VEER NARMAD SOUTH GUJARAT UNIVRSITY
DEPAREMENT OF PHYSICS
SURAT- 395007 (GUJARAT)
Revised syllabus (Effective from June-2011)
M.Sc.(PHYSICS)
Structure for Semester IV

FOURTH SEMESTER:

Course No.	Title	Theory\ lab Hours per Week			Marks		
		Theory	Tutorial	Total Hours	External	Internal	Total
PH-541	Subatomic Physics	04	01	05	70	30	100
PH-542	Atomic and Molecular Physics	04	01	05	70	30	100
PH (E)-543	Microelectronics	04	01	05	70	30	100
PH(E)- 544	Electronic Communication	04	01	05	70	30	100
PH(M)-543	Properties of Materials	04	01	05	70	30	100
PH(M)-544	Techniques for Material Science	04	01	05	70	30	100
PH(T)-543	Advanced Quantum Mechanics	04	01	05	70	30	100
PH(T)-544	Group theory and Quantum Theory of field	04	01	05	70	30	100
PH-545	Practical	09	01	10	140	60	200

Practicals: Practicals and Projects work will be given in the Laboratory Work.

DISTRIBUTION OF INTERNAL MARKS:

For each Theory Papers :	Weightage of Marks
1. One Unit Test per Semester	20
2. One Tutorial Test per Paper Per Semester	05
3. One Assignment per Paper Per Semester	05
Total	30

For each Practical Course :	Weightage of Marks
1. One Practical Test per Semester	40
2. Assessment of Journal Per Semester	20
Total	60

M. Sc. (Physics): Semester-IV

PH-541: Sub-Atomic Physics

UNIT-1

Brief history: developments in nuclear and particle physics. Fundamental interactions, classification of particles: fermions, bosons, leptons, hadrons (mesons and baryons), excited states, resonances.

Nuclear properties: nomenclature, symbols, charge, mass, charge and potential radii, spin, statistics, isospin, magnetic dipole moment, electric quadrapole moment, binding energy

Nuclear force: saturation property, charge independence, exchange forces, tensor force, symmetry and nuclear force, low energy n-p and p-p scattering, low energy scattering parameters, nuclear potential, Intermediate bosons.

UNIT-2

Nuclear Models

Liquid-drop model: semiempricial mass formula, nuclear stability

Fermi-Gas Model; *Single Particle Shell Model*: evidence of shell structure, magic numbers, Spin-orbit coupling, parity, spin and moments of nuclear ground states, Schmidt lines,

Collective Models: evidence for collective motion, brief introduction to vibrational and rotational states, single particle motion in deformed potential.

UNIT-3

Gamma Transitions: Measurement of life-times of excited states, theoretical predictions of decay constants, selection rules, angular correlation, internal conversion.

Alpha Decay: Barrier penetration, reduced widths of alpha unstable states, energy levels.

Beta Decay: Fermi theory of beta decay, Kurie plots, comparative half-lives, selection rules, electron capture decay, parity violation in beta decay, double beta decay.

UNIT-4

Nuclear Reactions: Theories of nuclear reactions, partial wave analysis of reaction cross-section, Compound-nucleus (CN) formation and breakup, resonance scattering and reaction, optical model of particle induced nuclear reactions, direct reactions- theory of stripping reactions, Spontaneous fission, induced fission, fission theories, heavy-ion reactions.

UNIT-5

Symmetries: continuous symmetry transformations, symmetry and degeneracy, conservation laws, parity, charge conjugation and time reversal, CPT theorem (statement), Permutation symmetry, Isospin, G-parity, strangeness and other quantum numbers. CP Eigenstates of K^0, Strangeness oscillation, Violation of CP invariance, Semi-leptonic K^0 decays.

UNIT-6

Standard Model: quarks and leptons, static quark model of hadrons, magnetic dipole moment of baryon octet, hadrons mass and quark–quark interaction. Weak isospin and color symmetry,guage bosons, dynamics of guage particles and symmetry breaking, QCD and confinement. Cabbibo angle and the GIM mechanism, CKM matrix, Higgs bosons

Beyond standard model: grand unification, supersymmetry (SUSY), gravity, supergravity and superstrings.

Recommended Books

1. H.A. Enge, Introduction to nuclear Physics, Addison Wesley, 1982.
2. A. Das and T. Ferbel, Introduction to Nuclear and Particle Physics, 2nd ed. World Scientific, 2003.
3. S.S.M. Wong, Introductory Nuclear Physics, PHI, 2002.
4. M.P. Khanna, Introduction to Particle Physics, PHI, 2004.
5. W.E. Burcham and M. Jacobs, Nuclear and Particle Physics, Addison, Wesley, 1998.
6. D.H. Perkins, Introduction to High Energy Physics, Addison Wesley, 1987.
7. B. L. Cohen, Concepts of Nuclear Physics, TMGH, 1984
8. Y. R. Waghmare, Introductory Nuclear Physics, Oxford-IBH, 1981

Theory Tutorials
PH-541: Sub-Atomic Physics
(Discussion and problem solving sessions)

1. Calculation of nuclear binding energy.
2. Shell model, collective model.
3. SU(2), SU(3)
4. Quarks, charge, mass, flavour, colour etc.
5. About W^+ and Z bosons.
6. Idea of parity and its violation.
7. Exoergic and endoergic reactions.
8. Idea of basic interactions and their unification.
9. Application of carbon dating C^{14}.
10. Idea of radioactive sources, their production.
11. Use of radioactive sources in industry and other branches of science.
12. General properties of Nuclear forces.

M.Sc. (PHYSICS): SEMESTER- IV

PH-542: Atomic and Molecular Physics

UNIT-1:

One-electron atoms, The Schrödinger equation and its solution, energy-levels and Eigen- -Functions, special hydrogenic systems, interaction of one-electron atoms with electromagnetic radiation, the dipole selection rules. Fine structure of hydrogenic atoms The Lamb shift and its determination, Hyperfine structure and isotopic shifts; Atomic unit system

UNIT-2

Schrödinger equation for Two-electron atoms - the role of Pauli exclusion principle, Energy levels of He atom. Level Scheme of two-electron atom Doubly excited states, Auto-ionization;

UNIT-3:

The central field Approximation the Thomas-Fermi theory (model) for atoms, The Hatree-fock method, Correction to the central field Approximation, correction effects , L-S coupling and j-j coupling.

Many electron atom in an electromagnetic field, Selection rules for electric dipole transition, Retardation effects, magnetic dipole, electric quadrupole transitions,

UNIT-4:

General nature of molecular structure, The born –oppenheimer separation for diatomic molecules, The electronic spin and Hunds cases, The structure of polyatomic molecules

UNIT-5:

Molecular spectra, Rotational spectra of diatomic molecules, Electronic spectra of diatomic molecules, Spin –dependent interaction and electric dipole transition, The Nuclar spin, The inverse spectrum NH_3

UNIT-6:

Further developments and application of atomic and molecular physics, Magnetic resonance, Atomic optics, Atoms in cavities and ion in traps, Atomic Clocks.

Recommended Books:

1. *Physics of Atoms and Molecules* – by B. Bransden and C. J. Joachain (Pearson Education Publ – New Delhi)
2. *Elements of spectroscopy* – by Gupta, Kumar and Sharma (Pragati Prakashan Meerut)
3. *Spectroscopy (Atomic and molecular)* by G. Chatwal and S. Anand.
4. *Fundamentals of molecular spectroscopy* by C. N. Banvel.
5. Introduction to Atomic Spectra by white
6. Vibrational Spectroscopy by D N Sathyanarayana.

Theory Tutorials

PH-542: Atomic and Molecular Physics

(Discussion and problem solving/exercise sessions)

1) Classical scattering by central problem
2) Angular momentum useful formula and results
3) Write all possible term symbol for the following electron configuration
   [He] 2s 2p
4) Write all possible term symbol for the following electron configuration
   [Be] 2p3d
5) Write all possible term symbol for the following electron configuration
   [Be] 2p2d
6) Helium atom has two forms orthohelium and para helium, Explain why orthohelium is metastable?

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M.Sc. (PHYSICS): SEMESTER- IV

PH(E)- 543:MICROELECTRONICS

Unit-1 :

MOSFET : Enhancement MOSFET, Enhancement MOSFET Volt-ampere characteristics, MOSFET ,Circuit symbols, MOSFET as a Resistance, biasing the enhancement MOSFET, Small Signal Operation of the enhancement MOSFET amplifier, MOS amplifier with enhancement MOS, Load MOS analog switches, CMOS devices, BIFET-BIMOS Circuits.

Unit- 2 :

Monolithic Integrated Circuit Technology, Planer process, bipolar transistor fabrication, fabrication of FETs, CMS Technology, Monolithic Diodes, Metal semiconductor contact, Integrated circuit resistors, Capacitors, Integrated circuit Packaging, Characteristics of integrated circuit components, Microelectronics circuit lay out.

Unit -3 :

BJT biasing for integrated circuits, Wilder current sources three transistor current sources, discrete component biasing and design, common-emitter amplifier with an emitter resistance high frequency response of a common-emitter stage, common-source stage at high frequency, emitter and source followers at high frequencies, time constant ,method of obtaining the response.

Unit -4 :

General Analysis of multistage feedback amplifiers, multi-loop feedback amplifiers,stability, test for stability compensations, frequency response of feedback amplifier the double pole transfer functions. Phase margin of the two-pole feedback amplifier, three pole feedback amplifier response, approximate analysis of a multi-pole feedback amplifier, approximate determination of the open-loop poles, compensation revisited.

Unit -5 :

NMOS, Inverter, Propagation delay of an NMOS inverter, NMOS logic gates, CMOS inverter, CMOS logic gates emitter-coupled logic circuits, Programmable ROM, Erasable PROMs, Programmable Array Logic, Programmable Logic Arrays.

Unit -6 :

Dynamic MOS shift register, ratio-less shift register stages, CMOS domino logic RAM, Read-write memory cells, Charge Coupled Devices, CCD structures, Integrated Injection logic.

Recommended Books:

1. J.Millman and A.Grable, Microelectronics, McGraw Hill, 1987.
2. A.S.Sedra & K.C.Smith, Microelectronics Circuits, Holt-Saunders, Japan, 1991.
3.D.E.Hodges & H.G.Jackson, Analysis and Design of Digital integrated circuits, McGraw Hill, 1983.
4.P.R.Gray & R.G. Meyor, Analysis and design of Analog integrated circuits, John Wiley, 1984.

Theory Tutorials

PH(E)- 543:MICROELECTRONICS

(Discussion and problem solving/exercise sessions)

-BJT's and FET's.

-VLSI Circuits design concepts.

-Low Frequency & High Frequency response Models.

-Bode Diagrams.

- Operational Transfer Functions & Frequency Transfer Functions.

-IC based Electronics Instruments.

M.Sc. (PHYSICS): SEMESTER- IV

PH(E)- 544: Electronic Communication

Unit-1:

Review of General communication system

Transmitter, Channel & Noise, Source, Receiver, Need for modulation, Bandwidth requirement, Spectral analysis, Sampling function, Response of a linear system, Normalized power in a Fourier expansion, Power spectral density, Effect of transfer function on power spectral density, Convolution, Power & energy transfer through a network, Correlation between waveforms, Power & cross correlation, Autocorrelation, Autocorrelation of a periodic waveform, Autocorrelation of non-periodic waveform of finite energy.

Unit- 2

Frequency Translation

A method of frequency translation, Recovery of the base-band signal, Amplitude modulation Double sideband suppressed carrier AM, Generation of DSB-SC signals, Demodulation of DSB-SC Signals. Conventional amplitude modulation, Sideband & carrier power, Generation & demodulation of AM signals single sideband AM, Generation & demodulation of SSB Signals, Vestigial side band modulation, Comparison of various amplitude modulation systems, Frequency division multiplexing.

Unit-3

Frequency modulation

Mathematical representation of an FM signal, Spectrum of an FM signal, Phase modulation, Stereophonic FM broadcasting, Comparisons: Frequency & phase modulation, Frequency & Amplitude modulation, Generation of FM waves: Indirect method of Armstrong & Direct generation, Demodulation of FM signals, Phase locked loop, Analysis of phase locked loop, Second order phase locked loop.

Unit-4

Noise

External & internal noise, Noise calculations, Noise figure, Noise temperature, Noise in Amplitude modulation system, Advantage of super-heterodyne principle : Single channel, SSB-SC, DSB-SC, Square law & Envelope demodulator.

Unit-5

Noise in FM systems :

Calculation of output signal & noise powers, Pre-emphasis & de-emphasis: Single Channel, Pre-emphasis & de-emphasis in commercial FM broadcasting.Sampling theorem: low pass signals, Pulse amplitude modulation, Other forms of pulse modulation, Time division multiplexing, Bandwidth required for transmission of PAM signals, Comparison of FDM & TDM systems.

Unit-6

Quantization of signals :

Quantization error, Pulse code modulation, PCM system, Companding & Differential PCM Delta modulation & Adaptive Delta modulation. Digital carrier schemes : FSK, PSK & DPSK, Compatible color Television (CCTV) Multiplexing & De-multiplexing of Luminance & Chrominance signals.

Recommended Books:

1. H.Taub & D.L.Schilling Principles of communication systems, McGraw-Hill.
2. G.K.Mithal, Radio Engineering : Applied Electronics Vol.II
3. B.P.Lathi, Modern Digital & Analog communication systems, Prism Books Pvt.Ltd.
4. G. Kennedy, Electronic communication systems, McGraw-Hill
5. J.G.Proakis & M. Salehi,,Fundamentals of communication systems: Pearson Education.
6. D. Roddy & J. Coolem, Electronic communications, PHI.
7. K. Samshanmugum, Digital & Analog communication systems, Johan Wiley & Sons.

Theory Tutorials

PH(E)- 544: Electronic Communication

(Discussion and problem solving/exercise sessions)

1 Review of Fourier series and Fourier transform

2 Parseval's theorem

3 Introduction to modulation & demodulation

4 Normalized power

5 Comparison of FDM & TDM

6 Phase locked loop application

7 Natural & Flat-top sampling

8 Elements of a digital communication system source encoder / decoder, channel, modulator - demodulator & other functional blocks

9 Comparison of Analog & digital communication systems.

M.Sc. (PHYSICS): SEMESTER- IV

PH(M)-543 : PROPERTIES OF MATERIALS

UNIT :I

Magnetic Properties:Types of material, the flounce of temperature on magnetic behavior, soft and hard magnetic materials, Application of magnetic materials curie temperature, susceptibility, superconducting, magnates, Ceramic magnets.

UNIT :II

Optical properties:,Optical properties of mates & nm metals, Luminescence Properties, electroluminescence. Application of luminescence optical parameters Refractive Index, Reflectance, Transparency Translucency, capacity color,

UNIT :III

Electrical and conducting, Bard Gap and Resistively of material, Dielectrically Properties of Material conductors Electrical Classification at Thermocouples Super Conductors, Insulators, Ferro electronics Piezoelectric

UNIT: IV

Mechanical Properties ,Electric behaviors – Atomic model of Electric behaviors, The modulus as a parameter in design, Rubber- like Electricity, An elastic behaviors viscoelastic behaviors, Plastic Deformation.

UNIT: V

Plastic deformation, The Tensile Stress –Strain cure, Dislocation model, multiplication of dislocations during deformations mechanism of creep, grip Resistant materials fracture mechanism maps methods of protection against fracture fatigue micro Harden and their measurement

UNIT: VI

Material properties Engineering Design Parameters selection of structural Materials, Environmental aspens of Material design

Recommended Books:

1 W. D. callsstor .:

Materials Science & Engineering, John Wiley (1997).

2 A.G. Gay

Essentials & Materials Science

, Mc Graw Hill (1976).

3 Mans Chanda

Science of Engineering Materials, Vol.1-3

Macmillan (1980)

James. I.Shackelford,M.K.Muralidhara

Introduction to Material science For Engineers,(Sixth Edition)

Pearson Education Press,India(2009)

V.Raghavan

Materials Science & Engineering

A First Course,(Fifth Edition)

PHI-Prentice Hall India Publishers(2005)

Theory Tutorials

PH(M)-543 : PROPERTIES OF MATERIALS

(Discussion and problem solving/exercise sessions)

1 Magnetic Bubbles
2 Luminescence excitation & emission
3 Hardening & tempering of Steel
4 Importance of band gap in optical properties.
5 Fundamentals of Materials.
6 Materials and our Environment

M.Sc. (PHYSICS): SEMESTER- IV

PH(M)-544:Techniques of Material Science

Unit I Vacuum Science and Technology

Introduction Vacuum , Brief History of Vacuum technology, Units of Vacuum, characteristics of vacuum, classification of vacuum ranges, applications of vacuum, vacuum system,

Unit II Production and Measurement of Vacuum

Classification of vacuum pumps, Rotary pumps, Roots pumps, Diffusion pumps, Molecular drag and turbo molecular pumps, Sorption pumps, cryogenic pump, , Getter and ion pumps, Measurement of pumping speed, Constant pressure methods.

Classification of vacuum gauges, Mechanical gauges, Bourdon gauge, Diaphram gauge, McLeod gauge, Thermal conductivity gauges, Pirani gauge, Thermocouple gauge, Bayard-Alpart gauge, modified Ionization gauges.

Unit III Preparation of Thin Film

Physical methods: vacuum evaporation, Types of evaporation sources, Resistive heating, electron beam evaporation, flash evaporation, Laser ablation. Epitaxial deposition, molecular beam epitaxy,

Sputtering methods: Glow discharge, DC and RF Sputtering, Reactive Sputtering, Magnetron Sputtering, Ion plating, Ion beam deposition

Chemical methods: Electroplating, Thermal spray and detonation technology, plasma chemical vapor deposition (PCVD), Metal organic Chemical vapor deposition (MOCVD)

Unit IV Growth and structure of Thin Film, Thickness Measurement of Thin Film

Condensation, Nucleation and growth of Thin Films, The four stage film, incorpation of defects during growth

Thickness measurement: Classification of Thickness measurement, Quartz Crystal thickness monitor

Unit V Transport and Optical Properties of Thin Film

Metallic films: Source of resistivity in metallic conductors, Sheet resistance and temperature coefficient of resistance of thin films, Annealing, agglomeration and oxidation

Reflection and Transmission at an interface: Reflection and transmission by single film, Determination of optical constant by ellipsometry

Unit VI Chemical and Physical characterization of Thin Film by Analytical Techniques And Non –Destructive Testing

Surface Analytical Techniques: Auger Electron Spectroscopy (AES), Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Rutherford Back Scattering(RBS)

Optical Analytical Techniques: Fourier Transform Infrared Spectroscopy (FTIR)

Non-destructive testing,: Basic test methods, leakage testing, penetrant method, magnetic methods, ultrasonic testing, radiography and applications, eddy current methods, recent developments in non-destructive testing

Recommended Books

1. Vacuum Science and Technology V.V. Rao, T.B. Ghosh and K.L. Chopra Allied Publishers Limited (India).
2. Vacuum Technology , A. Roth, North-Holland,1986.
3. " Hand book of Thin film technology" L. I. Maissel and R. I Glang,Mc Graw Hill book Co. New york,1970.
4. "The Material Science of Thin Films" M. ohring, Academic press, New York 1992.
5. Hand Book Technologies of Films and Coatings, R. F. Bunshah, Noyes publication, 1996.
6. P.J. Grandy and G.A. Jones, Electron microscopy in study of materials, Edward Arnold, 1976.
7. Instrumental method of analysis Willard
8. Instrumentation, measurement and analysis. B. C. Nakra and K. K. Chaudhry
9. R. Hamshaw, Non-destructing Testing, Edward Arnold, 1987.
10. Practical Non- Destructive Testing BaldevRaj etc. Narosa Publishing House. 2009.

Theory Tutorials

PH(M)-544:Techniques of Material Science

(Discussion and problem solving/exercise sessions)

(1) Description of Gas state

(2) Kinetic theory of gases

(3) Maxwell-Boltzmann Velocity distribution

(4) Transport of heat in gases and thermal conductivity

(5) Evaporation Rate

(6) Important equation in physics of ideal gases

(7) Vacuum metallurgy

(8) Non destructive testing and Terminology

(9) Evaluation of measurement ; Uncertainty of measurements.

M.Sc. (PHYSICS): SEMESTER- IV

PH(T) - 543: ADVANCED QUANTUM MECHANICS

Unit-1: **The Principles of Quantum Dynamics:**
The Evolution of Probability Amplitudes and the Time Development Operator, The Pictures of Quantum Dynamics, The Quantization Postulates for a Particle, Canonical Quantization and Constants of the Motion, Canonical Quantization in the Heisenberg Picture, The Forced Harmonic Oscillator

Unit-2: **The Quantum Dynamics of a Particle:**
The Coordinate and Momentum Representations, The Propagator in the Coordinate Representation, Feynman's Path Integral Formulation of Quantum Dynamics, Quantum Dynamics in Direct Product Spaces and Multiparticle Systems, The Density Operator, the Density Matrix, Measurement and Information

Unit-3: **Time-Dependent Perturbation Theory:**
The Equation of Motion in the Interaction Picture, The Perturbation Method, Coulomb Excitation and Sum Rules, The Atom in a Radiation Field, The Absorption Cross Section, The Photoelectric Effect, The Golden Rule for Constant Transition Rates, Exponential Decay and Zeno's Paradox

Unit-4: **The Formal Theory of Scattering:**
The Equations of Motion, the Transition Matrix, the S Matrix and the Cross Section, The Integral Equations of Scattering Theory, Properties of the Scattering States, Properties of the Scattering Matrix, Rotational Invariance, Time Reversal Symmetry and the S Matrix, The Optical Theorem

Unit-5: **Identical Particles:**
The Indistinguishability of and the State Vector Space for Identical Particles, Creation and Annihilation Operators, The Algebra of Creation and Annihilation Operators, Dynamical Variables, The Continuous One-Particle Spectrum and Quantum Field Operators, Quantum Dynamics of Identical Particles

Unit-6: **Applications to Many-Body Systems:**
Angular Momentum of a System of Identical Particles, Angular Momentum and Spin One-Half Boson Operators, First-Order Perturbation Theory in Many-Body Systems, The Hartree-Fock Method, Quantum Statistics and Thermodynamics

REFERENCE BOOKS:

(1) Quantum Mechanics by Eugen Merzbacher (Third Edition)

(2) Elements of Advanced Quantum theory by J. M. Ziman

(3) Modern Quantum Mechanics by J. J. Sakurai

(4) Quantum Mechanics by Franz Schwabl

Theory Tutorials

PH(T) - 543: ADVANCED QUANTUM MECHANICS

(Discussion and problem solving/exercise sessions)

(1) Find the equation of motion for the Heisenberg $\overline{\langle L_j, t|}$.

(2) Show that the operators $x^2 p_x^2 + p_x^2 x^2$ differ $\left(x^2 p_x^2 + p_x^2 x^2\right)/2$ only by terms of order $\hbar^2$.

(3) Prove that

$$\langle \mathbf{r}'|F(\mathbf{r}, \mathbf{p})|\Psi\rangle = F\left(\mathbf{r}', \frac{\hbar}{i}\nabla_{\mathbf{r}'}\right)\langle \mathbf{r}'|\Psi\rangle = F\left(\mathbf{r}', \frac{\hbar}{i}\nabla_{\mathbf{r}'}\right)\psi(\mathbf{r}')$$

$$\langle \mathbf{p}'|F(\mathbf{r}, \mathbf{p})|\Psi\rangle = F(i\hbar\nabla_{\mathbf{p}'}, \mathbf{p}')\langle \mathbf{p}'|\Psi\rangle = F(i\hbar\nabla_{\mathbf{p}'}, \mathbf{p}')\phi(\mathbf{p}')$$

(4) If a gauge transformation is performed, what happens to the propagator? Derive its transformation property.

(5) For the 1S → 2P (Lyman α) transitions in the hydrogen atom, evaluate the total integrated absorption cross section.

(6) Derive the Golden Rule for stimulated emission induced by a harmonic perturbation. This case occurs when the final unperturbed energy E_K lies below the initial energy E_S.

(7) Work out the Green's function $\langle x|G_+(E)|x'\rangle$ for a free particle.

(8) Prove that (i) $T = V\Omega^{(+)}$ and $S = [\Omega^{(-)}]^\dagger\Omega^{(+)}$

(9) Prove that the occupation number operators N_i for different i commute for either Bose-Einstein or Fermi-Dirac statistics.

(10) Prove from the commutation relations that

$$\langle 0|a_i a_j a_k^\dagger a_\ell^\dagger|0\rangle = \delta_{jk}\delta_{i\ell} \pm \delta_{ik}\delta_{j\ell}$$

the sign depending on the statistics, B.E. (+) or F.D. (-). Also calculate the vacuum expectation value $\langle 0|a_h a_i a_j a_k^\dagger a_\ell^\dagger a_m^\dagger|0\rangle$.

(11) Verify that the one-particle Hartree-Fock Hamiltonian H_{HF} is Hermitian.

(12) Prove that the expectation value of $\mathcal{H}$, in the "ionized" state $a_k|\psi_\nu\rangle$ with n -1 particles is

$$\langle \mathcal{H}\rangle = E_\nu - \varepsilon_k \quad (\textit{Koopmans'}\ \textbf{theorem})$$

M. Sc. (Physics): Semester-IV

PH(T)-544: Group Theory and Quantum Field Theory

UNIT-1

Group axioms (postulates), examples of groups, subgroups, representations of a group, irreducible representation, Schur's lemma (statement), permutation group, Young tableaux, continuous groups, compactness, connectedness.

UNIT-2

Lie groups and Lie algebra, U(n), SU(n), Lie algebra of U(n), SU(n), SU(2), SU(2) representation, applications of SU(2), SU(2) breaking, SU(3), SU(3) representation, higher representation, Gell-mann-Okubo mass formula.

UNIT-3

Introduction to Quantum theory of Fields, choosing Lagrangian, field quantization, quantization of Schrödinger-, Klein-Gordon- fields (real and complex), electromagnetic interactions.

UNIT-4

Covariant perturbation theory, normal product, time ordered products, propagators, Feynman graphs, applications, higher order, renormalization in quantum electrodynamics.

UNIT-5

Gauge field theories, gauge transformation U(1), Abelian transformation, electrodynamics of Dirac field, non-Abelian gauge transformation, local and global gauge symmetries SU(2) and SU(3), spontaneous symmetry breaking.

UNIT-6

Electroweak interaction, quantum chromodynamics, Lagrangian for standard model, evidence for quantum chromodynamics and standard model.

Recommended Books

1. A. W. Joshi,Group theory for physicists, New Age Publication (2005).
2. M. P. Khanna, Introduction to particle physics, PHI, 1990.
3. C. Itzykson and J.B. Zuber, Quantum Field Theory, McGraw Hill, 1980.
4. B.K. Agarwal, Quantum Mechanics and Field Theory, Asia, 1976
5. I. J. R. Aitchison and A. J. R.Hey, Guage theories in Particle Physics, Adam Hilger (U.K.) 1992.
6. J. J. Sakurai, Advanced Quantum Mechanics, John Wiley
7. W.E. Burcham and M. Jacobs, Nuclear and Particle Physics, Addison, Wesley, 1998.

Theory Tutorials

PH(T)-544: Group Theory and Quantum Field Theory

(Discussion and problem solving/exercise sessions)

1. Schur's lemma (derivation, application).
2. Discussion about classical and quantum fields.
3. Derivation of four-dimensional Euler-Lagrange equation.
4. QED examples, Bhabha, Moller scattering, electron-muon scattering etc.
5. Examples for E-L equation.
6. Evaluating $2\otimes2$, $3\otimes3$, using graphical, tensor and Young tableaux.
7. Evaluating $3\otimes3\otimes3$, $8\otimes8$ etc using Young tableaux.
8. For SU(2) matrices prove $e^{i\,\mathbf{r}.\boldsymbol{\sigma}} = \cos r + (\mathbf{r}.\boldsymbol{\sigma})\sin r$.
9. SU(2) isospin breaking effects.
10. SU(3) algebra in terms of quark fields.
11. Prove $D(p,q) = \frac{1}{2}(p+1)(q+1)(p+q+1)$ by different methods. Get different D(p,q) multiplets octet, decuplet etc.
12. Coupling of SU(2) vector representation for constructing SU(2) invariant πNN, ρππ, ωρπ coupling.
13. Taking doublet $\psi(\psi_1, \psi_2)$ show $S= \psi^+ \psi$, $V= \psi^+ \boldsymbol{\sigma} \psi$, (σ, Pauli matrices) as scalar and vectors under infinitesimal and finite rotations.
14. Application of SU(3) to particle physics.
15. SU(4) (extension of SU(3)) introduction.
16. SU(6) (introduction).
17. GUT (introduction).
18. Basics of supersymmetry.
19. Introduction to string theory.
20. Cosmology and particle physics (brief discussion).
21. Running constants in QED, QCD.
22. Yang Mills field.
23. Higgs mechanism.
24. Evidence for color, QCD, standard model.

M. Sc. (Physics): Semester-IV

PH-545: Practicals

Note:

Practicals consist of experiments in two groups **A** and **B**.

Group **A** experiments are common for all the specialization.

Group **B** experiments are different for different specializations.

Group A: List of Experiment **(3 hours/ week + 1 hour/week tutorial)**

C-Programming Experiments:

1. Writing and testing C programs for Interpolation and inverse interpolation using Lagrange's formula.
2. Writing and testing C programs for Numerical integration using Simpson's 1/3rd rule.
3. Writing and testing C programs for solving ordinary differential equations.

Nuclear Physics Experiments:

4. Determination of plateau for Geiger-Müller tube and radiation absorption coefficient of a material.
5. Gamma ray spectrometer: calibration and finding gamma ray energy of a source.
6. Rutherford Scattering experiment.

Laboratory Tutorial

- Discussion of techniques of actual numerical computation, program writing concepts, error analysis to supplement actual exercise given for numerical analysis and computer programming.
- Construction and working of GM tube detector
- Principles behind gamma ray spectrometer.
- Alpha radioactive sources and detectors.

Group B: List of Experiments **(6 hours/ week)**

Specialization: Electronics

Laboratory project works in Electronics.

Specialization: Materials Science

Laboratory project works in Materials Science.

Specialization: Theoretical Physics

Laboratory project works in Theoretical Physics.