SEMESTER I

Paper: PHY701C (Core)
Classical Mechanics
Credits: 3+1+0=4

Theory: 48 Lectures

An overview of the Lagrangian and Hamiltonian formalism

Simple applications of Lagarange's and Hamilton's equation of motion: Small oscillation,Lagrangian for dissipative system, Conservation principle.

[8Lectures]

Hamilton's principle

Calculus of variations, simple applications, Hamilton's principle; Lagrange's equation from Hamilton's principle; Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action.

[6 Lectures]

Canonical transformations

Generating functions; examples of canonical transformations; group property; Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations.

[6 Lectures]

Hamilton-Jacobi theory

The Hamilton Jacobi equation for Hamilton's principle function; The harmonic oscillator problem; Hamilton's characteristic function; Action angle variables.

[4 Lectures]

Rigid bodies

Independent coordinates; Rotation as orthogonal transformations (finite and infinitesimal); Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation.

[8 Lectures]

Fluid Mechanics:

Elements of fluid mechanics Energy and momentum flux, Navier -Stokes Equation. [6 Lectures]

Introduction to Chaos

Periodic motions and perturbations; Attractors; Chaotic trajectories and Liapunov exponents; The logistic equation. [4 Lectures]

Classical field theory

Lagrangian and Hamiltonian formulation for continuous systems, Symmetry and conservation principles – Noether's Theorem, Classical field theory.

[6 Lectures]

Recommended Books:

1. Classical Mechanics: H.Goldstein, Narosa Publishing House
2. Mechanics: Landau and Lifshitz
3. Theoretical Mechanics: Murry r. Spiegel
4. Fluid Mehanics: L.D Landau and E.M. Lifshitz
5. Classical Mechanics: John R Taylor
6. Classical Mechanics: Jeol A Shapiro
7. Classical Mechanics: Rana and Joag
8. Introduction to Mathematical Physics, Methods and Concepts: C.W. Wong
9. Chaos and Nonlinear Dynamics: R.C.Hibron

Paper: PHY702C (Core)
Quantum mechanics I
Credits: 3+1+0=4

Theory: 48 Lectures

Wave Particle Duality and Uncertainty Principle

Wave Particle Duality and Uncertainty Principle: Particles and waves in classical physics. Quantum view of particles and waves (Double slit experiment with wave and particles), de Broglie's hypothesis of matter wave. Probabilistic interpretation of wave function. Uncertainty relation. Wave packet description of a particle: Gaussian and square wave packets. Wave packet and uncertainty principle. Group velocity and phase velocity. **(8 lectures)**

Schrodinger's Equation

Schrodinger's Equation. Eigenfunctions and eigenvalues. Time dependent and time independent Schrodinger's equation. Probability density and probability current density. Simple applications of Schrodinger Equation: particle in a box, the harmonic oscillator, tunnelling through a barrier. The hydrogen atom. **(8 lectures)**

Operators, States and Measurements:

Stern-Gerlach experiment. Kets, bras and operator. Basis and matrix representations. Eigenstates, orthogonality and completeness . Change of basis and unitary transformation. Measurements, observables and uncertainty principle. Probability of outcome of measurements. Expectation value. Postulates of quantum mechanics. Continuous spectra. Position and momentum basis. **(10 lectures)**

Quantum Dynamics:

Translation operator; momentum operator and its representations. Time evolution of states. Unitary time evolution operator. Schrodinger and Heisenberg picture. Heisenberg's equation of motion. Ehrenfest's theorem.

(6 lectures)

Application of the Operator method:

The harmonic oscillator, ladder operators, coherent states. **(4 lectures)**

Relativistic quantum mechanics:

Relativistic quantum mechanics. Klein Gordon equation and its physical significance, Klein- Gordon equation in the presence of electromagnetic field and its non-relativistic approximation. Dirac equation and plane wave solutions. Electron spin and its relationship with magnetic moment. Non-relativistic limit of the Dirac equation. Hydrogen atom problem. **(12 lectures)**

Recommended Books:

1. Quantum Mechanics: C. Cohen-Tannoudji, B. Diu, and F. Laloe

2. The Principles of Quantum Mechanics: P. A. M. Dirac

3. Quantum Mechanics: N. Zettili

4. The Feynman Lectures on Physics: R. Feynman, R. Leighton and M. Sands

5. Quantum mechanics: A. Ghatak and S. Lokanathan

6. Quantum Mechanics: A. Arhuldass

7. Quantum Mechanics: S. N. Biswas

8. Introduction to Quantum Mechanics: D. J. Griffiths

9. Modern Quantum Mechanics: J.J.Sakurai

10. Advanced Quantum Mechanics, J.J. Sakurai

Paper: PHY703C (Core)
Mathematical Physics I
Credits: 3+1+0=4

Theory: 48 Lectures

Complex Analysis:

Complex numbers. Functions of a complex variable: single and multiple valued functions. Limit and continuity. Differentiation: Cauchy-Riemann equations and their applications. Analytic and harmonic functions. Complex integrals. Cauchy's theorem (elementary proof only). Cauchy's Integral Formula. Taylor and Laurent expansion. Classification of singularities. Branch point and branch cut. The residue theorem and evaluation of some typical real integrals using this theorem. Cauchy's principal value of an integral. **(20 lectures**)

Vector Spaces:

Linear vector space. Linear independence. Completeness. Basis and dimension. Norm. Inner product. Orthogonal basis. Gram-Schmidt orthogonalization.

Infinite dimensional spaces. Hilbert space. Applications in physics. **(12 lectures)**

Fourier Transforms:

Fundamental properties. Fourier transfrom of derivatives of a function. Shift theorem. Change of scale. Modulation theorem. Convolution theorem. Parseval's identity. Fourier transform of complex conjugates of functions. **(8 lectures)**

Laplace Transforms:

Laplace transform of elementary functions. Basic properties. Change of scale theorem. Shift theorem. Laplace transform of derivatives and integrals of functions. Derivatives and integrals of Laplace transforms. Convolution theorem. Inverse Laplace Transform (Bromwich Integral). Solution of differential equations. **(8 lectures)**

Recommended Books:

Mathematical Methods for Physicists, George B. Arfken, Hans J. Weber and Frank E. Harris, Academic, Press, 2013.

Mathematics for Physicists, P. Dennery and A. Krzywicki, Dover, 1995.

Complex Variables, Murray R. Spiegel, Schaum's Outline Series, McGraw Hill, 1981.

Mathematical Physics, A. K. Ghatak, I. C. Goyal and S. J. Chua, Macmillan, 1995.

Introduction to Mthematical Physics, Charlie Harper, Prentice-Hall, 1976.

Complex Variables and Applications, R. V. Churchill and J. D. Brown, McGraw Hill 1980.

Paper: PHY704C (Core)
Electronics
Credits: 3+1+0=4

Theory: 48 Lectures

Network Analysis: [4 lectures]

Network properties of transfer function of linear and lumped systems; Zero input and zero state response; system stability; poles and zeros of network; Routh array and Bode plotting.

MOS and CMOS devices and applications: [10 lectures]

Static and dynamic characteristics; depletion and enhancement modes; use of the devices

in amplifiers and oscillators.

(a) TUNNEL diode and applications: Tunnelling effect; transfer coefficient; tunnel diode characteristics; use of tunnel diode as oscillator and amplifier.

(b) GUNN diode and applications: Transferred electron effect; TE modes; Gunn diode in oscillation circuit.

(c) IMPATT/AVALANCHE diode and applications: Drift and scattering velocity; relation between fields, current and terminal impedance; equivalent circuits of the diodes and their use in amplifiers and oscillators.

OP-AMP applications [6 lectures]

Oscillators: Phase shift, Wien bridge and high frequency and voltage controlled oscillators; saw-tooth generator.

Filters: active low and high pass filters; Butterworth filter (up to 2nd order).

Analog computation: solution of differential equation (up to second order), solution of Simultaneous equations.

Digital Circuits [6 lectures]

Mapping of logic expression and function minimization: SOP, POS expressions and circuit configurations; combinatorial logic gates; working and configuration of TTL, DTL, RTL, CMOS, MOSFET, ECL and L2L gates

Sequential circuits: RS, JK, D and T Flip Flops

Register: serial, parallel and shift register -- their design

Counter: synchronous counter and design (up to module-10 counter)

Microprocessor: flow chart; assembly language; solution of simple problems

Signal Transmission and Devices: [8 lectures]

Transmission line: Basic conception of transmission of LF and HF in open wire and coaxial lines; wave equations; characteristic impedance; VSWR; short and open circuit impedance; matching and stub matching.

Waveguides: fundamental concepts of signal propagation through a waveguide; rectangular waveguides; relation between cut-off frequency and waveguide dimension.

Antenna: $\lambda/4$ dipole; antenna arrays; end fire and broadside. Horn antenna, dual mode, E/Hplane, directivity, phase error, reflector, cylindrical, doubly curved, lens antenna: single surface dielectric, stepped lenses, metal plate lens antenna, aperture and field, microstrip antenna: cavity model, impedance, radiation pattern.

Modulation and De-modulation : [8 lectures]

Amplitude modulation: Bandwidth and frequency spectra.

Frequency modulation: Narrow band and wide band; power; bandwidth; improvement of

S/N with emphasis and de-emphasis circuits

Detection: Balanced detector; zero-crossing detector; PLL.

PAM: Basic principles; baseband binary PAM.

PCM: Sampling of signal; quantization of signal; noise and bandwidth.

Digital Communication and Modulation Techniques [6 lectures]

Incoherent ASK (amplitude shift keying), FSK (frequency shift keying), coherent ASK and

FSK, differential PSK (DPSK)

Reading List:

1. Modern digital electronics: R. Jain
2. Electronic Communication System: G. Kennedy and B. David
3. Microwaves: K. Gupta

Paper: PHY705L (Lab)
Electronics Experiments
Credits: 0+0+4=4

Practical: Credits: (0 + 0 + 3) =3, 48 Classes (2hours in each class)
Workshop: Credits: (0 + 0 + 1) =1, 16 Classes (2 hours in each class)

List of laboratory Experiments (At least 8 experiments must be performed)

1. To design an RC-coupled class A amplifier and

a) Draw the frequency response graph and find the half power points

b) Measure the output impedance of the amplifier

c) Measure the gain bandwidth product

2. Draw the characteristic curve for a FET and measure the pinch-off voltage

3. Using a IC 741

a) Design an integrator circuit and a differentiator circuit

b) Draw the wave form

c) Measure the rise and fall time

d) Compare the result with theoretical values

4. Design a Wien Bridge Oscillator and find the frequency of oscillation. Compare the result with theoretical values.

5. To design 1st and 2nd order low-pass filters using IC 741 and

6. (i) Draw the frequency response and find the roll-off rate.

(ii) Determine the gain and cut-off frequency and compare with theoretical values.

7. Simplify given Boolean equations and verify with NAND/NOR gates.

8. Construct AND, OR, NOT, NOR, XOR and half adder with the help of NAND gates and verify their truth tables

9. Solve simple problems using microprocessor 8085/8086

(b) Workshop Practice:

A. Machine Workshop

1. Introduction to machines in workshop.
2. Introduction to safety rules.
3. Sketches of tools and equipments.
4. Demonstration of tools and equipments to be used in practical job.
5. Practical job -- to make nut and bolt from mild steel rod, measuring, hacksaw cutting, lathe turning, drilling, making hexagonal shape by filing and thread cutting with dia and tape.

B. Electronics Workshop

1. Safety precautions
2. Familiarization with Tools and equipments, Electronic components, Power supply
3. Computer hardware overview

C. Assignment

1. To make a PCB for a required circuit
2. To design transistor regulated power supply, IC regulated power supply, amplifier, oscillator, transmitter etc and Transformer.