St. Xavier's College – Autonomous
Mumbai

Syllabus
For 5th Semester Courses in PHYSICS
(June 2018 onwards)

Theory Syllabus for Courses

- S.PHY.5.01: Classical Mechanics
- S.PHY.5.02: Statistical Mechanics
- S.PHY.5.03: Electronics
- S.PHY.5.04: Atomic and Molecular Physics
- S. PHY.DIP. AC. 5: Digital Image processing

Practical Course Syllabus for: S. PHY. 5. PR

Practical Course Syllabus for: S. PHY.DIP.AC. 5. PR

T.Y. B.Sc. PHYSICS **Course: S.PHY. 5.01**
Title: Classical Mechanics
Number of lectures: 60
Learning objective: To understand physical phenomena of mechanical systems

UNIT-I **(15 LECTURES)**

Special Relativity: Relativity, Galilean Relativity, The Postulates of Special Relativity, The Relativity of Time; Time Dilation, Length Contraction, The Lorentz Transformation, The Relativistic Velocity-Addition Formula, Four-Dimensional Space-Time; Four-Vectors, The Invariant Scalar Product, The Light Cone, The Quotient Rule and Doppler Effect, Mass, Four-Velocity, and Four-Momentum, Energy, the Fourth Component of Momentum, Collisions, Force in Relativity, Massless Particles; the Photon. Problems

UNIT- II **(15 ECTURES)**

1. **Calculus of Variations:** Action Principle, The Euler-Lagrange Equation, Applications of the Euler-Lagrange Equation, More than Two Variables, Introduction to Hamiltonian, Problems

2. **Lagrange's Equations:** Lagrange's Equations for Unconstrained Motion , Constrained Systems; Examples of Lagrange's Equations, Generalized Momenta and Ignorable Coordinates, More about Conservation Laws, Lagrange's Equations for Magnetic Forces, Lagrange Multipliers and Constraint Forces.Problems

UNIT- III **(16 ECTURES)**

1. **Two-Body Central-Force Problems**: The Problem, CM and Relative Coordinates; Reduced Mass , The Equations of Motion,The Equivalent One-Dimensional Problem, The Equation of the Orbit,The Kepler Orbits, Virial theorem,The Unbounded Kepler Orbits,Changes of Orbit, Problems.

2. **Mechanics in Noninertial Frames:** Acceleration without Rotation, The Tides, The Angular Velocity Vector, Time Derivatives in a Rotating Frame, Newton's Second Law in a Rotating Frame, The Centrifugal Force, The Coriolis Force, Free Fall and the Coriolis Force, The Foucault Pendulum,Coriolis Force and Coriolis Acceleration, Problems.

3. **Collision Theory:** The Scattering Angle and Impact Parameter , The Collision Cross Section,Generalizations of the Cross Section, The Differential Scattering Cross Section, Calculating the Differential Cross Section,Rutherford Scattering, Cross Sections in Various Frames, Relation of the CM and Lab Scattering Angles,Problems.

UNIT- IV **(15 ECTURES)**

1. **Rotational Motion of Rigid Bodies:** Properties of the Centre of Mass, Rotation about a Fixed Axis Rotation about Any Axis; the Inertia Tensor,Principal Axes of Inertia, Finding the Principal Axes; Eigenvalue Equations, Precession of a Top due to a Weak Torque , Euler's Equations,Euler's Equations with Zero Torque, Euler Angles , Motion of a Spinning Top. Problems.

2. **Coupled Oscillators and Normal Modes:** Two Masses and Three Springs, Identical Springs and Equal Masses, Two Weakly Coupled Oscillators, Lagrangian Approach: The Double Pendulum, The General Case, Three Coupled Pendulums , Normal Coordinates . Problems

Main References:

1. Classical Mechanics- John R Taylor

Additional References:

1. Classical Mechanics - Herbert Goldstein
2. Mechanics - Keith Simon
3. Classical Mechanics –Takawale & Puranik
4. Mechanics - Berkley Physics course vol.I- – Kittel, Knight & Ruderman.

CIA: **PROBLEM SOLVING/ ASSIGNMENTS/ LITERATURE REVIEW**

T.Y.B.Sc Physics **COURSE:S.PHY.5.02**

Title:Statistical Physics

Number of lectures: 60

Learning objective: To study statistical behavior of many particle systems.

UNIT I **(15 Lectures)**

1. **Description of a system**: particle and system states, Micro and Macro states, Equilibrium and fluctuations, irreversibility, equiprobability postulate, Statistical ensemble, phase space, reversible processes.

2. **Thermal and adiabatic interactions**: Zeroth law of thermodynamics, Canonical distribution, Energy fluctuations, entropy of a system in heat bath, Helmoltz free energy, Adiabatic interaction and Enthalpy.

UNIT II **(15 Lectures)**

1. **Thermal interactions** First law of thermodynamics, infinitesimal general interaction, Gibb's free energy, phase transitions, Clausius- Clapeyron equation, vapour pressure curve.

2. **Classical Gas:** classical approximation, Maxwell velocity distribution, RMA, average and most probable speeds, equipartition of energy, perfect classical gas, ideal monatomic gas, equation of state of an ideal classical gas, Baromatric formula, validity of classical approximation, <u>heat capacity of perfect Diatomic gases, Real classical gas, van der Waals equation of state</u> (self study)

UNIT III **(15 Lectures)**

1. **Thermodynamics**: Applications of the first law, work done in stretching a wire, magnetic work, Heat engines, second law of thermodynamics, absolute scale of temperature, Thermodynamic potentials, Maxwell's Thermodynamic relations, the difference C_p- C_v ,

Joule expansion , the Joule-Thomson Process (self study), adiabatic demagnetization, Third law of thermodynamics (Revision in 2-3 lectures)

2. **System with Variable number of particles:** Chemical potential, Grand Canonical Distribution, Grand potential, Number fluctuations, Chemical reactions- Saha's ionization formula.

F-D, B-E distributions: Comparison of distributions, Fermion and Boson gases of structureless particles, Equations of state of weakly degenerate Fermion and Boson gases, strongly degenerate Fermion gas.

UNIT IV **(15 Lectures)**

1. **Applications of quantum statistics**: Electronic heat capacity of metals, Thermionic emission, Strongly degenerate Boson gas, Liquid Helium-4, Black body radiation, Thermodynamics of Black body radiation, Kirchoff's Law.

2. **Transport Phenomena:** Mean Free path, Viscocity, Thermal conductivity, Self-diffusion, Electrical conductivity, Wiedemann-Franz law

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

CIA: **PROBLEM SOLVING/ ASSIGNMENTS/ LITERATURE REVIEW**

T. Y. B.Sc: Physics **COURSE:S.PHY.5.03**
Title: Electronics
Number of lectures: 60
Learning objective: To understand the technology of different electronic devices

Unit 1

(1)**JFET and MOSFETs** : Construction and working of JFET drain and transfer characteristics, Shockley current relation, Applications , Depletion type and Enhancement type MOSFET , CMOS , MESFET .

(2) **FET Biasing:** Fixed biasing**,** self biasing, voltage-divider biasing, common gate configuration.

(3) **FET Amplifiers:**JFET small signal model, fixed bias and voltage divider bias configuration for amplifier, source follower with ac analysis.

(4) **Self study for projects**: Designing FET amplifier network, Effect of $R_L$and R_{sig} ,cascade configuration and troubleshooting , Low frequency and High frequency response of FET amplifier

Unit 2

(1)**Operational Amplifiers:** Differential amplifier circuit,Op-Amp basics, Practical Op-Amp circuit, DC offset parameter, frequency parameter, Differential and common mode operation.

(2**) Op- Amp Applications:** Integrator, Differentiator, Comparator, astablemultivibrator, sine wave generator,higher order butterworth filters (for project).

(3**) Linear DigitalICs**:Comparator unit operation, Digital-Analog converter, Timer unit operation, voltage controlled oscillator, phase locked loop.

Unit 3

(1)**Feedback and Oscillator Circuits**: feedback amplifiers – phase and frequency considerations, oscillator operation,phase shift oscillator, Wien bridge oscillator, Tuned oscillator, crystal oscillator, unijunction oscillator.

(2)**Power Supplies**: General filter consideration, capacitor filter, RC filter,discrete transistor voltage regulation,IC voltage regulation.

(3)**Other Two-Terminal Devices**: DIAC, TRIAC, Schottky barrier diode, solar cells, photodiode, photoconductive cells, IR emitters.

Unit 4

(1)**TTL** and **FET** logic families, **Flip Flops, Registers,counters**- Revision (Malvino & Leach)

(2)**Fundamentals of Microprocessor** : Data bus, Address bus, Control bus, Microprocessor based system- Basic operation, Microprocessor operation, Architecture, Instruction set ,The 8085 A Microprocessor, Programming with Microprocessor.

Main References:

1. Electronic devices and circuit theory, Boylestead and Nashalsky
2. Digital Principle and Applications, Malvino and Leach
3. Modern Digital Electronics , R P Jain

Additional References:

4. Electronic Principles , Malvino

5. Microprocessor Architecture, Programming and Applications with the 8085 , R. Gaonkar**CIA**: **PROBLEM SOLVING/ ASSIGNMENTS/ LITERATURE REVIEW**

T.Y.B.Sc. PHYSICS **COURSE: S.PHY.5.04**
Title: Atomic & Molecular Physics
Learning Objectives: To study atomic structure and atomic and molecular spectra.
No. of Lectures: 60

UNIT I: **(15 lectures)**

1. **Mathematical Formalism for Quantum Mechanics**:
   Linear Algebra, Function Spaces, The generalized Statistical Interpretation, The Uncertainty Principle
2. **Quantum Mechanics in Three Dimensions:**
   Schrodinger Equations in Spherical Coordinates, The Hydrogen Atom, Angular Momentum, Spin.

Unit II: **(15 lectures)**

1. **Identical Particles**
   Two-Particle Systems, Atoms, Solids, Quantum Statistical Mechanics (in brief)
2. **Time independent Perturbation Theory**
   Nondegenerate Perturbation Theory, Fine Structure of Hydrogen, The Zeeman Effect, Hyperfine Splitting
3. **Analysis of Zeeman and Paschen Back effect in sodium spectrum.**

UNIT III: **(15 lectures)**

1. **Molecular Spectra -I**
   Rotational Spectra, Microwave Spectrometer.Vibrational Spectra, Vibrational - Rotational Spectra, Infrared Spectrometer.
   Electronic Spectra, Born Oppenheimer Approximation, Intensity of Vibration -Electronic Spectra, Frank – Condon Principle.

UNIT IV: **(15 lectures)**

1. **Molecular Spectra-II**
   Raman Effect: Classical Theory, Quantum Theory, Pure Rotational Raman Spectra, Vibrational Raman Spectra, Raman Activity of CO_2 and H_2O, Experimental Techniques.
   Nuclear Magnetic Resonance - theory, experimental method, applications
   Electron Spin Resonance - theory, experimental method, applications.

References: -

1. Introduction to Quantum Mechanics – D. J. Griffiths
2. Molecular spectra - C. M. Banwell & McCash.

Additional References:

1. Quantum mechanics concepts and applications – N. Zeittili
2.Quantum physics – Eisberg and Resnick- 2nd edition

3. Introduction to Atomic spectra- H.E. White
4. Quantum Mechanics – Pauling and Wilson

CIA: PROBLEM SOLVING/LITERATURE REVIEW / ASSIGNMENT

Practicals
T.Y.B.Sc. Physics **Course: S.PHY.5.PR**
Minimum Six experiments to be performed from each group

Group I: Classical and Statistical Mechanics
1. Determination of 'g' by Kater's Pendulum
2. Coupled pendulum
3. Vibrational modes of coupled oscillator (simulation experiment)
4. Verification of a Lagrangian of a bob in motion on a movable inclined plane.
5. Random walk in 1 & 2 dimensions
6. Gaussian distribution of position of dart
7. Experimental verification of probability of two dice system
8. Statistical Data analysis

Group II: Electronics and Atomic –Molecular Physics
1. IC – 555 timer as an astable multivibrator, VCO
2. OP-Amp astable
3. D/A converter using R-2R ladder and Binary weighted resistor(with Op-Amp)
4. Multiplexer & Demultiplexer , Encoder & Decoder
5. LM-317 voltage regulator
6. JK flip-flop using manual clock
7. Counters and registers
8. Rydberg's Constant of Hydrogen
9. Resolving power of diffraction grating spectrometer
10. Zeeman effect
11. Study of molecular vibrational spectra of some compounds

Group III: Project
One project per theory course (worked in pair) is mandatory

References:
1. Advanced course in practical physics – D. Chattopadhyay, P.C. Rakshit& B. Saha
2. B. Sc. Practical physics – Harnam Singh
3. B. Sc. Practical physics – C. L. Arora
4. Practical physics – C. L. Squires
5. University Practical physics – D. C. Tayal

T.Y. B.Sc. PHYSICS
Course: S. PHY.DIP. AC. 5
Title: Digital Image Processing-I

Number of lectures: 60

Learning objective: To study the mathematical modeling of digital images

UNIT I (15 LECTURES)

Introduction(2 lec.): What Is Digital Image Processing?The Origins of Digital Image Processing, Gamma-Ray Imaging X-Ray Imaging, Imaging in the Ultraviolet Band, Imaging in the Visible and Infrared Bands, Imaging in the Microwave Band, Imaging in the Radio Band, Examples in which Other Imaging Modalities Are Used, Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Problems
THIS CHAPTER IS ONLY OVERVIEW (not for exam)

Digital image fundamentals (3 lec.): Elements of Visual Perception, Light and the Electromagnetic Spectrum, Image Sensing and Acquisition, Image Sampling and Quantization, Some Basic Relationships between Pixels, An Introduction to the Mathematical Tools Used in Digital Image Processing, Problems

Image enhancements in spatial domain (8 lec.): Background, Some Basic Intensity, Transformation Functions, Histogram Processing, Smoothing Spatial Filters, Sharpening Spatial Filters, Combining Spatial Enhancement Methods, Problems

UNIT II (15 LECTURES)
Image enhancements in frequency domain: Background, Preliminary Concepts, Sampling and the Fourier Transform of Sampled Functions, The Discrete Fourier Transform (DFT) of One Variable
Extension to Functions of Two Variables, Some Properties of the 2-D Discrete Fourier Transform
The Basics of Filtering in the Frequency Domain, Image Smoothing Using Frequency Domain Filters, Image Sharpening Using Frequency Domain Filters, Selective Filtering, Implementation
Problems

UNIT –III (15 LECTURES)
Image restoration: Image Restoration and Reconstruction, A Model of the Image, Degradation/Restoration Process, Noise Models, Spatial and Frequency Properties of Noise, Some Important Noise Probability Density Functions, Periodic Noise, Estimation of Noise Parameters
Restoration in the Presence of Noise Only-Spatial Filtering, Mean Filters, Order-Statistic Filters
Adaptive Filters, Periodic Noise Reduction by Frequency Domain Filtering, Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering, Geometric Mean Filter
Image Reconstruction from Projections, Problems

Unit IV(15 lectures)
Color image processing: Color Fundamentals, Color Models, Pseudo-color 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

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

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C.I.A.:

Problem Solving / Multiple Choice Questions /Assignments/ Literature Review / Field trips

Practicals:-
T.Y.BSc Digital Image processing-I COURSE: S.PHY.DIP.AC.5.PR

Digital processing of given images using software
Tutorials on image processing
Projects

C.I.A.