Assignment Questions
Paper 301

Unit 3 (Lagrangian formulation)

- State D'Alembert's principle and obtain Lagrangian equation of motion for a conservative holonomic system.
- Obtain the expression for kinetic energy in case of double pendulum using generalized coordinates.
- Find the acceleration in case of a spherical pendulum and prove that its angular momentum is a constant.
- Discuss velocity dependent potential in detail.
- Derive Euler's equation of motion and prove that $\omega.N = \frac{dT}{dt}$.
- Define Spherical top, Symmetric top, Asymmetric top and rigid rotor.
- State Euler's theorem.
- and Chasles' theorem.

Unit-01

(01) Separate Helmholtz equation completely in spherical co-ordinate system.

(02) Separate Helmholtz equation completely in cylindrical co-ordinate system.

(03) Separate Helmholtz equation completely in cartesian co-ordinate system.

(04) Separate Laplace equation completely in spherical co-ordinate system.

(05) Separate Laplace equation completely in cylindrical co-ordinate system.

(06) Separate Laplace equation completely in cartesian co-ordinate system.

(07) Using the Schrodinger equation for a free particle Obtain Helmholtz equation

(08) Give answer in short.

(01) State Poisson's equation is given by?

(02) State Diffusion's equation is given by?

(03) State Laplace's equation is given by?

(04) State Wave's equation is given by?

(05)State two importance of mathematical physics.

(06) Can all equation be separate in any co-ordinate system? Why?

Assignment-2 Questions
Paper 301

Unit 2 (2^{nd} Order Differential Equations)

- Find the finite singular point for following differential equation and determine the nature of singularity $x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}+(x^2-m^2)y=0.$
- Find the finite singular point for following differential equation and determine the nature of singularity $x^2\frac{d^2y}{dx^2}+(1-x)\frac{dy}{dx}+ay=0.$
- Find the nature of singularity of Bessel's equation for point at infinity.
- Find the nature of singularity for Legendre equation

$$(1-x^2)\frac{d^2y}{dx^2}-2x\frac{dy}{dx}+\left[\lambda-\frac{m^2}{1-x^2}\right]y=0.$$

- Solve the given differential equation by power series method

$$\frac{d^2y}{dx^2}+(\lambda-x^2)y=0\ .$$

- Find power series solution of given differential equation

$$(1-x^2)y''-2xy'+m(m+1)y=0.$$

- Solve Bessel's equation by the method of Frobenius

$$x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}+(x^2-m^2)y=0$$

- Write solution of the given differential equation using Frobenius method

$$x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}+\left(x^2-\frac{1}{9}\right)y=0.$$

Short Questions

- Write Legendre equation.
- Write Bessel's equation.
- Define Ordinary point.
- Define Singular point.
- Define regular and irregular singular point.

Unit 4

1. Define The Ladder Operator, Using Ladder Operator Obtain energy eigen value of simple harmonic oscillator.
2. Determine the eigen value spectrum of a Harmonic oscillator using its ladder operators.
3. Obtain the energy eigen value of simple harmonic oscillator.
4. Define ladder operator a and a+ of simple harmonic oscillator using ladder operator and obtain the energy eigen function of harmonic oscillator.
5. The normalization function $\phi(x)$ is given by $\phi(x)=\frac{1}{\sqrt{2\pi}}e^{im\phi}$ Starting with expression $$(1-\omega^2)\frac{d^2k}{d\omega^2}-2\omega(|m|+1)\frac{dk}{d\omega}+[l(l+1)-|m|(|m|+1)k=0$$ obtain and expression for spherical harmonic $Y_{lm}(\theta,\phi)$ for operator L^2.
6. Define parity operator.
7. What is a pseudo vector?
8. Discuss Parity operator and determine the parity of spherical harmonics.
9. Show that L^2 and L_z commute.
10. Plot a polar diagram of $Y_{lm}(\theta,\phi)$ for $l=1$ and $m=-1, m=+1$
11. Write series of differential equation, $v''-2\rho v'+(\lambda-1)=0$ for simple harmonic oscillator.| Obtain the energy eigen functions $u_n(x)=N_nH_n(\alpha x)e^{\frac{-1}{2}\alpha^2x^2}$
12. Explain: The Ladder operators and The Eigen value spectrum
13. Explain parity operator and show that for all ψ , $PL_z=L_zP$
14. Write expression for energy eigen values En of the simple harmonic oscillator.
15. Write the generating function $G(\rho,\xi)$ of the Hermite polynomials.
16. In the case of simple harmonics oscillator establish eigen value equation for energy and show that how it leads to the energy eigen values , $E_n=(n+\frac{1}{2})\hbar\omega$
17. Write the eigen value equation for L^2 operator. Solve it to obtain its eigen values of L^2 operator.
18. Obtain the normalization constant for one dimension simple harmonic oscillator and hence energy eigen function of simple harmonic oscillator.
19. Write the eigen value equation for L^2 and solve its to obtain eigen values of L^2 operator.
20. What are spherical harmonics? Obtain $Y_{lm}(\theta,\phi)$ for(l,m) =(1,0)(1,1) and (1,-1). Express these function in terms of Cartesian co-ordinates plot Polar diagram for same values of l and m. Why 'm' is called magnetic quantum number.
21. Write energy eigen value for ground state simple harmonic oscillator.
22. Obtain the energy eigen value spectrum of a simple harmonic oscillator.

23. Discuss the properties of stationary states of a simple harmonic oscillator.

24. Show that the uncertainty product $(\Delta x)(\Delta p)$ takes its minimum value $\frac{1}{2}\hbar$ in the ground state of Harmonic Oscillator.

25. Obtain the following relation for Harmonic-Oscillator

$$(um, xun) = \sqrt{\frac{n+1}{2}} . \frac{1}{\alpha} (m = n+1)$$

$$(um, xun) = \sqrt{\frac{n}{2}} . \frac{1}{\alpha} (m = n-1)$$

26. Mention the degeneracy of the eigen value of L^2 operator.

27. Write down the generating function for $H_n(\rho)$ and prove that

$$H_n(\rho) = (-1)^n e^{\rho^2} \frac{d^n e^{-\rho^2}}{d\rho^n}$$ and hence derive the value

$$H_0(\rho),\ H_1(\rho),\ H_2(\rho)$$

28. Prove that $2xH_n(x) = H_{n+1}(x) + 2nH_{n-1}(x)$

29. Express $f(x) = 8x^3 - 2x + 4$ in terms of Hermite polynomials.