UNIVERSITY OF CALCUTTA

Notification No. CSR/ 12 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 28.05.2018 (vide Item No.14) approved the Syllabi of different subjects in Undergraduate Honours / General / Major courses of studies (CBCS) under this University, as laid down in the accompanying pamphlet:

List of the subjects

Sl. No.	Subject	Sl. No.	Subject
1	Anthropology (Honours / General)	29	Mathematics (Honours / General)
2	Arabic (Honours / General)	30	Microbiology (Honours / General)
3	Persian (Honours / General)	31	Mol. Biology (General)
4	Bengali (Honours / General /LCC2 /AECC1)	32	Philosophy (Honours / General)
5	Bio-Chemistry (Honours / General)	33	Physical Education (General)
6	Botany (Honours / General)	34	Physics (Honours / General)
7	Chemistry (Honours / General)	35	Physiology (Honours / General)
8	Computer Science (Honours / General)	36	Political Science (Honours / General)
9	Defence Studies (General)	37	Psychology (Honours / General)
10	Economics (Honours / General)	38	Sanskrit (Honours / General)
11	Education (Honours / General)	39	Social Science (General)
12	Electronics (Honours / General)	40	Sociology (Honours / General)
13	English ((Honours / General/ LCC1/ LCC2/AECC1)	41	Statistics (Honours / General)
14	Environmental Science (Honours / General)	42	Urdu (Honours / General /LCC2 /AECC1)
15	Environmental Studies (AECC2)	43	Women Studies (General)
16	Film Studies (General)	44	Zoology (Honours / General)
17	Food Nutrition (Honours / General)	45	Industrial Fish and Fisheries – IFFV (Major)
18	French (General)	46	Sericulture – SRTV (Major)
19	Geography (Honours / General)	47	Computer Applications – CMAV (Major)
20	Geology (Honours / General)	48	Tourism and Travel Management – TTMV (Major)
21	Hindi (Honours / General /LCC2 /AECC1)	49	Advertising Sales Promotion and Sales Management –ASPV (Major)
22	History (Honours / General)	50	Communicative English –CMEV (Major)
23	Islamic History Culture (Honours / General)	51	Clinical Nutrition and Dietetics CNDV (Major)
24	Home Science Extension Education (General)	52	Bachelor of Business Administration (BBA) (Honours)
25	House Hold Art (General)	53	Bachelor of Fashion and Apparel Design – (B.F.A.D.) (Honours)
26	Human Development (Honours / General)	54	Bachelor of Fine Art (B.F.A.) (Honours)
27	Human Rights (General)	55	B. Music (Honours / General) and Music (General)
28	Journalism and Mass Communication (Honours / General)		

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 4th June, 2018

Paul 4/6/18
(Dr. Santanu Paul)
Deputy Registrar

U.G. Syllabus

for

Physics (Honours & General)

University of Calcutta

2018

1 Scheme of CBCS Curriculum

1.1 Basic Courses Types under CBCS

In CBCS there are some basic types of courses. The ones that are relevant to the B.Sc. curricula have been described below.

1. **Core Course (CC)**: A *discipline specific compulsory* basic course.
2. **Discipline Specific Elective Course (DSE)**: A *discipline specific elective* course which is more advanced or specialized.
3. **Generic Elective Course (GEC)**: An *inter-disciplinary elective* course to be opted from a discipline other than ones main discipline(s) of choice (e.g., a course in a discipline other than in which honours has been taken).
4. **Skill Enhancement Course (SEC)**: A *discipline specific elective* skill enhancement course.
5. **Ability Enhancement Compulsory Course (AECC)**: These are *compulsory* courses. There are two of them. AECC-1 is Communicative English / Modern Indian Language (e.g.:Bengali, Urdu, Hindi.) & AECC-2 is Environmental Science.

1.2 Credit Structure

In CBCS, all courses have credits assigned to them.

For any course, one of the following three modes teaching will be used:

1. Theory + Practical
2. Theory + Tutorial
3. Theory only

The credit structure is described below:

	Theory + Practical		**Theory + Tutorial**		**Theory**	**Total Credits**
	Theory	**Practical**	**Theory**	**Tutorial**	**Theory**	
CC	4	2	5	1		6
DSE	4	2	5	1		6
GE	4	2	5	1		6
SEC					2	2
AECC					2	2

Class Assignments The class assignment for different course segments (theory, practical, tutorial) are as follows:

- **Theory: 1 credit = 1 hour / week**
- **Practical: 1 credit = 2 hours / week**
- **Tutorial: 1 credit = 1 hour / week**

Duration of the Semesters The semesters will comprise **15 to 18 weeks of direct teaching.**

Grading The evaluation and final grading will also depend crucially on the credits of the papers.

A Grade Point Average system will be used. The weight factor (or importance) with which a particular paper will contribute to the final CGPA (Cumulative Grade Point Average) will depend on the credit of the course.

Please refer to the University Regulations for details.

1.3 Selection of DSE

Honours

- A student must choose four DSE papers from his/her honours subject - two papers in the 5th semester and two papers in the 6th semester.
- There are two groups of DSE papers, DSE-A and DSE-B. Each of these groups are further divided into two subgroups DSE-A1, DSE-A2, and DSE-B1, DSE-B2 respectively.
- In the 5th semester a student will be expected to choose one paper from DSE-A1 and one paper from DSE-B1.
- Similarly, in the 6th semester a student will be expected to choose one paper from DSE-A2 and one paper from DSE-B2.

General

- A student must choose six DSE papers.
- For each subject of the student's chosen combination (e.g.: Physics- Chemistry-Mathematics), a student must choose two DSE papers - one in the 5th semester and one in the 6th semester.
- For each subject there will be two groups of DSE papers, DSE-A and DSE-B.
- The DSE paper in the 5th semesters must be chosen from DSE-A and the DSE paper in the 6th semester must be chosen from DSE-B.

1.4 Selection of SEC

Honours

- A student must choose two SEC papers from the honours discipline - one in the 3rd semester and one in the 4th semester.
- For each subject there will be two groups of SEC papers, SEC-A and SEC-B.
- The SEC paper in the 3rd semester must be chosen from Group A and the SEC paper in the 4th semester must be chosen from Group B.

General

- A student must choose four SEC papers - one each in the 3rd, 4th, 5th and 6th semesters.
- The four SEC papers must be chosen from two of the subjects in his/her chosen combination (e.g.: Physics, Chemistry, Mathematics).
- Two of the papers must be chosen from one subject and two from the other.
- For each subject there will be two groups of SEC papers, SEC-A and SEC-B.
- The SEC papers in the 3rd and 5th semesters must be chosen from Group-A of two subjects.
- The SEC papers in the 4th and 6th semesters must be chosen from Group-B of the same subjects as above.

1.7 B.Sc. General - Semesterwise Courses

The number of different types of courses to be taken in the different semesters have been specified in the table below.

	Sem-1	Sem-2	Sem-3	Sem-4	Sem-5	Sem-6	Total	Credits
CC	3	3	3	3			12	$12 \times 6 = 72$
DSE					3	3	6	$6 \times 6 = 36$
GE								
SEC			1	1	1	1	4	$2 \times 4 = 8$
AECC	1	1					2	$2 \times 2 = 4$
Total	4	4	4	4	4	4	24	120

Note:

1. **The CC must be chosen from three different disciplines.**
2. **The four SEC must be chosen from two different disciplines.**

1.8 B.Sc. General - Course Details

Core Courses (General)

Sem	Course Type	Course Name	Teaching Mode	Credits	Marks
1	CC	Mechanics	Theory	4	50
			Practical	2	30
2	CC	Electricity and Magnetism	Theory	4	50
			Practical	2	30
3	CC	Thermal Physics	Theory	4	50
			Practical	2	30
4	CC	Waves and Optics	Theory	4	50
			Practical	2	30

Choices for DSE (General)

Sem	Course Type - Group	Course Name	Teaching Mode	Credit	Marks
5	DSE-A (Any one)	Electronics and Instrumentation	Theory	4	50
			Practical	2	30
		Modern Physics	Theory	5	65
			Tutorial	1	15
6	DSE-B (Any one)	Solid State Physics	Theory	4	50
			Practical	2	30
		Nuclear and Particle Physics	Theory	5	65
			Tutorial	1	15

Choices for SEC (General)

Sem	Course Type - Group	Course Name	Teaching Mode	Credit	Marks
3/5	SEC-A (Any one)	Basics of Programming and Scientific Word Processing	Theory	2	80
		Electrical Circuits and Network Skills	Theory	2	80
4/6	SEC-B (Any one)	Computer Algebra System and Figure Drawing Skill	Theory	2	80
		Renewable Energy and Energy Harvesting	Theory	2	80

Part II
Physics Syllabus : General Course

5 Syllabi for Core Courses (General)

These courses will also serve as Generic Elective (GE) courses for students who have honours in a subject other than Physics.

5.1 Semester - 1: Mechanics

Mechanics (Theory)

Paper: PHS-G-CC-1-1-TH **Credits: 4**

1. Mathematical Methods
   (a) Vector Algebra: Vectors as directed line segments. Addition of vectors and multiplication by a scalar. Scalar and vector products. Basis and representation of vectors.
   (b) Vector Analysis: Derivatives of a vector with respect to a parameter. Gradient, divergence and Curl. Vector integration, line, surface and volume integrals of vector fields. Gauss'-divergence theorem and Stoke's theorem of vectors (Statement only).
2. Laws of Motion
   (a) Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Conservation of momentum. Centre of Mass.
3. Work and Energy
   (a) Work-energy theorem. Conservative forces. Concept of Potential Energy. Conservation of energy.
4. Gravitation
   (a) Motion of a particle in a central force field. Conservation of angular momentum leading to restriction of the motion to a plane and constancy of areal velocity. Newton's Law of Gravitation. Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness.
5. Oscillations
   (a) Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Forced oscillations with harmonic forces. Compound pendulum.

6. Rotational Motion

   (a) Rotation of a rigid body about a fixed axis. Angular velocity and angular momentum. Moment of Inertia. Torque. Conservation of angular momentum.

7. Elasticity

   (a) 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.

   (b) Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion. Torsional pendulum.

   (c) Bending of beams.

   (d) Work done in stretching and work done in twisting a wire.

8. Surface Tension

   (a) Synclastic and anticlastic surface - Excess of pressure - Application to spherical drops and bubbles - variation of surface tension with temperature.

9. Viscosity

   (a) Rate flow of liquid in a capillary tube - Poiseuille's formula.

Reference Books

- University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison- Wesley
- Mechanics Berkeley Physics course,v.1: Charles Kittel, et. Al. 2007, Tata McGraw- Hill.
- Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley.
- Engineering Mechanics, Basudeb Bhattacharya, 2 nd edn., 2015, Oxford University Press.
- Physics for Degree Students (For B.Sc. 1st Year); C.L. Arora & P.S. Hemme; S.Chand Publishing.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Mechanics (Practical)

PHS-G-CC-1-1-P **Credits: 2**

List of Practicals

1. Determination of Moment of inertia of cylinder/bar about axis by measuring the time period, of the cradle and with body of known moment of Inertia.

2. Determination of Y modulus of a metal bar of rectangular cross section by the method of flexure.

3. Determination of rigidity modulus of wire by measuring the time period of torsional oscillation of a metal cylinder attached to it.

4. Determination of Moment of Inertia of a flywheel.

5. Determination gravitational acceleration, g using bar pendulum.

6. To determine the height of a building using sextant.

General Topic

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.

2. To study the random error in observations.

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.

- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

5.2 Semester - 2: Electricity and Magnetism

Electricity and Magnetism (Theory)

Paper: PHS-G-CC-2-2-TH **Credits: 4**

1. Electrostatics

   (a) Coulombs law. Principle of superposition. Electrostatic Field.

   (b) Divergence of the Electrostatic field. Flux, Gauss's theorem of electrostatics. Applications of Gauss theorem to find Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor.

   (c) Curl of the Electrostatic Field. Electric potential as line integral of electric field. Potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Electric potential and field due to an electric dipole. Electric dipole moment. Force and Torque on a dipole.

   (d) Conductors: Electric field and charge density inside and on the surface of a conductor. Force per unit area on the surface. Capacitance of a conductor. Capacitance an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field.

   (e) Electric Fields inside matter: Electric Polarisation. Bound charges. Displacement vector. Gauss's theorem in dielectrics. Linear Dielectric medium. Electric Succeptibility and Permittivity. Parallel plate capacitor completely filled with dielectric.

2. Magnetism

   (a) Biot-Savart's law and the Lorentz force law. Application of Biot-Savart's law to determine the magnetic field of a straight conductor, circular coil, solenoid carrying current. Force between two straight current carrying wires.

   (b) Divergence of the magnetic field. Magnetic vector potential.

   (c) Curl of the magnetic field. Ampere's circuital law. Determination of the magnetic field of a straight current carrying wire. Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole.

   (d) Magnetic fields inside matter: Magnetization. Bound currents. The magnetic intensity - H. Linear media. Magnetic susceptibility and Permeability. Brief introduction of dia-, para- and ferro-magnetic materials.

3. Electromagnetic Induction

4. Ohms law and definition of E.M.F. 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.

5. Linear Network

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

6. Maxwell's Equations and Electromagnetic Wave Propagation

   (a) Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves,. Polarization of E.M. waves.

Reference Books

- Itroduction to Electrodynamics, David J Griffiths 3rd Edn, 1998, Benjamin Cummings.
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Electricity and Magnetism; R.Murugeshan; S. Chand Publishing.

Electricity and Magnetism (Practical)

Paper: PHS-G-CC-2-2-P **Credits: 2**

List of Practicals

1. Determination of unknown resistance by Carey Foster method.
2. Measurement of a current flowing through a register using potentiometer.
3. Determination of the horizontal components of earths magnetic field.
4. Conversion of an ammeter to a voltmeter.

5. Conversion of a voltmeter to an Ammeter.

6. Verification of Thevenin & Norton theorem and superposition theorem.

General topics

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances (e) Checking electrical fuses (f) circuit continuity check and (g) moving coil galvanometer (in dead beat and ballistic mode), etc.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

5.3 Semester - 3: Thermal Physics and Statistical Mechanics

Thermal Physics and Statistical Mechanics (Theory)

Paper: PHS-G-CC-3-3-TH **Credits: 4**

1. Laws of Thermodynamics

   (a) Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_v, Work Done during Isothermal and Adiabatic Processes. Compressibility and Expansion Coefficients, Reversible and irreversible processes. Second law and Entropy, Carnot's cycle & Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, unattainability of absolute zero.

2. Thermodynamical Potentials

   (a) Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for $(C_P - C_V)$, C_P/C_V, TdS equations.

3. Kinetic Theory of Gases

   (a) Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

4. Theory of Radiation

   (a) Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

5. Statistical Mechanics

   (a) Phase space, Macrostate and Microstate. Ensemble - Ergodic hypothesis. PEAP, Entropy and Thermodynamic probability - Boltzmann hypothesis. Maxwell-Boltzmann law - distribution of velocity - Quantum statistics (qualitative discussion only) - Fermi-Dirac distribution law (statement only) - electron gas as an example of Fermi gas - Bose-Einstein distribution law (statement only) - photon gas as an example of Bose gas- comparison of three statistics.

Reference Books

- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill.
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa.
- Heat, Thermodynamics and Statistical Physics; B. Lal, N. Subramanyam and P.S.Hemme; S.Chand Publishing.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Thermal Physics and Statistical Mechanics (Practical)

Paper: PHS-G-CC-3-3-P **Credits: 2**

List of Practicals

1. Determination of the coefficient of thermal expansion of a metalic rod using an optical lever.
2. Verification of Stefan's law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point.
3. Calibration of a thermocouple by direct measurement of the thermo emf using operational amplifier.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT) using constant current source.
6. Determination of the pressure coefficient of air using Jolly's apparatus.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

5.4 Semester - 4: Waves and Optics

Waves and Optics (Theory)

Paper: PHS-G-CC-4-4-TH **Credits: 4**

1. Superposition of Two Collinear Harmonic oscillations
   (a) Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).
2. Superposition of Two Perpendicular Harmonic Oscillation
   (a) Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

3. Wave Motion - General

   (a) Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

4. Sound

   (a) Review of SHM, damped & forced vibrations - resonance. Fourier's Theorem - Application to saw tooth wave and square wave. Intensity and loudness of sound - Decibels - Intensity levels. Musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

5. Wave Optics - General

   (a) Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

6. Interference

   (a) Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stoke's 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.

7. Michelson's Interferometer

   (a) Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.

8. Diffraction

   (a) Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating.

   (b) Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

9. Polarization

10. Transverse nature of light waves. Plane polarized light - production and analysis. Circular and elliptical polarization. Optical activity.

Reference Books

- Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill.
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.
- Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications.
- Mechanics; D.S.Mathur and P.S.Hemme; S.Chand Publishing.

Waves and Optics (Practical)

Paper: PHS-G-CC-4-4-P **Credits: 2**

List of Practicals

1. Determination of the refractive index of material of a lens and that of a liquid using a convex lens and a plane mirror.
2. Determination of the focal length of a concave lens by auxiliary lens method.
3. Determination of the frequency of a tuning fork with the help of sonometer using $n - l$ curve.
4. Determination of radius of curvature / wavelength of a monochromatic / quasi monochromatic light using Newtons ring.
5. Measurement of the spacing between the adjacent slits in a grating by measuring $\sin\theta$ vs λ graph of a certain order of grating spectra.
6. Measurement of specific rotation of active solution (e.g., sugar solution) using polarimeter.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

6 Syllabi for Discipline Specific Elective Courses (General)

6.1 DSE-A: Electronics and Instrumentation

Electronics and Instrumentation - (Theory)

Paper: PHS-G-DSE-A-TH **Credits: 4**

1. Semiconductor Devices and Amplifiers

   (a) Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

   (b) Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplifier. H-parameter, Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

2. Operational Amplifiers

   (a) Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector.

   (b) Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator.

3. Digital Circuits

   (a) Difference between Analog and Digital Circuits.

   (b) Binary Numbers. Decimal to Binary and Binary to Decimal Conversion.

   (c) AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra.

   (d) Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(e) Binary Addition. Binary Subtraction (using 2's Complement Method).

(f) Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

4. Instrumentations

(a) Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge. Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency. Basic idea about capacitor filter.

(b) Zener Diode and Voltage Regulation.

(c) Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

Reference Books

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill.
- Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.
- OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

Electronics and Instrumentation - (Practical)

Paper: PHS-G-DSE-A-P **Credits: 2**

List of Practicals

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To study the characteristics of a Transistor in CE configuration.
6. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
7. To design an inverting and a non-inverting amplifier of given gain using Op-amp 741 and to study their frequency response.

Reference Books

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4th Edn, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

6.2 DSE-A: Modern Physics

Modern Physics - (Theory)

PHS-G-DSE-A-TH **Credits: 5 (+1 for Tutorial)**

1. Special Theory of Relativity
   (a) Michelson-Morley experiment. Lorentz transformation. Time dilation and length contraction. Velocity addition rule.
   (b) Relativistic dynamics. Elastic collision between two particles. Idea of relativistic momentum and relativistic mass. Mass-energy equivalence.

2. Elements of Quantum Mechanics

   (a) Blackbody Radiation, Planck's quantum, Planck's constant. Photoelectric effect and Compton scattering - light as a collection of photons. Davisson-Germer experiment. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a particle following a trajectory.

   (b) Limitations of Ruherford's model of atomic structure. Bohr's model, its successes and limitations.

   (c) Quantum states as normalized functions and observables as linear hermitian operators. Significance of the eigenvalue equations. Application to a particle in one dimension: Position, Momentum and Energy operators.

   (d) Time evolution of the quantum state: Schrodinger's equation. Stationary states. Properties of wave function. Probability and probability current densities in one dimension.

   (e) Bound states: Particle in a one dimensional rigid box. Energy eigenvalues and eigenvectors.

   (f) Scatterring: Scatterring by a step potential and rectangular barrier. Tunnelling.

3. Atomic Physics

   (a) Quantum theory of hydrogen-like atoms

      i. Schrodinger equation in spherical polar coordinates. Separation of variables. Angular equation and orbital angular momentum. (Solution to the differential equations should be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for the radial wavefunctions (Solution to the differential equation should be assumed). Shapes of the probability densities for ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d,shells.

   (b) Generalized Angular Momenta and Spin.

      i. Generalized angular momentum. Electron's magnetic moment and Spin Angular Momentum. Gyromagnetic Ratio and Bohr Magneton and the g - factor. Energy associated with a magnetic dipole placed in magnetic field. Stern-Gerlach Experiment.

      ii. Addition of angular momenta - statement only. Restriction of eigenvalues from $|j_1 - j_2|$ to $|j_1 + j_2|$.

      iii. Zeeman effect.

(c) Many electron atoms

i. Identical particles. Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's Rule. Periodic table.

Reference Books

- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- Special Relativity (MIT Introductory Physics). A.P. French, 2018, CRC Press.
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Cooper, 2002, Tata McGraw Hill.
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill.
- Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan Additional Books for Reference Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Modern Physics; R.Murugeshan & K.Sivaprasath; S. Chand Publishing.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill..

6.3 DSE-B: Solid State Physics

Solid State Physics - (Theory)

Paper: PHS-G-DSE-B-TH **Credits: 4**

1. Preliminary Topics

(a) Review of Schrodinger equation in one dimension, stationary states. Maxwell-Boltzman distribution law.

2. Crystal Structure

   (a) Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

3. Elementary Lattice Dynamics

   (a) Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids - T^3 law (qualitative discussions only).

4. Magnetic Properties of Matter (qualitative discussions only)

   (a) Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia- and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss .

5. Dielectric Properties of Materials (qualitative discussions only)

   (a) Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations.

6. Elementary band theory (qualitative discussions only)

   (a) Kronig Penny model (results should be assumed - no analysis required). Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility.

Reference Books

- The Oxford Solid State Basics. S. H. Simon, 2013, Oxford.
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India ► Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.

- Solid State Physics, Rita John, 2014, McGraw Hill.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
- Solid State Physics; R.K.Puri and V.K.Babbar; S. Chand Publishing.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Solid State Physics - (Practical)

Paper: PHS-G-DSE-B-P **Credits: 2**

List of Practicals

1. To study PE hysteresis of ferroelectric crystal.
2. To study BH hysteresis of ferromagnetic material.
3. Measurement of susceptibility of paramagnetic solution by Quink"s tube method.
4. Measurement of magnetic susceptibility of solids.
5. Determination of variation of dielectric constant with frequency.
6. Measurement of hall voltage by four probe method.

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.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

6.4 DSE-B: Nuclear & Particle Physics

Nuclear & Particle Physics - (Theory)

Paper: PHS-G-DSE-B-TH **Credits: 5 (+1 for Tutorial)**

1. General Properties of Nuclei
   (a) Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.
2. Nuclear Models
   (a) Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies.
   (b) Evidence for nuclear shell structure - nuclear magic numbers. Basic assumptions of shell model, concept of mean field, residual interaction, concept of nuclear force.
3. Radioactivity
   (a) α - decay: basics of α - decay processes. Theory of α - emission, Gamow factor, Geiger Nuttall law, α - decay spectroscopy.
   (b) β - decay: energy and kinematics of β decay, positron emission, electron capture, neutrino hypothesis.
   (c) γ - decay: Gamma ray emission & kinematics, internal conversion.
4. Nuclear Reactions
   (a) Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).
5. Interaction of Nuclear Radiation with matter
   (a) Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron's interaction with matter.

6. Detector for Nuclear Radiations

   (a) Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

7. Particle Accelerators

   (a) Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

8. Particle Physics

   (a) Fundamental particles and their families. Fundamental particle-interactions and their basic features. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm. Quark model, color quantum number and gluons. Quark structure of hadrons.

Reference Books

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

7 Syllabi for Skill Enhancement Courses (General)

7.1 SEC-A: Basics of Programming and Scientific Word Processing

Basics of Programming and Scientific Word Processing - (Theory)

Paper: PHS-G-SEC-A-TH **Credits: 2**

1. Elements of Programming
   (a) An overview computers: History of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language.
   (b) Algorithms and Flowcharts:
      i. Algorithm - definition, properties and development.
      ii. Flowchart - Concept of flowchart, symbols, guidelines, types.
2. Basic programming in C/FORTRAN
   (a) Constants, Variables and Data types.
   (b) Operation and Expressions - Arithmetic operators, relational operators, logical operators.
   (c) Managing input/output.
   (d) Decision Making and Branching.
   (e) Decision making and Looping.
   (f) Arrays : One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
   (g) User-defined Functions.
3. Visualization
   (a) 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.
4. Scientific word processing:
   (a) 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.

(b) 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,

(c) Fonts, Picture environment and colors, errors.

Reference Books

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
- Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)
- E. Balagurnsamy, Programming in ANSI C, Tata McGraw Hill, 2004.
- C. Xavier, C-Language and Numerical Methods, New Age International.
- V. Rajaraman, Computer Oriented Numerical Methods, Prentice Hall of India, 1980.
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010).
- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison- Wesley, 1994).

7.2 SEC-A: Electrical Circuits and Network Skills

Electrical Circuits and Network Skills - (Theory)

Paper: PHS-G-SEC-A-TH **Credits: 2**

1. Basic Electricity Principles

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

2. Understanding Electrical Circuits

   (a) Main 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.

3. Electrical Drawing and Symbols

   (a) 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. Generators and Transformers

   (a) DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

5. Electric Motors

   (a) Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

6. Solid-State Devices

   (a) Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

7. Electrical Protection

   (a) Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection.Page 97 Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

8. Electrical Wiring

   (a) 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, split bolts, and solder. Preparation of extension board.

Reference Books

- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja.
- Performance and design of AC machines - M G Say ELBS Edn.

7.3 SEC-B: Computer Algebra System & Figure Drawing Skill

Computer Algebra System & Figure Drawing Skill - (Theory)

Paper: PHS-G-SEC-B-TH **Credits: 2**

1. Elementary symbolic computation using some computer algebra system (CAS) like Yacas or Maxima.
   (a) Arithmetic and other operations on numbers.
   (b) Calculus and elementary functions, Simplification of expressions, Solvers, Differential Equations.
   (c) Linear Algebra
   (d) Operations on polynomials
   (e) List operations
   (f) Predicates
   (g) Input/output and plotting
   (h) Probability and Statistics
   (i) Numerical methods using CAS
   (j) Physics specific applications
2. Figure generation using drawing tools like xfig/ latexdraw/ inkscape etc.
   (a) Drawing lines with/without arrows with different line styles.
   (b) Drawing curves with different line styles including brazier curves.
   (c) Drawing different types of shapes including circle, ellipse, polygons etc.
   (d) Changing figure properties like position, colour, orientation, size, shape, line properties, filling properties etc.
   (e) Grouping and ungrouping of figures.
   (f) Exporting the figure into different file formats.

Reference

- https://yacas.readthedocs.io/en/latest/reference_manual/
- The Maxima Book; Paulo Ney de Souza Richard J. Fateman Joel Moses Cliff Yapp; http://maxima.sourceforge.net/docs/maximabook/maximabook-19-Sept-2004.pdf.
- Get Started With Maxima: https://www.whoishostingthis.com/resources/maxima/
- Xfig user manual: http: //mcj.sourceforge.net/

- LaTeXDraw Manual: https://github.com/arnobl/latexdraw/wiki/Manual
- The Book of Inkscape: The Definitive Guide to the Free Graphics Editor (1st ed.), No Starch Press, p. 476, ISBN 1-59327-181-6
- https://www.youtube.com/watch?v=zUIOEXssTSE

7.4 SEC-B: Renewable Energy and Energy Harvesting

Renewable Energy and Energy Harvesting - (Theory)

Paper: PHS-G-SEC-B-TH **Credits: 2**

1. Fossil fuels and Alternate Sources of energy
   (a) Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.
2. Solar energy
   (a) Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
3. Wind Energy harvesting
   (a) Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
4. Ocean Energy
   (a) Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
5. Geothermal Energy
   (a) Geothermal Resources, Geothermal Technologies.
6. Hydro Energy
   (a) Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting

   (a) Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

8. Electromagnetic Energy Harvesting

   (a) Linear generators, physics mathematical models, recent applications

   (b) Carbon captured technologies, cell, batteries, power consumption.

   (c) Environmental issues and Renewable sources of energy, sustainability.

Reference Books

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi.Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009.
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy.

8 Note on Syllabi for Generic Elective Courses

The Core Courses (CC) for the B.Sc. General Curriculum with Physics, provided in section 5 above, are to be treated as Generic Elective Course for students studying an honours course in a subject other than Physics.