Objectives: To introduce the classical formulation approaches like Lagrangian and Hamiltonian dynamics in understanding mechanical systems and solving of problems.


Unit 2: RIGID BODY DYNAMICS - Kinematics - degrees of freedom - Euler angles - Euler's theorem on the motion of a rigid body - Rotations - finite and infinitesimal. Angular momentum and kinetic energy - Inertia tensor - Principal axes - Euler's equations - Torque free motion of a rigid body - Symmetric top - Precession and nutation - applications – Motion in rotational frames – centrifugal and coriolis force.

Unit 3: HAMILTONIAN FORMULATION - Legendre transformation and Hamiltonian equations - Cyclic coordinates and conservation theorems - Hamiltonian equations from Variational principle - Canonical transformations - Poisson brackets - equations of motion - conservation theorems in Poisson bracket formulation - angular momentum Poisson brackets - generation of canonical transformations.


Unit 5: SMALL OSCILLATIONS - the eigenvalue equation - the principal axis transformation - free vibrations - normal coordinates - linear triatomic molecule – double pendulum – triple pendulum – triple parallel pendulum.

BOOKS FOR STUDY:

BOOKS FOR REFERENCE:
PH1818 - ELECTRODYNAMICS

Class : I M.Sc.  Credits: 4
Semester : I  Hrs./week : 6

Objective: To study the laws governing the distribution and propagation of electromagnetic fields created by static and dynamic charge distributions and their interaction with matter.

UNIT 1: Electric and Magnetic potential: Divergence and curl of \( E \) - Electric scalar potential - Poisson's and Laplace's equations - uniqueness theorems - potential of a localised charge distribution - electric potential - energy of a continuous charge distribution - multi pole expansion: approximate potentials at large distances - monopole and dipole terms - electric dipole moment - electric field of a dipole.

Divergence and curl of \( B \) - Energy in the magnetic fields due to current carrying elements - Magnetic vector potential - magnetic potential at any point due to current carrying elements - multi pole expansion of the vector potential - magnetic dipole moment - magnetic field of a dipole.

UNIT 2: Electrodynamics: Maxwell's equation in free space and in matter, displacement current, boundary conditions, Gauge transformations - Coulomb and Lorentz gauge - momentum - Poynting's theorem - Polarisation - monochromatic plane waves - energy and momentum in electromagnetic waves.

Propagation in linear media - reflection and transmission at (i) normal incidence (ii) oblique incidence - laws of geometrical optics - Fresnel's equation - Brewster's angle - boundary conditions - absorption and dispersion in conductors - skin depth - reflection at a conducting surface - dispersion and anomalous dispersion - Cauchy's formula

UNIT 3: Relativistic electrodynamics: Four vectors - tensor algebra, Lorentz transformation - invariance of Maxwell's equations under Lorentz transformation - transformation of electromagnetic field intensities - electromagnetic field tensor - electromagnetic field invariants - covariant form of Maxwell's equations - electromagnetic energy - momentum tensor, conservation laws of vacuum electrodynamics.

Relativistic Lagrangian for a free particle - energy - momentum of a free particle - Lagrangian and Hamiltoninan for a charged particle in an electromagnetic field.


UNIT 5: Guided waves and magneto hydrodynamics (MHD): Essential conditions for guided waves - TEM waves in coaxial cables - TE waves - rectangular wave guide - electric and magnetic fields on the surface and inside rectangular wave guide - TE and TM waves in rectangular wave guide - cut off frequency and wavelength - circular waveguides - energy flow and attenuation in wave guides - cavity resonators - phase and group velocity

MHD - Definitions - magneto hydrodynamic equations - magnetic diffusion - viscosity and pressure

Books for study:
PH1819 - ELECTRONICS AND PROGRAMMING

Class : I M.Sc.  Credits: 4
Semester : I  Hrs./week : 6

Objective: The students are exposed to the wide applications of Operational amplifiers and focuses on in depth understanding of the architecture and working of microprocessor Intel 8086. This paper also introduces the learner to the basics of C++ programming with emphasis on using C++ to solve physics related problems.

UNIT I: Operational Amplifiers and A/D & D/A Converters
Ideal Op - Amp - inverting, non - inverting, logarithmic, summing and difference amplifiers - integrator and differentiator - as a comparator - CMRR – differential amplifier – A/D and D/A converters.
Applications: Solving simultaneous and differential equations - weighted resistor and R - 2R D/A converters - parallel, binary counter and successive approximation AID converters.

UNIT II: Intel 8086 Architecture, Instruction set and Introduction to Macro Assembler (ASM86)
CPU architecture - addressing modes - instruction formats - instruction set - execution timing - Assembler directives – assembler operators - assembly process - translation of assembler instructions - simple programs.

UNIT III: Modular Programming and Multiprogramming
Linking and relocation - access to external identifiers – procedures - interrupts and their routines –macros - process management and IRMX86 - semaphore operations - common procedure sharing.

UNIT IV: I/O consideration, Interrupts and System bus structure
Programmed I/O - Interrupt I/O - block transfer and DMA - basic 8086 bus configuration - minimum and maximum modes - system bus timings - interrupt priority management - single and multiple 8259.
Applications (Units II to IV): Assembly language programs involving arithmetic and logical operations - use of subroutines - manipulating arrays - solving equations - keys and LEDs interface – delays - interfacing D/A and D/A converters - generation of waveforms - simulation of counter and successive approximation AID converters.

UNIT V: Programming in C++
Basic program structure - Simple data types, variables, constants, operators, comments - Control Flow; if, while, for, do - while, switch – Functions, Types, parameters, prototypes, recursion - Array usage Pointers, addresses and types, call by reference Pointer - array duality, Strings - Arrays of pointers - Structures - Member accessing - pointers to structures - Arrays of structures, linked lists

BOOKS FOR STUDY:

BOOKS FOR REFERENCE:

PH1820 - MATHEMATICAL PHYSICS - I

Class : I M.Sc.  Credits: 4
Semester : I  Hrs./week : 5

OBJECTIVE: The foundations to various mathematical techniques and tools like numerical methods, transform techniques and special functions which forms the back bone of all higher physics is introduced.

UNIT 1: NUMERICAL METHODS:
Solution of Nonlinear equations: Newton - Raphson method – Regula Falsi method
Solutions of system of linear equations: Gauss elimination method with and without pivoting - Gauss - Siedel iterative method
Solution of ordinary differential equations: Euler method - Euler modified method – Runge - Kutta method( 2nd order)

UNIT 2: COMPLEX ANALYSIS:
Analytic function - Cauchy - Riemann equations - Laplace equation and harmonic function - Line integral in complex plane - Cauchy’s theorem - multiple connected regions - Cauchy integral formula - Derivatives of analytic function - Taylor and Laurent series - Singularities - Residue theorem - Evaluation of real integrals
Application: Potential theory - (1) Electrostatic fields and complex potentials - Parallel plates, coaxial cylinders and an annular region (2) Heat problems - Parallel plates and coaxial cylinders

UNIT 3: LINEAR VECTOR SPACE:

UNIT 4: TENSOR ANALYSIS:
Tensors in Physics - Notation and conventions - Contra and covariant tensors of rank one and two - Transformation from Cartesian to polar coordinates - Algebra of tensors - outer and inner products - Contraction - Symmetric and anti symmetric tensors - Quotient law - Conjugate tensors - Metric tensor - Raising and lowering of indices
Cartesian tensors - Rotation and translation - Orthogonal transformations - Transformation of divergence and curl of vectors - Stress, strain and Hooke’s law - Piezoelectricity and dielectric susceptibility - Moment of inertia tensor

UNIT 5: SPECIAL FUNCTIONS - I
Series solution with simple examples - Gamma and Beta functions - Properties - Legendre polynomial and function - Generating function - Rodrigue formula – Orthogonality property - Associated Legendre function - Recurrence relations - spherical harmonics - Graphs of Legendre functions - Bessel function - Generating function - Hankel function - Recurrence relations - Spherical Bessel function - Graphs - Orthonormality relation

BOOKS FOR STUDY:
1) Mathematical Physics by H.K.Dass, S. Chand & Company Limited (2010) (Unit 1)


5) Special functions for scientists and engineers by W. W. Bell, Reprint, Courier Dover Publications (2004) (Unit 5)

BOOKS FOR REFERENCE


7) Special Functions and Their Applications by Nikolaï Nikolaevich Lebedev, Courier Dover Publications, (1972)

PH1821 - PRACTICAL I

Class : I M.Sc. Credits: 4

Semester : I Hrs./week : 8

Objectives: The course aims at exposing the students to the intricacies of handling sophisticated equipments, designing electronic circuits, trouble shooting and analysis of results.

In each Semester, the laboratory sessions must expose the students to a minimum of eighteen experiments conducted in two cycles of nine experiments each.

1. Transistorised Amplifier - RC coupled
2. Power Amplifier - IC
3. Design of Gates - transistor (NOT, AND, OR, NAND)
4. A/D converter - Parallel conversion using LM339
5. 7 segment display - 2 digit optically controlled counter
6. 555 Timer - Astable Multivibrator
7. 555 Timer - Temperature control (thermistor)
8. Op - Amp 741 - Introduction (basic functionality)
9. Op - Amp 741 - Solving Simultaneous Equations
10. Op - Amp 741 - Second order filters
11. Op - Amp 741 - Astable Multivibrator
12. Op - Amp 741 - D/A converter (R - 2R & Weighted)
13. Microprocessor 8086 - Introduction I (arithmetic - immediate mode)
14. Microprocessor 8086 - Introduction II (arithmetic and logical - all modes)
15. Microprocessor 8086 - Introduction III (code conversions and arrays)
16. Microprocessor 8086 - Solving equations
17. Microprocessor 8086 - Subroutines
The staff in charge shall select any 15 from this list. The remaining 3 experiments can be chosen from this list or can be new experiments included by the staff in charge with prior approval of the department.

**BOOKS FOR REFERENCE:**

PH2814 - EMBEDDED SYSTEMS

Class : I M.Sc.          Credits: 5
Semester : II           Hrs./week : 6

Objective : This paper aims at introducing the learner to the very popular Intel 8051, the PIC24 family and the widely used ARM7 embedded processors.

UNIT 1 : 8051 ARCHITECTURE AND PROGRAMMING


UNIT 2 : PIC18/24 ARCHITECTURE

UNIT 3 : PIC18/24 PERIPHERALS


UNIT 4 : ARM ARCHITECTURE
Advanced RISC Machine – Core & Architectures - Registers – Pipeline - Interrupts – ARM organization - ARM processor family – Co - processors. Instruction set – Thumb instruction set – Instruction cycle timings -

UNIT 5 : ARM PROGRAMMING

BOOKS FOR STUDY:

REFERENCE:
4. www.arm.com

PH2815 - MATHEMATICAL PHYSICS II

Class : I M.Sc.          Credits: 5
Semester : II           Hrs./week : 5

OBJECTIVE: Advanced mathematical tools essential for various theoretical models in all branches of physics are introduced with aim to enable students solve problems.

UNIT 1 : INTEGRAL TRANSFORM:
Laplace transform and its inverse - Transforms of derivatives and integrals - Differentiation and integration of transforms - Transforms of Heavyside and Dirac delta functions.
Application: (1) Response of an RC circuit to a single square wave (2) Response of a damped vibrating system to a single square wave and to a unit impulse (3) Systems of two differential equations - two masses connected by a spring
Fourier transform and its inverse - Fourier transform of elementary functions - Transform of Gaussian function and Dirac delta function - Fourier transform of derivatives - Cosine and sine transforms - Convolution theorem.


UNIT 2: PARTIAL DIFFERENTIAL EQUATIONS:
Solution of partial differential equations of first order - Solution of initial boundary value problem by Laplace transform method: Diffusion equation, wave equation - Finite Fourier sine and cosine transform methods -

UNIT 3: SPECIAL FUNCTION - II
Hermite polynomials - Generating function - Orthogonality properties - Recurrence relations - Laguerre polynomials - Generating function - Orthogonality properties - Recurrence relation - Associated Laguerre polynomial - Properties - The error function and related functions

UNIT 4: GROUP THEORY:
Groups - Symmetry transformation of a square - Conjugate element and classes - multiplication of classes - Subgroups - cyclic group - Normal subgroups and factor groups - Direct product of groups - Isomorphism and homomorphism - Permutation groups - Distinct groups - representation theory of finite groups - Molecular point groups - irreducible representation of point groups - reducible representation - Schur’s lemma and the orthogonality theorem - character of the representation - the example of $C_{4V}$ - irreducible representation and regular representation - Continuous groups and their representations - Lie groups - Axial rotation group SO(2) - Three dimensional rotation groups SO(3) and SU(2)

UNIT 5: PROBABILITY:
Definitions - Laws of probability - Mean, Standard deviation - Poisson distribution - Binomial distribution - Normal distribution - Moments of distribution - Recurrence relations - Sampling of variables - Variance - The t-distribution - The Chi-Square distribution

BOOKS FOR STUDY:

BOOKS FOR REFERENCE

**PH2816 - Quantum Mechanics - I**

Class : I M.Sc.  
Semester : II  
Credits : 5  
Hrs./week : 5

**Unit – 1: General Formalism**


**Unit – 2: Matrix Formalism (Representation theory)**


**Unit – 3: Approximation methods**


**Unit – 4: Angular momentum**


**Unit – 5: Scattering theory and applications**


**BOOKS FOR STUDY:**


**BOOKS FOR REFERENCE:**
7. Modern Quantum Mechanics by J.J. Sakurai, Pearson Education India

PH2817 - PRACTICAL II

Class : I M.Sc.  
Credits: 5
Semesters : II  
Hrs./week : 8

Objectives: The course aims at exposing the students to the intricacies of handling sophisticated equipments, designing electronic circuits, trouble shooting and analysis of results.

In each Semester, the laboratory sessions must expose the students to a minimum of eighteen experiments conducted in two cycles of nine experiments each.

1. 7 segment display - 2 digit optically controlled counter
2. Op - Amp 741 - Solving Simultaneous Equations
3. Op - Amp 741 - Second order filters
4. Microprocessor 8086 - Subroutines
5. Microprocessor 8086 - Interface I (LEDs)
6. Microprocessor 8086 - Interface II (LEDs & switches)
7. Microprocessor 8086 - Interface III (Freq. generation)
8. Microprocessor 8086 - Interface IV (Waveform generation)
9. Microprocessor 8086 - Interface V (Traffic lights simulation)
10. Microprocessor 8086 - Introduction I (simple programs - all modes of addr.)
11. Microprocessor 8086 - Introduction II (equations and arrays)
12. "C++" - Language - Introduction III (use of library functions)
14. MASM - Introduction I (using DOS interrupt 21h)
15. Turbo Debugger - Introduction I (simple programs - Trace mode)
16. Elastic constants of glass - Cornu's method
17. Dielectric studies
18. Electrical conductivity studies - Four Probe Method
19. GM counter – Feather Analysis.

The staff in - charge shall select any 15 from this list. The remaining 3 experiments can be chosen from this list or can be new experiments included by the staff in - charge with prior approval of the department.

BOOKS FOR REFERENCE:

**PH2955 - ASTROPHYSICS**

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<td>Semester</td>
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**Unit 1: General Astronomy**
System of Coordinates - Altazimuth, Equatorial (local and Universal), Ecliptic and Galactic systems. Magnitude scale and magnitude systems - correction for observed magnitudes. The proper motion - stellar parallax - Trignometric, cluster and secular parallaxes. Method of Luminosity distance.

**Unit 2: Stellar temperatures and sizes**

**Unit 3: Stellar structure**

**Unit 4: Stellar evolution**
The virial theorem - application to an isothermal gas sphere - evolution of stars near the main sequence - effect of hydrogen depletion - Schoenberg - Chandrasekhar limit of an isothermal core - nuclear time scale - ages of clusters - Star formation - Jean's criterion.

**Unit 5: Stellar energy sources**
Thermonuclear fusion - CN cycle - pp chain - simple formulae for the energy generation rates - abundances for the elements in the stars structure of the sun from helioseismology - problems of nucleosynthesis.

**BOOKS FOR STUDY:**

**BOOKS FOR REFERENCES:**

**PH2956 - GEOPHYSICS**

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**Objective:** To provide brief introduction to seismology and to have a look at the experimental data supporting electric and magnetic properties of earth.

**Unit 1: seismology:**
Introduction - Seismology - P - waves - S waves, their velocities - Time distance curves and the location of epicenters - Effect of Boundaries - Major discontinuities - Properties of rocks and minerals and factors that control them - Seismic energy sources - Detectors. Reflection and refraction field surveys and interpretation of time and distance curves.

Unit 2: internal structure of earth
Introduction - Seismic waves - Rayleigh waves and love waves - Study of earth by seismic waves - Earthquake seismology - Horizontal and vertical seismograph - Seismograph equation - Internal structure of earth.

Unit 3: Earth's age and electrical properties:

Unit 4: Geomagnetism:
Geomagnetism - Definitions, magnetic field, main field, external field and local anomalies, rock susceptibility - Method of Gauss - Saturation induction magnetometers - Proton precession magnetometer - Dynamo theory of earth magnetism - Magnetic surveying - application.

Unit 5: Geodynamics:
Plate dynamics - Earth's size and shape - Earth's rotation - absolute and relative methods of Measurement of gravity - Gravity measurements - reduction of gravity data - separation of regional and residual. Interpretation of gravity data obtained over spherical and cylindrical objects - Application of gravity methods.

BOOKS FOR STUDY:

BOOKS FOR REFERENCE:

PH2957 - GRAVITATION AND COSMOLOGY

Class : I M.Sc. Credits: 3
Semester : II Hrs./week : 4

OBJECTIVES:
1. To introduce the students to the general theory of relativity with an emphasis on the physical aspects.
2. To discuss the observational inputs from astrophysics and cosmology.

Unit 1: Theories of Gravitation - Conflict between Newtonian gravitation and special relativity - general theory of relativity - Mach’s principle - Space - Time and co-ordinate systems - Tensors - Parallel transport - Covariant differentiation - The Riemannian Affine connection - The Lie derivative - Space - Time curvature.

Unit 3: The experimental tests of the general theory of relativity - the gravitational red shift - Planetary motion - the bending of light - the radar echo delay - the precession of a gyroscope - Gravitational radiation.


Unit 5: Cosmology - the observational background - the cosmological postulates - cosmological red shift - the Hubble law - the Olber's paradox - red shift - magnitude relation - counting of radio sources - angular diameters - age of the universe - the abundance of elements - the microwave background.

BOOKS FOR STUDY:

BOOKS FOR REFERENCE:

PH2958 - PARTICLE PHYSICS

Class : I M.Sc.  Credits: 3
Semester : II  Hrs./week : 4

OBJECTIVES:
1) To provide a concise but accessible introduction to the standard model of particle physics.
2) To develop the theoretical concepts from the electromagnetic and weak interactions of leptons and quarks to the strong interactions of quarks.
3) To look at the experimental data supporting the model.

Unit 1: The particle physicist's view of Nature: The construction of the standard model - leptons - quarks and systems of quarks - spectroscopy of systems of light quarks - more quarks - quark colour - electron scattering from nucleons - particle accelerators.

Lagrangian formulation of Lorentz covariant field theory - the Klein-Gordon equation - the energy – momentum tensor - complex scalar fields - A Lagrangian density for electromagnetism - the energy density of the electromagnetic field - massive vector fields.

Unit 2: The Dirac equation and the Dirac field - spinors - free space solutions of the Dirac equation - the energy and momentum of the Dirac field - Dirac equation with an electromagnetic field – charge conjugation - electrodynamics of a charged scalar field - Boson and Fermion field quantization.

Unit 3: SU(2), SU(3) symmetry – U(1) gauge symmetry – Non - Abelian (SU(2), SU(3)) gauge symmetry – Spontaneous symmetry breaking - Higgs - Kibble mechanism.


Unit 5: Quantum chromodynamics - The theory of strong interactions - A local SU(3) gauge theory - colour gauge transformations on quarks and gluons - asymptotic freedom - the quark - anti - quark interaction at short distances.

BOOKS FOR STUDY:

BOOKS FOR REFERENCE
PH3914 - STATISTICAL MECHANICS

Objective: To create a thorough understanding of how a real system should be understood by the linking of thermodynamics with kinetic theory using statistical methods – the importance of entropy in this linking – learn the concept of ensembles – tackle the simplest case of ideal gas in different ensembles – invoke the quantum picture, density matrix and quantum gases – understand more about thermodynamics and phase transitions as required at a PG level

Unit 1: Ensemble Theory

Unit 2: Canonical Ensembles

Unit 3: Grand Canonical ensemble

Unit 4: Bose – Einstein statistics

Unit 5: Ideal Fermi gas

BOOKS FOR STUDY

BOOKS FOR REFERENCE

PH815 - SPECTROSCOPY

Objective: To have in depth understanding of various techniques of spectroscopy and to study its applications to modern science.
UNIT 1: MICROWAVE SPECTROSCOPY: Rotation of molecules-Rotational spectroscopy-Rigid and non-rigid diatomic rotator-Intesity of spectral lines-Isotopic substitution-Poly atomic molecules (Linear and symmetric top)-Hyperfine structure and quadrupole effects-Inversion spectrum of ammonia-Chemical analysis by microwave spectroscopy-Techniques and instrumentation-microwave oven

UNIT 2: VIBRATIONAL SPECTROSCOPY: Infrared spectroscopy-Vibration of molecules-Diatomic vibrating rotator-Vibrational rotational spectral sequence-Interactions of rotations and vibrations-Influence of rotation on the Vibrational spectrum of linear and symmetric top and poly atomic molecules-Analysis by infrared techniques-Instrumentation-FTIR spectroscopy

Raman spectroscopy: Classical and quantum mechanical picture of Raman effect-Polarizability –Pure rotational Raman spectrum-Vibrational Raman Spectrum-Raman activity of vibrations of CO$_2$ and H$_2$O-Rule of mutual exclusion-Overtones and combination-Rotational fine structure-Depolarization ratio-Vibrations of spherical top molecule-Structural determination from IR and Raman spectroscopy-techniques and instrumentation-FT Raman spectroscopy


UNIT 4: NUCLEAR SPECTROSCOPY: Nuclear magnetic resonance spectroscopy-Introduction-Interaction of spin and magnetic field-population of energy levels-Larmor precession-Relaxation times- Double resonance-Chemical shift and its measurement-Coupling constant-Coupling between several nuclei- Quadrupole effects-C$^{13}$ NMR spectroscopy- Interpretation of simple spectrum - Mossbauer spectroscopy: Principle-instrumentation- Isomer shift-Effect of electric and magnetic fields- Magnetic hyperfine interaction.


BOOKS FOR STUDY:

BOOKS FOR REFERENCE:
3. Tuniz C., Kutschera W., Fink D., Herzog G.F Accelerator Mass Spectrometry
4. CRC press 2011
7. www.ups.edu/faculty/hanson/chemwebsites/organicwebsites.htm
8. www.rsc.org/.../InterestGroups/ESRSpectroscopy/index.asp

PH3816 - PRACTICAL III
Objectives: The course aims at exposing the students to the intricacies of handling sophisticated equipments, designing electronic interface circuits, trouble shooting, programming and analysis of results.

1. Microprocessor 8086 - Interface (A/D - Counter)
2. Microprocessor 8086 - Interface (A/D - Successive approx.)
3. Microprocessor 8086 - Interface (Calculator - 16 switches)
4. Microprocessor 8086 - Interface (Stepper motor control)
5. Microprocessor 8086 - Interface (7 segment display multiplexing)
6. Microprocessor 8086 - Interface (Stop clock - light operated)
7. Microprocessor 8086 - Interface (7x5 LED dot matrix display)
8. Microprocessor 8086 - Interface (Rolling display)
9. Microprocessor 8086 - Interface (LCD display)
10. Micro controller 8051 - Introduction I
11. Micro controller 8051 - Introduction II
12. Micro controller 8051 - Interface (LCD display)
13. Embedded ARM7 – Introduction I
14. Embedded ARM7 – Introduction II
15. Embedded ARM7 – Introduction III
16. Embedded PIC – Introduction I
17. Embedded PIC – Introduction II
18. Embedded PIC – Introduction III
19. Inverter - Low D.C. to High A.C. converter
20. A/D - Binary counter - IC 7493
21. PLL - remote control applications
22. MASM - 2 digits arithmetic operations
23. Turbo Debugger - Arrays manipulations
24. “C++” - Language - Introduction to graphics
25. “C++” - Language - Interface (Stepper motor control)

The staff in-charge shall select any 10 from this list. The remaining 8 experiments can be chosen from this list or can be new experiments included by the staff in-charge with prior approval of the department.

BOOKS FOR REFERENCE:

PH3875 - NANO SCIENCE

Class: II M.Sc.  Credits: 5
Objectives: The course will introduce the students to the rapidly developing field of nanoscience and technology with special focus on the methods of synthesis, characterization techniques and applications of nanomaterials with interdisciplinary approach involving Physics and Chemistry. The course is expected to provide the necessary understanding in nanotechnology and the students must be able to perform their project works related to the synthesis and characterization of nanomaterials by direct experience.

Unit 1: Fundamentals of Nanoscale Science

1.1. Introduction - nano and nature - background to nanotechnology - scientific revolutions opportunities at the nanoscale - time and length scale in structures - surfaces and dimensional space - evolution of band structures and Fermi surfaces - electronic structure of nanocrystals - bulk to nano transition - size and shapes - dimensionality and size dependent phenomena.

1.2. Energy landscapes basic intermolecular forces - interdynamic aspects of intermolecular forces.

Unit 2: Classification of nanoparticles and its properties

2.1. Metal Nanoparticles: Size control of metal nanoparticles, Structural, Surface, electronic and optical properties.

Semiconductor Nanoparticles: solid state phase transformation, Excitons, Quantum confinement effect, Semiconductor quantum dots (SQDs), Correlation of properties with size, Quantum Well, Quantum Wires, Super lattices band and Band offsets, Quantum dot lasers.


2.2. Semiconductor Nanocomposites: Types of Nanocomposites (Metal oxides, ceramic and Glass), Core - Shell nanoparticles - Types of systems - properties of nanocomposites.

Carbon Nanostructures: Introduction, Fullerenes, C60, CNT, mechanical, optical and properties.

Unit 3: Synthesis of Nanomaterials

3.1. Physical methods: Thermal evaporation, Spray pyrolysis, Molecular beam epitaxy (MBE), Physical vapour deposition (PVD), Microwave heating, Electric arc deposition, Ion implantation.

B. Chemical methods: Chemical and co - precipitation, Sol fundamentals - sol - gel synthesis of metal oxides, Micro emulsions or reverse micelles, Solvothermal, Sonochemical synthesis, Electrochemical synthesis, Photochemical synthesis, Langmuir - blodgett (LB) technique, Chemical vapour deposition (CVD)

Unit 4: Characterization Techniques

4.1. Powder X - Ray Diffraction, Scanning electron microscope (SEM), Transmission electron microscope (TEM), Scanning tunnelling microscope (STM), Atomic force microscope (AFM), Scanning probe microscopy (SPM), UV - Visible absorption, Impedance measurement, V - I characteristics, Vibrating sample magnetometer (VSM).

4.2. Brunauer - Emmett - Teller (BET) Surface Area Analysis, Energy dispersive X - ray (EDX), X - ray photoelectron spectroscopy (XPS) and Photoluminescence.

Unit 5: Applications of Nanomaterials and Nanocomposites

5.1. Nanophotonics and Devices: ID, 2D, 3D Photonic crystals, Couplers, Waveguides, Photonic crystal fibres, Optical data storage systems and Quantum computing

Medical applications: Imaging of cancer cells, Biological tags and Targeted nano drug delivery system.

5.2. Nanosensors: Sensors based on physical properties - Electrochemical sensors, Sensors for aerospace, defence and Biosensors.

Energy: Solar cells, LEDs and Photovoltaic device applications.

Photocatalytic applications: Air purification, Water purifications and Volatile organic pollution degradation.
Carbon nanotubes: Field emission, Fuel cells and Display devices.

**BOOKS FOR STUDY:**

**BOOKS FOR REFERENCE:**

**Note:** The first part of all sections will be handled by the Physics faculty and the second part will be handled by Chemistry faculty.

**PH3953 - CRYSTAL PHYSICS**

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<th>Class</th>
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<td>Semester</td>
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<td>Hrs./week</td>
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<td>Credits</td>
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**Objectives:** To provide a qualitative idea on the fundamentals of growing crystals and characterizing the grown samples. This paper will serve as an eye opener for students keen in research activities particularly in experimental physics.


**UNIT 3 : MELT AND VAPOUR TECHNIQUES** - Growth from melt – Bridgman, Czochralski, zone melting, Verneuil techniques - physical vapour deposition - flux growth - chemical vapour deposition - chemical vapour transport - hydrothermal growth - epitaxial growth.

**UNIT 4 : OPTICAL STUDIES** - Atomic absorption spectroscopy - UV - Visible - NIR spectroscopy - Experimental set ups for Fourier Transform Infrared analysis, FT - Raman vibrational spectroscopy - Illustrations with selected crystals - Nonlinear optical phenomenon (qualitative) - Kurtz powder SHG method - photoconductivity and schematic set up for measurements - negative photoconductivity.

**UNIT 5 : CRYSTAL CHARACTERIZATION** - Thermal analysis - methods of thermal analysis - thermogravimetric analysis (TGA) - Differential thermal analysis (DTA) - Differential Scanning Calorimetry (DSC) - Mechanical studies - methods of hardness testing (qualitative) - Vickers hardness testing - correlation
of microhardness with other properties - estimation of hardness number and work hardening coefficient (n) -
dielectric studies - dielectric constant and dielectric loss measurements.

BOOKS FOR STUDY AND REFERENCE:
3. Crystal growth by Harold Eugene Buckley, John Wiley and Sons, New York (1951)

PH3954 - DATA COMMUNICATION AND COMPUTER NETWORKS

Class : II M.Sc. Credits: 3
Semester : III Hrs./week : 4

Objective : The advances in the information and communication technology during the last decade have left
an indelible mark in all walks of life. This paper is aimed at exposing the students to the latest techniques in
data communication and computer networks.

UNIT 1 : DATA TRANSMISSION AND ENCODING - Concepts: Analog and Digital transmission, Transmission
impairments - Transmission media - Synchronous / Asynchronous transmission - Line configurations -
interfacing.
Digital data digital signals - Variations of NRZ and bi-phase - Digital data Analog signals - ASK, FSK, PSK, QPSK -
Analog data digital signals - PCM, DM.

UNIT 2 : DATA LINK CONTROL
Flow control, Error control - HDLC, Multiplexing.

UNIT 3 : INTRODUCTION TO COMPUTER NETWORKS AND THE PHYSICAL LAYER - Introduction: The uses of
computer networks - Network hardware - Network software - Reference models - Example of networks -
Network standardization.
The physical layer: The theoretical basis for data communication - Guided Transmission media - Wireless
transmission.

UNIT 4 : THE DATA LINK AND THE NETWORK LAYERS - The Data Link Layer: Data link layer design issues -
Error detection and correction - Elementary data link protocols - Sliding window protocols - Example of data
link protocols - ETHERNET.
The network layer: Network layer design issues - Routing algorithms - Congestion control algorithms.

UNIT 5 : THE TRANSPORT AND THE APPLICATION LAYERS - The transport layer: Transport layer design issues -
Transport protocols - Simple transport protocol - Internet transport protocols UDP, TCP.
The application layer: Domain name system - Electronic mail - World Wide Web.
BOOKS FOR STUDY:

BOOKS FOR REFERENCE:
PH3955 - REACTOR PHYSICS

Class : II M.Sc. Credits: 3
Semester : III Hrs./week : 4

OBJECTIVES: - To expose the students to the physics of neutrons and fuel inside a reactor. Also the construction of a nuclear reactor and precautions to be taken in its operation will be dealt in this paper.

Unit 1 : Nuclear energy
Nuclear mass - Binding energy-Radioactivity - Nuclear reactions - Nuclear fission - Mechanism of fission - Fuels - Products of fission - Energy release from fission - Reactor power - Fuel burn up - Consumption.

Unit 2 : Neutron diffusion
Multiplication factor - neutron balance and conditions for criticality - Conversion and breeding - Classification of reactors.
Diffusion of neutrons: Flux and current density - Equation of continuity - Fick's law - Diffusion equation - Boundary conditions and solutions - Diffusion length - Reciprocity theorem.

Unit 3 : Neutron moderation
Fermi theory of Bare thermal reactor : Criticality of an infinite reactor - One region finite thermal reactor - Critical equation - Optimum reactor shape.

Unit 4 : Reactor kinetics
Infinite reactor with and without delayed neutrons - Stable period - Prompt jump - Prompt criticality - Negative reactivity - Changes in reactivity - Temperature coefficient - Burn up and conversion.

Unit 5 : Control and shielding
Reactor control : Road worth - One control rod - modified one group, two group theory - ring of rods.
Radiation shielding : Reactor safeguards - Reactor properties over life - core life estimation.

BOOKS / WEBITES FOR STUDY AND REFERENCE: 
4. www.ans.org/PowerPlants
5. npcil.nic.in/main/AllProjectOperationDisplay.aspx

PH4810 - QUANTUM MECHANICS II

Class : II M.Sc. Credits: 5
Semester : IV Hrs./week : 6

Objective: To introduce time dependent perturbation theory, its applications, the concepts of relativity and relativity in quantum mechanics, symmetries in QM and to introduce the concepts of quantum field theory.

Unit – 1: Time dependent perturbation theory

Unit – 2: Relativistic Mechanics

Unit – 3: Relativistic Quantum Mechanics

**Unit – 4: Identical particles, Symmetries and conservation laws**

Identical particles in quantum mechanics – exchange degeneracy – permutation operators - two- particle system – symmetric and antisymmetric kets– system with arbitrary number of particles – parity

Symmetry transformations – conservation laws and degeneracy – discrete symmetries – parity or space inversion – parity conservation – time reversal

**Unit – 5: Elements of field quantization**


**BOOKS FOR STUDY:**

**BOOKS FOR REFERENCE:**

**PH4811 - NUCLEAR PHYSICS**

**Class**: II M.Sc.  
**Semester**: IV  
**Credits**: 5  
**Hrs./week**: 6

**Objective**: This paper aims to explore the understanding of nuclear models and various physical properties of nucleus.


**UNIT 3: Nuclear reactions**: Nuclear reactions and cross - sections - Breit - Weigner single - level formula - Resonance scattering - The compound nucleus - Continuum theory - Optical model - Absorption cross - section at high energies. - Stability of heavy nuclei - Relativistic heavy ion collision – Controlled chain reaction – basic ideas of reactors.


**BOOKS FOR STUDY:**
2. Nuclear Physics (VI and VII), Mermier, Shelton.

**BOOK FOR REFERENCE:**

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PH4812 - SOLID STATE PHYSICS

**Objective:** This paper aims to give an understanding of the basic theoretical models to study the properties of matter from a microscopic point of view.

**UNIT 1: Crystal structure and lattice dynamics:**
- Lattice vibrations for a linear mono atomic lattice - linear diatomic lattice - acoustical and optical modes - extinctions and optical branch in ionic crystals- quantisation of lattice vibrations- - lattice dynamics of a BCC three dimensional solid - inelastic scattering of phonons.

**UNIT 2: Theory of metals and semiconductor:**
- Brillouin zones - electrons in periodic potential- Bloch's theorem - Kronig- Penney model - nearly free electron model- effective mass - zone schemes- band model of metal, semiconductor and insulator.
- Intrinsic semiconductor- carrier concentration- impurity semiconductors ( n and p type) - carrier concentration- steady state diffusion- pn junction - homogeneous semiconductors.

**UNIT 3: Transport phenomena and dielectric properties:**
- Thermal conductivity: of lattice - of free electrons - Fermi surface - effect of electric field on Fermi surface - effect of magnetic field on Fermi surface - mobility of charge carriers in semiconductors: intrinsic region and impurity range - Hall effect.
- dipole moment - atomic polarisability - Classius - Mossotti equation - theory of electronic polarisation - frequency dependent polarisability - ferro electricity

**UNIT 4: Magnetism:**
- Larmor diamagnetism - Langevin's theory of para magnetism - Hund's rules- origin of magnetic interaction - molecular field theory of ferromagnetism - failure of independent electron approximation
- Spin Hamiltonian and Heisenberg model - Magnons and thermal excitation of magnons - domain theory of hysteresis and anti ferromagnetic magnons- types of magnetic structure.

**UNIT 5: Superconductivity:**
- Historical survey of superconductivity - critical parameters - Isotope effect- Meissner effect- type I and II superconductors- thermodynamics of superconducting transition - other properties.
BOOKS FOR STUDY:

BOOKS FOR REFERENCE:
5. Solid state Physics, Dr. Ajay Kumar Saxena, MacMillan India Ltd (2005)

PH4813 - PROJECT

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