St. Xavier's College – Autonomous
Mumbai

Syllabus
For 6th Semester Courses in PHYSICS
(June 2015 onwards)

Contents:
Theory Syllabus for Courses:
  S.PHY.6.01 –**Statistical Mechanics**
  S.PHY.6.02 –**Atomic and Molecular Physics**
  S.PHY.6.03 – **Nuclear Physics**
  S.PHY.6.04 **– Solid State Physics**
 S.PHY.DIP. AC.6: **Digital Image processing-II**
Practical Course Syllabus for: S. PHY.6. PR
Practical Course Syllabus for: S. PHY.DIP.AC.6. PR

T.Y. B.Sc. PHYSICS   **Course: S.PHY.6.01**

Title: Statistical Mechanics
Learning Objectives:
    To study statistical behaviour of many particle systems.
Number of lectures: 60

UNIT I   **(15 Lectures)**
1.   Probability: Set theory, introduction to probability, conditional probability, Random walk problem, discrete Random variables, combining probabilities of events, probability distribution moments, the moment generating function, the characteristic function, binomial distribution, the central limit theorem.
2.   Introduction to Statistical Mechanics: description of a system, thermal and adiabatic interaction, classical gas.

UNIT II   **(15 Lectures)**
   1. **Kinetic theory**: phase space formulation, the Boltzmann transport equation, the postulate of molecular chaos, the H theorem, the Maxwell-Boltzmann distribution (emphasize the connection with the proof of the central limit theorem), the most probable distribution, Liouville's theorem and its connection to the H theorem.

UNIT III   **(15 Lectures)**
   1. **The methods of statistical mechanics:** the postulate of equal a priori probability in phase space, the microcanonical ensemble, entropy, the equipartition theorem, classical ideal gas, Gibbs paradox. The canonical ensemble, the partition function, the Helmholtz free energy, energy fluctuations in the canonical ensemble.

UNIT IV   **(15 Lectures)**
   1. The grand canonical ensemble, density fluctuations in the grand canonical ensemble, first order phase transitions, the meaning of the Maxwell construction.
   2. Quantum Statistics of ideal geases: Bose – Einstein statistics, black-body radiation, The Rayleigh-Jeans formula, The Planck radiation formula, Fermi – Dirac statistics, comparison of results, Transition between states.

References:
            1. Statistical and thermal physics – S. Loknathan, R. S. Gambhir
            2.   Statistical Mechanics - Kerson Huang (Indian edition exists)
            3. Statistical Mechanics (Berkeley Physics Course, vol 5) - E. Reif
            4. Statistical and thermal physics - F. Reif
            5. Mathematical Methods of Physics - J. Mathews and R. L. Walker

            CIA: Problem solving/ MCQs

T.Y.B.Sc. PHYSICS   **COURSE:S.PHY.6.02**

Title: Atomic& Molecular Physics
Learning Objectives: To study atomic structure and atomic and molecular spectra.
No. of Lectures:60

UNIT I : Structure of atom   **(15 lectures)**
  1. Review of Hydrogen atom problem, Role of rotation symmetry
  2. Pauli's Exclusion Principle**,** Hund's Rule, Symmetric &Antisymmetric Wave Function
  1. Vector Atom Model , Spin Orbit Coupling, LS Coupling, JJ Coupling.

Unit II: Atomic spectra   **(15 lectures)**
  1. Review concepts of quantum mechanics , Origins of Spectral Lines & Selection Rules.
  2. Visible spectra, Alkali Spectra, Physics of LASERs (3level system).
  3. X-ray spectra: Characteristic, Continuous, Mosley's Law, K, L, M Series.
  4. Atoms in External magnetic field: Normal Zeeman Effect, Lande's Factor, Anomalous Zeeman Effect,
  5. Paschen Back Effect:-Theory, selection rules, application to Principal Series Doublet.

UNIT III: Molecular Spectra (Diatomic Molecule)   **(15 lectures)**
  1. Rotational Spectra, Microwave Spectrometer.
  2. Vibrational Spectra, Vibrational - Rotational Spectra, Infrared Spectrometer.
  3. Electronic Spectra, Born Oppenheimer Approximation, Intensity of Vibration Electronic Spectra, Frank – Condon Principle.
  4. Raman Effect: Classical Theory, Quantum Theory, Pure Rotational Raman Spectra, Vibrational Raman, Raman Activity of CO_2 and H_2O, Experimental Techniques.

UNIT IV: Resonance Spectroscopy   **(15 lectures)**
  1. Electron spin resonance, theory, experimental method, applications
  2. Nuclear magnetic resonance, theory, experimental method, applications
  3. Solid state surface spectroscopy.

References: -
  1.Perspective of Modern Physics – A.Bieser.
  2. Atomic Spectra - White.
  3. Molecular spectra - C. M. Banwell & McCash.

CIA: PROBLEM SOLVING/MULTIPLE CHOICE QUESTIONS/ ASSIGNMENT

T.Y.B.Sc. PHYSICS   **COURSE:S.PHY. 6.03**
Title:NUCLEAR PHYSICS
No of Lectures:60

Learning Objectives:-To Understand the constituents of the nucleus, their properties, detection and reactions.

UNIT-I: **(15 LECTURES)**
1.Properties of the nucleus: Rutherford scattering & measurement of nuclear size, Measurement of nuclearradius by Hofstadter experiment, Nuclear forces and their properties, Meson theory of nuclear forces, Yukawa Potential.

2. The Q equation:- Types of nuclear reactions, the balance of mass and energy in nuclear reaction , the Q equation and solution of Q equation

3. Radioactive decay: Decay chains.**Alpha decay :** Range of alpha particles, Disintegration energy, Alpha decay paradox: Barrier Penetration, Gamow's theory of alpha decay and Geiger-Nuttal law. Velocity and energy, Absorption of alpha particles: Range, Ionization and stopping power, energetics, energy levels & decay schemes. **Beta decay:** Introduction, Continuous beta ray spectrum-Difficulties encountered to understand it, Pauli's neutrino hypothesis, Velocity and energy of beta particles, energetics, energy levels and decay schemes. **Gamma decay:** internal conversion, nuclear isomerism.

UNIT-II   **(15 LECTURES)**
1.Binding Energy and Mass formula: (Review of Liquid drop model &Weizsacher's semi-empirical mass formula), Mass parabolas - Prediction of stability against beta decay for members of an isobaric family, Stability limits against spontaneous fission. Qualitative predictions of shell model & Magic numbers.

2. Nuclear energy : Introduction, Asymmetric fission - Mass yield, Emission of delayed neutrons, energy release in fission, Nature of fission fragments, Energy released in the fission of U^{235}, Fission chain reaction, Fusion of lighter nuclei, Neutron cycle in a thermal nuclear reactor (Four Factor Formula), Comparison of fission and fusion processes.

UNIT-III   **(15 LECTURES)**
 1. Applications of nuclear energy :- nuclear reactors:- pressurized water reactors, boiling water reactors, breeder reactors, fusion reactors.**Nuclear detectors**:- Ionization chamber, Proportional counter, G.M. Counter, Scintillation counter, Solid State detectors , Cloud and Bubble chamber, **Mossbauer effect, Detection of neutrino**, nuclear power generation, nuclear safety and hazards.

 UNIT-IV   **(15 LECTURES)**
1.Accelerators:-Introduction, the LINAC, cyclotron, synchrocyclotron, betatron synchrotron, proton synchrotron, Electrostatic Accelerators.

2. Elementary particles : Introduction, Classification of elementary particles based on conservation laws, particles and antiparticles, The Fundamental interactions, elementary particle quantum numbers, conservation laws and symmetry, quark model,.

References:

1. Concepts of modern physics   Arthur Beiser (6th edition, TMH)
2. Nuclear Physics   S.B. Patel (Wiley Eastern Ltd.).
3. Nuclear Physics   Irving Kaplan   (2nd Ed.) (Addison Wesley).
4. Nuclear Physics   S. N. Ghoshal   (S. Chand & Co.)
5.Nuclear   Physics   D. C. Tayal   (Himalayan Publishing House)
6. Modern Physics   Murugesan&KiruthigaSivaprasath (S. Chand & Co.)
7. Nuclear physics   Kakani & Kakani
Additional References.
1. Atomic & Nuclear Physics   A B Gupta &DipakGhosh(Books & Allied (P) Ltd.)
2.Nuclei and particles   E.Segre. (W.A. Benjamin, Inc.)

CIA: PROBLEM SOLVING/MULTIPLE CHOICE QUESTIONS/ ASSIGNMENTS

T.Y.B.Sc. PHYSICS   **COURSE:S.PHY.6.04**
Title:Solid State Physics
No of Lectures:60
Learning objective: To understand the fundamental properties of materials and devices

UNIT I :   **(15 lectures)**
Crystal physics: Introduction, lattice, basis, crystal structure, unit cell & primitive cell, crystal classes & crystal systems in two & three dimensions, Bravais lattices, atomic packing factors in cubic system and hexagonal lattice. Crystal structures of diamond, ZnS, Nacl, CsCl, Miller indices, Inter-planar spacing. Experimental diffraction methods, derivation of scattered wave amplitude, Brillouin zones , - Kittle 5thed

UNIT - II   **(15 lectures)**
Theory of metals : Classical free electron theory of metals, Relaxation time, Collision time and mean free path, Drawbacks of classical theory, Quantum theory of free electrons, Fermi-Dirac statistics and electronic distribution in solids, Density of energy states and Fermi energy, The Fermi distribution function, Heat capacity of the electron gas, Mean energy of electron gas at 0 K, Electrical conductivity from quantum mechanical considerations, Hall effect. Ch.6 – Kittle 5thed

UNIT - III   **(15 lectures)**
1. **Band theory of solids:** The Kronig- Penney model Brillouin zones, Number of wave functions in a band, Motion of electrons in a one-dimensional periodic potential, Distinction between metals, insulators and intrinsic semiconductors.

2. **Band theory of Semiconductors:** Electrons and Holes in an Intrinsic Semiconductor, Conductivity, Carrier concentrations, Donor and Acceptor impurities, Charge densities in a Semiconductor, Fermi level in extrinsic semiconductors, Diffusion, Carrier lifetime, The continuity equation.
Ch. 7, 8 – Kittle 5th ed

UNIT - IV   (15 lectures)
1. **Magnetic properties of Matter:** Diamagnetism and Paramagnetism, The origin of permanent magnetic dipoles, Diamagnetism and Larmor precession, The static paramagnetic susceptibility. Quantum mechanical theory of paramagnetism, Ferromagnetism- the Weiss molecular field, Comparison of the Weiss theory with experiment, the Weiss field, the anisotropy energy, the Bloch wall, coercive force and hysteresis. Ch. 18, 19 – Dekker
2. **Superconductivity** : concept, achievement at low temp, attempts at room temp. Examples.
   References :
   (i)   Introduction to solid state physics - Charles Kittel
   (ii)   Solid State Physics - A. J. Dekker
   (iii)   Solid State Physics (Problems and solutions) - S. O. Pillai
   (iv)   Solid State Physics - S. O. Pillai
   (v)   Solid State Physics - S.P.Kakani and AmitKakani

CIA:PROBLEM SOLVING/MULTIPLE CHOICE QUESTIONS

T.Y.B.Sc. PHYSICS   **Course: S.PHY.6.PR**

Minimum four expts to be performed from first three groups

Group – I

   1) Double Refraction.
   2) Log Decrement.
   3) Velocity of Ultrasonic waves in a liquid.
   4) Rydberg's Constant – H_2 Spectrum.
   5) Wavelength of spectral lines of Hg using Grating.

Group – II

   1) Energy band gap of semiconductor using diode / thermistor.
   2) Semiconductor diode as a temp. sensor.
   3) Determination of Planck's constant with the help of a photoelectric cell.
   4) Absolute Capacitance using B.G
   5) Conversion of micrometer to a multirange milliammeter and voltmeter (Ohmmeter only Calculations.)

Group – III
   1) JFET Amplifier.
   2) Wien's Bridge Oscillator using OpAmp.

3) Log Amplifier – using OpAmp.
4) Active Integrator & Differentiator (learning skill of soldering).
5) Monostable multivibrator& Ramp generator using 555 timer.
6) First Order – Active filter (Low Pass / High Pass) with phase shift measurement (with skill of use of Breadboard).

Group – IV
One Project equivalent to 10 practical turns under the guidance of a teacher.

References:
1. Advanced course in practical physics – D. Chattopadhyay, P.C. Rakshit& B. Saha
2. B. Sc. Practical physics – Harnam Singh
3. A text book of practical physics – Samir Kumar Ghosh
4. B. Sc. Practical physics – C. L. Arora
5. Practical physics – C. L. Squires
6. University Practical physics – D. C. Tayal
7. Advanced Practical physics – Worsnop& Flint

CIA: MCQs on Conceptual understanding/ experimental skills for first three groups
       Planning, designing and preparation of synopsis of the project

---

COURSE:S.PHY.DIP.AC.6

DIGITAL IMAGE PROCESSING -II   **[60 LECTURES]**

Learning objective: To study the mathematical modelling of digital images

UNIT I   **(15 LECTURES)**

Color image processing
Color Fundamentals
 Color Models
Pseudocolor Image Processing
Basics of Full-Color Image Processing
Color Transformations
Smoothing and Sharpening
Image Segmentation Based on Color
Noise in Color Images
Color Image Compression
Problems

Wavelets and multi-resolution processing
Background
Multi-resolution Expansions

Wavelet Transforms in One Dimension
The Fast Wavelet Transform
Wavelet Transforms in Two Dimensions
Wavelet Packets
Problems

UNIT II   (15 LECTURES)
Image compression
Fundamentals
Some Basic Compression Methods
Digital Image Watermarking

UNIT III   (15 LECTURES)
Morphological image processing
Preliminaries
Erosion and Dilation
The Hit-or-Miss Transformation
 Basic Morphological Algorithms
Gray-Scale Morphology

UNIT –IV   (15 LECTURES)
Image segmentation
Fundamentals
Point, Line, and Edge Detection
Thresholding
Region-Based Segmentation
Segmentation Using Morphological Watersheds
The Use of Motion in Segmentation

Reference :
1. Digital image processing, third edition
        -Gonzalez and woods
2. . Digital image processing, third edition
        -A. K. Jain
3. . Digital image processing using MATLAB
        -Gonzalez and woods

_____

Practicals
T.Y.BSc Digital Image processing-II   COURSE: S.PHY.DIP.AC.6.PR

Digital processing of given images using software
Tutorials on image processing