ST. JOSEPH'S COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)
CUDDALORE – 607001

PG & RESEARCH DEPARTMENT OF PHSYSICS

SUBJECT : Relativity, Quantum Mechanics and Mathematical Methods
SUBJECT CODE: PH610
STAFF INCHARGE: Dr.P.Praveen (Shit-I) &
Ms.S.Sangeetha Margreat (Shit-II)

Unit 1

Two Mark's

1. What is meant by twin paradox?
2. State the laws of Addition of velocities.
3. Define length contraction.
4. Explain gravitational red shift.
5. List the postulates of special theory of relativity.
6. Explain twin paradox.
7. State the postulates of the special theory of relativity.
8. What is meant by time dilation?
9. What are inertial frames of reference?
10. Give the postulates of special theory of relativity.

Five Mark's

1. Write short note on Relativity of simultaneity.#
2. Discuss in detail the length-contraction.
3. Derive the Lorentz's transformation and inverse transformation equations.
4. Derive the equation for the addition of velocities. #
5. Explain the gravitational red shift.
6. Discuss the Lorentz FitzGerald Length contraction in relativity.
7. Derive the relation for addition of velocities in special theory of relativity.
8. Derive Einstein's Mass – Energy relation.
9. Derive the relativistic addition of velocities. Hence prove that no particle can move with a velocity greater than that of light.

Ten Mark's

1. What is the meaning of mass-energy equivalence? Obtain Einstein's mass energy relation. Show that 1u=931 Mev.
2. Describe in detail the Michelson-Morley's experiment and also discuss its negative results.
3. Derive the expression for the variation of mass with velocity.
4. What is meant by relativistic variation of mass? Derive an expression for the mass of on object with respect to an observer in moving frame.
5. Derive Lorentz transformation equations.

Unit 2

Two Mark's

1. Mention any two postulates of wave mechanics.
2. A microsope using photons, is employed to loate an electron in an atom to within a distance of 0.2 A^0. What is the uncertainity in the momentum of the electron located in this way?
3. What is de Broglie wavelength?
4. DifferentiateEigen value and Eigen function.
5. Define wavefunction.
6. What are expectation values?
7. What are called De Broglie waves?
8. Write the equation to find the expectation value of an observable.
9. What is known as expectation value?
10. What is a wave function?

Five Mark's

1. Discuss the physical significance of wave function.
2. What are de Broglie waves? Derive de Broglie wave length.
3. Write a note on the uncertainty principle. #
4. Give a physical interpretation of the wave function and mention the conditions on it.
5. State and explain Heisenberg's Uncertainty principle.
6. What are expectation values? Explain.
7. Give the relation between wave velocity and group velocity.
8. Obtain expressions for wave and group velocities and distinguish between them.
9. State and explain the postulates of wave mechanics.

Ten Mark's

a. Explain the term group velocity and also obtain a relation between group velocity and wave velocity.
    a) Give the proof of Uncertainty principle.
    b) List the postulates of wave mechanics.
b. List the properties of wave function.
c. What are operators? Explain them with examples.
d. Discuss the operator formalism in wave mechanics.
e. Describe wave – particle dualism of matter waves. Also obtain an expression for the de Broglie wavelength of matter waves.

Unit 3

Two Mark's

1. What is meant by the zero-point energy? #
2. What is Schrodinger's wave equation?
3. What is zero point equation? #
4. List the quantum numbers associated with an atom.

5. Define quantum mechanical tunneling.
6. What is meant by tunneling effect?
7. Give Schroedinger's time independent wave equation.
8. Write radial equation for a hydrogen atom.

Five Mark's

1. Derive Schrodinger's time dependent wave equation.
2. An electron is moving in a one dimensional box of infinite height and width $1A^0$. Find the minimum energy of electron (h=6.6x10P-34P Js, me=9.1x10^{-31}kg).
3. Derive the Schrodinger time dependent equation. #
4. Derive the Schrodinger time independent equation. #
5. Obtain the Eigen value and Eigen function of an electron in a 1D box of width 10Å.
6. Deduce the Eigen value and Eigen function of a particle in a 1D box.
7. What is meant by particle in a box? And derive an expression for the energy of such particle in 1D box.
8. Set up radial equation for a hydrogen atom. Find its energy Eigen value and complete wave function.

Ten Mark's

1. Formulate Schrodinger's equation for a rigid rotator. Find its Eigen value and Eigen functions.
2. Using Schrodinger's equation derive the Eigen value and Eigen function of a linear Harmonic Oscillator.
3. Solve the Schrodinger's equation for a hydrogen atom in polar co- ordinates.
4. Solve the problem of linear harmonic oscillator using Schrödinger equation and obtain expressions for energy and wavefunction.
5. Obtain the Schrodinger equation for a one dimensional linear harmonic oscillator. Solve it to find the energy Eigen values and Eigen functions.

Unit 4

Two Mark's

1. State Green's theorem. #
2. Define gradient of a scalar function φ.
3. State Gauss Divergence theorem.
4. Show that **a**is perpendicular to **b** if |a+b|=|a-b|. #
5. State Stokes theorem. #
6. Write Guass divergent theorem.
7. Explain the term curve linear coordinates.

Five Mark's

1. State and prove Green's theorem. #
2. Derive Laplacian operator in orthogonal Curvilinear Co-ordinates.#
3. Write a note on the orthogonal curvilinear co-ordinates.

4. Prove that $\nabla.[\nabla u \times \nabla v]=0$. #
5. Discuss the relation between spherical polar coordinates and Cartesian coordinates.
6. Derive the expression for divergent interms of spherical polar coordinates
7. Evaluate the integral using Stokes theorem $\int[(2x-y)dx - yz^2dy - y^2\, zdx]$.

Ten Mark's

1. State and prove stoke's theorem. #
2. State and prove Green's theorem.
3. Distinguish between Cartesian and curve linear coordinates.
4. State and prove Gauss divergence theorem.

Unit 5

Two Mark's

1. Write down Legendre's differential equation.
2. Show that the $\sqrt{(1)} = 1$.
3. Give the transformation relations from spherical to Cartesian Co-ordinates.
4. Give the Hermite differential equation.
5. Give ∇^2 in spherical co-ordinates.
6. Define Beta function.#
7. Write down the standard form Legendre differential equation.
8. Define Gamma function.
9. Write down thegenerating function for Bessel function.

Five Mark's

1. Show that $\beta\, (m,n)=\int_0^a \frac{y^{m-1}}{(1+y)^{m+n}}$
2. Find the value of $\sqrt{(-5/2)}$.
3. Arrive at the relation between β and Γ functions.
4. Show that $J_{-n}(X)=(-1)^n J_n(X)$.
5. Write Bessel differential equation and its series solutions.
6. Show that $J_{1/2}(x)= \sqrt{(2/\pi x)} \sin x$.
7. Discuss Gammafunctions.
8. Discuss Legendre Polynomials.
9. Prove that $\beta\,(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$.
10. Obtain Rodrigue's formula for Hermite polynomial.

Ten Mark's

1. Obtain the solution of Bessel's differential equation using power series technique.
2. Derive the solution of Laguerre's differential equation. #
3. Discuss Hermite's polynomial equations.
4. Find the solution of the Bessel differential equation $x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2-n^2)y = 0$.