with lines (w l), with linespoints (w lp), linetype (lt), linewidth (lw). Using the set command for samples, xrange, yrange, xlabel , ylabel, title etc. The using option.

2. **Introduction to programming in python** (Version 3.x):
(a) Introduction

• Using the python interpreter as a calculator
• Variable and data types (int, float, complex, list, tuple, set, string, the type() function)
• Basic mathematical operations
• Compound statements in python
– Conditionals (if, elif, else)
– Loops (for, while)
– User defined functions def: (return statement, default values for arguments, keyword arguments), lambda function.
• Importing modules with math and cmath as examples
• Using help and dir command to use the inbuilt manual
• Python scripts, I/O operations (including opening and writing to files)

The python data types
• List: defining lists, reading and changing elements from lists, slicing, list comprehension.

– built in functions involving lists: range(), len(), sum(), min(), max() – list methods: append(), extend(), count(), index(), sort(), insert(), pop(), remove(), reverse()
• Tuples: Contrast and compare with lists, packing/unpacking using tuples (including a,b=b,a to swap variables)
• Strings: defining strings, the use of single, double or triple quotes as string delimiters, len(), indexing, slicing, string concatenation, some string methods: split(), join(), find(), count(), replace()

Recommended Texts:

1. Gnuplot in Action understanding data and Graphs, Phillipp K. Janert
2. Scientific Computing in Python. Abhijit Kar Gupta, Techno World
3. Computational Physics, Mark Newman, Amazon Digital.
3. Physics in Laboratory including Python Programming (Semester I), Mandal, Chowdhury, Das, Das, Santra Publication
4. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd
5. Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
6. Numerical Mathematical Analysis, J. B. Scarborough, OXFORD and IBH Co. Pvt. Ltd.
7. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition
8. Gnuplot 5, Lee Phillips, Alogus Publishing, edition 2012.
9. Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
10. Python 2.1 Bible Dave Brueck, Stephen Tanner, Hungry Minds Inc, New York

SEMESTER- 2

PAPER: MDC-2/MDC Minor-2: BASIC PHYSICS - II

THEORY [3 Credits, 50 Lecture Periods]

(A) Basic Electricity and Magnetism [22 LP]

1. Electrostatics: Coulomb's law, Electric field, Electric field lines. Superposition Principle. Electric flux. Idea of charge density (linear, surface, volume) and continuous charge distributions. Gauss' Law (in integral form) with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Introduction to electrostatic potential, Equipotential surfaces. Calculation of potential for linear, surface and volume charge distributions: simple cases (e.g.: uniform line charge, disc, spherical shell, sphere etc). Potential and field due to a physical dipole; Torque, force and Potential Energyof an electric dipole in a uniform electric field.

Electrostatic energy of a system of charges, a charged sphere. Conductors in an electrostatic Field. Mechanical force on the surface of a charged conductor. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Capacitance for parallel-plate, cylindrical, spherical capacitors (without dielectrics). Energy stored in the Electrostatic field.[11 LP]

2. Lorentz force: Force on a moving charge in simultaneous electric and magnetic fields, force on a current carrying conductor in a magnetic field. Trajectory of charged particles in uniform electric field, crossed uniform electric and magnetic fields. Basic principle of cyclotron. [3 LP]

3. Magnetostatics: Concept of current density (linear, surface, volume). Equation of continuity. Biot and Savart's law, magnetic field due to a straight conductor, circular coil, Helmholtz coil, solenoid. Ampere's circuital law with applications (Infinite long wire, infinite solenoid, infinite current sheet). Magnetic field due to a small current loop - concept of magnetic dipole. Torque and force on magnetic dipole in a uniform magnetic field. [8 LP]

(B) Introduction to Thermodynamics [28 LP]

1. *Kinetic theory*: Macroscopic and microscopic description of matter, Postulates of molecular kinetic theory of an ideal gas, Relation between microscopic and macroscopic state variables, Maxwell's velocity distribution, Concept of pressure and temperature. [3 LP]

2. *Zeroth and First Law of Thermodynamics*: Extensive and intensive thermodynamic variables. Thermodynamic equilibrium, zero-th law of Thermodynamics & concept of temperature. Concept of work & heat, State Functions, internal energy and first law of Thermodynamics, its differential form, 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. [9 LP]

3. *Second Law of Thermodynamics*: Reversible and irreversible process with examples. Interconversion of work and heat. Heat engines. Carnot's cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, Kelvin-Planck and Clausius statements for the second law and their equivalence. Carnot's Theorem. Applications of second law of Thermodynamics: Thermodynamic scale of temperature and its equivalence to perfect gas scale. [10 LP]

3. *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. Principle of increase of Entropy. Temperature- Entropy diagrams for different cycles. Third law of Thermodynamics. Unattainability of absolute zero. [6 LP]

Recommended Texts for Theory:

(For Electromagnetism portion)

1. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings
3. Electricity and Magnetism, D.Chattopadhyay and P.C.Rakshit, New Central Book Agency, 2011
4. Fundamentals of Electricity and Magnetism, B. Ghosh, Books and Allied (P) Ltd., 4th edition, 2015.
5. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill
6. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
7. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press

8. Classical Electromagnetism, Jerrold Franklin, Pearson Education
9. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
10. Electricity and Magnetism, D. C. Tayal, Himalayan Publisher

(For Thermal portion)

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill
2. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa
3. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
4. Thermodynamics, E. Fermi, 2007, Sarat Book House
5. Basic Thermodynamics, E. Guha, 2010, Narosa
6. Kinetic theory of gasses, Loeb, Radha Publishing House
7. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press
8. Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley
9. Elements of Classical Thermodynamics A.B. Pippard , 1957, Cambridge University Press
10. গ্যাসের আণবিক তত্ত্ব, প্রতীপ চ ৌধুরী, পশ্চিমবঙ্গ রাজ্য পুস্তক পর্ষদ।
11. তাপগতিতত্ত্ব, অসীমকুমার চট্টোপাধ্যায়, পশ্চিমবঙ্গ রাজ্য পুস্তক পর্ষদ।

PRACTICAL [1 Credit, 30 Laboratory Periods]

Pre-requisites: Ideas about handling electrical apparatus & components; Safety against electrical hazards; Use of digital multimeter; Reading colour codes for carbon resistors etc.

1. Conversion of an ammeter to voltmeter and vice versa.

2. Determination of an unknown low resistance using Carey-Foster's Bridge.

3. Measurement of current by potentiometer.

4. Measurement of pressure coefficient of expansion of air by Jolly's apparatus.

5. Measurement of coefficient of thermal expansion of a metallic rod by optical lever arrangement.

Recommended Texts for Practical:

1. Advanced Practical Physics (Vol 2), B. Ghosh, Sreedhar Publication

PAPER: IDC (INTERDISCIPLINARY): FRONTIERS IN PHYSICS

1. Nature of Science: Role of proper reasoning and experiments, with examples. Inductive and deductive logic. The character of physical laws, including universality. Difference betweenscience and pseudoscience.

2. Universe: The Copernican revolution, Kepler's laws and the Solar system, Galileo and birth of Telescopic Astronomy, Modern observations: Stars and galaxies, Life cycle of stars. Birth of the Universe, Big Bang and Hubble expansion, Dark matter and dark energy.

3. Matter:
Atoms and molecules: The physical basis of the Periodic table.
Heat and Thermodynamics: Basic idea about the kinetic theory of gases; Distinction between ideal and real gases; The three laws of thermodynamics. Concept of Entropy.
Radioactivity: Alpha, beta & gamma decay; X-Rays – Properties.
Structure of the atom: Electron, Nucleus: proton and neutron. Mention of the Standard Model of particles & interactions.

4. Forces: Laws of falling bodies, Inertia, Gravitation, Electricity and Magnetism, Light and its dual property.
The microscopic world of Quantum Mechanics.
Special and General Theory of Relativity (brief and qualitative ideas only)

[No Mathematical derivation beyond simple algebra should be used]

Suggested Texts:

1. Six Easy Pieces – Richard P. Feynman
2. The first three minutes – Steven Weinberg
3. The character of physical laws – Richard P. Feynman
4. Introduction to Astronomy: From Darkness to Blazing Glory – J. W Scott, JAS Educational Publications
5. আধুবিক বিজ্ঞানের ক্রমবিকাশ, সম্পাদনা সুকান্ত মজুমদার, ভূপবত ক্রিতী, অনুষ্টুপ প্রকাশনী।

DETAILED SYLLABI OF THE COURSES OF SEMESTERS III-VII WOULD BE PROVIDED AFTERWARDS.