# SEMESTERWISE BREAK DOWN AND CURRICULUM FOR M. Phil PHYSICS

# WOMEN UNIVERSITY MARDAN

## Scheme of Studies for M. Phil (Physics)

The M.Phil Physics is a postgraduate degree program of 18 years education related to Pure and Applied Physics. This is minimum 02 years full time degree program which includes teaching of advanced courses and fulfillment of research project under supervision of PhD experts and provided firm commitment to bring prolific conclusions which would help to stand the female of Pakistan in the row of Advanced Countries. This degree is the requirement of Lectureship in the University and also requisite of admission into a Doctoral program (PhD) in the said discipline. The M.Phil Physics program has delivered the courage to female students in order to get higher education in the field of Physics and promote scientific research in the country. The Department is striving in order to augment the standard of Research in Physics and will produce eminent and competent Physicists. The faculty of Physics Department carries out research in the fields of Materials Science, Solar cell technology, Nuclear Physics and Theoretical Physics.

## Admission Criterion

- The applicants must have completed 4-year BS (Physics) with CGPA 2.0 out of 4.0; or M.Sc in Physics with at least 2nd Division or equivalent grade.
- GAT-General conducted by the National Testing Service with a minimum cumulative score of 50% or GRE (International) Subject Test with 50 percentile score or GAT subject test with 60 % marks will be required at the time of admission.

## The Program

i) The student must complete 24 credit hours course work with CGPA ≥2.5.

ii) Having obtained CGPA ≥ 2.5 in course work, the M. Phil student will complete a 6-credit hour thesis and will successfully defend it in order to qualify for the award of M. Phil degree.

iii) Thesis evaluation and viva voice will be conducted by one external examiner (from a university in Pakistan other than university of enrollment) and one internal examiner.

Semester wise details are given in the following tables:

## SEMESTER –I

| S.No | Course Title | Course Code | Credit Hours |
|---|---|---|---|
| 1. | ELECTROMAGNETIC THEORY | PHY-711 | 03 |
| 2. | MATHEMATICAL METHODS | PHY-712 | 03 |
| 3. | CLASSICAL MECHANICS | PHY-715 | 03 |
| 4. | MATERIAL SCIENCE | PHY-726 | 03 |
| **Total credit hours** | | | **12** |

## SEMESTER –II

| S.No | Course Title | Course Code | Credit Hours |
|---|---|---|---|
| 1. | ADVANCED QUANTUM MECHANICS | PHY-713 | 03 |
| 2. | STATISTICAL PHYSICS | PHY-714 | 03 |
| 3. | PLASMA PHYSICS | PHY-725 | 03 |
| 4. | INTRODUCTION TO NANOPHYSICS | PHY-730 | 03 |
| **Total credit hours** | | | **12** |

## SEMESTER –III & IV

| **Sr. No.** | **Course Code** | **Course Title** | **Credit Hours** |
|---|---|---|---|
| 1. | PHY-799 | Research Thesis in 3rd & 4th semester | 06 |

## List of All Core Courses for M. Phil Physics

| COURSE CODE | TITLE | CREDIT HOURS |
|---|---|---|
| | **Compulsory/Core Courses for MPhil** | |
| PHY-711 | ELECTROMAGNETIC THEORY | 3(3+0) |
| PHY-712 | MATHEMATICAL METHODS | 3(3+0) |
| PHY-713 | ADVANCED QUANTUM MECHANICS | 3(3+0) |
| PHY-714 | STATISTICAL PHYSICS | 3(3+0) |
| | **Other Core Courses for MPhil** | 3(3+0) |
| PHY-715 | CLASSICAL MECHANICS | 3(3+0) |
| PHY-716 | ADVANCED SOLID STATE PHYSICS | 3(3+0) |
| PHY-717 | ATOMIC AND MOLECULAR PHYSICS | 3(3+0) |
| PHY-718 | EXPERIMENTAL TECHNIQUES | 3(3+0) |
| PHY-719 | PARTICLE PHYSICS | 3(3+0) |
| PHY-720 | SUPERCONDUCTIVITY | 3(3+0) |
| PHY-721 | DIELECTRIC AND OPTICAL PROPERTIES | 3(3+0) |
| PHY-722 | REACTOR PHYSICS | 3(3+0) |
| PHY-723 | PHYSICS OF THIN FILMS | 3(3+0) |
| PHY-724 | SEMICONDUCTOR DEVICES | 3(3+0) |
| PHY-725 | PLASMA PHYSICS | 3(3+0) |
| PHY-726 | MATERIAL SCIENCE | 3(3+0) |
| PHY-727 | QUANTUM FIELD THEORY | 3(3+0) |
| PHY-728 | GROUP THEORY | 3(3+0) |
| PHY-729 | LASER PHYSICS | 3(3+0) |
| PHY-730 | INTRODUCTION TO NANOPHYSICS | 3(3+0) |

Note: Overall 24 teaching credit hours for M. Phil program are mandatory. However, the research supervisor of students may recommend additional courses. The Department will offer the courses keeping in view the availability of teachers and nature of research to be conducted.

# Course Outline for M. Phil Physics

## Course Code: 711 Course Title: Electromagnetic Theory

**Course Outline:**

Coulomb's Law and Electric Field; Gauss's Law; Another Equation of Electrostatics and the Scalar Potential; Surface Distribution of Charges and Discontinuities in the Electric Field (Excluding the part on the Dipole Layer); Poisson and Laplace Equations; Green's Theorem; Uniqueness of the Solution with Dirichlet or Neumann Boundary Conditions; Formal Solution of Electrostatic Boundary-Value Problem with Green Function; Electrostatic Potential Energy and Energy Density
Method of Images; Point Charge in the Presence of a Grounded Conducting Sphere; Point Charge in the Presence of a Charged, Insulated, Conducting Sphere; Point Charge Near a Conducting Sphere at Fixed Potential; Green Function for the Sphere, General Solution for the Potential; Orthogonal Functions and Expansions; Separation of Variables, Laplace Equation in Rectangular Coordinates
Laplace Equation in Spherical Coordinates; Legendre Equation and Legendre Polynomials (Rodrigue's formula, Recurrence relations, Orthogonality - no derivations); Boundary-Value Problem with Azimuthal Symmetry; Associated Legendre Functions and the Spherical Harmonics; Addition Theorem for Spherical Harmonics (no derivation); Expansion of Green Functions in Spherical Coordinates
Multipole Expansion; Multipole Expansion of the Energy of a Charge Distribution in an External Field; Elementary Treatment of Electrostatics with Ponderable Media; Boundary-Value Problems with Dielectrics; Electrostatic Energy in Dielectric Media
Introduction and Definitions; Biot and Savart Law; Differential Equations of Magnetostatics and Ampere's Law; Vector Potential; Magnetic Fields of a Localized Current Distribution, Magnetic Moment; Force and Torque on and Energy of a Localized Current Distribution in an External Magnetic Induction; Macroscopic Equations, Boundary Conditions of B and H; Faraday's Law of Induction; Energy in the Magnetic Field
Maxwell's Displacement Current; Maxwell Equations; Vector and Scalar Potentials; Gauge Transformations, Lorentz Gauge, Coulomb Gauge; Green Functions for the Wave Equation; Retarded Solutions for the Fields: Jefimenko's Generalizations of the Coulomb and Biot-Savart Laws; Poynting's Theorem and Conservation of Energy and Momentum for a System of Charged Particles and Electromagnetic Fields; Transformation Properties of Electromagnetic Fields and Sources under Rotations, Spatial Reflections, and Time Reversal

**Recommended Books:**


1. Jackson J. D, “Classical electrodynamics”. 5th ed., John Willey & Sons, New York, 2012.
2. Mathew N. O. Sadiku, “Elements of Electrodynamics”. 5th ed., Oxford University Press, USA, 2009.

## Course Code: 712 Course Title: Mathematical Methods

**Course Outline:**

Vector analysis, Scalar Vectors dot and cross product gradient, Divergence curl vector integration, Gauss's Theorem, Stokes's Theorem, Potential theory, Gauss's Law, Poisson Equation, Helmholtz's Theorem, Coordinate systems, Rectangular Cartesian special Coordinate systems, Circular cylindrical coordinates, Spherical polar coordinates, Tensor analysis, Determinants, Matrices and group theory, Infinite series, Function of a compels variables, Cauchy Riemann Conditions, Cauchy's integral theorem and formula, Function of a compels variable II, Calculus of residues, Differential equations, Sturm-Lowville theory, Orthogonal functions, The Gamma function (Factorial function), Beta function, The incomplete gamma function and related functions, Bessel functions, Hankel function, Asymptotic expressions, Spherical Bessel functions, Legendary function, Spherical harmonics, Angular momentum, Ladder operator, Legendre function of second kind, Special functions, Hermit function, Laguerre function, Fourier series, Applications of Fourier series, Gibb's phenomenon, Discrete orthogonality and discrete Fourier transform, Convolution.
Laplace theorem, Laplace transformation of derivatives, Integral equations, Green's Function in One, two and three dimensions, Calculus of variations, Application of Euler equation, Lagrange multipliers, Rayleigh-Rits variation techniques.

**Recommended Books:**

1. Mathematical Methods for Physicists, Arfken & Weber (Academic Press, 6th edition, (2005).
2. Mathematical Methods for Physicists, Tai L. Chow (Cambridge University Press, 2002).

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## Course Code: 713 Course Title: Advanced Quantum Mechanics

**Course Outline:**

Brief overview of wave mechanics, Schrodinger equation, quantum mechanics in one dimension, unbound particles such as potential step, barriers and tunnelling, bound states such as rectangular well, ,Operator methods such as uncertainty principle, time evolution operator. Ehrenfest's theorem, Heisenberg representation, quantum harmonic oscillator, coherent states, Quantum mechanics in more than one dimension, Rigid rotor, angular momentum, raising and lowering operators, Charged particle in an electromagnetic field, normal Zeeman effect, gauge invariance and the Aharonov-Bohm effect, Landau levels. Spin, Stern-Gerlach experiment, spinors, spin operators and Pauli matrices, spin precession in a magnetic field, parametric resonance, addition of angular momenta. Time-independent perturbation theory,,first and second order , perturbation, degenerate perturbation theory, Stark effect, nearly free electron model, ,,,Identical particles,, Particle indistinguishability and quantum statistics, space and spin wave functions. Atomic structure,, Relativistic corrections– spin-orbit coupling, Darwin structure, Lamb shift, hyperfine structure. Multi-electron atoms, Helium, Hartree approximation and beyond, Hund's rule.

**Recommended Books:**

1. B. H. Bransden and C. J. Joachain, Quantum Mechanics, (2nd edition, Pearson, 2000).
2. S. Gasiorowicz, Quantum Physics, (2nd edn. Wiley 1996, 3rd edition, Wiley, 2003).

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## Course Code: 714 Course Title: Statistical Physics

**Course Outline:**

Thermodynamic variables, thermodynamic limit, thermodynamic transformations. First law of thermodynamics, application to magnetic systems, heat and entropy, Carnot cycle. Absolute temperature, temperature as integrating factor, entropy of ideal gas. Helmholtz free energy, Gibbs potential, Maxwell relations, chemical potential. First-order phase transition, condition for phase coexistence. Phase space, distribution function, microcanonical ensemble, the most probable distribution, Lagrange multipliers. Pressure of an ideal gas, equipartition of energy, entropy, relation to thermodynamics, fluctuations, Boltzmann factor. collisionless and hydrodynamic regimes, Maxwell's demon, non-viscous hydrodynamics, sound waves, diffusion, conduction, viscosity. Thermal wavelength, identical particles, Fermi and Bose statistics, pressure, entropy, free energy, equation of state, Fermi gas at low temperatures, application to electrons in solids and white dwarfs. Photons, phonons, Debye specific heat, Bose-Einstein condensation, equation of state, liquid helium. Partition function, connection with thermodynamics, fluctuations. Minimization of free energy, photon fluctuations, pair creation. The order parameter, Broken symmetry, Ising spin model, Ginsburg Landau theory, mean-field theory, critical exponents, fluctuation-dissipation theorem, correlation length, universality.

**Recommended Books:**

1. Introduction to Statistical Physics, Kerson Huang, (Taylor and Francis, 2001).
2. Statistical Mechanics, Raj Kumar Pathria, 2nd edition (India, 1996).

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## Course Code: 715 Course Title: Advanced Classical Mechanics

**Course Outline:**

Survey of elementary principles, Mechanics of a particle and a system of particles, Constraints, D'Alembert principle and Lagrange's equation, Variational principle and Lagrange's equation, Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle, The two body central force problem, Center of mass and relative coordinates, The center of mass frame, Elastic collision, CM and Lab cross sections, The Kepler's problem, The Laplace-Runge-Lenze vector, The kinematics of rigid body motion, The Euler angles, The Cayley-Klein parameters and related quantities, The rigid body equation of motion, Small oscillations, Special relativity in classical mechanics, Lorentz transformations in real four dimensional space, The Hamilton equation of motion, Cyclic coordinates and conservation theorem, Canonical transformations, Hamilton-Jacobi theory, Canonical perturbation theory, The Lagrangian and Hamiltonian formulation for continuous systems and fields, Proof of Bertrand's theorem, Noether's theorem, Euler angles in alternate convention.

**Recommended Books :**

1. S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; $5^{th}$ ed. (2003).
2. T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, $5^{th}$ ed. (2004).

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## Course Code: 716 Course Title: Advanced Solid State Physics

**Course Outline:**

The Drude theory of metals, The Somerfield theory of metals, Failure of free electron model, Crystal lattices, The reciprocal lattice, Determination of crystal structure by X-ray diffraction, Classification of Bravais lattices and crystal structures, Electron levels in a periodic potential: general properties, Electron in a weak periodic potential, The tight binding approximation, Other methods for calculating band structure, the semi-classical theory of conduction in metals, Measuring the Fermi surface, Band structure of selected metals, Beyond the relaxation time approximation, Beyond the independent electron approximation.

**Recommended Books:**

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, $8^{th}$ ed. (2005).
2. M. A Omar, "Elementary and Solid State Physics", Pearson Education, (2000).

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## Course Code: 717 Course Title: Atomic and Molecular Physics

**Course Outline:**

Historical development in atomic spectra, Classification of series in Hydrogen, Alkali metals and periodic table, The vector model of an atom, Multiplets in complex spectra, The Russell Saunders coupling scheme, Landes theory of multiplet separation and the Zeeman effect, General theory of multiple structure, Elementary theory of multiplets, Matrix components of the Hamiltonian for central field problem, Energy values for simple multiplets, Closed shells and average energies, The average energy of a configuration, Formulation of multiplet calculations in terms of average energy.

Rotation and vibration of diatomic molecules, The rigid rotator, The harmonic oscillator, The Raman spectrum of rigid rotator and harmonic oscillator, The anharmonic oscillator, The symmetric top, Thermal distribution of quantum states, Symmetry properties of the rotational level, The electronic states and electronic transitions, Electronic energy and total energy, Vibrational structure of electronic transitions, Rotational structure of electronic bands.

**Recommended Books:**


1. B. H. Bransden and C. J. Joachain, “Physics of Atoms and Molecules”, Pearson Education, $2^{nd}$ ed. (2008).
2. C. J. Foot, “Atomic Physics”, Oxford University Press, (2005).
3. W. Demtroder, “Atoms, Molecules and Photons”, y, Springer, $2^{nd}$ ed. (2010).


## Course Code: 718 Course Title: Experimental Techniques

**Course Outline:**

Solutions of equations by the method of iteration (Newton-Rapson method). Solution of differential equations of higher order. Monte-Carlo methods. Resume of theory of errors and experimental statistics. Least-squares fit to a polynomial. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation. Physical principles of diffusion and rotary pumps. Ultra-high vacuum by ionization. Sorption and cryogenics. +Methods of recording diffraction patterns. Examples of structure determination. Analysis of results.

**Recommended Books:**


1. Methods of Experimental Physics by R. L. Horovitz and V. A. Johnson (Latest Edition).
2. Methods of Experimental Physics by D. Williams (Academic), 2014


## Course Code: 719 Course Title: Particle Physics

**Course Outline:**

History and basic concepts, Classification of particles-Fermions and Bosons, Basic Fermions constituents, Quarks and Leptons, Hadron-Hedron interactions, Cross-sections and decay rates, Particle detectors and accelerators, Interaction of charged particles and radiations with matter, Accelerators, Detectors of single charged particle, Shower detectors and calorimeters, Examples of the applications of detection techniques to experiments, Invariance principle and conservation laws, Invariance in classical and quantum mechanics, Parity, Positronium decay, Time reversal invariance, Hadron-Hedron interactions, Isospin G-parity, Dalitz plots, Wave optical discussion of Hadrons scattering, The Regge-Pole model, Static quarks model of Hadrons, The vector mesons, Electromagnetic mass differences and Isospin symmetry, Heavy mesons spectroscopy and quarks model, Weak interactions, Classification of weak interactions, Nuclear β-decay-Fermi theory, Lepton-quark interaction, Parton model of Hadrons, Fundamental interactions and their unification, Renormalizability in quantum electrodynamics, Quantum electrodynamics predictions of electron an muon magnetic moments.

**Recommended Books:**

1. A Modern Introduction to Particle Physics, Fayyazuddin and Riazuddin, Publisher: World Scientific Pub Co Inc. 2nd Edition, September 29, 2000.
2. An Introduction to Quantum Field Theory, by M.E. Peskin and D.V. Schroeder, Publisher: Addison Wesley Publishing Company, 1995.

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## Course Code: 720 Course Title: Superconductivity

**Course Outline:**

Phenomenon of superconductivity, The thermodynamic transition, The Meissner Ochsenfeld Effect, The critical field, The energy gap, Coulomb interactions between electrons, The Bose-Einstein gas model, The quasi-chemical equilibrium theory, The concept of electron pair as quasi molecules, Thermodynamic of chemical equilibrium, Treatment of ground state, The BCS and Bogoliubov theories at zero temperature, Thermodynamics in the quasi equilibrium theory, The Meissner effect, Persistent currents, Quantum theory of normal conductivity.

**Recommended Books:**

1. Von L. M., "Theory of Superconductivity". Academic Press, New York, 1994.
2. Grag K. B., and Bose S. M, "High Temperature Superconductivity Ten Years After its Discovery". Narosa Publishing, London, 1998.

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## Course Code: 721 Course Title: Dielectric and Optical Properties

**Course Outline:**

Dielectrics, Polarization in dielectrics, dielectric losses, relaxation models, permittivity tensor, magnetic permeability, magnetic losses, ferrites, permeability tensor, and Faraday rotation.
Conduction, free charges, Ohm and Fick law, charges relaxation and currents diffusion, dielectric medium, dielectric dipoles, polarization, susceptibility and permittivity, Interfacial, ionic and electronic polarization.
Capacitive and inductive structures, capacity and inductance matrices, reciprocity theorem, Foster and Slater theorems.
Theory of transmission lines and wave guides, elements of the antenna theory, gain and impedance, capacitive and inductive antennas.
Multiple moments of a charge distribution and energy in an external field, relation of microscopic electrostatics to macroscopic fields, dielectric materials E & M waves, boundary conditions, polarization, reflection and refraction. Waves in general dielectric medium, phase

and group velocities and the uncertainty relation. Dispersion, absorption and the Kromers-Kronig relation. Waves in a conduction medium. Wave guides: conducting and dielectric. Fiber optic modes. Novel dielectric materials, high temperature polymers and composites, Nano-dielectrics.

**Recommended Books:**

1. Moulson A. J. and J.M. Herbert J. M., "Electro ceramics: Materials, Properties, and Applications". 2nd ed. John Wiley & Sons Ltd, England, 2003.
2. Jackson J. D., "Classical Electrodynamics". 3rd ed. John Wiley & Sons, 1998.

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## Course Code: 722 — Course Title: Reactor Physics

**Course Outline:**

Principles concepts in the Physics of nuclear systems, Radiations, Radioactive decay, Buildup and depletion of isotopes in nuclear systems, Neutron-Nucleus interactions and nuclear cross-sections, Transport or radiation using one-group and two-group diffusion theory, Concept of criticality and time dependant reactors, Neutron-Nucleus interactions and nuclear cross-section calculations, Neutron transport theory, Heterogeneous reactor calculations.

**Recommended Books:**

1. Baranger M., "Advances in Nuclear Physics". 1st ed. McGraw Hill, 1999.
2. Grotz K., "Weak Interactions in Nuclear Particles and Astrophysics". John Willey and Sons, 1998.

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## Course Code: 723 — Course Title: Physics of Thin Films

**Course Outline:**

Thin film; an introduction, Thermodynamics of thin film growth, nucleation and growth, *chemisorption and physisorption*, wetting angle, stability of the surface, growth modes; Frank-Van Der Merwe, *Volmer-Weber*, *Stranski–Krastanov*, Step formation and step motion. Growth modems; BCF and Mullins. Structure of thin film (internal and external), Thin film deposition techniques (PVD, CVD). Criteria for selection of deposition techniques, Thin film characterization, Post-deposition treatment, Application of thin films, Properties of thin film (thermal, optical, electrical, magnetic, mechanical etc)

**Recommended Books:**

1. Seshan K., "Hand Book of thin film deposition processes and techniques". Novyes Publication, USA 2002.
2. Online materials, research papers

3. Heavens O. S., “Thin Film Physics”. Methuen and Co. Ltd, 1989.

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## Course Code: 724 Course Title: Semiconductor Devices

**Course Outline:**

Semiconductor Principles, Survey of semiconductor chemistry, Semiconductor crystal growing, Control of composition in semiconductors, Defect interactions in semiconductors, Diffusion process Germanium and Silicon, The chemistry of some compound semiconductors, Group IV semiconductors, Properties of some covalent semiconductors, Infrared absorption of semiconductors, Recombination and trapping, Effect of imperfections.

**Recommended Books:**

1. Hannay N. B., “Semiconductors”. Reinhold Publishing Corporation, 1989.
2. Shockley W., “Electrons and Holes in Semiconductors”. Princeton D. Van, 1988.

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## Course Code: 725 Course Title: Plasma Physics

**Course Outline:**

Controlled Fusion: Introduction to confinement scheme. Magnetic confinement and stability. Description of tokamaks, mirror machines and pinch devices. Supplementary heating. Diffusion: Diffusion in weakly ionized gases. Diffusion across a magnetic field. Diffusion in fully ionized plasmas. Bohm diffusion and neoclassical diffusion. Equilibrium and Stability (With Fluid Model): Hydromagnatic equilibrium. The concept of Diffusion of magnetic field into a plasma. Classification of instabilities. Two stream instability. The gravitational instablity. Resistive drift waves. The Vlasov Theory Of Plasma Waves: Solution of linearized Vlasov equation. Time asymptotic solution. Vlasov theory of small amplitude waves in field-free uniform/nonuniform magnetized cold/hot plasmas. The Vlasov theory of plasma-stability.

**Recommended Books:**

1. R. J. Goldston and P. H. Rutherford, “Introduction to Plasma Physics”, Bristol and Philadelphia; 1st Edition, (1995).
2. F. F. Chen, “Introduction to Plasma Physics”. Plenum press, 2015.

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## Course Code: 726 Course Title: Materials Science

**Course Outline:**

Structure of materials. Ionic bond. Covalent bond. Metallic bond. Van der Waal's bond. Crystallography. Translational periodicity. Crystal classes. Crystal forms. Point and space groups. Crystal growth. Methods of purification. Zone refining. Zone leveling. Impurity control. Methods of perturbing the concentration of impurities in semiconductors. Formation of n-p and n-p-n junctions. Different techniques of growing single crystals. Polymer chains. Polymerization. Polymer processing. Ceramics. Oxide and silicate structures. Phase transformations. Fabrication technology of semiconductor electronic devices

**Recommended Books:**


1. Materials Science and Engineering an Introduction, by W. D. Callister, Jr., publisher John Wiley & Sons Inc (2007)
2. The Physics and Chemistry of Materials, by J. I. Gersten and F. W. Smith, publisher John Wiley & Sons Inc (2001)


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## Course Code: 727 Course Title: Quantum Field Theory

**Course Outline:**

Classical Field Theory. Canonical Quantization. Noether's theorem. (3 week). Real Klein-Gordon field. Complex Klein-Gordon field. Covariant commutation relations. Meson propagator Number representation for fermions. Quantization of Dirac field. Spin-statistics theorem. Fermion propagator. Classical electromagnetic field. Covariant quantization. Photon propagator. Interaction Lagrangian and gauge invariance. Interaction picture. S-matrix expansion. Wick's theorem. Feynman Diagrams. Feynman rules for QED. Cross sections and decay rates.

**Recommended Books:**


1. Bjorken, J. D. and Drell, S. D. "Relativistic Quantum Field Theory". Dover Publications,2012.
2. Schweber, S. S. "Introduction to Relativistic Quantum Field Theory". Harper and Row, 2007.


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## Course Code: 728 Course Title: Group Theory

**Course Outline:**

Linear vector spaces. Groups. Representations of groups. Characters. Schur's Lemmas. Lie groups. Representation of lie groups. Rotation group and SU(3). Clebsch-Gordon coefficients. Rotation matrices. Wigner-Eckart theorem. Kronecker product of irreducible representations. Spinor representations of Lorentz roup. Elementary theory of Wigner's unitary representations of Poincare group.

**Recommended Books:**

1. Hamermesh, M. “Group Theory and its application to physical problems”. Addison-Wesley, 1962.
2. Wigner, E. P. “Group Theory and its application to quantum mechanics”. Academic press, 1959.

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## Course Code: 729 Course Title: Laser Physics

**Course Outline:**

Review of quantum mechanics. Interaction of radiation and atomic systems. The density matrix. Homogeneous and inhomogeneous broadening of atomic transitions. Gain and saturation effects. Hole burning. Optical resonators. Gaussian beams. Laser oscillation. Rate equations for a laser oscillator. Amplitude fluctuations and spiking. Some specific laser systems. Q-switching and mode locking. Focusing of laser beams.

**Recommended Books:**

1. Yariv, A. “Quantum Electronics”. John Willey & Sons, Inc., 1989.
2. Sargent III, M., Scully, M. O. and Lamb Jr. W. E. “Laser Physics”. Westview press, 1978.

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## Course Code: 730 Course Title: Introduction to Nanophysics

**Course Outline:**

Introduction to nanophysics and nanotechnology – scaling laws and limits to smallness; quantum nature of nanoworld; Nano fabrication (top-down and bottom-up process); nanoscopy (electron microscopy, atomic force microscopy, scanning tunneling microscopy). Properties and application of dielectric and metal nanostructures - individual nanoparticles and nanoclusters; nanostructured materials; carbon nanostructures; nanomagnets. Properties and application of semiconductor nanostructures - fabrication of semiconductor nanowires and quantum dots; electronic and optical properties (2D and 3D quantum confinement); optical spectroscopy of semiconductor nanostructures (local probe techniques); quantum dots nanowire- and quantum-dot-based electronic and photonic devices**.**

**Recommended Books:**

1. Edward L. Wolf., “Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience”. 3rd ed., Wiley-VCH, Germany, 2015.
2. Pradeep, T., “Nano, The Essentials: Understanding Nanoscience and Nanotechnology” 1st ed., Tata McGraw-Hill Publishing Company Limited, USA, 2007.