Rs. 15/-

NORTH MAHARASHTRA UNIVERSITY
JALGAON - 425 001

SYLLABUS

FOR

M.Sc. [ENERGY STUDIES]

FROM JUNE, 1992.

SEMESTER I TO IV

DEPARTMENT OF PHYSICAL SCIENCES

SYLLABUS

for

M.Sc. [Physics with ENERGY STUDIES Specialization]

SEMESTER I

ES 101 : Mathematical Methods for Physical Sciences.

ES 102 : Classical Mechanics.

ES 103 : Quantum Mechanics.

ES 104 : Electronics.

ES 105 : General Laboratory I

SEMESTER II

ES 201 : Solid State Physics

ES 202 : Statistical Mechanics

ES 203 : Electrodynamics

ES 204 : Computational Methods and Computer Programming

ES 205 : General Laboratory II.

SEMESTER III

ES 301 : Physics of Semiconductor Devices

ES 302 : Atomic and Molecular Physics

ES 303 : Global and Indian Energy Scenario

ES 304 : Special Laboratory I

ES 305 : Project

SEMESTER IV

ES 401 : Solar Energy Conversion I

ES 402 : Solar Energy Conversion II

ES 403 : Energy Management and Conservation.

ES 404 : Special Laboratory II

ES 405 : Project

ES 101 : MATHEMATICAL METHODS FOR PHYSICAL SCIENCES

1. LINEAR SPACES

Introduction to finite dimensional spaces, Linear dependence, basis and dimension, Subspace, Linear operators, Representation theory of operators, Eigen function and eigenvalues, Strum Liouville theory, Self adjoint differential equation, Hermitian operator, Schmidt Orhtogonalization, Inner product and normal spaces, Schwartz inequality.

2. SPECIAL FUNCTIONS :

Bessel functions - generating function, orthogonality of Bessel functions, properties of Bessel functions, introduction to second kind Bessel function.

Hermite functions - generating function, orthogonality of Hermite functions, properties of Hermite functions.

Legendre functions - generating function, orthogonality of Legendre functions, properties of Legendre functions.

Dirac delta function and its properties.

3. MATRICES :

Special matrices - Symmetric, orthogonal, Hermitian and unitary, Eigenvalue equation, eigen vectors and eigen values, Similarity transformations, Diagonalisation.

4. FOURIER SERIES AND TRANSFORMS :

Fourier series, odd and even functions, half range Fourier Sine and Cosine series, Complex form of Fourier series, Parseaval's identity for Fourier series, Finite Fourier transform, Fourier integral, Fourier transform - sine and cosine transform, the convolution theorem, Parseval's identity for Fourier transform, Applications.

5. LAPLACE TRANSFORMS :

Definition, important theorems on Laplace transforms, Inverse Laplace transform, methods of finding inverse Laplace transform by partial fractions, convolution theorm,Applications of Laplace transform.

6. TENSOR ANALYSIS :

Contravarient and covariant vectors and tensors, Mixed tensor, scalars, Kronecker delta, symmetric and skew symmetric tensors, fundamental operation with tensors, Metric tensor, raising and lowering of suffixes, Dyclics.

REFERENCES

1. Mathematical methods for Physicist
   G. Aefken,Academic Press, 1985.

2. Mathematical Methods for Physics
   J.Mathew and R.L.Walker, Benjamin (IBH), 1979.

3. Linear Algebra
   Lipsuitz, Schaum's Series.

4. Mathematics for Physics and Chemistry, Vol.I
   H.M.Margenau and G.M.Murphy, East-West Press.

ES 102 : CLASSICAL MECHANICS

1. Mechanics of a particle and system of particles - Applications and problems.

2. VARIATIONAL PRINCIPLE :

   Configuration space, some techniques of calculus of variations, d-notation, applications of variational principle, equivalence of Lagrange's and Newton's equations, advantages of the Lagrangian-formulation, electromechanical analogies, Lagrange's undetermined multipliers, Lagrange's equation for non-holonomic systems, application of Lagrangian method of undetermined multipliers.

3. HAMILTON'S EQUATIONS AND ITS APPLICATIONS :

   Hamilton's function and Hamilton's equation of motion, Properties of the Hamiltonian and Hamiltonian's equation of motion, Phase space and state space.

4. CANONICAL TRANSFORMATIONS AND THE POISSON BRACKET :

   Gauss transformation, canonical transformation, condition for transformation to be canonical, generating functions, properties of canonical transformations,canonical transformation of the free particle Hamiltonian,Poisson bracket-definition, some useful indentities, Poisson theorem, Jacobi-Poisson theorem, invariance of Poisson bracket under canonical transformation, Lagrange bracket.

5. HAMILTON-JACOBI THEORY :

   Hamilton-Jacobi equation, separation of variables,Jacobi's theorem,connection with canonical transformation, applications of Hamilton-Jacobi theory, action angle variables.

6. SMALL OSCILLATIONS :

   Types of equilibria and the potential at equilibrium, study of small oscillations using generalised coordinates,eigen vectors and eigen frequencies, orthogonality of eigen vectors, small oscillations of particle on string.

7. RIGID BODY MOTION :

   Euler's angles, moment of inertia tensor, its eigen value and principle axis transformation, method of solving rigid body problems and Euler's euations of motion.

REFERENCES

1. Classical Mechanics, Ed.II
   H.Goldstein, Addison Wesley, 1980.

2. Introduction to Classical Mechanics
   R.G.Takwale and P.S.Puranik, Tata McGraw Hill Company

3. Introduction to the Principles of Classical Mechanics
   Hauser, Addison Wesley.

4. Classical Mechanics
   N.C.Rana and P.S. Joag, Tata McGraw Hill Company, 1991

5. Classical Mechanics
   Y.R.Waghmare, Prentice Hall of India.

ES 103 : QUANTUM MECHANICS

1. GENERAL FORMULATION OF WAVE MECHANICS :

Fundamental postulates of wave mechanics, correspondance principle, eigenvalues, eigenfunctions, completeness and normalization of wavefunctions, closure property, expansion coefficients, eigen functions in momentum space, introduction to bra and ket notation and their properties.

2. OPERATORS IN QUANTUM MECHANICS :

Operators, their eigenvalues and eigenfunctions, Hermitian, Unitary, parity operators and their properties, Commutators- definition, commutator algebra, fundamental commutators in quantum mechanics, commuting operators and their physical significance. Solution of 1-D Harmonic Oscillator using ladder operators.

3. ANGULAR MOMENTUM

Angular momentum operator, Linear momentum operator as generator of translation, orbital angular momentum operator as generation of rotation, eigen values and eigenfunctions of L^2 and L_z using explicit forms of L^2 and L_z in spherical co-ordinates, Various commutation relations between L^2, L_x,L_y and L_z. determination of eigenvalue spectrum of J^2, J_z where J is any angular momentum operator, Addition of two angular momenta : development of the necessary theory, Clebesch-Gordon coefficients.

4. MATRIX FORMULATION IN QUANTUM MECHANICS

Matrices in Quantum Mechanics, transformation theory, Unitary matrix, Projection operator.

5. APPROXIMATE METHODS IN QUANTUM MECHANICS

Variational method : General characteristics of the method, application to estimation of enrgy of ground state and excited state.

Time independent perturbation theory : Stationary perturbation theory for degenerate and non-degenerate case, first order and second order perturbation, Applications to problems such as perturbation of an oscillator, Zeeman effect without electron spin, first order Stark effect in Hydrogen.

REFERENCES :

1. Quantum Mechanics
   L.I. Schiff, Mc Graw Hill, Koga Kusha, 1968.
2. A text book of Quantum Mechanics
   P.M.Mathew and K.Venkatesan, Tata Mc Graw Hill, 1981.
3. Quantum Mechanics, Vol.I
   A. Messiah, North Holland, 1972.
4. Quantum Mechanics,
   E.Merzbacher, Wiley Eastern, 1970.
5. Quantum Mechanics,
   A.K.Ghatak and S.Lokanathan, MacMillan India, 1979.
6. Quantum Mechanics,
   A.S.Davydov, Pergamon Press, 1976.

ES 104 : ELECTRONICS

1. DIODES AND CIRCUIT APPLICATIONS:

Forward bias and reverse bias I-V characteristics, ideal diode, diode large signal and small signal model.

Applications: Rectifiers, Clipping or limiting circuits, Clamping, Voltage multipliers, Amplitude demodulation, Diode logic gates.

2. BIPOLAR JUNCTION TRANSISTORS:

Transistor operation (p-n-p & n-p-n), characteristics(input, output & transfer), small signal and large signal models, common base, common emitter and common collector configurations, Biasing circuits: Fixed, and self biasing, Design of Biasing circuit, load line(ac and dc), Transistor as an amplifier, Transistor as a switch.

3. FET and MOSFET:

Juction FET, I-V characteristics, JFET as an amplifier, Comparision with BJT, MOSFET(depletion and enhancement type), Biasing circuit for JFET and MOSFET.

4. FEEDBACK AMPLIFIERS AND OSCILLATORS:

Basic concept of feedback, positive feedback, negative feedback, Effect of negative feedback on gain, input impedance, output impedance, bandwidth, noise and distortion.

Feedback configurations: shunt-shunt, series-series, series-shunt and shunt-series.

Oscillators: Sinusoidal oscillators, nonsinusoidal oscillators, RC oscillators and LC oscillators, Phase shift, Wien bridge, Colpitt, Hartley and tuned circuit, crystal oscillators.

5. OPAMP and Applications:

Ideal OPAMP parameters, Basic circuit block, input and output offset current and voltages, bias current, slew rate, Inverting non-inverting amplifier, voltage follower, comparator, integrator and differentiator, logarithmic amplifier.

6. POWER SUPPLIES :

ERPS using IC 723, design of positive voltage regulator, concept of negative regulator. Extension to high voltage and high current. Concept of constant current source and DC to DC convertor. Three terminal regulators, 78XX and 79XX series voltage regulators , SCR controlled power supplies. Programmable power supplies.

7. INTRODUCTION TO NUMBER SYSTEMS AND LOGIC GATES:

Number systems: Binary,octal,hexadecimal,BCD,Gray, ASCII, EBCDIC, Excess- 3 code etc. and their interconversion.

Basic logic operations: NOT,OR and AND. Positive and negative logic.

logic gates: AND, OR, NOT, XOR, NOR, NAND, NAND and NOR as a universal building blocks. standard TTL NAND gate, IC gates, Propagation delay, fan in, fanout,power dissipation etc.

8. FLIP FLOPS , MULTIVIBRATORS AND ARITHMATIC CIRCUITS:

SR latch,JK flip flop, JK master slave flip flop, D flip flop, T flip flop.

Multivibrator circuits: Monostable,astable and bistable , FF as a bistable multivibrator circuit,IC 555 as a timer, Multivibrator circuits using IC 741 and IC 555.

Arithmetic circuits: Binary addition and subtraction, Half adder,Full adder and subtractor circuits.

REFERENCES :

1. Electronic Principles,
   A.P.Malvino, McGraw Hill Company.

2. Electronic Fundamentals and Applications,Edition 5
   J.D.Ryder, Prentice Hall of India, 1981.

3. Integrated Electronics
   J.Millman and C.C.Halkias, Mc Graw Hill Company, 1981.

4. Electronic Devices and Circuits,
   A.Mottershead, Prentice Hall of India, 1981.

5. Operational Amplifiers,
   G.B.Clayton, Butterworth.

6. Digital Principles and Applications, Edition 4
   A.P.Malvino and D.P.Leach, McGraw Hill Company.

ES 105 : GENERAL LABORATORY I

PART- A

1. Electronically regulated power supply using IC 723 and measurements of performance with DMM.
2. Operational Amplifier - Characteristics and parameter measurements.
3. Differential Amplifier - Characteristics and parameter measurements.
4. Voltage to Frequency convertor using IC 741.
5. Design, build and test Wien bridge oscillator.
6. Design,build and test Phase shift oscillator using IC 741/transistor.
7. Study of Multivibrators.
8. Verification of De Morgan's theorem using logic gates.
9. Study of ADDER and SUBTRACTER circuits using logic gates.

PART - B

1. Resistivity of germanium at various temperatures using Four probe method.
2. Fermi level determination as a function of temperature.
3. Study of thermionic emission and determination of work function.
4. Measurements of ultrasonic velocity in liquids.
5. Study of the dispersion relation for the monoatomic lattice and diatomic lattice.
6. Energy band gap measurement of a semiconductor.
7. Ionic conductivity of NaCl.
8. Study of temperature to frquency convertor.
9. Determination of ultrasonic velocities in metals,polymers etc.

Note : Students are advised to complete at least 6 experiements from each part.

ES 201 : SOLID STATE PHYSICS

1. CRYSTAL STRUCTURES :

Classification of crystals, Lattice, Miller indices, Crystal structures such as NaCl, CsCl, Wurtzite, Diamond, HCP etc. Reciprocal lattice, Ewald's construction, Brillouin zones, Wigner-Seitz cell, X-ray diffraction, Laue theory, geometrical structure factor, atomic structure factor for FCC, BCC and diamond structure X-ray diffraction methods - Laue, rotating crystal and powder method.

2. ELECTRONIC STRUCTURE AND RELATED PROPERTIES :

Free electron model. energy levels and density of orbitals in one dimension and three dimensions, Band theory of solids, origin of energy gap, Kroning penny model and its solution, concept of effective mass of electron and hole, Umpklapp processes and its application to conductivity, motion of electrons in 3-D, tight bound electron approximation, application to simple cubic lattice. Overlapping of energy bands.

3. FERMI SURFACES :

Characteristics and construction of Fermi surfaces, Fermi surface and Brillouin zones, Fermi surfaces of metals such as aluminium, copper and gold. Effect of electric field on Fermi surfaces, Experimental study of Fermi surfaces.

4. DIELECTRIC PROPERTIES :

Polarization, depolarization field, Lorentz field, dielectric constant and polarizability, Clausius Mossotti relation, atomic polarizability [electronic, ionic and dipolar].

5. MAGNETIC PROPERTIES :

Diamagnetism, Paramagnetism, Ferromagnetism, Ferrites and their behaviour at high frequencies.

6. DEFECTS IN SOLIDS :

Point, line and planer defects in crystals, Schottky and Frankel defects,estimation of vacancies, Diffusion, color centres, dislocations.

REFERENCES

1. Solid State Physics,
   A.J.Dekkar, Mc Millan Students Ed.

2. Introduction to Solid State Physics,
   C.Kittel, Wiley Eastern Ltd., Edition 5

3. Solid State Physics,
   C.M.Kachhava, Tata Mc Graw Hill Edition.

4. Solid State Physics,
   N.W.Ashcroft and N.D.Mermin. Hol - Saunders International Ed.

5. Solid State Physics,
   L.Azzroff, Tata Mc Graw Hill Edition.

ES 202 : STATISTICAL MECHANICS

1. Specification of the state of system (classical as well as quantum), Phase space, Liouville's theorem, statistical ensemble, accessible states, postulate of equal a priori probability, density of states and its behaviour for ideal monoatomic gas in classical limit, statistical definition of entropy.

2. ENSEMBLES AND THERMODYNAMIC QUANTITIES :

   Microcanonical ensemble, canonical ensemble, Grand canonical ensemble, partition function, evaluation of thermodynamic quantities from partition function, application to ideal gas, Gibb's paradox.

3. FORMULATION OF QUANTUM STATISTICS :

   Density matrix, Liouville's theorem in quantum statistical mechanics, condition for statistical equilibrium, ensembles in quantum mechanics.

4. MAXWELL BOLTZMANN, BOSE EINSTEIN AND FERMI DIRAC STATISTICS :

   Quantum distribution functions, the Boltzmann limit of Bose Einstein and Fermi Dirac gas, evaluation of the partition function, partition function of diatomic molecules, equation of state of an ideal gas.

5. IDEAL BOSE SYSTEM :

   Photon gas, Planck's law, Bose Einstein condensation.

6 IDEAL FERMI SYSTEM :

   Fermi energy, mean energy of Fermion at $T = 0\,^{o}K$, electron gas, Fermi energy as a function of temperature, electronic specific heat.

7. Boltzmann transport equation and its application to electrical conductivity.

REFERENCES :

1. Fundamentals of Statistical and Thermal Physics,
   F.Reif, Mc Graw Hill Company.

2. Statistical Mechanics,
   Kerson Huang, Wiley Eastern Ltd., 1963.

3. Introduction to Statistical Mechanics,
   B.B.Laud, Macmillan, India, 1981.

4. Statistical Mechanics,
   J.E.Mayer and M.G.Mayer, John Wiley, 1940.

5. Statistical Physics, Ed.II
   L.D.Landau and E.M.Lifshitz, Pergamon Press, 1958.

6. Statistical Physics,
   R.K.Pathria, Pergamon Press, 1972.

RS 203 : ELECTRODYNAMICS

1. MAXWELL'S EQUATIONS :

Electrodynamics before Maxwell, modification of Ampere's law, maxwell's equations, magnetic charge, Faraday's law for moving media, maxwell's equations for moving media.

2. ENERGY, FORCE AND MOMENTUM RELATION IN ELECTROMAGNETIC FIELD

Energy relations in quasi stationsry current system, force on a current stystem, Inductance, Magnetic volume force, general expressions for electromagnetic energy-Poynting's theorem.

3. WAVE EQUATION FOR ELECTROMAGNETIC FIELDS :

The wave equations, plane waves, radiation pressure, plane waves in moving media, reflection and refractions at plane boundaries, the waves in conducting media, metallic reflection.

4. THE INHOMOGENEOUS WAVE EQUATION :

Scalar and vector potentials, Gauge transformations, Coulomb gauge and Lorentz gauge, the wave equation for potentials, solution by Fourier analysis, radiation fields, Hertz potential, electric dipole radiation.

5. COVARIANT FORMULATION OF ELECTRODYNAMICS :

Experimental basis for special relativity,. the Lorentz transformations, law of velocity addition, the Lorentz transformation of Four vector, four velocity, four accelaration, four momentum, relation between energy momentum and mass, the Minkowski force, four vectors to charge and potential, electromagnetic field tensor, Lorentz force, invariance of Maxwell's field equations under relativistic (Lorentz's) transformation, covarience and tensor form of Maxwell's field equation, covarience form of Lorentz transformation.

REFERENCES

1. Classical Electrodynamics,Ed.II
W.K.H. Panfsky and M.Philips, Addison-Wesley, 1962.

2. Classical Electrodynamics,Ed.II
J.D.Jackson, Wiley Eastern Company Ltd.,1978.

3. Foundations of Electromagnetic Theory, Ed.II
J.R.Reitz and F.J.Milford, Addison Wesley,1967.

4. Introduction to Electromagnetic Fields and waves,
D.R.Corson and P.Lorrain, Freeman, 1962.

5. Classical Electrodynamics, Ed.II
Griffits, Prentice Hall of India.

6. Electromagnetics, Ed.II
B.B.Laud, Wiley Eastern Ltd.

ES 204 : COMPUTATIONAL METHODS AND COMPUTER PROGRAMMING

I. Some Computer Programming Topics :

Functions and Subroutines, Common Block and Equivalence declarations.

II.Numerical Mehtods in FORTRAN :

In the following topics on numerical methods, students are expected to be able to write programs, subprograms or program segments as well as perform numerical calculations using electronic calculators and mathematical tables.

1. ITERATIVE METHODS FOR SOLUTION OF ALGEBRAIC EQUATIONS

Newton Raphson method, iteration method, method of false position, rate of convergence, comparison of these methods, choice of an iterative method and implementation.

2. SOLUTION OF SIMULTANEOUS EQUATIONS

Direct methods - Cramer rule, Gauss elimination method, pivotal condensation, iterative methods -Gauss Seidal method, Jacobi method.

3. INTERPOLATION

Lagrange and Newton interpolation methods, Finite differnece operators, interpolating polynomials using finite differences, differnece tables- central, forward, backward.

4. NUMERICAL INTEGRATION

Methods based on interpolation, methods based on undetermined coefficients, composite integration methods- Trapezoidal and Simpson's rules, double integration [derivation applications and errors in the formulae, comparison of two formulae].

5. NUMERICAL DIFFERENTIATION

Methods based on interpolation, finite differences and undetermined coefficients

6. SOLUTION OF DIFFERENTIAL EQUATIONS

Numerical methods-Euler's method, Backward Euler method, Single step methods- Taylor series method, Runge Kutta methods, Multistep methods, Stability analysis.

REFERENCES

1. Programming with FORTRAN 77, Ram Kumar, Tata Mc Graw Hill Company.

2. Introductory methods of Numerical Analysis, S.S.Sastry, Prentice Hall of India.

3. Numerical Mathematical Analysis, J.B.Scarborough, Oxford, 1964.

4. Computer Programming in FORTRAN IV, V.Rajaraman, Prentice Hall of India, 1974.

5. Computer Oriented Numerical Methods, V.Rajaraman, Prentice Hall of India.

ES 301 : PHYSICS OF SEMICONDUCTOR DEVICES

1. **PROPERTIES OF SEMICONDUCTORS**

Review of crystal structures and Energy bands of semiconductors (Ge, Si, GaAs, IV-V, III-V, II-VI compound semiconductors), charge carriers, minority and majority carriers, excess carriers and life time, diffusion of carriers and Einstein's relation, Intrinsic and extrinsic semiconductors, Position of Fermi level, degenerate and non-degenerate semiconductors, carrier concentration in degenerate and non-degenerate cases, current transport, internal field in a semiconductor with non-uniform doping.

2. **MEASUREMENT OF ELECTRICAL PARAMETERS OF SEMICONDUCTOR**

Resistivity, mobility, carrier concentration, carrier types by Hall effect, Haynes-Schockley experiment-mobility, diffusion constant and life time of minority carriers.

3. **P-N JUNCTION DEVICES**

The junction diode : Junction in equilibrium, junction with forward and reverse bias, current-voltage characteristic of junction diode, electron hole injection efficiency, the geometry of the depletion layer, depletion layer capacitance, diffusion capacitance, Small signal equivalent circuit of a P-N junction, switching characteristic, Breakdowns in P-N junctions.

Zener Diode : Reverse bias breakdown, principle of operation, device design for particular breakdown voltage.

Varactor Diode : Capacitance of p-n junction, principle of operation, equivalent circuit, power relation, applications.

Tunnel Diode : Degenerate semiconductors, principle of operation, circuit operation, applications as an oscillator.

P-I-N Diode : Intrinsic layer, principle of operation behaviour of forward and reverse bias, equivalent circuit, applications.

4. **METAL-SEMICONDUCTOR JUNCTION DIODE**

Structure, metal-semiconductor contact, energy band diagram for different cases, barrier formation, Schottky diodes-principle of operation, current transport theory and applications.

5. **BIPOLAR JUNCTION TRANSISTOR**

Structure, the principles of operation, the Ebers-Moll equations and large signal transistor model, the dependence of Ebers-Moll parameters on the structure and operating point, maximum transistor current, voltage and power rating, transistor as a switch.

6. **FIELD EFFECT TRANSISTOR**

JFET, Principle of IGFET, MOS capacitor, MOS transistor operation, charge coupled devices (CCD), MOS transistor as a memory elements.

7. **POWER SEMICONDUCTOR DEVICES**

General consideration, bipolar power transistor, thyristor family - the SCR , diac and triac.

8. **NEGATIVE CONDUCTANCE MICROWAVE DEVICES**

IMPATT devices - Read diode, principle of operation, applications, other structures.

GUNN devices - two valley semiconductors, transferred electron mechanism, formation and drift of space charge domain, applications in resonant circuits.

REFERENCES

1. Solid State Electronic Devices
B. G. Streetman, Printice Hall of India

2. Semiconductor and Electronic Devices
Adhir Bar-Lev, Printice Hall of India.

3. Physics of Semiconductor Devices
S.M.Sze, Wiley Eastern Ltd.

4. Semiconductor Devices and Circuits
Henry Zanger, John Wiley and Sons.

5. Physics of Microwave Semiconductor Devices and their application
H.A.Watson

RS 302 : ATOMIC AND MOLECULAR PHYSICS

1. ATOM MODEL FOR TWO VALENCE ELECTRONS

ll coupling, ss coupling, LS coupling, Pauli exclusion principle, coupling schemes for two electrons, Ψ factors for LS coupling, Lande interval rule, j j coupling branching rule, selection rules, intensity relations.

Magnetic moment of the atom, Zeeman effect, intensity rules, calculation of Zeeman pattern, Paschen back effect - LS and jj coupling and Paschen back effect, Breits scheme for derivation of spectral terms, Pauli's exclusion principle.

2. COMPLEX SPECTRA

Displacement law, alteration law of multiplicities, vector model for three or more valence electrons, Lande interval rule, inverted terms, Hund's rule.

Zeeman effect and magnetic quantum nos. in complex spectra, magnetic energy and Lande g factor, Paschen back effect in complex spectra.

3. HYPERFINE STRUCTURE-

Introduction, hyperfine structure, and Lande interval rule, nuclear interaction with one valence electron, hyperfine structure of two or more valence electrons, Zeeman effect in hyperfine structure, Back Goudsmit effect in hyperfine structure.

4. PURE ROTATION SPECTRA

Rotation of a linear system (classical and quantum mechanical), rigid rotator, rotational energy levels and their populations, interaction of radiation with rotating molecules, rotational spectra of rigid rotators, selection rules for linear molecules, determination of moment of inertia and bond length from rotational spectra, relative intensities of spectral lines, Stark effect in molecular rotational spectra, molecular rotation-nuclear spin coupling.

5. VIBRATIONAL SPECTRA

Vibrations of a single particle, vibrations of two particles connected by a spring (classical), Harmonic oscillator, vibrational energies of diatomic molecules, interaction of radiation with vibrating molecules, vibrational spectra of diatomic molecules, unharmonic oscillator, deduction of molecular properties from vibrational spectra of diatomic molecules.

6. ROTATION - VIBRATION SPECTRA

Diatomic vibrating rotator coupling of rotation and vibration, rotation-vibration spectra, selection rules and transitions for the vibrating rotator, intensities in rotation and vibration spectrum, Parallel and perpendicular bands of Linear molecules, Isotope effect-vibration, rotation.

7. ELECTRONIC SPECTRA OF DIATOMIC MOLECULES

Electronic energy, potential energy curves, stable and unstable moleculer states, vibrational structure of electronic transitions, general formula, graphical representation, isotope effect, rotational structure of electronic spectra, the branches of band, band head formation, shading of bands: Fortrat diagram, isotope effect, intensities in electronic bands-vibrational structure- Franck condon principle, absorption and emission, rotational structure, transition.

REFERENCES

1. Atomic Spectra - White H.E.
   (for topic 1 to 3)

2. Introduction to Molecular Spectroscopy - C.M.Barrow
   Mc Graw Hill ,International Edition (for topic 4 to 6)

3. Spectra of diatomic molecules - Hersberg
   (for topic 7)

4. Atomic structure and chemical bond - Manas Chanda
   Mc Graw Hill

ES 3Ø3: GLOBAL AND INDIA ENERGY SCENARIO

1. Importance of energy in the modern industrial society.
2. Energy utilization,demand pattern in the different countries.
3. Commercial and non-commercial energy resources.
4. Fossil Fuels : Coals, Oil ,Natural gas, Nuclear energy (their resources, demand and techniques for conversion)
5. Energy crisis.
6. Thermonuclear energy.
7. Hydropower and its potential.
8. Indian energy scene.
9. Alternative energy resources for future.
10. Energy and Environmental pollution.
11. Energy policy issues.

REFERENCES

1. Energy for a sustainable world: Jose Goldemberg,Thomas B. Johensson, Amulya K. Reddy and Robert H. Williams, Willey Eastern Ltd.,(1988).
2. ERG Review Series,Ed: Ashok Desai,Willey Eastern Ltd.(199Ø).
3. Patterns of Energy use in developing countries,Ed. M Ali Kettani; ERG Review Series; Willey Eastern Ltd.
4. How industrial societies use energy: J. Darmstadter, J. Dunkerley and J.Alterman; John Hopkins University Press.

ES 304: SPECIAL LABORATORY I

1. Study of magnetic susceptibility in liquids.
2. Study of magnetic properties of MnSo4 (Guoy Method)
3. Determination of Hall coefficient of a given sample.
4. Study of Electron Spin Resonance.
5. To study the intensity of Beta rays as they pass through different thickness of alluminium and to determine the linear absorption coefficient.
6. Study the characteristic of a GM tube and determination of its operating VOLTAGE.
7. Characteristic of solar cell Voc, Isc, Rs, dark/illuminated, temparature dependance,spectral distribution,CV measurement.
8. Refractive index measurement by Emulsion technique.
9. Study of Haynes Schokley experiment for the determination of mobility and diffusion constant.
10. Comparison black body and solar energy radiation.
11. Analysis of wind data.
12. Study of Storage batteries.
13. To find the efficiency of DC-AC converter.
14. Electrochemical dissociation of H_2O
15. Seeback measurement and conductivity measurements.
16. Study Hysterisis curve.

ES 401 : SOLAR ENERGY CONVERSION -I

1. SOLAR ENERGY

Importance of Solar energy; Nature of Solar radiation, Sun as a fusion reactor, Spectral distribution of Solar radiation, seasonal variation in the solar radiation, measurement of global and diffuse solar radiation, different routes to convert solar energy into different forms.

2. SOLAR THERMAL DEVICES

Basic principles, different types of solar collectors, energy balance equation, heat losses and efficiency of the solar collector. Solar cooker, domestic hot water systems, industrial hot water system, Solar dryers, Solar pond, Solar disalination, Solar furnace, Solar refrigeration, Solar power generation.

3. FLAT PLATE COLLECTORS

Theory of flat plate collectors, energy balance equation, evaluation of heat losses and efficiency of solar collectors.

4. SELECTIVE COATING FOR SOLAR THERMAL DEVICES

Ideal characteristics of selective coating. different types of selective coating materials and techniques for making selective absorbers, effect of selective coating on the efficiency of solar thermal collectros.

5. SOLAR COLLECTORS

Point focus, Line focus, Solar concentrators, cylindrical, paraboloid, compound paraboloid type Solar concentrators, fresnel lens, theory of solar concentrators and their efficiency, application of solar concentrators.

6. THERMAL ENERGY STORAGE

Sensible and latent storage systems, chemical energy storage systems, heat exchangers.

7. Design aspects of solar thermal systems

REFERENCES

1. Sun power - J.C.Hveigh, Pergamon Press, 1983
2. Solar Energy Engineering - A.A.M.Sayigh, Academic Press, 1977
3. Solar Energy Thermal Processes- J.A.Duffie and W.A.Beckmann, Wiley Inter Science, 1980
4. Solar Energy Conversion - J.D.Dixon and A.E.Lesile, Pergamon
5. Solar Energy - S.P.Sukhatme, Mc Graw Hill Company.
6. Principles of Solar Engineering - F.Kreith, J.F.Kreider, Mc Graw Hill, 1978

ES 402 : SOLAR ENERGY CONVERSION - II

1. **PHOTOVOLTAIC DEVICES**

Basic Principles, photovoltaic effect and its applications to conversion of solar energy into electricity, photovoltaic materials and their characterization, dark and illuminated characteristics of solar cells, use of homo-junction heterojunction, Schottky barriers for solar cells.

2. **SOLAR CELL TECHNOLOGY**

Fabrication of single crystal silicon solar cell starting from raw silicon

3. **OTHER MATERIALS FOR SOLAR CELL**

Polycrystalline GaAs solar cells, amorphous Si solar cells, preparation, characterization and technology, thin film solar cells, CdTe, CdS, CuInSe2,tandom solar cells

4. **PHOTOVOLTAIC SYSTEMS:**

Basic components of the system, PV street light, radio, TV, PV pump, PV power system.

5. **Storage batteries for photovoltaic systems**

6. **WIND ENERGY**

Energy available from wind, velocity and power duration curve, various types of wind mills and wind farm.

7. **BIO-ENERGY**

Bio-mass as a source of energy, different types of biomass for energy use.

8. **BIO-CONVERSION**

Pyrolysis, combustion and gasification, liquid fuels, aerobic and anaerobic digestion, biogas production from animal waste, human waste and industrial waste.

9. **HYDROGEN ENERGY**

Properties of hydrogen as source of energy, source of hydrogen, thermodynamics of water splitting, photoelectrolysis of water,direct thermal decomposition of water, thermochemical production of hydrogen, biological and biochemical methods.

REFERENCES

1. Solar Cells - Marteen Green
2. Fundamentals of Solar cells - A.H.Faharenbrouch, R.H.Bube Academic press
3. PV devices - Jonston
4. Thin Film Solar Cells -
5. Solar Energy Conversion - A.E.Dixon and J.D.Leslie Pergamon Press
6. Biomass - D.O.Hall

ES 403 : ENERGY MANAGEMENT AND CONVERSION

1. General principle of energy management.
2. Planning for energy management.
3. Management of heating and cooling.
4. Electrical load and lighting management.
5. Process energy managemnt.
6. Energy audit and energy efficiency analysis.
7. The economics of energy.efficient use.
8. Energy conservation in boilers, process heating, burners. furnaces, electrical and mechanical devices.
9. Waste heat recovery techniques.
10. Energy saving through use of alternative energy resources.

REFERENCES

1. Managing energy in commerce and industry - Gordan A.Payne, Buteerworths,1984

ES 404 : SPECIAL LABORATORY :

1. To determine pumping speed of rotary pump.
2. Thin film deposition by evaporation method.
3. Calorific value of fuel.
4. Efficiency of wood stone.
5. Study of solar still.
6. Study of flat plate collector.
7. Study of hot air collector.
8. Study of biogas plant.
9. Study of selective coating measurement of **alpha** and **epsilon**.
10. Properties of transparent conductive coating - sheet resistance ,visible transmittance, UV/IR, XRD.
11. Study of solar dryer.
12. Efficiency of improved chulla.
13. Experiments of Gasifier.
14. Thermograph of biomass.
15. To find temparature distribution for fin tube absorber.
16. Study of photoelectrochemical solar cell.
17. Electroplating and study of adhesionporosity and etching.
18. Experiments on He-Ne Laser :

    i) Study of power distribution within Laser beam and determine the Laser beam quality.

    ii) Study of beam divergence and beam diameter.

    iii) Study of pointing stability.

    iv) Study of depth of focus of a lens.

    v) Study of focus spot size.