Elective VII-(C) :(Renewable Energy)

Semester –VI
Elective Paper –VII-(C) :Renewable Energy

No. of Hours per week: 04 **Total Lectures:60**

UNIT-I (12 hrs)

1. Introduction to Energy: Definition and units of energy, power, Forms of energy, Conservation of energy, second law of thermodynamics, Energy flow diagram to the earth. Origin and time scale of fossil fuels, Conventional energy sources, Role of energy in economic development and social transformation.

2. Environmental Effects: Environmental degradation due to energy production and utilization, air and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Effect of pollution due to thermal power station, nuclear power generation, hydroelectric power stations on ecology and environment.

UNIT-II (12 hrs)

3. Global Energy Scenario: Energy consumption in various sectors, projected energy consumption for the next century, exponential increase in energy consumption, energy resources, coal, oil, natural gas, nuclear and hydroelectric power, impact of exponential rise in energy usage on global economy.

4. Indian Energy Scene: Energy resources available in India, urban and rural energy consumption, energy consumption pattern and its variation as a function of time, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources.

UNIT-III (12 hrs)

5.Solar energy: Solar energy, Spectral distribution of radiation, Flat plate collector, solar water heating system, Applications, Solar cooker. Solar cell, Types of solar cells, Solar module and array, Components of PV system, Applications of solar PV systems.

6. Wind Energy: Introduction, Principle of wind energy conversion, Components of wind turbines, Operation and characteristics of a wind turbine, Advantages and disadvantages of wind mills, Applications of wind energy.

UNIT-IV (12 hrs)

7. Ocean Energy: Introduction, Principle of ocean thermal energy conversion, Tidal power generation, Tidal energy technologies, Energy from waves, Wave energy conversion, Wave energy technologies, advantages and disadvantages.

8. Hydrogen Energy: History of hydrogen energy - Hydrogen production methods - Electrolysis of water, Hydrogen storage options – Compressed and liquefied gas tanks, Metal hydrides; Hydrogen safety - Problems of hydrogen transport and distribution - Uses of hydrogen as fuel.

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UNIT-V (12 hrs)

9. Bio-Energy

Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion – Properties of biomass – Biogas plants – Types of plants – Design and operation – Properties and characteristics of biogas.

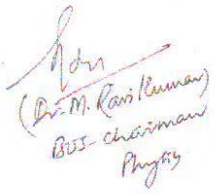
References:

1. Solar Energy Principles, Thermal Collection &Storage, S.P.Sukhatme: Tata McGraw Hill Pub., New Delhi.
2. Non-Conventional Energy Sources, G.D.Rai, New Delhi.
3. Renewable Energy, power for a sustainable future, Godfrey Boyle, 2004,
4. The Generation of electricity by wind, E.W. Golding.
5. Hydrogen and Fuel Cells: A comprehensive guide, Rebecca Busby, Pennwell corporation (2005)
6. Hydrogen and Fuel Cells: Emerging Technologies and Applications, B.Sorensen, Academic Press (2012).
7. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009.
8. Fundamentals of Renewable Energy Resources byG.N.Tiwari, M.K.Ghosal, Narosa Pub., 2007.

Elective Paper-VII-C: Practical: Renewable Energy
2hrs/Week

Minimum of 6 experiments to be done and recorded

1. Preparation of copper oxide selective surface by chemical conversion method.
2. Performance testing of solar cooker.
3. Determination of solar constant using pyrheliometer.
4. Measurement of I-V characteristics of solar cell.
5. Study the effect of input light intensity on the performance of solar cell.
6. Study the characteristics of wind.



Semester –VI
Cluster Electives VIII-C
Cluster Elective Paper –VIII-C-1 :Solar Thermal and Photovoltaic Aspects

No. of Hours per week: 04 **Total Lectures:60**

UNIT-I (12 hrs)

1. Basics of Solar Radiation: Structure of Sun, Spectral distribution of extra terrestrial radiation, Solar constant, Concept of Zenith angle and air mass, Definition of declination, hour angle, solar and surface azimuth angles; Direct, diffuse and total solar radiation, Solar intensity measurement – Thermoelectric pyranometer and pyrheliometer.

2. Radiative Properties and Characteristics of Materials: Reflection, absorption and transmission of solar radiation throughsingle and multi covers; Kirchoff's law – Relation between absorptance, emittance and reflectance; Selective Surfaces - preparation and characterization, Types and applications; Anti-reflective coating.

UNIT-II (14 hrs)

3. Flat Plate Collectors (FPC) : Description of flat plate collector, Liquid heating type FPC, Energy balance equation,Efficiency, Temperature distribution in FPC, Definitions of fin efficiency and collector efficiency, Evacuated tubular collectors.

4. Concentrating Collectors: Classification, design and performance parameters; Definitions of aperture, rim-angle, concentration ratio and acceptance angle; Tracking systems; Parabolic trough concentrators; Concentrators with point focus.

Unit-III (14 hrs)

5. Solar photovoltaic (PV) cell: Physics of solar cell –Type of interfaces, homo, hetero andschottky interfaces, Photovoltaic Effect, Equivalent circuit of solar cell, Solar cell output parameters, Series and shunt resistances and its effect on cell efficiency; Variation of efficiency with band-gap and temperature.

6. Solar cell fabrication: Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) methods, Silicon wafer fabrication, Wafer to cell formation, Thin film solar cells, Advantages, CdTe/CdS cell formation, Multi-junction solar cell; Basic concept of Dye-sensitized solar cell, Quantum dot solar cell.

UNIT-IV (8 hrs)

Solar PV systems: Solar cell module assembly – Steps involved in the fabrication of solar module, Module performance, I-V characteristics, Modules in series and parallel, Module protection – use of Bypass and Blocking diodes, Solar PV system and its components, PV array, inverter, battery and load.

UNIT-V (12 hrs)

Solar thermal applications: Solar hot water system (SHWS), Types of SHWS, Standard method of testing the efficiency of SHWS; Passive space heating and cooling concepts, Solar desalinator and drier, Solar thermal power generation.

Solar PV applications: SPV systems; Stand alone, hybrid and grid connected systems, System installation, operation and maintenances; Field experience; PV market analysis and economics of SPV systems.

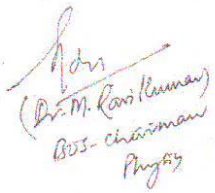
Reference Books:

1. Solar Energy Utilization, G. D. Rai, Khanna Publishers
2. Solar Energy- Fundamentals, design, modeling and applications, G.N. Tiwari, Narosa Pub., 2005.
3. Solar Energy-Principles of thermal energy collection & storage, S.P. Sukhatme, Tata Mc-Graw Hill Publishers, 1999.
4. Solar Photovoltaics- Fundamentals, technologies and applications, Chetan Singh Solanki, PHI Learning Pvt. Ltd.,
5. Science and Technology of Photovoltaics, P. Jayarama Reddy, BS Publications, 2004.

Cluster Elective Paper- VIII-C-1: Practical: Solar Thermal and Photovoltaic Aspects
2hrs/Week

Minimum of 6 experiments to be done and recorded

1. Measurement of direct solar radiation using pyrheliometer.
2. Measurement of global and diffuse solar radiation using pyranometer.
3. Measurement of emissivity, reflectivity and transsivity.
4. Measurement of efficiency of solar flat plate collector.
5. Performance testing of solar air dryer unit.
6. Effect of tilt angle on the efficiency of solar photovoltaic panel.
7. Study on solar photovoltaic panel in series and parallel combination.



Semester - VI

Cluster Elective Paper –VIII-C-2 :Wind, Hydro and Ocean Energies

No. of Hours per week: 04 **Total Lectures:60**

UNIT-I

1. Introduction: Wind generation, meteorology of wind, world distribution of wind, wind speed variation with height, wind speed statistics, Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics.

2. Wind Measurements:Eolian features, biological indicators, rotational anemometers, other anemometers, wind measurements withballoons.

UNIT-II

3. Wind Energy Conversion System:Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element andcombine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip losscorrection.

4. Design of Wind Turbine: Wind turbine design considerations; Methodology; Theoretical simulation of wind turbinecharacteristics; Test methods.

UNIT-III

5. Wind Energy Application: Wind pumps: Performance analysis, design concept and testing; Principle of wind energy generation; Standalone, grid connected and hybrid applications of wind energy conversion systems, Economics of wind energyutilization; Wind energy in India; Environmental Impacts of Wind farms.

UNIT-IV

6. Small Hydropower Systems: Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps andturbine; Selection and design criteria of pumps and turbines; Site selection;Speed and voltage regulation; Investment issues load management and tariff collection; potential of small hydro power in India.Wind and hydro based stand-alone hybrid power systems.

UNIT-V

7.Ocean Thermal, Tidal and Wave Energy Systems:Ocean Thermal - Introduction, Technology process, Working principle, Resource and site requirements, Location of OCET system, Electricity generation methods from OCET,Advantages and disadvantages, Applications of OTEC,

8. Tidal Energy - Introduction, Origin and nature of tidal energy, Merits and limitations, Tidal energy technology,Tidal range power, Basic modes of operation of tidal systems.Wave Energy – Introduction, Basics of wave motion, Power in waves, Wave energy conversion devices, Advantages anddisadvantages, Applications of wave energy.

Reference Books:

1. Dan Charis, Mick Sagrillo, LanWoofenden, "Power from the Wind", New Society Pub., 2009.
2. Erich Hau, "Wind Turbines-Fundaments, Technologies, Applications, Economics", 2ndEdition, Springer Verlag, BerlinHeidelberg, NY, 2006.

3. Joshue Earnest, Tore Wizelius, Wind Power and Project Developmen", PHI Pub., 2011.
4. T. Burton, D. Sharpe, N. Jenkins, E. Bossanyi, Wind Energy Handbook, John Wiley Pub., 2001.
5. Paul Gipe, "Wind Energy Basics", Chelsea Green Publications, 1999.
6. Khan, B.H., "Non-Conventional Energy Resources", TMH, 2nd Edition, New Delhi, 2009.
7. Tiwari, G.N., and Ghosal, M.K, Renewable Energy Resources – Basic Principles and applications, Narosa Publishing House,2007.

Cluster Elective Paper- VIII-C-2: Practical: Wind, Hydro and Ocean Energies
2hrs/Week

Minimum of 6 experiments to be done and recorded
1. Estimation of wind speed using anemometer.
2. Determination of characteristics of a wind generator
3. Study the effect of number and size of blades of a wind turbine on electric power output.
4. Performance evaluation of vertical and horizontal axes wind turbine rotors.
5. Study the effect of density of water on the output power of hydroelectric generator.
6. Study the effect of wave amplitude and frequency on the wave energy generated.

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(Dr. M. Ravi Kumar)
BOS- chairman
Physics

Semester - VI

Cluster Elective Paper –VIII-C-3 :Energy Storage Devices

No. of Hours per week: 04 **Total Lectures:60**

UNIT-I (12 hr)

1. Energy Storage: Need of energy storage; Different modes of energy storage, Flywheel storage, Electrical and magnetic energy storage: Capacitors,electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical,electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage.

UNIT-II (12 hrs)

2. Electrochemical Energy Storage Systems: Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Leadacid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes inelectrodes.

UNIT-III (12 hrs)

3. Magnetic and Electric Energy Storage Systems: Superconducting Magnet Energy Storage(SMES) systems; Capacitor and battery:Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor(EDLC), principle of working, structure, performance and application.

UNIT-IV (12 hrs)

4. Fuel Cell: Fuel cell definition, difference between batteries and fuel cells, fuel cell components, principle and working of fuel cell, performance characteristics,efficiency, fuel cell stack, fuel cell power plant: fuel processor, fuel cell powersection, power conditioner, Advantages and disadvantages.

UNIT-V (12 hrs)

5. Types of Fuel Cells: Alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell,molten carbonate fuel cell; solid oxide fuel cell,proton exchange membrane fuel cell, problems with fuel cells, applications of fuel cells.

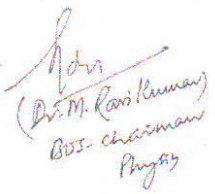
REFERENCE BOOKS

1. J. Jensen and B. Squrensen, Fundamentals of Energy Storage, John Wiley, NY, 1984.
2. M. Barak, Electrochemical Power Sources: Primary and Secondary Batteries by, P. Peregrinus,IEE,1980.
3. P.D.Dunn, Renewable Energies, Peter Peregrinus Ltd, London, 1986.
4. B.Viswanathan and M. A. Scibioh, Fuel Cells-Principles and Applications, University Press, 2006.
5. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork, 1989.

Cluster Elective Paper –VIII-C-3: Practical: Energy Storage Devices
2hrs/Week

Minimum of 6 experiments to be done and recorded

1. Study of charge and discharge characteristics of storage battery.
2. Study of charging and discharging behavior of a capacitor.
3. Determination of efficiency of DC-AC inverter and DC-DC converters
4. Study of charging characteristics of a Ni-Cd battery using solar photovoltaic panel.
5. Performance estimation of a fuel cell.
6. Study of effect of temperature on the performance of fuel cell.



UNIT-IV

4. Polarisation : 10h

Polarized light: methods of polarization, polarization by reflection, refraction, double refraction, scattering of light-Brewster's law-Mauls law-Nicol prism polarizer and analyzer-Quarter wave plate, Half wave plate-optical activity, determination of specific rotation by Laurent's half shade polarimeter-Babinet's compensator - idea of elliptical and circular polarization.

UNIT-V

5. Lasers and Holography : 7h

Lasers : Introduction, spontaneous emission, stimulated emission. Population inversion, Laser principle-Einstein coefficients-Types of lasers-He-Ne laser, Ruby laser- Applications of lasers.Holography: Basic principle of holography-Gabor hologram and its limitations, Applications of holography.

6. Fiber Optics : 7h

Introduction - different types of fibers, rays and modes in an optical fiber, fiber material,principles of fiber communication (qualitative treatment only), advantages of fiber optic communication.

CHOICE BASED CREDIT SYSTEM OF COMMON CORE SYLLABUS

PHYSICS : : SEMESTER III

Wave Optics

Work load : 60 hrs per semester **4 hrs/week**

UNIT – I

1. Aberrations : 8h

Introduction – monochromatic aberrations, spherical aberration, methods of minimizing spherical aberration, coma, astigmatism and curvature of field, distortion. Chromatic aberration-the achromatic doublet.Achromatism for two lenses (i) in contact and (ii) separated by a distance.

UNIT – II

2. Interference : 14h

Principle of superposition – coherence-temporal coherence and spatial coherence-conditions for interference of light.Fresnel's biprism-determination of wavelength of light – change of phase on reflection.Oblique incidence of a plane wave on a thin film due to reflected and transmitted light (cosine law) –colors of thin films.

Interference by a film with two non-parallel reflecting surfaces (Wedge shaped film). Determination of diameter of wire, Newton's rings in reflected light. Michelson interferometer. Determination of wavelength of monochromatic light using Newton's rings and Michelson Interferometer.

UNIT – III

3. Diffraction: 14h

Introduction, distinction between Fresnel and Fraunhoffer diffraction. Fraunhoffer diffraction – Diffraction due to single slit - Fraunhoffer diffraction due to double slit-Fraunhoffer diffraction pattern with N slits (diffraction grating). Resolving power of grating, Determination of wavelength of light in normal incidence and minimum deviation methods using diffraction grating.

Fresnel's half period zones-area of the half period zones-zone plate-comparison of zone plate with convex lens-difference between interference and diffraction.

UNIT-IV

4. Polarisation :

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UNIT-V

5. Lasers and Hol

Lasers : Intr
Laser principle-Ein
lasers.Holograph
Applications of hol

6. Fiber Optics :

Introductior
material,principles
optic communicati

16. Verification of Theremin's and Norton's theorems.
17. Bridge Rectifier – Filter circuits
18. Conversion of galvanometer into Ammeter of two ranges.
19. Conversion of galvanometer into Voltmeter of two ranges.
20. Construction and calibration of ohm meter.

Not for examination:

Servicing of domestic appliances – Electric Iron, immersion heater, fan, hot plate grinder, emergency lamp, battery charger, micro-oven, loud speaker, eliminator, cell-phones, servicing of refrigerator.

Suggested Books for Practicals

1. **A textbook of Practical Physics** by M.N. Srinivasan. *S. Chand & Co.*
2. **Practical Physics** by M. Arul Thakpathi by *Comptek Publishers.*
3. **A. Laboratory manual for Physics Course** by B.P. Khandelwal.
4. **B.Sc. Practical Physics** – C.L. Arora – *S. Chand & Co.*
5. **Viva-voce in Advanced Physics** – R.C. Gupta and Saxena P.N. – *Pragathi Prakashan, Meerut.*
6. **Viva-Voce in Physics – R.C. Gupta, *Pragathi Prakashan, Meerut.***

Practical Paper - III

90hrs
(3 hrs / week)

THIRD YEAR PRACTICALS

1. Carey Foster's Bridge – comparison of resistances.
2. Internal resistance of a cell by potentiometer.
3. Constants of table Galvanometer.
4. Voltage sensitivity of a moving coil galvanometer.
5. Calibration of high range voltmeter using potentiometer.
6. LR circuit (Frequency response)
7. LCR circuit series/parallel resonance, Q-factor
8. Impedance and Power factor of an A.C. circuit
9. Determination of ac-frequency-sonometer.
10. Design and construction of multimeter.
11. Construction of a model D.C. power supply.
12. Characteristics of a Junction diode
13. Characteristics of Transistor
14. Characteristics of Zener diode
15. Verification of Kirchoff's laws.
16. Determination of M and H
17. LR and CR circuits – Determination of L and C by applying AC.
18. Field along the axis of a circular coil carrying current – Stewart and Gee's method.

Practical Paper - IV

90 hrs
(3 hrs / week)

THIRD YEAR PRACTICALS

1. e/m of an electron by Thomson method.
2. Energy gap of semiconductor using a junction diode
3. Temperature characteristics of thermistor
4. R.C. coupled amplifier
5. Verification of Logic gates AND, OR NOT, X-OR gates
6. Verification of De Morgan's theorems
7. Construction and verification of truth tables for half and full adders.
8. Phase shift Oscillator
9. Hysteresis curve of transformer core
10. Determination of Planck's constant (photocell)
11. Study of spectra of hydrogen spectrum (Rydberg constant)
12. Maximum power transfer thereon.
13. Hall-probe method for measurement of magnetic field.
14. LDR characteristics.
15. Study of alkaline earth spectra using a concave grating.

Physics Syllabus-08

Practical Paper – I

90 hrs
(3 hrs / week)

FIRST YEAR PRACTICALS

1. Study of a compound pendulum determination of 'g' and 'k'.
2. Study of damping of an oscillating disc in Air and Water logarithmic decrement.
3. Study of Oscillations under Bifilar suspension.
4. Study of oscillations of a mass under different combination of springs.
5. 'Y' by uniform Bending (or) Non-uniform Bending.
6. Verification of Laws of a stretched string (Three Laws).
7. Moment of Inertia of a fly wheel.
8. Measurement of errors –simple Pendulum.
9. Determination of frequency of a Bar-Melde's experiment.
10. 'n' by torsion Pendulum.
11. Observation of Lissajous figures from CRO.
12. Study of flow of liquids through capillaries.
13. Determination of Surface Tension of a liquid by different methods.
14. Study of Viscosity of a fluid by different methods.
15. Volume Resonator –determination of frequency of a tuning fork.
16. Velocity of Transverse wave along a stretched string.

Practical Paper – II

90 hrs
(3 hrs / week)

SECOND YEAR PRACTICALS

1. Co-efficient of thermal conductivity of a bad conductor by Lee's method.
2. Measurement of Stefan's constant.
3. Specific heat of a liquid by applying Newton's law of cooling correction.
4. Heating efficiency of electrical kettle with varying voltages.
5. Thickness of a wire-wedge method.
6. Determination of wavelength of light –Biprism.
7. Determination of Radius of curvature of a given convex lens- Newton's rings.
8. Resolving power of grating.
9. Study of optical rotation-polarimeter.
10. Dispersive power of a prism
11. Determination of wavelength of light using diffraction grating minimum deviation method.
12. Wavelength of light using diffraction grating – normal incidence method.
13. Resolving power of a telescope.
14. Refractive index of a liquid and glass (Boys Method).
15. Pulfrich refractometer – determination of refractive index of liquid.
16. Wavelength of Laser light using diffraction grating.
17. Spectrometer – Canchy's Constants
18. Refractive index (m) of the material of a concave lens.

SYLLABUS

B.Sc. (Physics) CBCS Syllabus for All Universities of Andhra Pradesh

Semester-II

Paper-II: Waves and Oscillations

(For Maths Combinations)

Work load : 60 hrs per semester **4 hrs/week**

Unit-I

1. Simple Harmonic Oscillations (12 hrs)

Simple harmonic oscillator and solution of the differential equation – physical characteristics of SHM, torsion pendulum – measurement of rigidity modulus, compound pendulum, measurement of 'g', combination of two mutually perpendicular simple barmonic vibrations of same frequency and different frequencies, Lissajous figures.

Unit-II

2. Damped and Forced Oscillations (12 hrs)

Damped harmonic oscillator, solution of the differential equation of damped oscillator. Energy considerations, comparison with undamped harmonic oscillator, logarithmic decrement, relaxation time, quality factor, differential equation of forced oscillator and its solution, ampitude resonance and velocity resonance.

Unit-III

3. Complex Vibrations (10 hrs)

Fourier theorem and evaluation of the Fourier coefficients, analysis of periodic wave functions – square wave, triangular wave, saw tooth wave.

Unit-IV

4. Vibrations Strings (8 hrs)

Transverse wave propagation along a stretched string, general solution of wave equation and its significance, modes of vibration of stretched string clamped at ends, overtones, energy transport and transverse impedance.

5. Vibrations of Bars (9 hrs)

Logitudinal vibrations in bars – wave equation and its general solution. Special cases: (i) bar fixed at both ends, (ii) bar fixed at the mid point, (iii) bar free at both ends and (iv) bar fixed at one end, tuning fork.

Unit-V

6. Ultrasonics (9 hrs)

Ultrasonics, properties of ultrasonic waves, production of ultrasonics by piezoelectric and magnetostriction methods, detection of ultrasonics, determination of wavelength of ultrasonic waves, applications of ultrasonic waves.

CHOICE BASED CREDIT SYSTEM OF COMMON CORE SYLLABUS

B.Sc. 1st SEMESTER : PHYSICS

Paper I : Mechanics & Properties of Matter

(For Maths Combination)

Work load : 60 hrs per semester **4hrs/week**

UNIT – I (16 hrs)

1. **Vector Analysis (8 hrs)**

Scalar and vector fields, gradient of a scalar field and its physical significance. Divergence and curl of a vector field with derivations and physical interpretation. Vector integration (line, surface and volume). State and proof of Gauss and Stokes theorems.

UNIT – II (16 hrs)

2. **Mechanics of Particles (10hrs)**

Laws of motion, motion of variable mass system, motion of a rocket. Conservation of energy and momentum. Collisions in two and three dimensions. Concept of impact parameter, scattering cross-section. Rutherford scattering derivation.

UNIT – III (16 hrs)

3. **Mechanics of Rigid bodies (10 hrs)**

Definition of rigid body, rotational kinematic relations, equation of motion for a rotating body, angular momentum. Euler's equation, precession of a top. Gyroscope. Precession of the equinoxes.

4. **Mechanics of continuous media (6 hrs)**

Elastic constants of isotropic solids and their relations, Poisson's ratio and expression for Poisson's ratio in terms of y, n, k. Classification of beams, types of bending, point load, distributed load, shearing force and bending moment, sign conventions.

UNIT – IV (10 hrs)

5. **Central forces (12 hrs)**

Central forces, definition and examples, characteristics of central forces, conservative nature of central forces, conservative force as a negative gradient of potential energy, equation of motion under a central force. Derivation of Kepler's laws. Motion of Satellites.

UNIT – V (12 hrs)

6. **Special theory of relativity (12 hrs)**

Galilean relativity, absolute frames. Michelson-Morley experiment, negative result. Postulates of special theory of relativity. Lorentz transformation, time dilation, length contraction, addition of velocities, mass-energy relation. Concept of four-vector formalism.