Physics: General Course CBCS

Teaching Plan

Name of Teacher: Dr. Sandip Majumdar

Basic Course Structure for General Course (B.Sc. Programme)

Students of B.Sc. General or B.Sc. Programme should take three subjects in their carriculum. In first four semester students will take one core course, CC from each subject in each semester. We refer to the subjects as 111, 222 & 333. As a general student the subject code will be 111G, 222G, 333G. e.g., a student who had opted Physics, Chemistry and Mathematics his/her subject codes will be PHSG, CEMG, and MTMG. Thus 111 ≡PHS, 222 ≡CEM and 333 ≡MTM. Skill Enhancement Course, SEC must be opted in 3rd, 4th and 5th, 6th Semesters. SEC A is meant for odd (i.e., 3rd & 5th) Semesters and SEC B is meant for even (i.e., 4th & 6th) Semesters. Student will take two SEC A courses from two subjects in 3rd and 5th semesters and similarly he/she will take two SEC B courses from the same two subjects in 4th and 6th semesters. i.e., in each semester student will study one SEC. The details for choice of SEC is given later.

The core course (CC) are absent in 5th and 6th Semesters. Student should take Discipline specific elective courses, DSE there. DSE-A and DSE-B are for 5th and 6th Semesters respectively. Student will chose one DSE-A from each subject in 5th semester and similarly DSE-B from each subject in 6th Semester.

The DSE courses are so arranged that a student can choose practical based DSE or theoretical DSE as type A and B.

Detail plans with credits are given in following table (XXX for SEC will be cleared in fourth table).

General Course: Credit Distribution

Courses	Semester 1	Semester 2	Semester 3	Semster 4	Semester 5	Semester 6
CC	111G-CC-1 (6)	111G-CC-2 (6)	111G-CC-3 (6)	111G-CC-4 (6)		
	222G-CC-1 (6)	222G-CC-2 (6)	222G-CC-3 (6)	222G-CC-4 (6)		
	333G-CC-1 (6)	333G-CC-2 (6)	333G-CC-3 (6)	333G-CC-4 (6)		
SEC			XXXG-SEC A (2)	XXXG-SEC B (2)	XXXG-SEC A (2)	XXXG-SEC B (2)
DSE					111G-DSE-A (6)	111G-DSE-B (6)
					222G-DSE-A (6)	222G-DSE-B (6)
					333G-DSE-A (6)	333G-DSE-B (6)
AECC	AECC -1 (2)	AECC-2 (2)				
Total Credit	20	20	20	20	20	20
Number	400	400	400	400	400	400

The term in the parentheses represents credit of a course. Thus a general stuents completes $20 \times 6 = 120$ Credits in his/her course. In each semeser the student appear for four 100 marks paper. However, if student will take a course with practical module then the practical examination also will be there.

Physics courses for general students (B.Sc. Programme)

In physics all the core courses have practical.There are two types of SEC are there one is project type and other is theoretical paper. The DSE also of two types. In one type of DSE there is practical module and other type of DSE comprises of theoretical part only.

The courses offered in Physics general are given in the next Table.

General Course: Physics Modules distribution

Semester	Core Course	SEC-A	SEC-B	DSE-A	DSE-B
Semester-1	CC1/GE1 Mechanics				
Semester-2	CC2/GE2 Electricity & Magnetism				
Semester-3	CC3/GE3 Thermal Physics	SEC A-1 Scientific Writing Or SEC A-2 Renewable Energy			
Semester-4	CC4/GE4 Waves & Optics		SEC B-1 Arduino Or SEC B-2 Electrical Circuit & Network Skill		
Semester-5		SEC A-1 Scientific Writing Or SEC A-2 Renewable Energy		DSE-A(1) Analog Electronics Or DSE-A(2) Modern Physics	
Semester-6			SEC B-1 Arduino Or SEC B-2 Electrical Circuit & Network Skill		DSE-B(1) Digital Electronics Or DSE-B(2) Nuclear Physics

Choice of Skill Enhancement Course (SEC)

According to the CSR for CBCS it was mentioned that

One paper from Group A, i.e., SEC A of each of the two subjects to be chosen in the third and fifth semester; one papaer from Group B, i.e., SEC B of each of the two core subjects to be chosen in the fourth and sixth semester.

The stuedents take three subjects as core in B.Sc. Programme. For SEC he/she took pic up any two subjects among these three core subjects. Thus, three possible combinations are

- 111G & 222G
- 111G & 333G
- 222G & 333G

Again for a specific choice there are several distributions. Let us take for the subject combinations of 111G and 222G.

Combination	3rd Semester	4th Semester	5th Semester	6th Semester
1	111G SEC A	111G SEC B	222G SEC A	222G SEC B
2	111G SEC A	222G SEC B	222G SEC A	111G SEC B
3	222G SEC A	222G SEC B	111G SEC A	111G SEC B
4	222G SEC A	111G SEC B	111G SEC A	222G SEC B

To be specific if any one have opted Physics and Mathematics for SEC then the combinations are

Combination	3rd Semester	4th Semester	5th Semester	6th Semester
1	PHSG SEC A	PHSG SEC B	MTMG SEC A	MTMG SEC B
2	PHSG SEC A	MTMG SEC B	MTMG SEC A	PHSG SEC B
3	MTMG SEC A	MTMG SEC B	PHSG SEC A	PHSG SEC B
4	MTMG SEC A	PHSG SEC B	PHSG SEC A	MTMG SEC B

In Physics carriculum two SEC courses are given, one is for knowledge skill (theory type) other is for technical skill (project type). The evaluation process for knowledge skill SEC courses is theoretical examination (of 80 marks) and the skill based SEC will be evaluated through a project (of 60 marks) and an examination containing MCQ type questions (of 20 marks).

Choice of Discipline Specific Elective Course (DSE)

According to the CSR for CBCS it was mentioned that

A student shall have to study 6 DSE courses strictly on 3 subjects, opted for pursuing core courses, taking exactly two courses from each subject. Such a student shall have to study the carriculum of DSE of the subject concerned as specified for the relevent semester, i.e., DSE-A in the 5th Semester and DSE-B in 6th Semester.

Since, the students have taken three subjects as the core subjects they need to take one DSE A course from all those subjects in 5th Semester and one DSE B course from all those subjects in 6th Semster. The available DSE A courses and DSE B courses are mentioned in each subjects. Thus, the options are mentioned below

5th Semester	6th Semester
111G-DSE A	111G-DSE B
222G-DSE A	222G-DSE B
333G-DSE A	333G-DSE B

In Physics carriculum two DSE A courses are mentioned in 5th Semester and two DSE B courses are given in 6th Semester. DSE A(1) and DSE B(1) have both theory and practical components. Therefore, two examinations i.e., theory (for 50 marks) and practical (for 30 marks) will be held for these DSE courses. The second type DSE, i.e., DSE A(2) and DSE B(2) are of theory type. There will be theoretical examinations (for 80 marks) only for these DSE courses.

Choice of Generic Elective Subjects for Honours students

Students who will take **Honours** Course in subject other than physics may take **physics as a generic elective upto 4th semester** along with another subject. In that situation the student will have to study Physics general in any two semesters only.

In each semester there is a single core course offered for B.Sc. general students. The same coureses will be treated as generic elective subjects for them. That is why the courses are referred to as CC/GE in each semester. Students have to accept the course running in that semester in which they had decided to take physics general.

The Honours student can take Physics as Generic elective in any following combinations.

Combination	GE1	GE2	GE3	GE4
1	PHSG	OG	OG	PHSG
2	OG	PHSG	PHSG	OG
3	PHSG	PHSG	OG	OG
4	OG	OG	PHSG	PHSG
5	PHSG	OG	PHSG	OG
6	OG	PHSG	OG	PHSG

Here, PHSG represents generic elective from Physics and OG represents the other subject which is opted by the student as second generic subject.

Therefore, the SEC or DSE mentioned in previous sections are not for the students continuing Honours course in the subject other than Physics.

General: Semester 1

CC1/GE1
Name of Teacher: Dr. Sandip Mujumdar

CC 1/GE 1	Mechanics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60

1.1 Mechanics

1.1.1 Mechanics (Theory)

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

1. Mathematical Methods **15 Lectures**

(a) Vector Algebra: Addition of vectors and multiplication by a scalar. Scalar and vector products of two2 vectors, vector triple product. Representation of vectors in terms of basis 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) and their significances.

(c) Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous and inhomogeneous differential equations with constant coefficients.

2. Introduction to Newtonian Mechanics **5 Lectures**

(a) Laws of Motion: Idea of space time for Newtonian Mechanics, frames of reference, Newton's Laws of motion. Dynamics of a system of particles. Conservation of momentum. Centre of Mass.

(b) Work-energy theorem. Conservative forces. Concept of Potential Energy. Conservation of energy.

3. Rotational Motion **10 Lectures**

Rotation of a rigid body about a fixed axis. Angular velocity and angular momentum. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Torque. Conservation of angular momentum.

4. Central force and Gravitation **10 Lectures**

(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. Kepler's Laws (statement only). Newton's Law of Gravitation. Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS).

5. Oscillations **9 Lectures**

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.

6. Elasticity **6 Lectures**

(a) Hooke's law, 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, Cantilever.

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

7. Surface Tension **5 Lectures**

Molecular theory of surface tension, surface energy, comparison between surface tension and surface energy, variation of surface tension with temperature, application to spherical drops and bubbles Synclastic and anticlastic surface, excess of pressure, capilary rise of liquid.

Reference Books

1. A Handbook of Degree PHYSICS (Vol I), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison Wesley
3. Physics, Resnick, Halliday & Walker 9/e, 2010, Wiley.
4. Engineering Mechanics, Basudeb Bhattacharya, 2nd ed, 2015, Oxford University Press
5. Physics for Degree Students (For B.Sc. 1st Year); C.L. Arora & P.S. Hemme; S.Chand Publishing

1.1.2 Mechanics (Practical)

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

General Topics

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

2. Idea of systematic and random errors introduced in different instruments.

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 exure.

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.

Reference Books

1. A handbook of Degree PRACTICAL PHYSICS (Vol 1), Dasgupta, Das, Paul, Book Syndicate Private Limited
2. Porikshagare Podarthovidya, Das, Das, Santra Publication
3. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
4. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
5. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
6. Advanced Practical Physics, Vol 1, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

General: Semester 2

CC2/GE2

CC 2/ GE 2	Electricity and Magnetism	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60

2.1 Electricity and Magnetism

2.1.1 Electricity and Magnetism (Theory)

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

1. Essential Vector Analysis **5 Lectures**

(a) Vector Algebra: Addition of vectors and multiplication by a scalar. Scalar and vector products of two vectors.

(b) Vector Analysis: 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) and their significances.

2. Electrostatics **25 Lectures**

(a) Coulombs law, principle of superposition, electrostatic field. Electric field and charge density, surface and volume chargev density, charge density on the surface of a conductor. Force per unit area on the surface.

(b) Electric dipole moment, electric potential and field due to an electric dipole, force and Torque on a dipole. Electric Fields inside matter, Electric Polarisation, bound charges, displacement density vector, linear Dielectric medium, electric Succeptibility and Permittivity.

(c) 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. Gauss's theorem in dielectrics.

(d) Curl of the Electrostatic Field. Conservative nature of electrostatic field, Introduction to electriostatic potential, Calculation of potential for linear, surface and volume charge distributions, potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Energy per unit volume in electrostatic field.

3. Magnetism **15 Lectures**

(a) Introduction of magnetostatics through Biot-Savart's 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. Lorentz force law.

(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.

4. 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.

5. Electrodynamics **10 Lectures**

Maxwell's Equations, Equation of continuity of current, Displacement current, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, Poynting vector, decay of charge in conducting medium.

Referrence Books

1. A Handbook of Degree PHYSICS (Vol II), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House
4. Electricity and Magnetism; R.Murugeshan; S. Chand Publishing

2.1.2 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.

Reference Books

1. A handbook of Degree PRACTICAL PHYSICS (Vol 2), Dasgupta, Das, Paul, Book Syndicate Private Limited
2. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
3. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited

4. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
5. Practical Physics, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

General: Semester 3

CC3/GE3, SEC A

CC 3/ GE 3	Thermal Physics	Theory	Practical
	Credit 6	Credit 4	Credit 2
		Classes 60	Classes 60
SEC A 1	Scientific Writing	Theory	Project
	Credit 2	Credit 1	Credit 1
		Classes 15	Classes 15
SEC A 2	Renewable Energy	Theory	
	Credit 2	Credit 2	
		Classes 30	

3.1 Thermal Physics and Statistical Mechanics

3.1.1 Thermal Physics and Statistical Mechanics (Theory)

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

1. Laws of Thermodynamics **18 Lectures**

(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 Coeficients, Reversible and irreversible processes.

(b) Second law and Entropy, Carnot's cycle & Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams.

(c) Third law of thermodynamics, unattainability of absolute zero.

2. Thermodynamical Potentials **9 Lectures**

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

3. Kinetic Theory of Gases **10 Lectures**

Derivation of Maxwell's law of distribution of velocities and its experimental verication, 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 **8 Lectures**

(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 **15 Lectures**

Phase space, Macrostate and Microstate. Ensemble, Ergodic hypothesis. Entropy and Thermodynamic probability, Boltzmann hypothesis. Maxwell-Boltzmann law of 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

1. A Handbook of Degree PHYSICS (Vol III), C. R. Dasgupta, Asok Kumar Das, Book Syndicate Private Limited
2. Thermal Physics, A. B. Gupta, H. P. Roy, Books and Allied (P) Ltd

3.1.2 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. Verication of Stefan's law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point.

3. To determine Thermal coefficient of Resistance using Carey forster bridge.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

5. Determination of the pressure coefficient of air using Jolly's apparatus.

Reference Books

1. Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
2. B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited
3. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited
4. Advanced Practical Physics, B. Ghosh, K.G.Majumdar, Shreedhar Publishers

SEC A-1 (Technical Skill)

3.2 Scientific Writing (Project type)

3.2.1 Scientific Writing (Theory)

Paper: PHS-A SEC-B-TH **Credits: 1**

1. Introduction to LaTeX **2 Lectures**
The difference between WYSIWYG and WYSIWYM. Preparing a basic LaTeX file. Compiling LaTeX file.

2. Document classes : **1 Lectures**
Different type of document classes, e.g., article, report, book etc.

3. Page Layout **2 Lectures**
Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

4. List structures: **1 Lectures**
Itemize, enumerate, description etc.

5. Representation of mathematical equations **5 Lectures**
Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surface-volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

6. Customization of fonts **1 Lectures**
Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

7. Writing tables **2 Lectures**
Creating tables with different alignments, placement of horizontal, vertical lines.

8. Figures **1 Lectures**
Changing and placing the figures, alignments

Packages : amsmath, amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LaTeX commands and environments, Changing the type style, symbols from other languages. special characters.

Note: Software required: LaTeX in Linux and MikTeX in Windows. Preferred editor Kile/emacs in Linux and TeXStudio in Windows.

Reference Book

1. LaTeX- A Document Preparation System, Leslie Lamport, 1994, Addison-Wesley
2. LaTeXTutorials A PRIMER, Indian TeXuser group, E. Krishnan
3. Practical LaTeX, George Gratzer, Springer
4. Official LaTeXsite : https://www.latex-project.org/

5. The Not So Short Introduction to LaTeX: http://mirror.iopb.res.in/tex-archive/info/lshort/english/lshort.pd
6. LaTeX Wikibook https://en.wikibooks.org/wiki/LaTeX
7. TeXLive http://www.tug.org/texlive/

3.2.2 Scientific Writing (Project)

Paper: PHS-A SEC-B-PR	**Credits: 1**

List of some sample Projects

1. Writing articles/ research papers/reports
2. Writing mathematical derivation
3. Writing Resume
4. Writing any documentation of a practical done in laboratory with results, tables, graphs.
5. Writing graphical analysis taking graphs from outside.

SEC A-2 (Knowledge Skill)

3.3 Renewable energy and Energy Harvesting (Theory)

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

1. Fossil fuels and Alternate Sources of energy **5 Lectures**

Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Ocean shore 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 **5 Lectures**

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, role of maximum power point tracking for harvesting maximum energy and sun tracking systems.

3. Wind Energy harvesting **4 Lectures**

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. (only idea of synchronisation, current injection, islanding etc with utility grid)

4. Ocean Energy **4 Lectures**

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 **2 Lectures**

Geothermal Resources, Geothermal Technologies.

6. Hydro Energy **2 Lectures**

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting **3 Lectures**

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications.

8. Electromagnetic Energy Harvesting **3 Lectures**

(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.

9. Fuel cell **2 Lectures**

Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells

Reference Books

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