Course Structure & Syllabus of Ph.D. Physics
Applicable for Batch: 2021 Onwards

DIT UNIVERSITY

Dehradun

Detailed Course Structure & Syllabus

of

Ph.D. in Physics

Approved by the Academic Council at its 17th Meeting held on 24.03.2021

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Course Category	Course Code	Course Title	L	T	P	Credit
UC	MB901	Research Methodology	4	0	0	4
UC	CPE-RPE	Research and Publication Ethics	2	0	0	2
DE	PY***	Elective - I	4	0	0	4
DE	PY***	Elective - II	4	0	0	4
DE	PY***	Elective - III	4	0	0	4
DC	PY908	Seminar	1	0	0	1
		Total	**17**	**0**	**0**	**19**

List of Electives

Elective – I

1.	Materials characterization techniques	PY986
2.	Computational Physics	PY983

Elective – II

1.	Computational Techniques and Programming	MA748
2.	Nanoscience and nanomaterials	PY984

Elective – III

1.	Soft Materials Physics	PY988
2.	Particle Astrophysics	PY981
3.	Fundamentals of Quantum Computing	PY982
4.	Renewable Energy and Resources	PY985

Note: Apart from above listed Elective courses, Research Scholar may choose any course across departments being offered at PG level, if it is required/suggested by the Research Committee.

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<table>
<tr><td>Subject Code</td><td>MB901</td><td>Subject Title</td><td colspan="7">Research Methodology</td></tr>
<tr><td>LTP</td><td>4 0 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>UC</td><td>Year</td><td>1st</td><td>Semester</td><td>I / II</td></tr>
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Course Objective:
The main objective of this course is to make students understand the nuances of carrying out effective research. Scholars will become aware about to the research process and other associated concepts.

Course Pre/Co- requisite (if any): Business Statistics, Understanding about writing project.

Course Outcome:
After the end of this course, student shall be able to:

1. Carry out effective research
2. Write good research papers
3. Understand importance of intellectual property rights and consequences of plagiarism
4. Understand how to write a doctoral level research

Curriculum Content

UNIT – I
Fundamentals of Research: Defining research, Objectives of research, types, research process, deductive and inductive reasoning;
Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review,
Definition of variables: Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing.
Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

UNIT – II
Research Design: Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

UNIT – III
Sampling, Sampling distribution, and Data Collection: Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors. Sources of Data-Primary Data, Secondary Data, Data Collection methods

UNIT – IV
Statistical Data Analysis: Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

UNIT – V

Research Report: Writing a research report- Developing an outline, Formats of Report writing, Key elements- Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Text Books:

C.R.Kothari, "Research Methodology", 5th edition, New Age Publication,

Reference Books:

1. Cooper, "Business Research Methods", 9th edition, Tata McGraw hills publication
2. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
3. Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008.
4. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197 -222; 391 – 403

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Subject Code	PY986	**Subject Title**	**Materials Characterization Techniques**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Summary:
The course broadly covers various characterization techniques like optical microscopy, X=-ray diffraction, scanning electron microscope, transmission electron microscope, UV-Vis spectroscopy, thermogravimetric analysis.

Course Objective:
To understand the principles of optical and electron microscopy for study of macro and micro-structure of materials. To gain knowledge in understanding the tools and techniques for studying the substructure and atomic structure of materials. To build an expertise in characterization of engineering materials.

Course Pre/Co- requisite (if any) : no restricted pre-requisite

Course Outcome:
Having successfully completed this course, the student will be able to demonstrate knowledge and understanding of:

1. Appropriate characterization techniques for microstructure examination at different magnification level.
2. The crystal structure determination and phase analysis of the materials.
3. Examine the electronic structure, and the thermal behaviour of the materials.
4. Spectroscopic techniques and analysis
5. Thermal techniques to explain calorimetric behavior

Curriculum Content

UNIT 1
Optical microscope - Basic principles & components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Specimen preparation, Applications. 8 L

UNIT 2
Fundamentals of crystallography, X-ray diffraction techniques, Electron diffraction, Neutron diffraction. 8 L

UNIT 3
Interaction of electrons with solids, scanning electron microscopy, Transmission electron microscopy, Energy dispersive spectroscopy. 9 L

UNIT 4
Atomic force microscopy, scanning tunnelling microscopy, X-ray photoelectron spectroscopy. 9 L

UNIT 5
Atomic absorption spectroscopies, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy. 9 L

UNIT 6
Thermogravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry 9 L

Text book [TB]:

1. Gabriel, B. SEM- A Users's Manual, Plenum Press (1985).
2. Smallman, R.E., and Bishop, R.J., Metals and Materials – Science, Processes, Applications, Butterworth-Heinemann (2013).
3. Sibilia J.P., A Guide to Materials Characterization and Chemical Analysis, VCH (1997)

Reference books [RB]:

Cullity, B.D. Elements of X-Ray Diffraction, Addison Wesley (1967).

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Subject Code	PY984	**Subject Title**	**Nanoscience and nanomaterials**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DC	**Year**	1st	**Semester**	I / II

Course Summary:
The course starts with introduction to nanotechnology and covers synthesis techniques for preparing nanostructures and their applications

Course Objective:
To introduce and provide a broad view of the nascent field of nanoscience and nanotechnology to the students.

Course Pre/Co- requisite (if any): no restricted pre-requisite

Course Outcome:
Having successfully completed this course, the student will be able to demonstrate knowledge and understanding of:
1. Nanoscience and nanotechnology, including theory and experiment
2. Potential projects in nanoscience/nanotechnology
3. Nanoscience/nanotechnology as a student researcher and implementation of the same in experiments
4. Nanoscale analysis and better interpretation of results
5. Concepts to buildup new theories and simulations

Curriculum Content

UNIT 1
Nano science and nanotechnology, historical perspective of nano science and nano technology, classification of nano materials density of states in 1-D, 2-D and 3-D bands, variation of density of states and band gap with size of crystal, surface to volume ratio, aspect ratio, quantum confinement 13 L

UNIT 2
Homogenous and heterogenous growth, nano materials synthesis; top-down and bottom-up approaches, ball milling, machine tools, PVD, CVD, sol-gel technique, atomic manipulation, lithographic techniques
13 L

UNIT 3
Fabrication and properties; Carbon based nanomaterials; single walled and multiwalled carbon nanotubes, graphene, fullerenes, carbon dots, metallic and metal oxide nano particles, quantum dots and quantum wires
13 L

UNIT 4
Applications of nano materials; nano sensors, nano machines, nano computers, solar energy conversion, nanomaterials for data storage, photonics, plasmonics, chemical and biosensors, nanomedicine, drug delivery.
13 L

Text book [TB]:

1. Cao, G., Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Emperial College Press (2011)
2. Edward L. Wolf: Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2nd ed., Wiley-VCH (2015)

Reference books [RB]:

1. Poole, Jr. CP and Owens, FJ, “Introduction to Nanotechnology”, Wiley (2006)

Subject Code	PY988	**Subject Title**	**Soft Materials Physics**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Summary:

The course covers classification of soft materials, interactions, Thermotropic liquid crystals, Lyotropic liquid crystals, Colloidal dispersions in detail.

Course Objective:

To provide a broad context of the properties of soft condensed matter and make clear the connections between the physical properties of soft materials and their applications.

Course Pre/Co- requisite (if any): no restricted pre-requisite

Course Outcome:

Having successfully completed this course, the student will be able to demonstrate knowledge and understanding of:

1. Concepts of the physics of liquid crystals, polymers and colloids.
2. Phase transitions in soft matter.
3. Connections between liquid crystals, polymers and colloids.
4. Some key experimental techniques in relation to soft condensed matter.
5. Biological materials and their applications

Curriculum Content

UNIT 1

Classification of soft materials, surface energy and interactions, Van der Waals interactions, Electrostatic interaction, entropy-driven interactions, hydrogen bonding, hydrophobic, interactions, solvophobic interactions.
10 L

UNIT 2

Thermotropic liquid crystals, general structure of liquid crystalline molecules, structure of phases, order parameter, Maier-Saupe theory, structural, dielectric and electrooptic properties of liquid crystals and applications. Lyotropic liquid crystals, micelles, critical micelles concentration, spherical micelles, cylindrical micelles, vesicles, lamellar, hexagonal, sponge-like and bicontinuous phases, applications of lyotropic liquid crystals. 11 hr

UNIT 3

Terminology and nomenclature, polymerisation mechanisms, polar masses and distributions, chain - dimensions and structures, glass transition temperature, properties and application of polymers 11 hr

UNIT 4

Colloidal dispersions, Brownian Motion of colloidal particles, langevin Equation Theory of Dynamic Light Scattering (DLS), Gels, emulsions and foams, nanocolloids their properties and applications.

10 hr

UNIT 5

Bio molecules; Lipid bilayers, nature of the cell membrane, curvature elasticity, fluctuations of membranes, DNA, proteins, carbohydrates, lipids, nucleic acids, viruses and their applications in nanotechnology

10 hr

Text book [TB]:

1. Structured Fluids: Polymers, Colloids, Surfactants, T. A. Witten, Oxford (2004)
2. Biological Physics: Energy, Information, Life , P. Nelson W. H. Freeman (2003
3. Sibilia J.P., A Guide to Materials Characterisation and Chemical Analysis, VCH (1997)

Reference books [RB]:

1. Collings, P.J. & Hird, M. Introduction to Liquid Crystals: Chemistry and Physics, CRC Press (1997)
2. Hamley, I.W. Introduction to Soft Matter (Wiley) Chichester (2000)

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Subject Code	PY983	**Subject Title**	Computational Physics						
LTP	4- 0 -0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Summary:

This course covers programming language, latex documentation, numerical methods and various problem solving techniques in theoretical physics.

Course Objective:

The objective of this course is to familiarize students with the use of computer to solve physics problems. Students will learn a programming language namely FORTRAN further they will also learn to prepare document using latex. This course provides an introduction to methods and techniques of solving various problems in physics using numerical techniques.

Course Pre/Co- requisite (if any): no restricted pre-requisite

Course Outcome

Having successfully completed this course, the student will be able to:

1. Write basic computer programs using FORTRAN 90.
2. Use Linux command to prepare documentation.
3. Use different numerical methods to solve problems in physics numerically.
4. Apply numerical methods to theoretical physics problems.

Curriculum Content

UNIT 1

Introduction to FORTRAN: Importance of computers in Physics, basic element of FORTRAN: character set, Constant and their type, Keywords, Variable Declaration and concept of instruction and program, Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, looping statement (DO CONTINUE, DO ENDDO, DO-WHILE and Nested DO Loops) Examples from physics problems.

15 L

UNIT 2

Tools for documentation (LaTeX): Some fundamental Linux Commands (Internal and External commands), 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, Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation.

15L

UNIT 3

Numerical methods and techniques I:

Root finding and equation solving techniques: Bracketing, Bisection, Newton-Raphson Method, Euler's method, numerical differentiation and integration.

11L

UNIT 4

Numerical methods and techniques II (Solution of Physics problems):

Solving linear equations and ordinary differential equations (initial and boundary values), Solution of physics problems in classical and quantum mechanics, e.g., problems in classical electrodynamics and solution of Schrodinger equations by numerical techniques by writing programs in FORTRAN. 11L

Text book [TB]:

1. **Stephen J. Chapman, *Fortran 90/95 for Scientists and Engineers*, McGraw-Hill 2003**
2. **Rajaraman, V., *Computer programming in Fortran 90 and 95*, Prentice-Hall of India, 2008.**
3. **Helmut Kopka and Patrick W. Daly, *A Guide to LaTeX*, Addison-Wesley 2003**
4. **Press, William H. *Numerical Recipes in FORTRAN 90: The Art of Parallel Scientific Computing*. Cambridge: Cambridge University Press, 1996.**

Reference books [RB]:

1. **Landau, P´aez, & Bordeianu, *Computational Physics: Problem Solving with Computers,* John Wiley & Sons, Ltd, *2007.***
2. Sastry, Shankar S. Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.

Subject Code	MA748	**Subject Title**	Computational Techniques and Programming						
LTP	302	**Credit**	4	**Subject Category**	GEC	**Year**	2nd	**Semester**	IV

Course Objective: To have the students gain exposure in various computational techniques to solve physics problems using advance computer programming languages.

Course Pre/Co- requisite (if any): no pre-requisite

Course Outcome: The students will be able to gain competence in:

1. Numerical techniques
2. Complex curve fitting and execute problems in calculus using computer.
3. using numerical techniques to solve basic and advanced differential equations
4. Developing programs in Python for solving programs.

Curriculum Content

Unit I

Numerical Methods Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solutions of simultaneous linear equations, Gaussian elimination, pivoting, iterative Method, matrix inversion. Bisection method, Iterative method, Newton Raphson method, Secant method for solving transcendental equations. Builtin functions in MATLAB for solving transcendental Equations. Jacobi method, Gauss-Seidal method for solving system of equations, their comparative study using various stopping criterion. Builtin functions in MATLAB for solving system of equations.

Unit II

Eigenvalues and eigenvectors of matrices, Power and Jacobi Method

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline fitting. Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.Finite differences, interpolation with equally spaced and unevenly spaced points. Quadrature formulae, Programs for trapezoidal rule, Simpson's 1/3 and 3/8 rule and their comparison. Using builtin functions for numerical integration. Few builtin functions in MATLAB for interpolation, and curve fitting.

Unit III

Monte Carlo methods and numerical solution of differential equations

Random variate, Monte Carlo evaluation of integrals, Methods of importance sampling, Random walk and Metropolis method. Numerical solutions of ordinary differential equations, Euler and Runge -Kutta methods, Predictor and corrector methods, Elementary ideas of solutions of partial differential equations.Numerical solutions of ordinary differential equations. Euler's method and its variants, Runge Kutta methods for solving IVPs, programming in MATLAB. How to use builtin functions in MATLAB for solving IVPs and how to extend the code for solving system of IVPs. Elementary ideas of solutions of partial differential equations, and solving them in MATLAB using built in function pdepe.

Unit IV

FOSS TOOL: PYTHON

Installation of the software for Python, Basic syntax, Mathematical Operators, Predefined constants, Built in functions. Complex numbers, polynomials, Vectors, Matrix. Handling these data structures using built in functions. Programming, Functions, Loops, Conditional statements. Handling .py files, Graphics handling -2D, 3D, Function plotting, Data plotting. Two & three-dimensional graphics: basic plots, change in axes and annotation in a figure, multiple plots in a figure, saving and printing figures, mesh plots, surface plots and their variants. Built in functions for data representation: bar charts, histograms, pie chart, stem plots etc; for solving various type of differential equations; for specialized plotting e.g., contour plots, sphere, and animations.

Text book [TB]:

1. Gerald, C.F., and Wheatley P.O., Applied Numerical Analysis, Addison Wesley (2003).
2. Atkinson, K. E. and W. Han, Elementary Numerical Analysis, John Wiley & sons (2004).
3. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age International Publisher (2012).

Reference books [RB]:

1. Burden R. L. and Faires J. D., Numerical Analysis, Brooks Cole, 2004
2. Paul Barry, Head First Python**,** O'Reilly Media, Inc., 2nd Edition (2016).
3. Zed A Shaw, Learn Python the Hard Way, Zed Shaw's Hard Way Series, 3rd Edition (2013).

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Subject Code	PY982	**Subject Title**	**Fundamentals of Quantum Computing**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Summary:

The course covers an introduction to main ideas and techniques on the field of quantum computation, quantum information and their applications in various fields of theoretical physics.

Course Objective:

The objective of this course is to provide students an introduction to quantum computation. The aim of quantum computing is to do computation using the quantum mechanical effect. The study of quantum computation and information involves mathematics, physics and computer science.

Course Pre/Co- requisite (if any): Basic understanding of linear algebra.

Course Outcome

Having successfully completed this course, the student will be able to demonstrate knowledge and understanding of:

1. The basic principle of quantum computing.
2. An introduction to open quantum system.
3. Several basic quantum computing algorithms.
4. The classes of problems that can be expected to be solved by quantum computers.

Curriculum Content

UNIT 1

Introduction to quantum computing

Brief introduction to classical information theory, information content in a signal, Shannon's entropy theory, quantum states, axioms of quantum mechanics, the qubit, multiple qubit, Bloch sphere representation for qubit. 10 L

UNIT 2

The density operator

Density operator for pure and mixed states, key properties of density operator, time evolution of density Operator, the partial trace and reduced density operator, Schmidt decomposition of bipartite pure states.

10L

UNIT 3

Quantum Measurement Theory and Quantum Algorithm

Distinguishing quantum states and measurement, orthogonal measurement, generalized measurement, projective measurement, POVM measurements, composite systems, basic quantum circuit diagram, Hadamard Gate, Quantum Parallelism and Function Evaluation, Deutsch-Jozsa Algorithm, Shor's Algorithm and Grover's Algorithm

11 L

UNIT 4

Quantum noise and quantum operations

Introduction to quantum operations, completely positive trace preserving map, Krauss operators, introduction to Open quantum system, quantum noise channels, three quantum channels : amplitude damping, phase damping, depolarizing channel, Bloch sphere representation of channels, master equation for open quantum system, non-Markovian noise.

11 L

UNIT 5

Tools of quantum information theory

Entanglement, entanglement of formation and concurrence, teleportation and superdense coding, quantum cryptography, the No-clonning theorem, trace distance, fidelity, Holevo bound, classical information over noisy channel.

10L

Text book [TB]:

1. Nielsen, Michael A., and Isaac Chuang. Quantum computation and quantum information. 10th Edition, Cambridge University Press, 2013.
2. Breuer, Heinz-Peter, and Francesco Petruccione. *The theory of open quantum systems*. 1st Edition, Oxford University Press on Demand, 2002.
3. Jaeger, Gregg. *Quantum information*. Springer New York, 2007.

Reference books [RB]:

1. Le Bellac, Michel. *A short introduction to quantum information and quantum computation*. Cambridge University Press, 2006.
2. Lecture notes for Physics 229 : Quantum Information and Computation John Preskill, California Institute of Technology, September 1998.

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Subject Code	PY981	**Subject Title**	Particle Astrophysics						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I/II

Course Summary:

This course is for physics students who are specializing in particle astrophysics and cosmology. This is an introductory course to particle astrophysics and will focus on the modern topics at the forefront of the field.

Course Objective:

The objective of the course is to give the students a broad overview of the current state of particle astrophysics and introduce the students to the research topics in fields of particle physics and astrophysics.

Course Pre/Co- requisite (if any): A familiarity with quantum mechanics, electromagnetism and statistical mechanics and mathematical physics is required.

Course Outcome

On completion of the course, the student should be able to:

1. Understand the basic aspects of special and general relativity.
2. Classify elementary particles and their reactions in terms of quantum numbers and draw simple reaction diagrams.
3. Understand the theoretical basis for our modern cosmological view of the universe.
4. Understand the present status of physics of dark matter.
5. Learn the present status of the particle astrophysics.

Curriculum Content

UNIT 1

Review of special and general relativity: Poincare and Minkowski's 4-dimensional formulation, geometrical representation of Lorentz transformations in Minkowski's space and length contraction, time dilation and causality, time-like and space-like vectors, Riemann curvature; Einstein equations.

14 L

UNIT 2

Elementary Standard model of particle physics: An introduction to the Standard Model of particle physics, symmetries and conservation laws and their significance in particle physics, the unified electroweak interaction, W, Z and the Higgs boson.

10L

UNIT 3
Standard Model of Cosmology:

Historical development of cosmology, Hubble's law and the expanding Universe, Big Bang theory, Cosmological principle, homogeneity and isotropy, Newtonian cosmology, Friedmann equation, Distance measures in Cosmology

14L

UNIT 4

Selected topics in particle astrophysics (Qualitative description):
Neutrino decoupling temperature, Big-Bang Cosmology, Dark matter and its relic abundance, Inflationary Cosmology, Cosmic Microwave Background

14 L

Text book [TB]:

1. Ryden, B., *Introduction to Cosmology*, 2nd Edition, Cambridge University Press, 2016.
2. Andrew Liddle, *An Introduction to Modern Cosmology*, 3rd Edition, Wiley, 2015.
3. Griffiths D, *Introduction to elementary particles*, 2nd Edition, Wiley-VCH, 2008.
4. S. Dodelson, *Modern Cosmology,* Academic Press, Amsterdam, 2003.

Reference books [RB]:

1. Weinberg, Steven. *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*, 1st Edition Wiley, 2008
2. Brian R. Martin, Graham Shaw, *Nuclear and Particle Physics: An Introduction*, 3rd Edition, Wiley, 2019.
3. Donald Hill Perkins, *Particle Astrophysics*, Oxford University Press, 2009

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Subject Code	PY985	**Subject Title**	Renewable Energy and Resources						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Objectives

This course enables the students to:

1. Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.

2. Learn the fundamental concepts about solar energy systems and devices.

3. Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.

4. Understand the working of OTEC system and different possible ways of extracting energy from ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Course Outcomes

After the end of the course, a student should be able to:

1. Understand of renewable and non-renewable sources of energy

2. Gain knowledge about working principle of various solar energy systems

3. Understand the application of wind energy and wind energy conversion system.

4. Develop capability to do basic design of bio gas plant.

5. Understand the applications of different renewable energy sources like ocean

thermal, hydro, geothermal energy etc.

CURRICULUM CONTENT

UNIT I RENEWABLE ENERGY (RE) SOURCES

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

UNIT II WIND ENERGY

Power in the Wind – Types of Wind Power Plants (WPPs)–Components of WPPs-Working of WPPs- Sting of WPPs-Grid integration issues of WPPs

UNIT III SOLAR PV AND THERMAL SYSTEMS

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion - Types of PV Systems Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.

UNIT IV BIOMASS ENERGY

Introduction-Bio mass resources –Energy from Bio mas: conversion process - Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT V OTHER ENERGY SOURCES

Tidal Energy: Energy from the tides, Barrage and Non-Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell: Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems.

Text Books

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

2. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill

3. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.

4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.

5. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

Reference Books

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.

2. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 1996.

3. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw-Hill, 1986.

4. Tiwari. G.N., Solar Energy – “Fundamentals Design, Modeling & Applications”, Narosa Publishing House, New Delhi, 2002.

5. Freris. L.L., “Wind Energy Conversion Systems”, Prentice Hall, UK, 1990. 6. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, New York