M.Sc. (Final) Physics-Energy

Paper-: V- Advanced Quantum Mechanics & Quantum field Theory

Time-: 3 hrs. **Marks-: 100**

Note: Ten questions will be set in the question paper taking two from each unit. Candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal marks.

Unit-I

Scattering (Non-relativistic)-: Differential and total scattering cross section, solution of scattering problem by the method of partial wave and analysis, expansion of a plane wave into a spherical wave and scattering amplitude, optical theorem and its applications (scattering from the delta potential, square well potential and hard sphere), scattering of identical participles, energy dependence and resonance scattering, Breit Wigner formula, quasi stationary state, Lippman Schwinger equation and the Green's function approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

Unit-II

Relativistic Formulation and Direct equation: Attempt for relativistic formulation of quantum theory, Klein-Gordon equation, probability density and probability current density, solution of free particle K.G. equation in momentum representation, interpretation of negative probability energy solutions, Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction), Solution of the free particle, Dirac equations, orthogonality & completeness relation for Dirac spinors, interpretation of negative energy solutions & hole theory.

Unit-III

Symmetries of Dirac Equation: Lorentz boost, Lorentz covariance of Dirac equation, Proof of covariance & derivation of Lorentz transformation matrix and rotation matrices for Dirac spinors, projection operators involving four momentum & spin, parity (P), charge conjugation (C), time reversal (T) and CPT operators for Dirac spinors, bilinear covariants and their transformation behaviour under Lorentz transformation, P, C, T & CPT, expectation values of coordinate & velocity involving only positive energy solutions, Zitter Bewegung, Klein paradox.

Unit-IV

Photon as a quantum mechanical excitations of radiation field, fluctuations and the uncertainty relation, validity of classical description, matrix element for emission and

absorption, spontaneous emission in the dipole approximation, Rayleigh scattering, Thomson scattering & Raman effect, Radiation damping & resonance florescence.

Quantum Field Theory:- Scalar and vector fields, Classical Lagrangian field theory, Euler Lagrange's equation, Lagrangian density for electromagnetic field, occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, second quantization of systems of identical bosons, second quantization of real Klein-Gordan field and complex Klein-Gordan field, meson propagator, second quantization of systems of identical bosons, second quantization of real and complex Klein-Gordan field.

Unit-V

Occupation number representation for Fermions, second quantization of the Dirac field, Fermion propagator the e.m interaction & guauge invariance, covariant quantization of the free electromagnetic field, photon propagator.

S-Matrix: S-matrix expansion, Wick's theorem, diagrammatic representation in configuration space, momentum representation, Feynmann rules of QED, Feynmann diagrams of basic processes, Application of s-matrix formalism, coulomb scattering Bhabha scattering, Moller scattering, Compton scattering and pair production.

References:-

1.Quantum mechanism, A modern approach-Ashok das & A.C. Milissioes (Garden & Beach Science Pulishers).
2.Quantum Mechanics (second edition)-E. Merzbeker (John Wiley)
3.Relativistics Quantum Mechanics -Bjorken &Drell (Mc Graw hill)
4.Advance Quantum Mechanice-J.J.Sakurai(John Wily & Sons)
5.Quantum mechanics-Thankpapn V.K.(Wiley Eastern ltd. New Delhi)
6.Quantum fied Theory-F. Mandal & G Shaw (John Wiley)
7.Elements of Advance Quantum Theory- J.M. Ziman (Cambridge)
8.Quantum Mechanics -Kakani(Sultan Chand)

Paper: VI – Nuclear Physics

Time-: 3hrs. **Marks: 100**

Note-: Ten questions will be set in the question paper, taking two from each unit candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal marks.

Unit-I

Two Nucleon System and Nuclear Forces: General nature of the force between nucleons, saturation of nuclear force, charge independence & spin dependence, general forms of two nucleon interaction, central, non-central & velocity dependent potential, analysis of the ground state ($3s_1$) of deuteron using a square well potential, range depth relationship, excited states of deuteron, discussion of the ground state of deuteron under non central forces.

Unit-II

Nucleon-Nucleon Scattering & Potentials: Partial wave analysis of two neutron-proton scattering at low energy assuming a central potential with square well shape, concept of the scattering length, Coherent scattering of neutrons by protons in (ortho & para) hydrogen molecule, conclusion of these analysis regarding scattering lengths, range & depth of the potential, effective range theory (in neutron-proton scattering) and shape independence of nuclear potential, A qualitative discussion of proton- proton scattering at high energy, hard core potentials and Real hard core and soft core potentials, main features of the one boson exchange potential (OBEP)(on derivation).

Unit-III

Nuclear shell Model: Single particle & collective motions in nuclei, assumption & justification of the shell model, average shell potential, spin orbit coupling, single particle wave functions and level sequence, magic numbers, shell model predictions for ground state parity, angular momentum and their comparison with experimental data, configuration mixing, single particle transition probability according to the shell model selection rules, approximate estimates for transition probability and Weisskopf units, nuclear isomerism.

Collective nuclear models: Collective variables to describe the collective models of nuclear motion, Parameterization of nuclear surface, A brief description of the collective model, Hamiltonian (in the quadratic approximation), vibrational model of spherical nuclei, collective modes of deformed even-even nucleus and moments of inertia, collective spectra and electromagnetic transitions in even nuclei and comparison with experimental data, Nilsson model for the single particle states in deformed- nuclei.

Unit-IV

Nuclear Gamma & Beta Decay: Electric & Magnetic multipole moments and gamma decay probabilities in nuclear system (no derivation), reduced transition probability, selection rules: internal conversion & zero transition.
General characteristics of weak interactions, nuclear beta and lepton capture, electron energy spectrum and Fermi-Kurie plot. Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow Teller) for allowed transitions, general interaction Hamiltonian for beta decay with parity conserving and non conserving terms, forbidden transition, experimental verification of parity violation.

Nuclear Reactions: Theories of nuclear reactions, partial wave analysis of reaction cross section: compound nucleus formations & break-up resonance, scattering & reaction, Breit Wigner dispersion formula for s-wave (l=0), continuum cross section: statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions, electric quadruple & magnetic dipole moments, state mixture.
The optical model, stripping and pickup reactions and their simple theoretical description (Butler Theory) using plane wave Born approximation (PWBA), short coming of PWBA nuclear structure, studies with deuteron proton (d,p) stripping reaction.

Unit-V

Interaction of Neutrons, EM Radiation and Charged Particles with Matter: Law of absorption and attenuation coefficients, slowing down & law for neutron capture, photoelectric effect, Compton Scattering, pair production, Klein Nishima cross section for polarized & unpolarized radiation, angular distribution of scattered photon & electrons, energy loss of charged particles due to ionization, Bremsstrahlung energy, target and projectile dependence of all three processes, range energy curves, straggling.

Experimental techniques: Gas filled counters, BF counter, scintillation counters, solid state detectors, surface barrier detectors, neutron activation detector, electronic circuits used with typical nuclear detector properties, chambers, Nuclear emulsions techniques of measurement and analysis of tracks, proton synchrotron, electron accelerator and neutron generators, acceleration of heavy ions.

References:

1.Theoretical Nuclear Physics: J.M. Blatt & V.E. WeissKipf.
2.Introductory Nuclear theory: -L.R.B. Elton, ELBS Publs. Londan 1959.
3.Nuclear physics:- B.K. Agarwal, Lok Bharti Prakashn. Allahabad 1989.
4.Nuclear Structure: -M.K.Pal, affiliated East West Press,1982.
5.Nuclear physics:- R.R. Roy & B.P. Nigam. Willy Basten, 1979
6.Structure of the Nucleus: - M.A. Preston & R.K.Bhaervi, Addision Wesley.
7.Introucttion to Experimental: - R.M.Singru Wiley Easten pvt. Ltd.
8.Nuclear Physics:- Techniques of Nuclear Structure (vol. I) England.
9.The Atomic Nucleus :- R.D. Evans Mc Graw Hill, 1955.
10.Introduction to Nuclear Physics:-H.Enge.Addision Wesley.
11.Elements of Nuclear Physics:- W.E.Burcham, ELBS Longman.
12.Concepts of Nuclear Physics:- B.L. Cohen, Tata Mc Graw Hill,1988.
13.Nuclei & Particles -E.segre, Benjamin 1972.
14.Nuclear Physics:- L.Kaplan ,Addi Wesley 1963
15.Introductory Nuclear Physics:-D.Halliday Willey 1955
16.Introduction of Nuclear Physics & Chemistry :-Harvey.
17.The Physics of Nuclear Reactions :-W.M.Gibson,Pergamon Press.
18.Nuclear Interaction:- S.De Benedetti, Wiley 1955.

Paper-: VII- Solid state Physics

Time-: 3hrs **Marks: 100**

Note-: Ten questions will be set in the question paper, taking two from each unit candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal marks.

Unit -I

Lattice Vibrations and Thermal Properties: Lattice specific heat, theoretical estimates of Einstein and Debye temperatures, Wave mechanics of phonons, Elastic waves and lattice vibration in one dimensional crystal, Long range forces and the reciprocal lattice method, Lattice vibration of a diatomic linear chain, Dispersion relation for three dimensional crystals, Born- Von Karmon boundary conditions and density of states, Experimental observation of phonon frequencies, equation of state of the crystal lattice, Thermal Conductivity of insulators.

Unit-II

Theory of Metals: Fermi Dirac Distribution Function, density of states, temperature dependence of Fermi energy, Specific heat, Boltzmann equation and mean free path, relaxation time and scattering processes, thermal conductivity and electrical conductivity (using F-D statistics).
Widemann- Franz ratio, susceptibility, Drude's theory of light absorption in metals, Hall effect.

Band theory of metals: Bloch theorem, Kronig-penny model, Effective mass of electrons. Wigner-seitz approximation, nearly free electron model tight binding method and calculation of density of states for S-band in simple cubic lattice, Cyclotron Resonance and Hall effect, De Hass van Alphen effect, Experimental methods in determination of band structure, Limitations of band theory.

Unit-III

Semiconductors: Law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect recombination mechanism, Optical transitions and Shockley Read theory, excitons, photoconductivity, photo luminescence.

Nano-Science and Nano-Technology: Introduction to nano-science, nano-technology and nano-materials, evolution of nano-technology from micro-technology.

Imperfection in solids: Point, line planer defects, colour centers, F-Centre and aggregate centers in alkali halides, John Teller effect, Single crystal growth, crystal whiskers.

Unit-IV

Magnetism: Larmor diamagnetism, paramagnetism curie Langevin classical theory, Quantum theory of paramagnetism, susceptibility of rare and transition metals, Ferromagnetism: Weiss theory and Quantum theory of Ferromagnetism, origin of domains, Bloch Walls, Anti ferromagnetism, Ferrites, Magnons, magnetic resonance, Nuclear magnetic resonance, magnetic materials.

Superconductivity: Electromagnetic Properties, Thermal properties, isotope effect and electron phonon interaction, microscopic theory of superconductivity, Mc Millan's formula (no derivation), High temperature superconductivity in cuprates, fullerences (basic ideas), Organic supper conductors (basic ideas), Superconducting tunneling, application of super conductivity.

Unit-V

Quantum Statistics and Elementary Excitations of Electron Gas: Simple harmonic oscillator, Annihilation and creation Operators, coupled oscillators, linear chain, Bosons, Fermions, second Quantization, Hamiltonian for two particles, Fermions Boson Interaction, Landau theory of Fermi liquids.
Group theory: Group. Group Multiplications table, Representation of group (i) Representation of the triangle group (ii) Representation of the space group of a crystal.(iii) Normal modes of vibration of O3, molecule.

References:-

1.Intermediate Quantum theory of solids- A.D.E.Animalu,(Prentice Hall).
2.Solid state Physics-Kittel,(john Wilye 7^{th} ed.).
3.Quantum theory of Soilds- Kittel,(John Wiley).
4.Soild State Physics Source books- S.P.Parker,(Mc.Graw Hill).
5.Soild State Physics- Harrison, (Banjamin Press).
6.Quantum Solid State Physics-S.V.Vonsovsky & M.I.katsnelson,(Springer Verlag)
7.High.T. Superconductivity- Sinha,(Nova Science,New York USA)
8.Soild State Physics-Kakani,(Sultan Chand).
9.Superconductivity-key Prodlem-Kaklioi,(Arihant).
10.Nano-Science & Nano Technology-Retner-Retner.
11. Nano: The essentials: T. Pradeep, Tata Mraw Hill Publishing House, New Delhi.

Paper-VIII Energy

Time-: 3hrs **Marks:- 100**

Note: Ten questions will be set in the question paper. taking two from each unit candidates are required to attempt five questions in all selecting at least one question from each unit. All questions will carry equal mark.

Unit-I

Hydroelectric Power Generation: Principles, construction types, system components, energy conversion chain, losses and power curve.

Nuclear Energy: Nuclear sources and amounts of nuclear radiation, nuclear (thermal reactors), Fast breeder reactor, reactor safety.

Unit-II

Solar Photovoltaics: Silicon material, ribbon silicon, production of junctions, oxidation process, high efficiency solar cells, bifacial solar cells, laser fired contact cells; basic components of thin film solar cell, Si deposition on glass and high temperature resistant substrates; thin film materials- amorphous silicon, copper indium diselenide, tandem cells, organic solar cells, auger generation materials.
Characteristic curves of solar cell, module technology, electrical output properties of solar cells, SPV water pumping.

Unit-III

Solar Thermal Energy Conversion: Solar radiation; liquid flat plate collectors - performance analysis, collector efficiency factor, collector heat removal factor, parametric analysis, testing procedures, applications; evacuated tube collector.
Concentrating collectors: Flat plate collectors with reflectors, cylindrical parabolic collector, compound parabolic collector, parabolic dish collector, central receiver collector; Solar thermal power generation.

Unit-IV

Wind Power Generation: Physical principles, technical description of generation system, energy conversion, losses and characteristic power curve, power control, hybrid systems.

Energy Storage: Thermal (heat and cold), Chemical, Mechanical and Electrical Energy storage, Impacts on environment due to conventional and non-conventional sources of energy.

Unit-V

Laser Plasma Physics: Basic properties of plasma, importance of plasma for accelerating, charges particles, propagation of electromagnetic waves in plasma and their dispersion relation, plasma oscillations and plasma waves, elementary laser theory, pulsed laser (frequency comb, carrier envelope phase, representation of laser pulses), laser absorption in plasma, waves in laser produced plasma, laser induced electric field in plasma.

References:-

1. Energy Management: W.R.Murphy.G.Mekay (Butterworths).
2. Efficient Use of Energy: I.G.C.Dryden (Butterworth Scientific).
3. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
4. Renewable Energy: M. Kaltschmit, W. Streicher, A. Wiese, Springer 2007.
5. Energy policy for India: B.V. Desai (Weiley Eastern).

6. Modeling approachto long term demand and energy implication: J.K. Parikh.
7. Energy Economies: A.V. Desai (Wieley Eastern).
8. Principles of Energy Conversion: A.W. Culp.
9. Direct Energy Conversion: M.A.kettani.
10. Energy Conversion systems: Begamudre, Rakoshdas.
11. Renewable Energy Sources and Conversion Techonology: N.K. Bansal, M.K. Kaleemann.
12. Principles of Solar Thermal Process: Duffic and Beckman (J. Wiley).
13. Power Generation Through Renewable Sources of Energy: B.R.Pai,M.S.Ramprasad (Tat Mcgraw Hill).
14. Solar Power Engineering: B.S. Mangal (Tata-Mcgraw Hill).
15. Environmental Impact Analysis Handbook: J.C.Rau,D.C.Wood (Mcgraw Hill).
16. Introduction to plasma physics: F.F. Chen
17. Interaction of high power laser with plasma: Shalom Elizer, IOP.
18. Photovoltaic Solar Energy Conversion: A. Goetzberger, Springer.
19. Energy studies, Second Edition, W. Shepherd, World Scientific, Singapore.

PRACTICALS

Time: 12hrs **Marks: 200**

Scheme:
The examination will be conducted for two days, 6 hrs. each day. The distribution of the marks will be as follows.

A. Two experiments	100 marks (50 marks each)
B. Seminar (Write up is to be prepared and submitted with reference)	25 marks
C. Record	25marks
D. Viva voce	25marks
E. Project/field Work	25marks
Total	200 MARKS
Minimum Pass Marks	**72 marks**

List of Experiments:

1. Determinc fine structure constant using sodium doublet
2. Verify Cauchy's relation & determination of constants.
3. To determine e/m for an electron by Zeeman effect.
4. Determine the dissociation energy of lodinc molecule.
5. Study of characteristics curve of Klystron.
6. Determine the dielectric constant of turpentine oil with the help of Leacher wire system.
7. Determination of energy of a given ray from Re-De source.
8. Find out the percentage resolution of given scintillation spectrometer using Cs-137.
9. Find out the energy of a given X-ray source with the help of a scintillation spectrometer.

10. Plot the Gaussian distribution curve for a radioactive source.
11.To study the frequency and phase characteristics of band pass filter.
12.study the waveform characteristics of transistorized astable symmetrical multivibrator using CRO & determine its frequency by various C & R
13. Artificial transmission line.
14. To study the mode characteristics of reflex Klystron and hence to determine mode number,
15. Transmit time, Electronics, Tunning range, electronic tunning sensitivity.
16. Determine the dielectric constant of Benzene using plunge technique at room temperature.
17. To determine the unknown impedance using slotted line section smith chart in the k-band.
18. To study the microwave adsorption in dielectric sheets.
19. To determine e/m of an electron by magnetron value method.
20. To determine the velocity of waves in water using ultrasonic interferometer.
21. To determine the magnetic susceptibility of two given samples by Gouy's method.
22. Determination of Land 's 'g' factor for **IRRH** crystal using electron spin Resonance spectrometer.
23. To determine e/k using transistor characteristics.
24. To study dark and illumination characteristic of p-n-junction solar cell and to determine
(i) Its internal series resistance (ii) Diode ideality factor. **(**
25. To study the characteristics of following semiconductor devices.
(i) VDR (ii) photo transistor (iii) Thermistor (iv) IED
26.To study the characteristics of MOSTET and MOSFET amplifier.
27. To study dark and illumination characteristics of p- n- junction solar cell and to determine its.
28. Characteristics of efficiency of Solar cell.
29. Thermal conductivity of non- conducting materials.
30. Any other experiments of the equivalent standard can be set.

Energy Experiment:-

1. Determination of efficiency of boiler and analysis of flue gases.

2. Heat balance of the furnace and determination of efficieney.

3. COP for air- conditioning and refrigeration system.

4. Study of heat exchangers.

5. Study of variable speed drives.

6. COP of cooling towers.

7. Efficiency of electrical motors.

8. Study of diesel generator set.
9. Measurement of load and power factor for the electrical utilities.
10. Determination of efficiency of pumping system.
11. Performance evaluation of blower.
12. Performance evaluation of air compressors.
13. Determining efficiency of lighting system/loads.
14. Study of solar collector- efficiency Vs/AT/I.
15. Study of hot water system.
16. Determination of heat loss coefficients in flat plate collector.
17. Study of solar hot air collector/solar dryer.
18. Study of solar still.
19. Study of vacuum tube collectors.
20. Performance evaluation of box type and concetrating type solar cooker.
21. Study of heat pipe.
22. Power Vs. load characterisitics of SPV system.
23. Variation of power output with intensity of solar radiation and load.
24. Determination of efficiency of SPV water pump.
25. Determinationof efficiency of DC/AC inverter.
26. Vartiation of diesel replacement with load in gasifiers.
27. Study of bio-gas plant.
28. Study of storage battery-charging, discharging characterisites and maintenance.
29. Wind power and annual energy estimation from wind data.
30. Pay back analysis, financial work sheet of a renewable energy project.