University of Barishal

Department of Physics

Syllabus for M.S. in Physics

(Session 2023-24 and Onward)

Master of Science (M.S.) program in Physics divided into **two groups**, namely **general group and thesis group.** The program contains 34 credits. Its duration is one year for general group and one and a half of a year for thesis group. Courses for the program will be offered with the approval of departmental academic committee. All the M.S. students (both general and thesis group) have to take 6 (six) theoretical courses. Dissertations are also offered for the students based on the faculty rules.

Admission into M.S. in Physics: Student who has completed/passed B.S. (Honors) degree in physics from the University of Barishal will be eligible for admission to M.S. in physics under the faculty of science and engineering.

General Group: Students of this group have to take six theoretical courses of 24 credits from the offered courses decided by academic committee, laboratory work (6 credits), and general viva (4 credits). Distribution of credits for general group is as follows:

Distribution of Credits and Duration for the General Group

Course	Total Credits	Grand Total
6 Theoretical courses	24	34
Laboratory work	6	
General Viva-voce	4	

Thesis group: Students of this group have to take six theoretical courses of 24 credits from the offered courses decided by the academic committee, thesis work (4 credits), thesis viva (2 credits) and general viva voce (4 credits). Distribution of credits for thesis group is as follows:

Distribution of Credits and Duration for the Thesis Group

Course	Total Credits	Grand Total
6 Theoretical courses	24	34
Thesis	4	
Thesis Defense	2	
General Viva-voce	4	

The Courses for the M.S.in Physics

M.S. program comprises of the courses (units) listed below.

Course Code	Course Title	Credits
0533-PHY-5101	Advanced Quantum Mechanics	4
0533-PHY-5102	Advanced Material Science	4
0533-PHY-5103	Nanomaterials and Nanotechnology	4
0533-PHY-5104	Condensed Matter Physics	4
0533-PHY-5105	Advanced Nuclear Physics	4
0533-PHY-5106	Biophysics and Medical Physics	4
0533-PHY-5107	Advanced Health and Radiation Physics	4
0533-PHY-5108	Advanced Plasma Physics	4
0533-PHY-5109	Polymer Physics	4
0533-PHY-5110	High Energy Physics	4
0533-PHY-5111	Electronic and Fiber Optic Communication	4
0533-PHY-5112	Renewable Energy	4
0533-PHY-5113	Semiconductor Device & Technology	4
0533-PHY-5114	Advanced Reactor Physics	4
0533-PHY-5115	Atmospheric Physics	4
0533-PHY-5116	Magnetism and Magnetic Materials	4
0533-PHY-5117	Biomaterials	4
0533-PHY-5118	Computational Physics	4
0533-PHY-5119	Astrophysics and Cosmology	4
0533-PHY-5120	MS Laboratory Work	6
0533-PHY-5121	MS Thesis	6
0533-PHY-5122	Solar Photovoltaics Device and Technology	4
0533-PHY-5123	General Viva-voce	4

All examinations shall be conducted as per provisions of the relevant examination rules and the ordinance for M.S. degree of this university.

Marks Distribution for the Courses

Course Type	Internal Assessment	Final Examination	Total Marks (850)
Theory	40%	60%	600
Laboratory	40%	60%	150
Thesis			100
Thesis Defense			50
General Viva-voce			100

The framework for the Year System

As the programme is running with yearly system, (i) usually class duration should be one hour and there will be minimum two classes in a week for a full unit course (4 credits) and minimum one class for half unit (2 credits) course. A full unit course should be conducted with 60 lectures and 30 lectures for a half unit course in one academic year.

Grading System

Total marks obtained in each course will be converted into LG (Letter Grade) and GP (Grade Point) as follows:

Numeral Grade	Letter Grade		Grade Point
80% and above	A+	(A plus)	4.00
75% to less than 80%	A	(A regular)	3.75
70% to less than 75%	A-	(A minus)	3.50
65% to less than 70%	B+	(B plus)	3.25
60% to less than 65%	B	(B regular)	3.00
55% to less than 60%	B-	(B minus)	2.75
50% to less than 55%	C+	(C plus)	2.50
45% to less than 50%	C	(C regular)	2.25
40% to less than 45%	D		2.00
Less than 40%	F		0.00

0533-PHY-5102	Advanced Material Science	4 credits, 60 Hours Lecture

1. **Introduction to Materials**

   Selected characteristics; Types of materials; Structure and properties; Mechanical and electrical behaviors; Thermal characteristics.

2. **Organic Materials**

   Wood, coal, organic polymers; Three dimensional polymers; Deformation of polymers; Electrical properties of polymers; Stability of polymers.

3. **Ceramic Materials**

   Ceramic phases; Ceramic crystal; Multiphase compounds; Silicate structure; Glasses; Mechanical and electrical behaviors of ceramics.

4. **Magnetic Materials**

   Magnetic materials and theoretical models for their magnetic properties; Application of magnetic materials; Ferrites and garnets.

5. **Methods for Characterization of Materials**

   Diffraction methods: X-ray, electron and neutron diffraction methods; Electron microscopy.

6. **Composite Materials**

   Classification; Fibrous composites; Matrix materials; Reinforcement materials; Matrix dependent classification.

7. **Superconductor**

   BCS Theory, Flux Quantization, Transverse response: Landau diamagnetism, Microscopic derivation of London equation, Effect of disorder, Quasiparticles and coherence factors, Ginzburg-Landau theory, Tunneling and Josephson effect.

Recommended Books

1. W. D. Callister Jr. and D. G. Rethwisch: Material Science and Engineering, John Wiley & Sons.

2. L.H Van-Vlack: Elements of Materials Science and Engineering.
3. Marder, P. Michael . Condensed Matter Physics.
4. Starfield, M. J. and Shvager A. M.: Introductory Materials Science.
5. O'Handley, Robert C.: Modern Magnetic Materials: Principles and Applications. Wiley
6. D.C. Jiles: Introduction to Magnetism and Magnetic Materials
7. B. D. Cullity, C. D. Graham: Introduction to Magnetic

0533-PHY-5103	**Nanomaterials and Nanotechnology**	**4 credits, 60 Hours Lecture**

1. **Introduction to Nanomaterials**

   The Science of Nano, what is Nano-biotechnology, Historical development of nano-materials and nanotechnology, Classification of nano-materials.

2. **Structure and Bonding in Nano-materials**

   Chemical Bonds, Intermolecular Forces, Molecular and Crystalline Structures, Carbon Nanotubes (CNT), Graphenes, Quantum Dots and Semiconductor Nanoparticles.

3. **Nanomaterial Synthesis**

   Top-down approach and bottom-up approach, thin films methods: chemical vapor deposition, physical vapor deposition, Mechanical methods: ball milling, mechanical attrition, Sol-gel methods of special nano-materials: carbon nanotubes, fullerenes, nanowires, Spray pyrolysis, Chemical bath deposition, Nanocomposite fabrication, Nanolithography.

4. **Properties of Nanomaterial**

   Size dependent properties: Surface to volume ratio (SVR), Size Effects on Structure and Morphology of Nanoparticles, Size and Confinement Effects, Specific Surface Energy and Surface Stress, Effect on the Lattice Parameter, Optical properties of quantum dots: Excitons, weakly & tightly bound excitons, excitons in molecular crystals and nano structures, Non-linear Optics

5. **Applications**

Nano-electronics, Nano optics, Nano-scale chemical- and bio-sensing, Biological/bio-medical applications, Photovoltaic, fuel cells, batteries and energy-related applications, High strength nano-composites, Nano-energetic materials.

6. **Nanotechnology**

Nanometers, micrometers, Moore's law, Esaki's quantum tunneling diode, quantum dots of many colors, nano scale elements in traditional technologies.

Recommended Books

1. Dieter Vollath: Nanomaterials; An Introduction to Synthesis, Properties and Applications
2. Dinesh C Agrawal: Introduction to Nanoscience and nanomaterials
3. Omar Manasreh: Introduction To Nanomaterials And Devices
4. W. Goddard: Handbook of NanoScience, Engineering and Technology
5. Hari Singh Nalwa: Handbook of Nanostructured Materials and Nanotechnology: Electrical PropertiesVol.3
6. Hari Singh Nalwa: Handbook of Nanostructured Materials and Nanotechnology: Optical PropertiesVol.4

0533-PHY-5105	**Advanced Nuclear Physics**	**4 credits, 60 Hours Lecture**

1. **Compound Nucleus Formation and Breakup**

Bohr hypothesis of compound nucleus; The continuum theory of nuclear reaction; Statistical theory of nuclear reactions (Hauser-Feshbach formalism); Heavy ion reactions, including fusion and transfer processes.

2. **Direct Reactions**

Kinematics of stripping and pickup reactions; Semi-classical approach to nuclear reactions; Wave mechanical description using PWBA and DWBA; Stripping reactions and their connection to the Shell model.

3. **Nuclear Models and Potentials**

Kapur-Pearls dispersion formula; Butler's theories of nuclear reactions; Giant resonances (types and energy scales); Nilsson's distorted potential model.

4. **Electromagnetic Interaction with Nuclei**

   Sources of multipole radiation (electric and magnetic); Angular momentum of multipole radiation; Parity and selection rules for nuclear transitions; Transition probabilities (Weisskopf estimates); Gamma-gamma angular distribution and correlation for spin and parity determination.

5. **Elementary Particles and Nuclear Physics Beyond Standard Reactions**

   Spectrum and interactions of known particles; Hadrons spectroscopy and resonances; SU(3) Flavor classification of the lightest Hadrons; Introduction to the Standard model and fundamental forces; Neutrino masses and oscillations with experimental evidence.

Recommended Books

1. B. R. Martin: Nuclear and Particle Physics: An Introduction (2nd Edition, Wiley);
2. K. S. Krane: Introductory Nuclear Physics (Wiley);
3. H. A. Enge: Introduction to Nuclear Physics;
4. Blatt and Weisskopf: Theoretical Nuclear Physics;
5. M. A. Preston and R. Bhaduri: Structure of the Nucleus;
6. B. R. Martin and G. Shaw: Particle Physics;
7. W. E. Burcham and M. Jobes: Nuclear and Particle Physics;
8. C. A. Bertulani: Nuclear Physics in a Nutshell (Princeton University Press);
9. J. R. Lamarsh: Introduction to Nuclear Reactor Theory;
10. K. Heyde: Basic Ideas and Concepts in Nuclear Physics.

0533-PHY-5106	**Biophysics and Medical Physics**	**4 credits, 60 Hours Lecture**

1. **Properties and Structure of Macromolecules**

   Atomic and Molecular forces, Nucleic acid (DNA, RNA), Methods of replication, Amino Acids, Protein.

2. **The Cell Membrane**

Properties of membrane, Transport and diffusion of ions and molecules through the cell membrane, Basic physics of membrane potentials, Measurement of membrane potentials, Membrane Model.

3. **Physics of Heart**

   Electrical activity of heart, ECG/EKG measurement, Typical waveforms and physiological origins of the major peaks in the waveform, Artificial Pacemaker.

4. **Diagnostic Radiology and Radiation Therapy**

   Radioactivity and Radiation, Principles of radiation therapy, Radiotherapy treatment planning, Dosimetry protocols, X-rays, clinical applications of X-rays, Isodose curve, Simulator, Teletherapy, Brachytherapy, Linear Accelerator (LINAC), Boron neutron capture therapy (BNCT), Proton beam therapy.

5. **Nuclear and Personalized Medicine**

   Radiopharmaceuticals, production and application, Positron Emission Therapy (PET), Single Photon Emission Computed Tomography (SPECT), CAR T-cell therapy.

6. **Medical Imaging**

   Nature, production and detection of ultrasounds, A-scan, B-scan, M-scan, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and gamma camera, Clinical applications, Image processing and analysis.

Recommended Books

1. B.H. Brown and R.H Small wood: Medical Physics and physiological Measurements
2. J.R Cameron and J. Skofronick: Medical Physics
3. Kuchel, Philip W., Simon Easterbrook-Smith, Vanessa Gysbers, and J. Mitchell Guss. 2009. Schaum's Outline of Biochemistry. 3rd ed.
4. John Kuriyan, Boyana Konforti, David Wemmer: The Molecules of Life - Physical and Chemical Principles. 1st Edition

0533-PHY-5112	Renewable Energy	4 credits, 60 Hours Lecture

1. **Sources of Renewable Energy**

   Biogas energy, Biomass energy, Geothermal energy, Tectonic Plates, Wave energy, Tidal energy, Wave energy converters, Pelamis/Sea Snake, Floating Wave Power Vessel, Sting Ray Tidal Stream Generator, LIMPET (Land Installed Marine Power Energy Transformer), Oyster type wave energy converter, Wave Climates, Small Hydro Power, Oscillating Water Column(OWC).

2. **Available Solar Radiation**

   The Sun, The Solar Constant, Spectral Distribution of Extraterrestrial Radiation, Variation of Extraterrestrial Radiation, Angles for Tracking Surfaces. Extraterrestrial Radiation on a Horizontal Surface and tilted surface, Radiation measuring instruments: Atmospheric Attenuation of Solar Radiation, Solar Radiation measurement related issues.

3. **Collectors**

   Flat-Plate Collectors: Energy Balance Equation, Temperature Distributions, Overall Heat Loss Coefficient, Heat Removal Factor and Flow Factor, Critical Radiation Level, Mean Fluid and Plate Temperatures, Effective Transmittance-Absorptance Product, Effects of Dust and Shading, Heat Capacity Effects, Liquid Heater Plate Geometries, Air Heaters, Measurements of Collector Performance and Characterizations, Practical Considerations for Flat-Plate Collectors. Concentrating Collector Configurations, Concentration Ratio, Thermal and Optical Performance, Cylindrical Absorber Arrays, Optical Characteristics of non-imaging concentrators, Orientation and Absorbed Energy for CPC Collectors, Performance of CPC Collectors, Linear Imaging Concentrators: Geometry, Images Formed by Perfect Linear Concentrators, Images from Imperfect Linear Concentrators, Ray-Trace Methods for Evaluating Concentrators, Incidence Angle Modifiers and Energy Balances, Paraboloidal Concentrators, Central-Receiver Collectors, Practical Considerations, Solar Selective black coatings.

4. **Design of Solar Photovoltaic (SPV) Systems**

   Photovoltaic Converters, Solar Cells: Classification, Construction, PV Generator: Characteristics and Models, Cell Temperature, Load Characteristics and Direct-Coupled Systems, Controls and Maximum Power Point Trackers, Applications, Design Procedures, High-Flux PV Generators. Fill Factor, Conversion efficiency, I-V Characteristics of a solar cell, Solar Home system, Solar Building Integrated System, Solar Grid Connected System, Solar related instruments.

5. **Wind Energy**

Introduction, Wind Resource, One-Dimensional Wind Turbine Model, Estimating Wind Turbine Average Power and Energy Production, Wind Flow: Power in the wind, Conversion of wind power, Efficiency of wind power conversion (Cp), Wind Turbines: types, components, Wind turbine sizing and System Design, Annual Energy production: Approximate and Accurate, Wind turbine power rating, Wind speed distribution functions.

Recommended Books

1. Duffie JA and Beckmen: Solar Engineering of Thermal Process
2. SP Sukahtme: Solar Energy- Principles of Thermal Collection and Storage
3. HP Garg: Solar Energy
4. Muhammad Iqbal : An Introduction to Solar Radiation
5. KA Khan: An Introduction to Solar Energy

0533-PHY-5113	Semiconductor Device and Technology	4 credits, 60 Hours Lect.

1. **Semiconductor Device**

E-K Diagram- the band structure; The density of states ρ(k) and ρ(E); Density of states in a quantum well; Occupation probability and carrier concentration; Semiconductor heterostructures - Lattice-matched Layers; Strained layer; Epitaxy and quantum well structures; Bandgap Engineering; Heterostructure p-n junction; Schottky Junction and Ohmic contacts. Fabrication of heterostructure devices; 2DHG system; Quantum Dots; Nano-electronics device: metal-oxide-semiconductor field-effect-transistors (MOSFETs); Optoelectronics devices: Device structure and output characteristics of semiconductor Laser and devices; Spintronics devices; Valleytronics.

2. **Crystal Growth and Wafer Fabrication Technology**

Clean room technology and contamination control; Czhorkralski method, Preparation of Wafers: Scribing, Chemical Mechanical Polishing, Cleaning and Inspection of Wafers.

3. **Device Fabrication**

   Molecular Beam Epitaxy (MBE); Chemical Vapor Deposition (CVD); Atomic Layer deposition (ALD), Thermal oxidation; Dielectric deposition; Metallization; Ion Implantation; Lithography and Etching.

4. **Device Characterization**

   Physical Characterization: X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Secondary Ion Mass Spectrometry (SIMS); Surface morphology: Atomic Force Microscopy (AFM); Optical Characterization: Raman Spectroscopy, Photoluminescence (PL), Laser and Optical Microscopy, Ellipsometry; Mobility: Hall Effect and Mobility, Magnetoresistance Mobility; Capacitance-voltage (CV) Measurements; Contact Resistance and Schottky Barriers; Resistivity: Two-Point Versus Four-Point Probe.

Recommended Books

1. S. M. Sze & Kwok K. Ng: Physics of Semiconductor Devices (Third Edition)
2. Dieter k. Schroder Semiconductor Material and Device Characterization (Third Edition)
3. Yasuhiro Shiraki and Noritaka Usami: Silicon-Germanium (SiGe) nanostructures
4. S. M. Sze Semiconductor Devices: Physics and Technology
5. G. Ghione :Semiconductor Devices for High-speed Optoelectronics

0533-PHY- 5116	**Magnetism and Magnetic Materials**	**4 Credits, 60 Hours Lecture**

1. **Magnetostatics and Magnetization**

   Magnetic poles; Magnetic flux; Magnetic flux density; Magnetic moment; Magnetic dipole; Magnetic effect of current; Magnetic induction; Magnetization; Susceptibility; Permeability; Magnetic materials and their classifications; Types of magnetic ordering (diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, ferrimagnetic); Magnetization curves and hysteresis loops, including energy loss and coercivity.

2. **Magnetism**

Observing the diamagnetic effect and its susceptibility; Diamagnetic substances and their applications; Uses of diamagnetic materials; Classical theory of magnetism (Larmor precession); Free electron theory of metals; Pauli paramagnetic susceptibility and its applications; Molecular field theory and temperature dependence of magnetization; Ferromagnetic domains and their formation; Origin and structure of domain walls; Neutron diffraction and its role in studying magnetic structures; Weiss theory of antiferromagnetism and susceptibility above and at the Néel temperature (T_N); Negative molecular fields and applications of antiferromagnets.

3. **Ferrimagnetism and Magnetic Phenomena**

   Weiss theory of ferrimagnetism; Behavior above the Curie temperature (T_C); Ferrites: cubic ferrites, hexagonal ferrites and garnets; Half-metallic antiferromagnets and their applications; Magneto-crystalline anisotropy: origin, theory and measurement; Magnetic annealing and its effects; Magneto-resistance phenomena in normal and ferromagnetic metals; Technological applications of giant magneto-resistance (GMR) and colossal magneto-resistance (CMR).

4. **Magnetic Semiconductors and Insulators**

   II-VI diluted magnetic semiconductors; III-V diluted magnetic semiconductors; Oxide-based diluted magnetic semiconductors; Rare-earth group V compounds; Properties and applications of ferromagnetic insulators.

5. **Multiferroics**

   Comparison of ferromagnetism with other ferroic ordering (ferroelectrics, ferroelastics and ferrotoroidics); Mechanisms of multiferroicity and coupling effects; Challenges and solutions for coexistence of magnetism and ferroelectricity; Applications in spintronics and memory devices.

Recommended Books:

1. B. D. Cullity and C. D. Graham: *Introduction to Magnetic Materials* (2nd Edition);
2. Nicola A. Spaldin: *Magnetic Materials: Fundamentals and Applications* (2nd Edition);
3. S. Chikazumi: *Physics of Magnetism*;
4. R. Skomski: *Simple Models of Magnetism*;
5. D. Jiles: *Introduction to Magnetism and Magnetic Materials* (3rd Edition);

6. S. Blundell: *Magnetism in Condensed Matter*.

0533-PHY- 5118	Computational Physics	4 credits, 60 Hours Lecture

1. **Fundamentals of Atomistic Modeling**
   First Principles Energy Methods: Hartree-Fock and DFT; Technical Aspects of Density Functional Theory; Case Studies of DFT; Advanced DFT: Success and Failure; DFT Applications and Performance.

2. **Molecular Dynamics and Monte Carlo Techniques**
   Molecular Dynamics; First Principles Molecular Dynamics; Monte Carlo Simulations: Application to Lattice Models, Sampling Errors, Metastability; Free Energies and Physical Coarse-Graining; Model Hamiltonians; Ab-Initio Methods.

3. **Quantum Chemistry Principles**
   Electronic Spin; Spin Orbitals; Molecular Orbital Theory; Valence Bond Theory; Hartree-Fock Theory; Matrix Manipulations; Solution of Hartree-Fock Equations; Basis Sets Introduction; Gaussian Basis Sets; Correlation; CI and MP Perturbation Theories.

4. **Density Functional Theory and Mixed Systems**
   Density Functional Theory: Solution of Kohn-Sham Equations, Exchange-Correlation Functionals; Classical Molecular Dynamics; Car-Parrinello Molecular Dynamics; Embedding; Reaction Field Methods; Solvation; Combined QM/MM Techniques.

Recommended Books

1. Martin, Richard M. *Electronic Structure: Basic Theory and Practical Methods*. Cambridge University Press, 2004.
2. Szabo, Attila and Neil S. Ostlund; *Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory*. McGraw-Hill, Inc., 1989.
3. Jensen, Frank. *Introduction to Computational Chemistry*. John Wiley and Sons, 1998.
4. Hehre, Warren J., Leo Radom, Paul v.R.Schleyer and J. A. Pople. *Ab initio Molecular Orbital Theory*. John Wiley and Sons, 1986.

5. Parr, Robert G. and Weitao Yang. *Density-Functional Theory of Atoms and Molecules*. Oxford University Press, 1989
6. Ercolessi, Furio. *A Molecular Dynamics* Primer.
7. Levine, Ira N. *Quantum Chemistry*. 5th ed. Prentice Hall, 1999.
8. Cohen-Tannoudji, Claude, Bernard Diu and Franck Laloë. *Quantum Mechanics*. John Wiley and Sons, 1977.
9. Hill, Terrell L. *An Introduction to Statistical Thermodynamics*. Addison-Wesley Publishing Company, 1962.
10. McQuarrie, Donald A. *Statistical Mechanics*. Harper Collins Publishers, Inc., 1976.
11. Ashcroft, Neil W. and N. David Mermin. *Solid-State Physics*. Harcourt Brace College Publishers, 1987.

0533-PHY- 5119	**Astrophysics and Cosmology**	**4 credits, 60 Hours Lecture**

1. **The Life and Death of Stars**

   Properties of stars; Formation of stars; Energy source (nuclear fusion, p-p chain, triple-alpha, CNO cycle, lifetime of the Sun); Solar neutrinos; Basic stellar structure; Evolution beyond the main sequence; Formation of the heavy elements; Supernovae; Stellar remnants (white dwarfs, neutron stars, black holes, degeneracy pressure, Schwarzschild radius).

2. **Planets and Life in the Universe**

   Contents of the solar system; Planetary and cometary orbits; Equilibrium temperatures; Extra-solar planets (Doppler wobble, transits, microlensing; prospects).

3. **Galaxies**

   Formation and classification of galaxies; Cosmic rays; The Milky Way system; Spiral structure; Density wave theory; Active galaxies; Peculiar galaxies and quasars; Clusters of galaxies.

4. **Cosmology**

   Galaxies and the expanding Universe; Hubble's Law; The age of the universe; The Big Bang; Cosmic microwave background (blackbody radiation); Big Bang nucleosynthesis (cosmic abundances, binding energies, matter and radiation); Introductory cosmology (the cosmological principle, homogeneity and isotropy, Olber's paradox); Cosmological models (critical density, geometry of space, the fate of the universe); Dark energy and the accelerating universe.

Recommended Books:

1. Zeilik and Gregory: *Introductory Astronomy & Astrophysics*
2. I. Morison: *Introduction to Astronomy and Cosmology*
3. M.L. Kutner: *Astronomy: A Physical Perspective*
4. Bradley W. Carroll: *An Introduction to Modern Astrophysics*
5. M.A. Seeds: *Horizons: Exploring the Universe*

0533-PHY- 5122	**Solar Photovoltaics Device and Technology**	**4 credits, 60 Hours Lec.**

1. **Introduction to Course**

   Review of Semiconductor Physics; Charge Carrier Generation and Recombination; p-n Junction Model and Depletion Capacitance; Current-Voltage Characteristics in Dark and Light.

2. **Device Physics of Solar Cells**

   Principle of Solar Energy Conversion; Conversion Efficiency; Single and Tandem Multi-Junction Solar Cells; Numerical Solar Cell Modeling.

3. **Principle of Cell Design**

   Crystalline Silicon and III-V Solar Cells; Thin-Film Solar Cells; Amorphous Silicon Solar Cells; Quantum Dot Solar Cells.

4. **Dye-Sensitized Solar Cells**

   Fabrication of Dye-Sensitized Solar Cells; Design of Novel Dyes; Design of Solid Electrolyte Materials; Counter Electrode Engineering.

5. **Organic Solar Cells**

   Physics of Bulk Heterojunction (BHJ) Solar Cells; Morphology and Charge Separation in BHJ; Design of Low Band Gap Polymers; Novel Architecture in BHJ.

6. **Perovskite Solar Cells**

   Fabrication of Perovskite Solar Cells; Photo-Physics in Perovskite Solar Cells; Stability in Perovskite Solar Cells; Lead-Free Perovskite Solar Cells.

7. **Photovoltaic System Engineering**

   Thermo-Photovoltaic Generation of Electricity; Photo-Thermal Cells; Energy Economy and Management; Photovoltaics Modules, Systems and Applications.

8. **Nanomaterials for Photovoltaics**

   PV Panels with Nanostructures; Band Gap Engineering and Optical Engineering; Photo-Thermal Cells; Energy Economy and Management.

Textbooks, References and Reading Material:

1. Wenham, S., M. Green, et al. (2006). *Applied Photovoltaics*. 2nd ed. Routledge. ISBN: 9781844074013.
2. Luque, A. and S. Hegedus, eds. (2003). *Handbook of Photovoltaic Science and Engineering*. John Wiley & Sons, Ltd. ISBN: 9780471491965.
3. Nelson, J. (2003). *The Physics of Solar Cells*. Imperial College Press. ISBN: 9781860943409.
4. Green, M. (1995). *Silicon Solar Cells: Advanced Principles and Practice*. Centre Photovoltaic Devices & Systems. ISBN: 9780733409943.

0533-PHY-5101	Advanced Quantum Mechanics	4 credits, 60 Hours Lect.

1. **Introduction to Advanced Quantum Mechanics**

   Schrödinger wave equation; Stationary states, The Heisenberg equations of motion, Poisson brackets, Integral of motions and symmetry conditions, Group theory in quantum mechanics, The form of the Schrodinger equation in different coordinate systems.

2. **Scattering theory**

   General formulation of scattering theory, Classical and quantum scattering, Asymptotic condition, Moller's operators, Definition of one particle scattering operator and its unitarity, Energy conservation, S-matrix, T-matrix, Representation of S and T-matrix in the configuration space and in the momentum space, Relation between Green's function and T-matrix.

3. **Quantum Theory of Systems consisting of Identical Particles**

Schrodinger equation for a system consisting of identical particles, Elementary theory of the ground state of two electron atoms, Excited state of helium atom, Self-consistent Hartree-Fock field, The statistical Thomas-Fermi method.

4. **Relativistic Quantum Mechanics**

Schrodinger relativistic equation, Klein-Gordon and Dirac equation, Properties of Dirac matrices, Plane wave solution of Dirac Equation, Spin and Magnetic moment of the electron, Spin-orbit coupling, Energy level in Coulomb field.

5. **Quantum phenomenon in Nanostructures**

Electronic energy states in quantum confined system, Semiconductor heterojunctions, 2DEG system, Quantum dots, Quantum wires.

6. **Quantum Statistical Mechanics**

Basic concepts, Quantum ideal gas, Bose-Einstein and Fermi-Dirac statistics, Distribution laws, Sackur-Tetrode equation, Equations of state, Bose-Einstein condensation.

7. **Second Quantization for Bosons and Fermions**

Second quantization of a field corresponding to Bosons, Second quantization of the meson field, Application of second-quantization method of systems of interacting Bosons, Occupation number representation for Systems of non-interacting Fermions for small energies, Systems of Fermions interacting through pair forces, Bogolyubov's canonical transformation, Quantization of the electron-positron field.

Recommended Books

1. A.S. Davydov: Quantum Mechanics
2. John. R. Taylor: Scattering Theory
3. P.M.A. Dirac: Quantum Mechanics
4. J. Sakurai: Modern Quantum Mechanics

5. Cohen :Quantum Mechanics (Part I & II)
6. L. Schiff: Quantum Mechanics
7. V. K. Thankappan: Quantum Mechanics
8. J. Singh: Quantum Mechanics: Fundamentals and Applications to Technology

0533-PHY-5104	Condensed Matter Physics	4 credits, 60 Hours Lecture

1. **Elastic Properties of Solids**

   Elastic constants and modulii of elasticity; Analysis of elastic strains; Stress components, dilation of a cubic crystal, Elastic compliance and stiffness constants; Elastic longitudinal and transverse waves in [100], [110], [111] directions of a cubic crystals.

2. **Alloys**

   General considerations, Substitutional solid solutions and Hume Rothery rules; Order-disorder transformation; Elementary theory of order; Phase diagrams; Phase changes in Cu-Zn alloy systems; Transition metal alloys; Kondo effect.

3. **Characterization of Crystals**

   Bragg's law for X-ray diffraction, structure determination, characterization of Crystals by X-ray; Modified Braggs law, Monochromators, design of a monolithic monochromator; Lattice parameter measurements; Bonds methods, EXAFS (Extended X-ray Absorption Fine Structures); XFH (X-ray Fluorescence Holography) in crystals; Dynamical theory of X-ray diffractions and its applications.

4. **Electron States and Energy Bands in Solids**

   Energy bands, The nearly free electron model; Origin of the energy gap, The tight binding method; Energy calculation for SC, BCC and FCC crystals using tight binding model, Cellular method; Muffin-Tin potentials; Augmented plane wave (APW) method; Orthogonalized plane wave (OPW); Pseudo- potential theory; Hartee and Hartee- Fock approximation.

5. **Plasmons, Polaritons and Polarons**

Dielectric function of the electron gas; Plasma optics; Dispersion relation for electromagnetic waves; Transverse optical modes in a plasma; Longitudinal plasma oscillations; Plasmons; Electrostatic screening; Mott metal- insulator transition; Screening and phonons in metals; Polaritons; Electron-electron interactions; Polaron and electron phonon interaction; Peierls instability of linear metals.

Recommended Books

1. N. W. Ashcroft and N.D. Mermin: Solid State Physics (Thomson Press).
2. C. Kittel, :Introduction to Solid State Physics
3. J.R. Hook and H.E. Hall: Solid State Physics.
4. Marder, Michael P.: Condensed Matter Physics.
5. J. S Blakemore: Solid State Physics.
6. C. Kittel: Quantum Theory of Solids.
7. H. E Hall: Solid State Physics.
8. James D. Patterson: Introduction to the Theory of Solid State Physics.
9. Mysers, H.P: Introductory Solid State Physics.
10. Stephen Blundell: Magnetism in Condensed Matter

0533-PHY-5107	Advanced Health and Radiation Physics	4 credits, 60 Hours Lect.

1. **Evaluation of Radiation Safety Measures**

   Medical Surveillance; Estimation of internally deposited radioactivity; Individual monitoring; Radiation and contamination surveys; Air sampling; Continuous environmental monitoring; Combined exposures; Source control.

2. **Radiation Monitoring Instruments**

   Introduction; Operational quantities for radiation monitoring; Area survey meters; Individual monitoring.

3. **Treatment Machines For External Beam Radiotherapy**

Introduction; X-ray beams and x-ray units; Gamma ray beams and gamma ray units; Linacs; Radiotherapy with protons, neutrons and heavy ions; Shielding considerations; Cobalt-60 teletherapy units versus linacs.

4. **Clinical Treatment Planning in External Photon Beam Radiotherapy**

Introduction; Volume; Dose specification; Clinical considerations for photon beams.

5. **Interaction of Radiation with Matter**

Beta Rays: Range-energy relationship, mechanisms of energy loss (Ionization and Excitations, Bremsstrahlung); Alpha Rays: Range-energy relationship; Energy Transfer, Gamma Rays: Exponential absorption, interaction mechanisms, Neutrons: Production, classification, Interaction: Scattering, absorption, neutron activation.

6. **Radiation Dosimetry**

Units: Absorbed dose, exposure; Exposure Measurement: Free air chamber; Exposure Measurement: Air wall chamber, exposure dose relationship, Absorbed Dose Measurement: Bragg-Gray principle, kerma, Source Strength: Specific gamma ray emission, internally deposited radioisotopes, corpuscular radiation, effective half-life; Total Dose: Dose commitment, gamma emitters, MIRD method, neutrons.

7. **Biological Effects of Radiation**

Dose-Response Characteristics: Direct action, indirect action, Radiation Effects: Acute effects, delayed effects; Risk Estimates: BEIR III, Relative biological effectiveness (RBE) and quality factor (QF); Dose Equivalent: Sievert (and the Rem), high energy radiation.

8. **Health Physics Instrumentations**

Radiation Detectors: Particle counting instruments, gas filled particle counters, ionization chamber counter, proportional counter, Geiger counter, quenching a Geiger counter, Resolving Time: Measurement of resolving time, scintillation counters, nuclear spectroscopy, Cerenkov detector, semiconductor detector; Dose-Measuring Instruments: Pocket dosimeters, film badges, thermo luminescent dosimeter.

9. **External Radiation Protection**

Basic Principles; Techniques of External Radiation Protection: Time, distance, shielding, X-ray shielding, beta ray shielding, neutron shielding. Internal radiation hazard; Principles of Control: Control of the source, confinement, environmental; control of Man: Protective clothing, respiratory protection, surface contamination limits; Waste Management: High, intermediate and low level liquid wastes.

Recommended Books

1. Herman Cember: Introduction to Health Physics
2. Fayez Ahmed Khan: Physics for Radiotherapy
3. R.E. Lapp and H.L Andrews: Nuclear Radiation Physics
4. A. Martin and S.A. Harbison: An Introduction to Radiation Protection

0533-PHY-5108	**Advanced Plasma Physics**	**4 credits, 60 Hours Lecture**

1. **Review of Waves in Plasmas**

   Ion-acoustic waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Lower hybrid waves: Basic concept, Derivation of lower-hybrid frequency, Physical interpretation; Upper-hybrid waves: Basic concept, Derivation of upper-hybrid frequency, Physical interpretation; Shear Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Compressional Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation.

2. **Nonlinear Waves in Plasmas**

   Solitary waves; Shock waves; Ion-acoustic solitary waves: Derivation of Korteweg-de Vries (K-dV) equation, Stationary solitary wave solution of K-dV equation, Physical interpretation; Ion-acoustic shock waves: Derivation of Burgers equation, Stationary shock wave solution of Burgers equation, Physical interpretation.

3. **Concept of Dusty Plasma Physics**

   Definition of dusty plasmas; Characteristics of dusty plasmas; Differences between electron-ion plasma and dusty plasma; Occurrence of dusty plasmas; Typical dusty plasma parameters in space and laboratory devices; Aspects of dusty plasma physics.

4. **Linear Waves in Dusty Plasmas**

   Dust-ion-acoustic waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Dust-acoustic waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Dust-lower-hybrid waves: Basic concept, Derivation of dust-lower-hybrid frequency, Physical interpretation; Dust cyclotron waves: Basic concept, Derivation of dust-cyclotron frequency, Physical interpretation; Shear dust- Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation; Compressional dust Alfvén waves: Basic concept, Derivation of dispersion relation, Physical interpretation.

5. **Nonlinear Waves in Dusty Plasmas**

   Dust-ion-acoustic solitary waves: Derivation of K-dV equation, Stationary solitary wave solution of K-dV equation, Physical interpretation; Dust-acoustic solitary waves: Derivation of K-dV equation, Stationary solitary wave solution of K-dV equation, Physical interpretation; Dust-ion-acoustic shock waves: Derivation of Burgers equation, Stationary shock wave solution of Burgers equation, Physical interpretation.

Recommended Books

1. Chen, F. F. : Introduction to Plasma Physics and Controlled Fusion
2. Shukla, P. K. and Mamun, A. A.: Introduction to Dusty Plasma Physics

0533-PHY-5109	**Polymer Physics**	**4 credits, 60 Hours Lecture**

1. **Introduction**

   Nomenclature of Polymers, General notions, Structure of macromolecular compounds, Aggregation and phase states, transition temperatures, homopolymers, copolymers, classification criteria, classification of polymers, Isomerism in polymers.

2. **Polymer Conformations**

   Average end-to-end distance for model chains (freely-jointed, freely-rotating and hindered rotation chains); Characteristic ratio and statistical segment length; Semi-flexible chains and the persistence length; viscosity of polymers; advanced polymeric materials.

3. **Polymerization**

   Introduction to chain molecules, Chain-growth polymerization; Step-growth polymerization; Plasma polymerization, Properties and application of plasma-polymerized organic thin films; Polymer blends and composites: Compounding and mixing of polymer, Their properties and application; Electrical properties of polymers: Basic theory of the dielectric properties of polymers, Dielectric properties of crystalline and amorphous polymers.

4. **Thermodynamics of Polymer Solutions and Blends**

   Regular solution theory (for solution mixtures); Flory-Huggins theory (for polymer solutions);Osmotic pressure of solutions, Number-average molecular weight based on osmotic pressure, Predictions by Flory-Huggins theory.

5. **Polymer materials with special properties**

   Intelligent composite materials, interpenetrated polymer networks, liquid crystals in various materials, drug carrier polymers, metalocenes, polymers with biomedical applications, polymer membranes, carbon fibers and carbon fiber composites, conductor and semiconductor polymers, polymer sensors, biodegradable polymers; Network, gels and rubber elasticity; Viscosity of polymers; Glass transition, Techniques for complex polymer materials characterization.

Recommended Books

1. Fred W. Billmeyer :Textbook of Polymer Science
2. Von A. R. Blythe : Electrical properties of polymers
3. M. Rubinstein and R. Colby :Polymer Physics (Oxford University Press, 2003)
4. G. R. Strobl: The Physics of Polymers (Springer, 2007 or later)

0533-PHY-5110	**High Energy Physics**	**4 credits, 60 Hours Lecture**

1. **Introduction to Elementary Particles**

   The classical era, the photon, mesons, antiparticles, neutrinos, strange particles, the eightfold way, gravity, the quark model, the November revolution and its aftermath, intermediate vector bosons, the standard model, interactions of particles with matter, and detectors.

2. **Symmetries and Quarks**

   Symmetries and groups, SU(2), SU(3), models of mesons and baryons.

3. **Elementary Particle Dynamics**

   QED, weak interactions, parity violation, lepton-nucleon scattering, and structure functions, QCD, gluon field and color. W and Z fields, unification schemes, electro-weak unification, the CKM matrix.

4. **Electrodynamics of spinless and spin -1/2 particles**

   An electron in an electromagnetic field, spinless electron-muon scattering, electron-positron scattering: an application of crossing, Invariant variables, origin of the propagator, Moller scattering, Trace theorems and properties of γ-matrices, Helicity conservation at high energies, photons polarization vectors, Compton scattering and pair annihilation.

5. **Elementary Particle Interactions**

   Electron-proton scattering, inelastic electron-proton scattering, Nucleon-nucleon interactions, properties of nuclei, single and collective particle models. Electron and hadron interactions with nuclei, e^-e^+ annihilation. Relativistic heavy ion collisions, and transition to quark-gluon plasma.

6. **Quantum Chromodynamics**

   Feynman Rules for Chromodynamics, the Quark-Quark Interaction, Pair Annihilation in QCD, Asymptotic Freedom, Applications of QCD,

Recommended Books

1. David Griffiths :Introduction to Elementary Particles
2. Donald Perkins :Introduction to High Energy Physics .
3. Gordon Kane :Modern Elementary Particle Physics
4. Quarks and Leptons: An Introductory Course in Modern Particle Physics
5. Stephen Gasiorowicz: Elementary Particle Physics

6. James Bjorken and Sidney Drell: Relativistic Quantum Mechanics

0533-PHY-5111	Electronics and Fiber Optic Communication	4 credits, 60 Hours Lect.

1. **Communication Fundamentals**

   Communication; Block diagram of a communication system; Modulation; Transmission impairments and their types; Data; Signal and its types; Bit interval; Bit rate; Fiber optics in communications.

2. **Modern Telecommunication**

   Digital communication system, information & coding theory, Error correction and coding, Internet work, networking SMDS – Coupled modes in optical wave guides, Periodic & Optical filters, Optical solution Propagation, system design and applications.

3. **(i) Television**

   Fundamentals of TV Transmission and reception of picture information, Scanning, Standard scanning pattern, Synchronization, Blanking pulses, Composite video signal, Vestigial sideband transmission, Line of sight transmission, TV channels.TV Transmitter & Receiver: Fundamentals of TV receiver, Picture tubes, Deflection circuit, High voltage power supply, Folded dipole with directors and reflectors for TV receiver, TV Transmitter and TV studio design, HDTV. Color TV: Definition of Color TV, Types of color video signals, Matrix circuits, Colorplexed composite video signal, Fundamentals of color TV receiver, Color picture tube, LCD and other flat panel TV receivers

   (ii) Satellite Communication

   Orbits, station keeping, satellite altitude, transmission path, path loss, noise consideration, satellite system, saturation flux density, effective isotropic radiated power, multiple access methods, earth station antenna, satellite link design, frequency plan, satellite communication for Internet, VSAT network, One way, two way and open sky satellite communication, GNSS GPS and Galileo systems and GIS, Satellite Navigation, DBSTV.

   (iii) Radar

   Basic principles, Radar equation, factors influencing maximum range, effect of noise, power and frequencies used in Radar, types of Radar, Basic pulsed Radar system, Modulators, receivers, Bandwidth requirements, factors governing pulse characteristics, Duplexer, moving target indicator (MTI), tracking Radar systems and search systems.

4. Instrumentation

Transducers; Capacitive transducers- advantages and disadvantages, piezoelectric transducers, Hall effect transducers. Magneto-resistance effect, digital displacement transducers: tachometer, Seismic transducers, Ultrasonic flow transducers, Remote sensing, Instrumentation with operational amplifiers.

5. Optoelectronics

Electro-optic, magneto-optic and acousto-optic effects; Photodetectors: thermal, thermoelectric detectors; Photon devices: Photo-emissive devices, Photomultipliers, image intensifiers, phototransistors; Optical fiber waveguides

6. Optical fiber communication

(i) Introduction

Optical fibers; Structure, Step index and graded index fibers, Modes of propagation, modal theory for circular waveguide, Modal equations, Waveguide equations, Power flow in optical fibers, Signal degradation in optical fibers, Fiber attenuation, Distortion in optical guides, Dispersions, Mode coupling.

(ii) Optical Sources and Detectors

Optical modulation and detection schemes, Direct and coherent detection receivers configuration, operation, noise sources, sensitivity calculation, performance curves, Optical Amplifiers, Design of analog and digital receivers.

Recommended Books

1. John M. Senior :Optical Fiber Communications
2. Djafar K Maenbaev: Fiber Optic Communications Technology
3. Robert L. Shrader :Electronic Communication
4. R.R. Gulati: Monochrome & Color Television
5. Marcelo S. Alencar: Digital Television Systems
6. S. Y. Lao :Microwave devices and Circuits
7. Robert M Gagliardi :Satellite Communication

0533-PHY-5114	Advanced Reactor Physics	4 credits, 60 Hours Lecture

1. **Nuclear Reactors and Nuclear Power**

   Components of nuclear reactors; Non-nuclear components of nuclear power plants; Power reactors and steam supply systems; PWR, Organic-cooled reactors; Gas-cooled thermal reactors; Heavy-water reactor; Breeder reactors: LMFBR, MSBR.

2. **Neutron Spectrum in the Energy Region above 1 eV**

   Neutron Spectrum in an infinite assembly; High energy region; Slowing down region; Neutron spectra in a finite assembly; Effects of inelastic scattering on neutron spectrum.

3. **Energy Spectrum of Thermal Neutrons**

   Thermal spectrum in an infinite medium; The Maxwellian spectrum; Diffusion heating and cooling; Neutron spectrum in an ideal proton gas; Solution of Wigner-Wilkins equation for a weak 1/v-type absorber; Neutron spectrum of heavy gas model; The effect of temperature model.

4. **Heat Generation and Removal**

   General thermodynamic considerations; Heat generation in reactors; Heat flow by conduction; Heat transfer to coolants; Boiling heat transfer; Reactor coolants and associated phenomena.

5. **Reactor Materials**

   Structural materials; Moderator and reflector materials; Radiation effects on materials; Corrosion and chemical reactions in coolant circuit materials; Fuel materials; Production of reactor fuels; Properties of fuel element materials; Waste disposal.

6. **The Non-steady Nuclear Reactor**

   Reactor kinetics**;** Control rods and chemical shim, Temperature effects on reactivity, Fission production poisoning; Core properties during lifetime.

7. **Reactor Shielding and Safety**

Principles of reactor shielding; Different types of shielding systems and materials; Attenuation of fast neutrons and gamma rays; Principles of nuclear power plant safety; Reactor accidents and risk analysis.

Recommended Books

1. J.R. Lamarsh: Introduction to Nuclear Engineering.
2. J. R. Lamarsh: Introduction to Nuclear Reactor Theory.
3. S. E. Liverhant: Elementary Introduction to Nuclear Reactor Physics.
4. R. L. Murray: Introduction to Nuclear Engineering.
5. S. Glasstone and A. Sessonske: Nuclear Reactor Engineering.
6. Elmer E. Lewis; Fundamentals of Nuclear Reactor Physics.
7. Bell and Glasstine: Nuclear Reactor

0533-PHY- 5115	Atmospheric Physics	4 credits, 60 Hours Lecture

1. **Structure and composition**

   Classification, and Composition of the atmosphere, composition in upper layers, stratification, Basic laws, geopotential and geopotential height, lapse rates, moisture variables, atmospheric diagrams, dissociation, instability.

2. **Cloud Physics**

   Cloud formation, growth of cloud droplets by diffusion & coalescence, precipitation and formation.

3. **Dynamic Meteorology**

   Basic equation of motion, geostrophic approximation, thermal wind, PBL. Surfaces of constant pressure and Thermal wind equation.

4. **Atmospheric Waves**

   Introduction; Sound waves; Gravity waves; Rossby waves; Varticity equation; Three dimensional Rossby-type waves; Turbulence.

5. **Ozone physics**

Qzone in the earth's atmosphere, vertical distribution of Ozone decay, dynamics & transport of Ozone, Greenhouse gases, measurements of ozone.

6. **Tropical meteorology**

   Tropical depression & its Classification, weather system, monsoon & its classification.

7. **Climatology**

   Factors of climatic formation, climatic classification, Theories of climate change.

8. **Atmospheric Predictability & Climate Change**

   Short-term predictability; Variations of climate; Atmospheric feedback processes; Different kinds of predictability; Jupiter's great red spot; Challenge of climate research.

Recommended Books

1. D. G. Andrews : An Introduction to Atmospheric Physics, CUP.
2. D. G Andrews,. J. R. Holton and C. B. Leovy : Middle Atmosphere Dynamics,
3. J. Houghton, J. : The Physics of Atmospheres, CUP.
4. J. R. Holton : An Introduction to Dynamic Meteorology
5. H.R Byers: Introduction to General Meteorology.
6. J. M. Wallace and P. V. Hobbs : Atmospheric Science: An Introductory Survey
7. Rogers, R. R. and M. K. Yau (1989): A Short Course in Cloud Physics

0533-PHY- 5117	**Biomaterials**	**4 credits, 60 Hours Lecture**

1. **Introduction to Biomaterials**

   Definition of biomaterials; Bone structure and types; Biological materials; Designed biomaterials; Basic properties of biomaterials; Methods to characterize biomaterials surfaces; Role of water in biomaterials; Tissue engineering; Properties of ideal scaffold for tissue engineering; Classification of potential scaffold materials.

2. **Physico-Chemical Properties of Biomaterials**

Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance); tribological (friction, wear, lubricity); morphology and texture, physical (electrical, optical, magnetic, thermal), Chemical and Biological properties.

3. **Biomedical Glasses and Glass Ceramics**

   Introduction to Bioactive Glass; Types of Bioactive Glass; Phase diagram; Bioactivity spectrum; Melt-derived bioactive Bio glass; Sol-gel derived bioactive; Phases of surface reactions; In vitro evaluation of bioactivity; Foam scaffolds and their Applications.

4. **Dental Glass Ionomer Cements**

   Glass Design; Polyalkenoate Cements Setting Reaction; Fluorapatite Mullite Glass-Ceramics; Implanted FAP Glass; Implanted FAP Glass-Ceramic; Sr substituted aluminosilicate ionomer glass; Characterization of glasses and glass ceramics; APS and Crystallization; Schematic APS and Crystal Growth; Solid State Magic Angle Spinning Nuclear Magnetic Resonance MAS-NMR.

5. **Metals as Biomaterials**

   Mechanical properties of metallic biomaterials; Advantages of metallic biomaterials; Loading of Joint Prostheses; Stainless & ASS; Alloy Design; Pitting corrosion; Intergranular corrosion; Corrosion induced fracture of ASS stem; Alloy Development; Orthopaedic Applications; Orthodontic Applications; Surgical Instrument & Devices.

6. **Polymers as Biomaterials**

   Polymers; Major Biomedical Applications of Polymers; Biomedical Applications of Natural Polymers; The 2 types of polymer synthesis; Polyethylene – Addition Polymerization; Condensation Polymerization; Structural types of polymers; Structure of a semi-crystalline polymer; Thermoplastic polymers; The Reptation Model.

7. **Composites as Biomaterials**

   Bone grafting; Hydroxyapatite; Methods for synthesizing HA; Wet methods- Precipitation method; Glass reinforced HA Composites; Hydroxyapatite (HA) Preparation; Glass preparation; Composite preparation; Biological assessment of Glass reinforced HA Composites;

8. **Ceramics as Biomaterials**

Calcium phosphate ceramics; Applications of calcium phosphates; Hydroxyapatite; Bone; Ceramics according to their different levels of organization; Forms of HA graft; Calcium orthophosphate solubility; The influence of stirring of particle size; Hydroxyapatite ceramic processing; Surface modification of Si substituted apatite; Multifunctional SiHA particles; Functionalisation of SiHA; Crosslinking SiHA; tricalcium phosphate; Calcium orthophosphate cements; Calcium orthophosphate compositions; Chemistry of the cement setting reactions; Load-bearing cement.

Recommended Books

1. Mark D Miller: Review of Orthopedics.
2. Mark D Miller, Jennifer Hart, John MacKnight: Essential Orthopedics. Saunders Elsevier.
3. David J Warwick, Louis Solomon, Selvadurai Nayagam: Apley's system of orthopedic and fractures. 8th Edition
4. B.H. Brown and Small wood R.H, D.C Barber P V Lawford and D R Hose: Medical Physics and Biomedical Engineering.
5. Jeffrey O. Hollinger; An Introduction to Biomaterials

0533-PHY-5120	**MS Laboratory Work**	**6 credits**

Group-A

(One experiment to be performed in the examination)

Advanced Solid State Physics:

1. Determination of the Planck’s Constant.
2. Determination of lattice constants of crystals by Laue diagrams and Debeye-Scherrer photos.
3. Indexing the X-ray diffraction profile and determination of the lattice parameter.
4. Determination of crystalline size by Scherrer method.
5. Measurement of dielectric loss tangent and determination of activation energy of materials.

6. Nd: YAG laser: Alignment and determination of slope efficiency.

Advanced Electronics and Semiconductor Physics:

1. To study the characteristics of a piezoelectric transducer and a ceramic transducer.
2. Measurement /Calculation of energy band gap of the elemental/compound semiconductor.
3. Study on the energy band calculation and determination of band gap for given metal using Kronig Penny Model.
4. Energy band calculation and determination of band gap following Tight Binding Approximation.

Group-B

(One experiment to be performed in the examination)

Advanced Nuclear Physics:

1. Analysis of nuclear scattering data using squared Woods-Saxon potential.
2. Analysis of NaI (Tl)/HPGE gamma-ray spectra.
3. Calculation of some nuclear properties by computer programs.
4. Experiments on gamma ray spectroscopy using NaI Detectors and set of sources: Gamma analysis of 0.835 MeV spectrum of 54Mn.
5. Experiments on gamma ray spectroscopy using NaI Detectors and set of sources: Determination of Fermi age of neutrons in a given medium from the given data.

MATLAB:

1. Write codes for implementing different numerical techniques for solving ordinary differential equations.
2. Write codes for implementing different numerical techniques for solving Partial differential equations.
3. Write codes for Monte Carlo simulation.
4. Using MATLAB Analysis of Frequency response of a Low Pass Filter.
5. Using MATLAB Analysis of Temperature Effect on Diode Characteristics.

Solar Energy

1. Determination of the conversion efficiency of a Solar Cell.
2. A study on deterioration of Monocrystal Solar Photovoltaic Module.
3. A study on the Performance of two identical Solar Cells in (a) Series and (b) Parallel Combination.
4. To study the I-V characteristics of a solar cell /photoresistor as a function of the irradiance.

N.B. Any experiment to be set up in future may be included in the syllabus

0533-PHY-5121	**MS Thesis**	**6 Credits**

0533-PHY-5123	**General Viva-voce**	**4 Credits**

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