GOVERNMENT GENERAL DEGREE COLLEGE, KALNA-I

SYLLABUS
for

Three-Year/Four-Year (Honours) B.Sc. Programme

in

Major-Physics

with

Minor-Mathematics

Under Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) as per NEP, 2020
(With effect from the session 2023-2024)

Semester-I

Course Type	Title of the Course	Credit	Full Marks	Lecture Hour
Major Course **PHYS1011**	**Mathematical Physics-I**	**4** (Theory-03, Practicals-01)	**75** (Theory-40, Practical–20, Internal Assessment–15)	**75** (Theory-45, Practical-30)
Minor Course **MATH1021**	**Calculus, Geometry &Vector Calculus**	**4** (Theory-04)	**75** (Theory-60, Internal Assessment–15)	**60** (Lecture -45, Tutorial – 15)
Multi/ Interdisciplinary **ENGL1031**	**Communication Skills**	**3** (Theory-03)	**50** (Theory-40, Internal Assessment–10)	**45**
AEC **(L1-1 MIL)** **BENG1041**	**Sahityer Bodh O Bichar**	**2** (Theory-02)	**50** (Theory-40, Internal Assessment–10)	**30**
SEC **PHYS1051**	**Renewable Energy And Energy Harvesting**	**3** (Theory-03)	**50** (Theory-40, Internal Assessment–10)	**45**
Common Value-Added Course	**Environmental Science / Education**	**4** (Theory-04)	**100**	**60**
		Total Credit = 20	**Total Marks = 400**	

MAJOR-PHYSICS COURSE

Semester I

MAJOR-I: PHYS1011: MATHEMATICAL PHYSICS-I (Credits: Theory-03, Practical - 01)

F.M. = 75 (Theory – 40, Practical – 20, Internal Assessment –15)

COURSE OBJECTIVE: The aim of this course is to equip the students with mathematical methods that are important prerequisites for physics courses.

Theory: 45 Lectures

Calculus:

Recapitulation: Limits, Continuity, Average and instantaneous quantities, Differentiation. Plotting functions. Intuitive ideas of continuous, differentiable etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

(3 Lectures)

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of the existence and the Uniqueness theorem for Initial Value Problems. Particular Integral.

(9 Lectures)

Calculus of functions of more than one variable: Partial derivatives, Exact and inexact differentials.

(6 Lectures)

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

(5 Lectures)

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

(6 Lectures)

Vector Integration: Ordinary integrals of vectors, Multiple integrals, Jacobian. Notion of an infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field, Gauss' divergence theorem. Green's and Stokes Theorems and their applications (no rigorous proofs).

(10 Lectures)

Orthogonal Curvilinear Coordinates:

Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Vector Analysis, M R Spiegel, Schaums Outline Series.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Higher Engineering Mathematics, B S Grewal, Khanna Publisher.
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, H K Dass and R Verma, S. Chand & Company Pvt. Ltd.
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

MAJOR-I: PHYS1011: MATHEMATICALPHYSICS-I

Practical:

COURSE OBJECTIVE: The aim of this course is to learn computer programming and numerical analysis and to emphasize its role in solving problems in Physics.

Practical: 30 Lectures

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, Memory, Input/Output devices.
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, Algorithms, Sequence, Selection and Repetition, Single and double precision arithmetic, Underflow and overflow, Emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

Errors and Error-Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming Fundamentals	Introduction to Programming, Constants, Variables, Data types, Operators and expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data formatting, Control statements (Decision making statements: if statement, if else Statement, Nested if structure, else if ladder statement, Ternary Operator, goto statement, switch case statement. Unconditional and conditional looping: while loop, do-while loop, for loop, break and continue statements, Nested loops). Arrays (1D & 2D), Strings, User defined functions, Structure and Union, Idea of classes and objects.

Programs:

1. Write and execute a program in C/C++ to compute the factorial of a positive integer including Zero.
2. Write and execute a program in C/C++ to calculate sum of squares of n natural numbers.
3. Write and execute a program in C/C++ to find the area and the volume of a Sphere by varying the radius.
4. Write and execute a program in C/C++ to display Fibonacci series.
5. Write and execute a program in C/C++ to find the value of Sine function using power series (The argument will be given during execution).
6. Write and execute a program in C/C++ to find the value of Cosine function using power series (The argument will be given during execution)
7. Write and execute a program in C/C++ to find the value of ex (x will be given during execution of the program).
8. Write and execute a program in C/C++ to sort elements of an array of elements in ascending/ descending order.
9. Write and execute a program in C/C++ to separate odd and even integers in arrays.
10. Write and execute a program in C/C++ to find the largest and smallest in a given set of numbers.
11. Write and execute a program in C/C++ to calculate value of π.

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

Reference Books

1. Introduction to Numerical Analysis, S .S.Sastry,5 thEdn., 2012 ,PHI Learning Pvt.Ltd.
2. Schaum's Outline of Programming with C++ .J.Hubbard,2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al, 3rd Edn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher & C.Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis,K.E.Atkinson, 3rd Edn., 2007, Wiley India Edition.
6. An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press
7. Computational Physics, DarrenWalker, 1st Edn., 2015, Scientific International Pvt. Ltd.
8. Programming in ANSI C, E Balagurusamy, McGraw Hill Education.
9. Object Oriented Programming with C++, E. Balagurusamy, McGraw Hill Education.
10. Let Us C, Y Kanetkar, BPB Publications.

MINOR COURSES

Course Code: MATH121
Course Name: Calculus, Geometry &Vector Calculus
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives
To study calculus, geometry and vector calculus

Learning outcomes
On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence:

Knowledge: The students would gain knowledge about

i. higher order derivatives and its applications, concavity of curves, asymptotes and curve tracing techniques.
ii. reduction formula for integration of functions like $\sin nx$, $\sin^m x \sin^n x$ etc., area of surface of revolution, parametric curves etc.
iii. classification of conics and conicoids, polar equation of conics.
iv. vector valued functions and vector calculus.

Skills: The students would be able to

i. parametrize curves, sketch functions and plot them.
ii. visualize standard quadratic surfaces like cone, ellipsoid etc.
iii. apply calculus on vector valued functions.
iv. find gradient of scalar functions, divergence and curl of vector valued functions.

General competence: The students would gain

i. a general idea of advance calculus and its applications.
ii. the idea of solving complex problems using vector calculus and geometry.
iii. analytical and reasoning skills, which improve their thinking power and enhance their problem solving ability.

Contents:
Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax+b)^n \sin x, (ax+b)^n \cos x$, indeterminate forms, L'Hospital's rule, concavity of curves, points of inflection, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves. **[L-12H& T-4H]**
Reduction formulae, derivations and illustrations of reduction formulae for the integration of $\sin nx$, $\cos nx$, $\tan nx$, $\sec nx$, $(\log x)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **[L-10H& T-3H]**

Reflection properties of conics, translation and rotation of axes, general equation of second-degree, classification of conics, polar equations of conics, spheres, cylindrical surfaces. central conicoid, paraboloids, plane sections of conicoid, generating lines, classification of quadrics. **[L-11H & T-4H]**

Triple product of vectors, introduction to vector functions, algebraic operations on vector-valued functions, limits and continuity of vector functions, differentiation and partial differentiation of vector functions, gradient of a scalar function, divergence and curl of vector functions. [L-**12H& T-4H]**

Reading References:

Text Books:

1. Calculus - G.B. Thomas and R.L. Finney, 9th Ed., (Pearson Education, Delhi, 2005).
2. Calculus - M.J. Strauss, G.L. Bradley and K. J. Smith, 3rd Ed., (Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007).
3. Integral Calculus - K. C. Maity and R. K. Ghosh.,(New Central Book Agency (P) Limited, 1999).
4. An Elementary Treatise on Coordinate Geometry of three-Dimensions–R.J.T. Bell, (MacMillan & Co.).
5. The Elements of Coordinate Geometry- S.L. Loney, (MacMillan & Co.).
6. Vector Analysis- K. C. Maity and R. K. Ghosh, (New Central Book Agency (P) Ltd. Kolkata, 1999).

Reference Books:

1. Calculus- T. M. Apostol, (Volumes I and II. Vol-I, 1966, Vol-II, 1968).
2. Calculus- H. Anton, I. Bivens and S. Davis, 7th Ed., (John Wiley and Sons (Asia) P. Ltd., Singapore, 2002).
3. Introduction to Calculus and Analysis - R. Courant and F. John, (Volumes I & II), (Springer-Verlag, New York, Inc., 1989).
4. Analytical Geometry of two and three-dimensions- N. Dutta and R. N. Jana, (Shredhar Prakashani).
5. Calculus and Mathematical Analysis- S. Goldberg, 1989.
6. Vector Calculus- J. Marsden, and Tromba, (McGraw Hill, 1987).
7. Schaum's outline of Vector Analysis- M.R. Spiegel, (McGraw Hill, 1980).
8. Vector Analysis with Applications - A. A. Shaikh and S. K. Jana, (Alpha Science International Ltd., 2009).

INTERDISCIPLINARY COURSE 1

Communication Skills

Introduction to Communication Skills

Listening:

listening to casual conversations; listening to lectures; listening to instructions; listening to theatrical or movie dialogues; listening to news bulletins

Speaking:

speaking during casual conversations; speaking to a gathering; delivering a formal speech; offering instructions / advice; speaking as a presenter on television and radio; speaking during group discussions; speaking while facing an interview board

Reading:

Reading for pleasure; reading for examinations; reading for research; reading in a group; reading newspapers

Writing:

Writing formal letters; writing emails; writing messages on social media; writing for popular magazines; report writing for newspapers; feature writing for newspapers; writing a resume, writing applications for jobs, writing memos

4. AEC (L1-1 MIL) সাহিত্যের বোধ ও বিচার BENG1041

Course Title: সাহিত্যের বোধ ও বিচার

Course Code: 4

Course Credit: 2

Course Lecture Hour: 30

Objective of the Course: এই কোর্সের উদ্দেশ্য ভাষা এবং সাহিত্য বোধ ও সাহিত্য বিচারের প্রাথমিক ধারণা দেওয়া। কোনো সাহিত্যিক নিদর্শনকে শিক্ষার্থী তার বোধ ও বিচারশক্তি দিয়ে কীভাবে আয়ত্ত করতে পারে, সেটাই এই কোর্সে তাকে শেখানো হবে।

একক ১: ভাষা অংশ (Lecture Hour: 10)

ক. বোধপরীক্ষা: (নিম্নলিখিত পাঁচটি প্রবন্ধ পাঠ্য)

১. স্বদেশী সমাজ – রবীন্দ্রনাথ ঠাকুর

২. বাঙ্গালা ভাষা – স্বামী বিবেকানন্দ

৩. বই পড়া – প্রমথ চৌধুরী

৪. স্ত্রী জাতির অবনতি – বেগম রোকেয়া

৫. অপবিজ্ঞান – রাজশেখর বসু

একক ২: সাহিত্য অংশ (Lecture Hour: 20)

ক. কবিতার ভাবসৌন্দর্য বিশ্লেষণ

রবীন্দ্রনাথ ঠাকুরের নৈবেদ্য গ্রন্থের চারটি কবিতা পাঠ্য - (বৈরাগ্যসাধনে মুক্তি সে আমার নয়, শতাব্দীর সূর্য আজি, চিত্ত যেথা ভয়শূন্য, শক্তি দম্ভ স্বার্থ লোভ)

খ. ছোটোগল্পের শিল্পসার্থকতা বিচার

রবীন্দ্রনাথ ঠাকুরের গল্পগুচ্ছ থেকে তিনটি গল্প পাঠ্য – ছুটি, বলাই, মণিহারা

Outcome of the Course: এই কোর্স পড়ার পর শিক্ষার্থী সাহিত্যের বিষয় অনুধাবনের পাশাপাশি তার শিল্পসার্থকতা ও ভাবসৌন্দর্য বিশ্লেষণ করতে শিখল।

SEC-PHYSICS

Semester-I

SEC-1:PHYS1051: RENEWABLE ENERGY AND ENERGY HARVESTING (Credits: 03)

F.M. = 50 (Theory - 40, Internal Assessment - 10)

COURSE OBJECTIVE: To impart knowledge and hands on learning about various alternative energy sources like Wind, Solar, Mechanical, Ocean, Geothermal etc. To review the working of various energy harvesting systems which are installed worldwide.

Theory: 45 Lectures

Fossil Fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, Their limitation, Need of renewable energy, Non-conventional energy sources. An overview of the 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. (8 Lectures)

Solar energy: Solar energy and 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. (8 Lectures)

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces and grid interconnection topologies. (5 Lectures)

Ocean Energy: 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 Lectures)

Geothermal Energy: Geothermal resources, Geothermal technologies. (4 Lectures)

Hydro Energy: Hydropower resources, Hydropower technologies, Environmental impact of hydro power sources. (5 Lectures)

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling piezoelectric generators, Piezoelectric energy harvesting applications, Human power. (5 Lectures)

Electromagnetic Energy Harvesting: Linear generators, Related Physics, Mathematical models, Recent applications, Carbon captured technologies, cell, Batteries, Power consumption, Environmental issues and Renewable sources of energy, Sustainability. (5 Lectures)

COURSE OUTCOME: The students are expected to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.

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. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
5. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
7. http://en.wikipedia.org/wiki/Renewable_energy
8. Snatak Padartha Vigyan, Renewable Energy Sources, A M Rudra, A Bhattacharya and A Dan, The New Book Stall, 2018.

SEMESTER- I
VALUE ADDED COURSE
PAPER CODE: 1061 [COURSE NO. 1]
ENVIRONMENTAL SCIENCE/ EDUCATION
TOTAL CREDITS: 4
[3 – 0 - 1 :: 60+20+20]

TIME: 3 Hours **MARKS: 60**

Learning objectives

- *To create awareness and understanding of the environment and its different components*
- *To get knowledge on different current environmental problems and issues in national and international levels*
- *To impart knowledge about the management practices of different environmental problems*
- *To get real life experiences of different environmental resources, ecosystems and environmental degradation*

Unit 1: Basics of Environmental Studies: (05)

Definition, Nature, Scope and Importance; Components of environment: Environmental education

Unit 2: Natural Resources: Renewable and Nonrenewable Resources (10)

Nature and natural resources their conservation and associated problems:

- Forest resources: Uses, types and importance, Joint Forest Management & symbiotic relationship between tribal population and forests, Deforestation and its effects
- Water resources: Distribution of water on Earth; Use, over exploitation of surface and ground water; Dams: Benefits and problems; Flood and Drought
- Mineral resources: Mineral resources in India; Use and exploitation, Social impacts of mining
- Food resources: World food problems and food insecurities.
- Energy resources: Renewable and Nonrenewable energy sources; Use of alternate energy sources - Case studies
- Land resources: Land as a resource; Land degradation, landslides, soil erosion, desertification
- Use of resources for sustainable development (Concepts & Goals)

Unit 3: Ecology and Ecosystems (08)

- Concept of ecology, Population ecology, Community ecology
- Concept of an ecosystem, different types of ecosystem
- Food chains, food webs and ecological succession
- Energy flow in the ecosystem and energy flow models

Unit 4: Biodiversity and its conservation (08)

Biodiversity: Levels of biological diversity

- Values of biodiversity
- Hot-Spots of biodiversity, IUCN Red Data Book, Mega-biodiversity countries
- Threat to biodiversity
- Threatened and endemic species of India

- Conservation of biodiversity (*In- situ* and *Ex-situ)*
- Ecosystem services: Ecological, Economic, Social, Ethical, Aesthetical and Informational values

Unit 5: Environmental Pollution and Management (08)

(a) Nature, Causes, Effects and Control measures of – Air pollution, Water pollution, Soil pollution, Noise pollution

(b) Solid waste management: Causes, effects and disposal methods; Management of biomedical and municipal solid wastes

(c) Disaster management: Floods, Earthquake, Droughts, Cyclone and Landslides

Unit 6: Environmental Policies and Practices (10)

Constitutional Provisions for protecting environment- Article 48(A), 51A(g)

- Environmental Laws: The Environment (Protection) Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981; The Water (Prevention and Control of Pollution) Act 1974; Forest (Conservation) Act, 1980
- The wildlife Protection Act, 1972
- Climate change, Global warming, ENSO, Acid rain, Ozone layer depletion; Montreal and Kyoto Protocols

Unit 7: Human Communities and Environment (06)

- Human population growth; Impacts on environment
- Environment and human health: Concept of health and disease; Common communicable and Non- communicable diseases; Health awareness programmes in India
- Environment movements in India: Chipko Movements, Silent Valley Movement, *Narmada Banchao Aandolan*

Unit 8: Field Work Report/Project Report/Term paper **Marks: 20**

[Based on any one of the following topics and to be evaluated by internal teachers only)

- Environmental assets - River/Forest/Grassland/Hill/Mountain *etc*.
- Environmental pollution - Urban/Rural/Industrial/Agricultural
- Study of common Plants/Insect /Birds/Wild life *etc*.
- Study of simple ecosystems: Pond/River/Hill slope *etc*.

Learning outcomes

- *Understanding on environment and its importance*
- *Knowledge on different natural resources, causes of depletion and its sustainable uses*
- *Understanding the significance of biodiversity and its conservation*
- *Ideas on provisions of Indian Constitution for environmental protection*
- *Understanding the interrelationship among human population growth, environment and human health*
- *Knowledge of on-field experience on environmental issues through project work*

Department of Physics
Government General Degree College at Kalna -I

Lesson Plan
for
B.Sc. Semester-I
Subject: Physics
Paper Name: Mathematical Physics-I
Paper Code: Major-I: PHYS1011

Credits: Theory-03, Practicals-01
F.M.=75 (Theory-40, Practical–20, Internal Assessment–15)

COURSE OBJECTIVE: The aim of this course is to equip students with mathematical methods that are important prerequisites for physics courses.

Module-I **Calculus**
Contents Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.
Module Objectives: 1. Recapitulation of function, limit and continuity 2. To know the methods of solving the first order and second order differential equation. 3. To know the methods of solving the partial differential equation.

Lecture Serial	Topics of Discussion
Lecture-1	**Function:** Limits, continuity, average and instantaneous quantities, differentiation.
Lecture-2	**Function Plot:** Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves.
Lecture-3	**Approximation Method:** Taylor and binomial series
Lecture-4	**Nature of Differential Equations:** Definition of differential equation. Representation of differential equation. Ordinary differential equation, Degree of a differential equation, Partial differential equation.

Lecture-5	**First Order Differential Equation:** Definition, Linear Equations, Bernoulli Equations, Homogeneous Equation, Some examples on 1st order homogeneous equation.
Lecture-6	**Exact Differential Equation:** Condition for exact differential equation, Some examples regarding exact differential equation.
Lecture-7	**Inexact Differential Equation:** Integrating factor, Some examples related to inexact differential equation.
Lecture-8	**Second Order Differential Equations:** Homogeneous equation and non-homogeneous equation. Definition of Wronskian, Some problems regarding Wronskian.
Lecture-9	**Second Order Differential Equations:** The use of a known solution to find a another solution. Homogeneous equation with constant coefficients.
Lecture-10	**Second Order Differential Equations:** Nonhomogeneous second order differential equation, The method of undetermined coefficients.
Lecture-11	**Second Order Differential Equations:** Vibration in mechanical system.
Lecture-12	**Operator Method:** Particular solution of first and second order liner equations.
Lecture-13	**Particular Integrals:** Properties of particular integrals. Some examples regarding the particular integrals.
Lecture-14	**Existence and Uniqueness Theorems:** Statements and some examples of initial value problem.
Lecture-15	**Partial derivatives:** Exact and inexact differentials.
Lecture-16	**Partial derivatives: I**ntegrating factor, with simple illustration.
Lecture-17	**Lagrange Multipliers:** Constrained Maximization using Lagrange Multipliers.
Lecture-18	**Lagrange Multipliers:** Some examples regarding lagrange multipliers.

Tutorial Assignment—I

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

Module Objectives:

1. This module delivers idea about dot and cross products of vectors and their significance And one can understand the laws of vector algebra to solve various problems associated with Vector calculus.
2. This unit gives the students idea about vector differentiation
3. One can get knowledge about Gradient of scalar field, Divergence and curl of a vector field and their significance.
4. This unit enables the student to solve various problems associated with vector differentiation
5. This unit delivers idea about vector integration, both ordinary and multiple integration.
6. This unit enables the student to solve various problems associated with vector line, surface and volume integration.
7. One can also get knowledge about Vector Theorems and can apply them to solve various problems on vector integration.

Lecture Serial	Topics of Discussion
Lecture-19	**Introduction to Vector:** Vector definition, unit vector, polar and axial vector, Properties of vectors under rotations.
Lecture-20	**Product of Vectors:** Product of two vectors, Scalar product and its invariance under rotations. Vector product, Significance of dot and cross product.
Lecture-21	**Vector Product:** Scalar triple product and their interpretation in terms of area and volume respectively. Vector triple product.
Lecture-22	**Laws of vector algebra:** Properties of dot and cross product.
Lecture-23	**Scalar and Vector fields and Vector Derivatives:** Defination, Directional derivatives and normal derivative, Gradient of a scalar field and its geometrical interpretation.
Lecture-24	**Divergence of a vector field:** Defination, Some example regarding divergence, Physical significance of divergence of a vector field.
Lecture-25	**Curl of a vector field:** Defination, Some example regarding curl, Physical significance of curl of a vector field.
Lecture-26	**Vector Operator:** Del and Laplacian operators. Vector identities.
Lecture-27	**Vector Operator:** Some examples regarding vector operator
Lecture-28	**Vector Integrals:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian and its apllications.
Lecture-29	**Line Integrals:** Conservative vector field and scaler potential
Lecture-30	**Line Integrals:** Few instances regarding line integrals.
Lecture-31	**Surface Integrals:** Basic theory on surface integrals.
Lecture-32	**Surface Integrals:** Some examples regarding vector integrals
Lecture-33	**Surface Integrals:** Few instances regarding vector integrals
Lecture-34	**Volume Integrals:** Basic theory on volume integrals. Some example on volume integrals.
Lecture-35	**Green's Theorem:** Green's theorem in the plane. Discuss some exapmles.
Lecture-36	**Stokes' Theorem:** Statement of Stokes theorem. Application of Stokes' theorem.

Lecture-37	**Stokes' Theorem:** Verification of Stokes theorem.
Lecture-38	**Gauss' divergence theorem:** Statement of Gauss' theorem and its physical significant. Application of divergence theorem.
Lecture-39	**Few more Intergral Theorem:** Application of Stokes' and Gauss' divergence theorem.

Tutorial Assignment—II

Module-III **Orthogonal Curvilinear Coordinates**
Contents Orthogonal Curvilinear Coordinates: Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.
Module Objectives: 1. To understand the generalized coordinate system. 2. To learn and apply techniques of orthogonal curvilinear coordinate system in cylindrical and spherical coordinate system.

Lecture Serial	Topics of Discussion
Lecture-40	**Curvilinear Coordinates:** Unit Vector in Curvilinear coordinate system, Arc length and Volume elements
Lecture-41	**Differential operators:** Gradient of a scalar in orthogonal curvilinear coordinates.
Lecture-42	**Differential operators:** Divergence of a vector in orthogonal curvilinear coordinates, Laplacian operator.
Lecture-43	**Differential operators:** Curl of a vector in orthogonal curvilinear coordinates
Lecture-44	**Spherical Polar Coordinate:** Differential operators in terms of spherical coordinate.
Lecture-45	**Cylindrical Coordinate system:** Differential operators in terms of cylindrical coordinate.

Tutorial Assignment—III

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Vector Analysis, M R Spiegel, Schaums Outline Series.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

5. Higher Engineering Mathematics, B S Grewal, Khanna Publisher.
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, H K Dass and R Verma, S. Chand & Company Pvt. Ltd.
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Practical

COURSE OBJECTIVE: The aim of this course is to learn computer programming and numerical analysis and to emphasize its role in solving problems in Physics.

Contents
Introduction and Overview: Computer architecture and organization, memory and Input/output devices **Basics of scientific computing:** Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods **Errors and error Analysis:** Truncation and round off errors, Absolute and relative errors, Floating point computations. **Review of C&C++Programming fundamentals:** Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If statement. If else Statement. Nested if Structure. Else if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. For Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs:
1. Write and execute a program in C/C++ to sort elements of an array of Seven elements in ascending order.
2. Write and execute a program in C/C++ to find the area and volume of a Sphere by varying the radius.
3. Write and execute a program in C/C++ to find the value of Sine function using power series (The argument will be given during execution)
4. Write and execute a program in C/C++ to find the value of e x (x will be given during execution of the program).
5. Write and execute a program in C/C++ to compute the factorial of a positive integer including Zero.
6. Write and execute a program in C/C++ to calculate sum of squares of n natural numbers.
7. Write and execute a program in C/C++ to separate odd and even integers in arrays.
8. Write and execute a program in C/C++ to find the value of Cosine function using power series

(The argument will be given during execution)
9. Write and execute a program in C/C++ to sort elements of an array of Six elements in assending order.
10. Write and execute a program in C/C++ to calculate value of π.
11. Write and execute a program in C/C++ to find the largest and smallest in a given set of numbers.

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

Reference Books:

1. IntroductiontoNumericalAnalysis,S.S.Sastry,5thEdn.,2012,PHILearningPvt.Ltd.
2. Schaum'sOutlineofProgrammingwithC++.J.Hubbard,2000,McGraw-HillPub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M.Ascher&C.Greif,2012,PHI Learning.
5. ElementaryNumericalAnalysis,K.E.Atkinson,3rdEdn.,2007,WileyIndiaEdition.
6. AnIntroductiontocomputationalPhysics,T.Pang,2ndEdn.,2006,CambridgeUniv. Press
7. ComputationalPhysics,DarrenWalker,1stEdn.,2015,ScientificInternationalPvt. Ltd.
8. Programming in ANSI C, E Balagurusamy, McGraw Hill Education.
9. Object Oriented Programming with C++, E Balagurusamy, McGraw Hill Education.
10. Let Us C, Y Kanetkar, BPB Publications.

Department of Physics
Government General Degree College at Kalna -I

Lesson Plan
for
B.Sc. Semester-I
Subject: Physics
Paper Name: Mathematical Physics-I
Paper Code: Minor-I: PHYS1021

Credits: Theory-03, Practicals-01
F.M.=75 (Theory-40, Practical–20, Internal Assessment–15)

COURSE OBJECTIVE: The aim of this course is to equip students with mathematical methods that are important prerequisites for physics courses.

Module-I **Calculus**
Contents Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.
Module Objectives: 1. Recapitulation of function, limit and continuity 2. To know the methods of solving the first order and second order differential equation. 3. To know the methods of solving the partial differential equation.

Lecture Serial	Topics of Discussion
Lecture-1	**Function:** Limits, continuity, average and instantaneous quantities, differentiation.
Lecture-2	**Function Plot:** Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves.
Lecture-3	**Approximation Method:** Taylor and binomial series
Lecture-4	**Nature of Differential Equations:** Definition of differential equation. Representation of differential equation. Ordinary differential equation, Degree of a differential equation, Partial differential equation.

Lecture-5	**First Order Differential Equation:** Definition, Linear Equations, Bernoulli Equations, Homogeneous Equation, Some examples on 1st order homogeneous equation.
Lecture-6	**Exact Differential Equation:** Condition for exact differential equation, Some examples regarding exact differential equation.
Lecture-7	**Inexact Differential Equation:** Integrating factor, Some examples related to inexact differential equation.
Lecture-8	**Second Order Differential Equations:** Homogeneous equation and non-homogeneous equation. Definition of Wronskian, Some problems regarding Wronskian.
Lecture-9	**Second Order Differential Equations:** The use of a known solution to find a another solution. Homogeneous equation with constant coefficients.
Lecture-10	**Second Order Differential Equations:** Nonhomogeneous second order differential equation, The method of undetermined coefficients.
Lecture-11	**Second Order Differential Equations:** Vibration in mechanical system.
Lecture-12	**Operator Method:** Particular solution of first and second order liner equations.
Lecture-13	**Particular Integrals:** Properties of particular integrals. Some examples regarding the particular integrals.
Lecture-14	**Existence and Uniqueness Theorems:** Statements and some examples of initial value problem.
Lecture-15	**Partial derivatives:** Exact and inexact differentials.
Lecture-16	**Partial derivatives: I**ntegrating factor, with simple illustration.
Lecture-17	**Lagrange Multipliers:** Constrained Maximization using Lagrange Multipliers.
Lecture-18	**Lagrange Multipliers:** Some examples regarding lagrange multipliers.

Tutorial Assignment—I

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

Module Objectives:

1. This module delivers idea about dot and cross products of vectors and their significance And one can understand the laws of vector algebra to solve various problems associated with Vector calculus.
2. This unit gives the students idea about vector differentiation
3. One can get knowledge about Gradient of scalar field, Divergence and curl of a vector field and their significance.
4. This unit enables the student to solve various problems associated with vector differentiation
5. This unit delivers idea about vector integration, both ordinary and multiple integration.
6. This unit enables the student to solve various problems associated with vector line, surface and volume integration.
7. One can also get knowledge about Vector Theorems and can apply them to solve various problems on vector integration.

Lecture Serial	Topics of Discussion
Lecture-19	**Introduction to Vector:** Vector definition, unit vector, polar and axial vector, Properties of vectors under rotations.
Lecture-20	**Product of Vectors:** Product of two vectors, Scalar product and its invariance under rotations. Vector product, Significance of dot and cross product.
Lecture-21	**Vector Product:** Scalar triple product and their interpretation in terms of area and volume respectively. Vector triple product.
Lecture-22	**Laws of vector algebra:** Properties of dot and cross product.
Lecture-23	**Scalar and Vector fields and Vector Derivatives:** Defination, Directional derivatives and normal derivative, Gradient of a scalar field and its geometrical interpretation.
Lecture-24	**Divergence of a vector field:** Defination, Some example regarding divergence, Physical significance of divergence of a vector field.
Lecture-25	**Curl of a vector field:** Defination, Some example regarding curl, Physical significance of curl of a vector field.
Lecture-26	**Vector Operator:** Del and Laplacian operators. Vector identities.
Lecture-27	**Vector Operator:** Some examples regarding vector operator
Lecture-28	**Vector Integrals:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian and its apllications.
Lecture-29	**Line Integrals:** Conservative vector field and scaler potential
Lecture-30	**Line Integrals:** Few instances regarding line integrals.
Lecture-31	**Surface Integrals:** Basic theory on surface integrals.
Lecture-32	**Surface Integrals:** Some examples regarding vector integrals
Lecture-33	**Surface Integrals:** Few instances regarding vector integrals
Lecture-34	**Volume Integrals:** Basic theory on volume integrals. Some example on volume integrals.
Lecture-35	**Green's Theorem:** Green's theorem in the plane. Discuss some exapmles.
Lecture-36	**Stokes' Theorem:** Statement of Stokes theorem. Application of Stokes' theorem.

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Lecture-38	**Gauss' divergence theorem:** Statement of Gauss' theorem and its physical significant. Application of divergence theorem.
Lecture-39	**Few more Intergral Theorem:** Application of Stokes' and Gauss' divergence theorem.

Tutorial Assignment—II

Module-III **Orthogonal Curvilinear Coordinates**
Contents Orthogonal Curvilinear Coordinates: Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.
Module Objectives: 1. To understand the generalized coordinate system. 2. To learn and apply techniques of orthogonal curvilinear coordinate system in cylindrical and spherical coordinate system.

Lecture Serial	Topics of Discussion
Lecture-40	**Curvilinear Coordinates:** Unit Vector in Curvilinear coordinate system, Arc length and Volume elements
Lecture-41	**Differential operators:** Gradient of a scalar in orthogonal curvilinear coordinates.
Lecture-42	**Differential operators:** Divergence of a vector in orthogonal curvilinear coordinates, Laplacian operator.
Lecture-43	**Differential operators:** Curl of a vector in orthogonal curvilinear coordinates
Lecture-44	**Spherical Polar Coordinate:** Differential operators in terms of spherical coordinate.
Lecture-45	**Cylindrical Coordinate system:** Differential operators in terms of cylindrical coordinate.

Tutorial Assignment—III

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

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9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Practical

COURSE OBJECTIVE: The aim of this course is to learn computer programming and numerical analysis and to emphasize its role in solving problems in Physics.

Contents
Introduction and Overview: Computer architecture and organization, memory and Input/output devices **Basics of scientific computing:** Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods **Errors and error Analysis:** Truncation and round off errors, Absolute and relative errors, Floating point computations. **Review of C&C++Programming fundamentals:** Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If statement. If else Statement. Nested if Structure. Else if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. For Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs:
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(The argument will be given during execution)
9. Write and execute a program in C/C++ to sort elements of an array of Six elements in assending order.
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11. Write and execute a program in C/C++ to find the largest and smallest in a given set of numbers.

COURSE OUTCOME: On completion of this course, the student must be able to perform different mathematical operations like calculus and vector operations which are extremely essential to study theoretical and experimental physics.

Reference Books:

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2. Schaum'sOutlineofProgrammingwithC++.J.Hubbard,2000,McGraw-HillPub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M.Ascher&C.Greif,2012,PHI Learning.
5. ElementaryNumericalAnalysis,K.E.Atkinson,3rdEdn.,2007,WileyIndiaEdition.
6. AnIntroductiontocomputationalPhysics,T.Pang,2ndEdn.,2006,CambridgeUniv. Press
7. ComputationalPhysics,DarrenWalker,1stEdn.,2015,ScientificInternationalPvt. Ltd.
8. Programming in ANSI C, E Balagurusamy, McGraw Hill Education.
9. Object Oriented Programming with C++, E Balagurusamy, McGraw Hill Education.
10. Let Us C, Y Kanetkar, BPB Publications.

Department of Physics

Government General Degree College at Kalna -I

Lesson Plan

for

B.Sc. Semester-I

Subject: Physics

Paper Name: Renewable Energy And Energy Harvesting

Paper Code: SEC-1:PHYS1015

Credits: Theory-03

F.M.=50 (Theory-40, Internal Assessment-10)

COURSE OBJECTIVE: To impart knowledge and hands on learning about various alternate energy sources like wind, solar, mechanical, ocean, geothermal energy etc. To review the working of various energy harvesting systems which are installed worldwide.

Module-I Fossil fuels and Alternate Sources of energy, Solar energy, Wind Energy, Ocean Energy (15 lectures)
Contents **Fossil fuels and Alternate Sources of energy:** 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. **Solar energy:** 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. **Wind Energy harvesting:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **Ocean Energy:** 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.
Module Objectives: 1. To gain knowledge about conventional and non-conventional energy sources 2. To understand basic knowledge about solar energy, wind energy and ocean energy harvesting processes

Lecture Serial	Topics of Discussion
Lecture-1.	Conventional energy sources, Fossil fuels and nuclear energy, their limitations.
Lecture-2.	energy crisis, need of renewable energy, non-conventional energy sources.
Lecture-3.	An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems.
Lecture-4.	Overview of Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.
Lecture-5.	**Solar energy:** Solar energy and its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy
Lecture-6.	solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses.
Lecture-7.	solar cell: principle of operation, Difference between Photo thermal and Photo voltaic system
Lecture-8.	Absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
Lecture-9.	Advantages and disadvantages of solar energy harvesting
Lecture-10.	**Wind energy:** Wind Energy harvesting, Fundamentals of Wind energy, Advantages and disadvantages of wind energy harvesting
Lecture-11.	Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies
Lecture-12.	**Ocean Energy:** Ocean Energy Potential against Wind and Solar energy,
Lecture-13.	Wave Characteristics and Statistics, Wave Energy Devices.
Lecture-14.	Tide characteristics and Statistics, High tide and low tide, Tide Energy Technologies,
Lecture-15.	Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Tutorial Assignment—I

Module-II
Geothermal Energy, Hydro Energy, Piezoelectric Energy harvesting, Electromagnetic Energy Harvesting (15 lectures)
Contents
Geothermal Energy: Geothermal Resources, Geothermal Technologies. **Hydro Energy:** Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling piezoelectric generators, Piezoelectric energy harvesting applications, human power
Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications, Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.

Module Objectives:

1. To gain basic knowledge about Geothermal, Hydro Energy, Piezoelectric Energy, Electromagnetic Energy Harvesting
2. To understand Environmental issues and Renewable sources of energy, sustainability of renewable energy sources

Lecture Serial	Topics of Discussion
Lecture-1.	**Geothermal Energy:** Geothermal Resources, Geothermal Technologies
Lecture-2.	Advantages and disadvantages of Geothermal energy
Lecture-3.	**Hydro Energy:** Hydropower resources, hydropower technologies,
Lecture-4.	environmental impact of hydro power sources.
Lecture-5.	Conditions for developing Hydropower plants
Lecture-6.	Advantages and disadvantages of Hydro energy
Lecture-7.	**Piezoelectric Energy harvesting:** Introduction, Physics of piezoelectric effect, Piezoelectric crystal, creation of mechanical waves
Lecture-8.	materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling piezoelectric generators,
Lecture-9.	Piezoelectric energy harvesting applications, Advantages and disadvantages, human power
Lecture-10.	**Electromagnetic Energy Harvesting**: Conception about electromagnetic waves, Principle of operation of Linear generators, physics mathematical models, recent applications
Lecture-11.	Advantages and disadvantages of Electromagnetic energy harvesting.
Lecture-12.	Carbon captured technologies, cell, batteries, power consumption
Lecture-13.	Environmental issues and Renewable sources of energy, sustainability of renewable energy sources
Lecture-14.	Recapitulation of different conventional and renewable energy sources and their applications
Lecture-15.	Discussion on previous year questions

Tutorial Assignment—II

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi 2.
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.