CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations March 2023

Programme: Integrated B.Sc. M.Sc. (Chemistry/Mathematics)

Semester: I | **Session: 2022-23**

Course Title: Mechanics (GE) | **Max. Time: 3 Hours**

Course Code: SBS PHY03 101 GE 4004 | **Max. Marks: 70**

Instructions:

- Question no. 1 has seven parts and students need to answer any four. Each part carries three and half marks.
- Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Q1. (a) Find the value of $\vec{\nabla}(f)$, if $f = 3x^3y^2z^2$.

(b) To maintain a rotor at a uniform angular speed of 200 s^{-1}, an engine needs to transmit a torque of 180 N-m. What is the power of the engine required?

(c) If a particle of mass 1 kg starts rotating from rest according to $\theta = t^2 + 15t + 7$. Calculate the angular velocity and angular momentum at t = 10 seconds. Also, show that the angular acceleration of the particle is a constant.

(d) Prove that the damping force is independent of acceleration or displacement and is proportional to velocity?

(e) Calculate angular frequency and time period corresponding to a spring mass system having a frequency of oscillations 10 MHz.

(f) Why twisting a couple per unit twist is greater for a hollow cylinder than for a solid one of the same materials, mass, and length?

(g) A circular disc rotates at 60 rpm. A coin of 18 g is placed at a distance of 8 cm from the center. Calculate the centrifugal force on the coin.

(4 × 3.5 = 14)

Q2. (a) Consider $\vec{A} = 2\hat{i} + \hat{j} + \hat{k}$ and $\vec{B} = \hat{i} - \hat{j} + 2\hat{k}$. Find the unit vector which is perpendicular to both $\vec{A}$ and $\vec{B}$.

(b) The linear momentum of a body is increased by 10%. What is the percentage change in its kinetic energy?

(c) Show that the final velocity of a rocket in free-space is independent of rate at which fuel is expelled.

(2 × 7 = 14)

Q3. (a) Derive a relation between the Torque and Angular Momentum of a rigid body. Discuss the principle of conservation of Angular momentum with an example.

(b) State Kepler's three laws of planetary motion.

(c) A sphere of mass 19 Kg is attracted by another sphere of mass 150 Kg. When their centers are separated by a distance of 0.28 m with a force equal to the weight of 0.25 mg. Calculate the gravitational constant. If the distance is halved, what would be new force in Newton? Assume g = 9.8 m/s^2 .

$(2 \times 7 = 14)$

Q4. (a) If Y, K, σ represents Young's modulus, Bulk modulus, and Poisson's ratio respectively, then prove that $Y = 3K\ (1 - 2\sigma)$.

(b) How to determine Elastic constants Y, K, η and σ using the Searle method. Explain in detail.

(c) Explain the vibration of the kinetic and potential energies of a simple harmonic oscillator. Illustrate your answer with a suitable graph. Prove that average potential energy equals to the average kinetic energy $=\frac{1}{2}Ca^2$.

$(2 \times 7 = 14)$

Q5. (a) On the basis of Lorentz transformation, discuss the following kinematics effects: (a) Length contraction (b) Time dilation.

(b) Show by means of Lorentz transformation equations that $x^{2\prime} - c^2t^{2\prime} = x^2 - c^2t^2$

(c) Frame S' moves relative to frame S at $0.6c$ in the positive direction of x. In frame S' a particle is measured to have a velocity of $0.5c$ in the positive direction of x'. What is the velocity of the particle with respect to frame S? What will be the velocity of the particle in frame S if it is moving with velocity $0.5c$ in the negative direction of x'?

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations March 2023

Programme: Integrated BSc-MSc Physics **Session: 2022-23**

Semester: 1^{st} **Max. Time: 3 Hours**

Course Title: Mathematical Physics-I **Max. Marks: 70**

Course Code: SBS PHY 03 101 CC 4004

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Explain physical significance of gradient and divergence.

b) Find a unit vector perpendicular to the surface $x^2 + y^2 - z^2 = 11$ at point (4,2,3).

c) Solve the differential equation: $(D-1)^3 y = 16e^{3x}$

d) What do you understand by exact differential equation? Solve the differential equation: $(5x^4 + 3x^2y^2 - 2xy^3)dx + (2x^3y - 3x^2y^2 - 5y^4)dy = 0$

e) Calculate the scale factors for spherical polar coordinates.

f) Write and sketch the form of Dirac delta function.

g) The probability of horse A winning the race is 1/5 and the probability of horse B winning the race is 1/6. What is the probability that one of the horses win?

Q 2. (2X7=14)

a) What do you understand by homogenous differential equation? Solve the differential equation: $\frac{dy}{dx} = \frac{x+2y-3}{2x+y-3}$

b) Construct a differential equation for the motion of a simple pendulum and solve it to calculate displacement and period of oscillation.

c) Solve the differential equation: $\frac{d^2y}{dx^2} + 3\frac{dy}{dx} + 2y = e^{2x}\text{Sin}x$

Q3. (2X7=14)

a) For a position vector, $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, calculate (i) $Curl\left(\frac{\hat{k}}{r}\right)$, and (ii) $Curl\left(\frac{\vec{r}}{r^3}\right)$ (iii) Show that $div.(r^n r) = (3+n)r^n$

b) Prove that Curl (grad Ø) = 0 using Stokes' theorem.

c) Explain Gauss divergence theorem and hence evaluate: $\iint (x^3dydz + y^3dzdx + z^3dxdy)$, over a surface S of the sphere $x^2 + y^2 + z^2 = a^2$

Q 4. (2X7=14)

a) Derive an expression for length element in orthogonal curvilinear coordinates. Why curvilinear coordinates need not be lengths?

b) Explain cyllindrical coordinate system and calculate the value of scale factors in this system. Express gradient, divergence and curl in cyllindrical coordinate system.

c) (i) Show that the vector field $V = \frac{-x\hat{\imath}-y\hat{\jmath}}{\sqrt{x^2+y^2}}$ is a sink.

(ii) Find a, b and c such that $\vec{F} = (6xy + az^3)\hat{\imath} + (bx^2 - z)\hat{\jmath} + (3xz^2 + cy)\hat{k}$ is irrorational.

Q 5. (2X7=14)

a) Explain binomial distribution and Poission's distribution. Discuss their importance in Physics.

b) Find the mean deviation from the mean and standard deviation of the series: A, a+d, a+2d,.............., (a+2nd). Also show that the standard deviation is greater than this mean deviation.

c) Show by Wronskian that if $b \neq 0$, the functions $e^{ax}\cos bx$, $e^{ax}\sin bx$ are linearly independent over reals.

CENTRAL UNIVERSITY OF HARYANA

First Semester Term End Examinations March 2023

Programme: M.Sc. Physics **Session: 2022-23**

Semester: I **Max. Time: 3 Hours**

Course Title: Quantum Mechanics-I **Max. Marks: 70**

Course Code: SBS PHY 01 103 CC 3104

Instructions:

1. Question number 1 has seven sub parts and students need to answer any four. Each sub part carries three and half marks.
2. Question number 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question Number 1. (4X3.5=14)

a) What is zero-point energy of harmonic oscillator? How is it explained?

b) For the ground state of the hydrogen atom, evaluate the expectation value of the radius vector ***r*** of the electron.

c) A harmonic oscillator is in the ground state. Calculate the value of maximum probability density.

d) A 1-eV electron got trapped inside the surface of a metal. If the potential barrier is 4 eV and the width of the barrier is 2 Å, calculate the probability of its transmission.

e) An electron is in the ground state of a hydrogen atom. What will be the approximate value of probability when it is within the Bohr radius a_0?

f) Prove the Ehrenfest theorem: $\langle F \rangle = \frac{d\langle p \rangle}{dt}$.

g) Evaluate the wave function for the Gaussian wave packet.

Question Number 2. (2X7=14)

a) If A and B are Hermitian Operators, Evaluate the Hermicity of (AB + BA) and (AB - BA).

b) The wave function of a particle in a state is $\Psi = N\, exp(-x^2/2\alpha)$, where $N = (1/\pi\alpha)^{1/4}$. Evaluate $(\Delta x)(\Delta p)$.

c) Evaluate the commutator $[x,\ p_x^2]$ and $[xyz,\ p_x^2]$

Question Number 3. (2X7=14)

a) A particle in the infinite square well has the initial wavefunction $\Psi(x, 0) = A\sin^3(\pi x/a)$ $(0 \le x \le a)$. Determine A, find $\Psi(x, t)$, and calculate $\langle x \rangle$, as a function of time. What is the expectation value of energy?

b) The energies in the ground state and first excited state of a particle of mass $m = 1/2$ in a potential $V(x)$ are -4 and -1, respectively, (in units in which $\hbar = 1$). If the corresponding wavefunctions are related by $\Psi_1(x) = \Psi_0(x) sinhx$, then evaluate the ground state eigenfunction.

c) Given that $\hat{p}_r = -i\hbar\left(\frac{\partial}{\partial r} + \frac{1}{r}\right)$, then calculate the uncertainty Δp_r in the ground state of the hydrogen atom.

Question Number 4. (2X7=14)

a) A particle of mass m moves in a three-dimensional box of sides a, b, and c. If the potential is zero inside and infinity outside the box, find the energy eigenvalues and eigenfunctions.

b) Calculate the allowed energy and ground state wave function of the delta function potential for the bound state.

c) A particle of mass m confined to move in a potential $V(x) = 0$ for $0 \le x \le a$ and $V(x) = \infty$ otherwise. The wavefunction of the particle at time t = 0 is given by $\Psi(x, 0) = A sin(5\pi x/a) cos(2\pi x/a)$. Normalize $\Psi(x, 0)$, and find $\Psi(x, t)$. Is $\Psi(x, t)$ a stationary state?

CENTRAL UNIVERSITY OF HARYANA

First Semester Term End Examinations March 2023

Programme: M.Sc. Physics **Session: 2022-23**

Semester: I **Max. Time: 3 Hours**

Course Title: Quantum Mechanics-I **Max. Marks: 70**

Course Code: SBS PHY 01 103 CC 3104

Instructions:

1. Question number 1 has seven sub parts and students need to answer any four. Each sub part carries three and half marks.
2. Question number 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question Number 1. (4X3.5=14)

a) What is zero-point energy of harmonic oscillator? How is it explained?

b) For the ground state of the hydrogen atom, evaluate the expectation value of the radius vector $\boldsymbol{r}$ of the electron.

c) A harmonic oscillator is in the ground state. Calculate the value of maximum probability density.

d) A 1-eV electron got trapped inside the surface of a metal. If the potential barrier is 4 eV and the width of the barrier is 2 Å, calculate the probability of its transmission.

e) An electron is in the ground state of a hydrogen atom. What will be the approximate value of probability when it is within the Bohr radius a_0?

f) Prove the Ehrenfest theorem: $\langle F \rangle = \frac{d\langle p \rangle}{dt}$.

g) Evaluate the wave function for the Gaussian wave packet.

Question Number 2. (2X7=14)

a) If A and B are Hermitian Operators, Evaluate the Hermicity of (AB + BA) and (AB - BA).

b) The wave function of a particle in a state is $\Psi = N\, exp(-x^2/2\alpha)$, where $N = (1/\pi\alpha)^{1/4}$. Evaluate $(\Delta x)(\Delta p)$.

c) Evaluate the commutator $[x,\ p_x^2]$ and $[xyz,\ p_x^2]$

Question Number 3. (2X7=14)

a) A particle in the infinite square well has the initial wavefunction $\Psi(x, 0) = A\sin^3(\pi x/a)$ $(0 \leq x \leq a)$. Determine A, find $\Psi(x, t)$, and calculate $\langle x \rangle$, as a function of time. What is the expectation value of energy?

b) The energies in the ground state and first excited state of a particle of mass $\boldsymbol{m} = 1/2$ in a potential $V(x)$ are -4 and -1, respectively, (in units in which $\hbar = 1$). If the corresponding wavefunctions are related by $\Psi_1(x) = \Psi_0(x) sinhx$, then evaluate the ground state eigenfunction.

c) Given that $\hat{p}_r = -i\hbar\left(\frac{\partial}{\partial r} + \frac{1}{r}\right)$, then calculate the uncertainty Δp_r in the ground state of the hydrogen atom.

Question Number 4. (2X7=14)

a) A particle of mass $\boldsymbol{m}$ moves in a three-dimensional box of sides a, b, and c. If the potential is zero inside and infinity outside the box, find the energy eigenvalues and eigenfunctions.

b) Calculate the allowed energy and ground state wave function of the delta function potential for the bound state.

c) A particle of mass m confined to move in a potential $V(x) = 0$ for $0 \leq x \leq a$ and $V(x) = \infty$ otherwise. The wavefunction of the particle at time t = 0 is given by $\Psi(x, 0) = A sin(5\pi x/a) cos(2\pi x/a)$. Normalize $\Psi(x, 0)$, and find $\Psi(x, t)$. Is $\Psi(x.\ t)$ a stationary state?

Question Number 5. (2X7=14)

a) Show that $\Delta J_x \, \Delta J_y = \hbar^2[\, j(j+1) - m^2\,]/2$, where $\Delta J_x = \left(\langle \hat{J}_x^2 \rangle - \langle \hat{J}_x \rangle^2\right)^{1/2}$ and the same for ΔJ_y.

b) Calculate $[\hat{J}_x^2, \hat{J}_y]$, $[\hat{J}_z^2, \hat{J}_y]$, and $[\hat{J}^2, \hat{J}_y]$; then show $\langle j, m|\hat{J}_x^2|j,\ m\rangle = \langle j, m|\hat{J}_y^2|j,\ m\rangle$.

c) The wave function of a state of the Hydrogen atom is given by: $\Psi = \Psi_{200} + 2\Psi_{211} + 3\Psi_{210} + \sqrt{}\Psi_{21-1}$ where Ψ_{nlm} is the normalized eigen function of the state with quantum numbers n, l, m in the usual notation. Find out the expectation value of L_z in the state Ψ.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana

Name of Programme	: M.Sc. Physics	
Year & Semester	: March 2023, First Semester	
Course Name	: Mathematical Methods in Physics-I	
Course Code	: SBS PHY 01 101 CC 3104	
Maximum Marks	: 70	Duration : 3 Hrs

Note: All Questions are compulsory. Attempt any four parts from Question 1, each part carries 3.5 marks. Attempt any two parts from Question 2,3,4&5. Each part carries 7 marks.

1. (a) Given $P_k = \epsilon_{ijk}Q_{ij}$ with $Q_{ij} = -Q_{ji}$, antisymmetric, show that $Q_{mn} = \frac{1}{2}\epsilon_{mnk}P_k$.
(b) Use tensor methods to establish $(\mathbf{u} \times \mathbf{v}) \times \mathbf{w} = (\mathbf{u}.\mathbf{w})\mathbf{v} - (\mathbf{v}.\mathbf{w})\mathbf{u}$
(c) Find the matrix that diagonalizes the matrix $\begin{pmatrix} 10 & 3i \\ -3i & 2 \end{pmatrix}$.
(d) Two of the eigenvalues of the matrix $A = \begin{pmatrix} a & 3 & 0 \\ 3 & 2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ are 1 and -1. Determine the value of a and find the third eigenvalue
(e) Using Taylor's series expansion prove that $e^z \sin z = \sum_{n=0}^{\infty} 2^{n/2} \sin(\frac{1}{4}n\pi)\frac{z^n}{n!}$
(f) Describe the Newton-Raphson method for finding the roots of a polynomial.
(g) What do you understand by Poisson Probability distribution function. Derive its expression.

2. (a) Calculate the elements g_{ij} of the metric tensor for cyllindrical polar coordinates. Given that position vector of a general point is given in these coordinates as $\mathbf{r} = \rho\, cos\phi\, \mathbf{i} + \rho\, sin\phi\, \mathbf{j} + z\, \mathbf{k}$
(b) Verify that covariant derivative of contravariant componenet of a vector is 2nd rank tensor.
(c) Given that B and C are second rank tensors and that $A_{pk}B_{ik} = C_{pi}$. Prove that A is a second rank tensor as well.

3. (a) Using Stokes theorem, prove the Cauchy integral theorem for functions of complex variables. Use this theorem to derive

Cauchy integral formula.
(b) Convert the following Rodrigues formula for Hermite function into corresponding Schlaefli Integral.

$$H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n} e^{-x^2}$$

(c) Show that

$$\int_0^{2\pi} \frac{d\theta}{1 - 2t\cos\theta + t^2} = \frac{2\pi}{1 - t^2}, \qquad |t| < 1$$

. What happens if $|t| > 1$ and $|t| = 1$?
(d) Evaluate the integral

$$\int_{-\infty}^{\infty} \frac{cos(x)}{x^2 + a^2} dx$$

4. (a) Consider the matrix $M = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$. Find e^M.
(b) If an Abelian group $(p * q = q * p)$ is constructed with two distinct elements a and b such that $a^2 = b^2 = e$, where e is the identity element of the group. Construct the multiplication of smallest such group and find its order.
(c) The linear transformation $T : \mathcal{R}^3 \rightarrow \mathcal{R}^3$ is defined as

$$T(x_1, x_2, x_3) = (x_1 + x_2 - x_3, 2x_1 - x_3, x_1 + 2x_2)$$

Find the matrix representation of T in the basis consisting of $|a_1>= (1, 1, 0), |a_2>= (1, 0, -1)$ and $|a_3>= (0, 2, 3)$

5. (a) Using 4th order Runge-Kutta method solve the differential equation $\frac{dy}{dt} = y - t^2 + 1$. Given that $y(0) = 0.5$, find the value of y for $0 \leq t \leq 2$ assuming the step size h=0.5
(b) Describe the random walk problem. Find the distance travelled by a random walker in 50 random steps in a line starting from origin and assuming that probability of the walker taking the step to right is 0.56 and the step length is 1 meter.
(c) Evaluate $I = \int_1^2 \frac{dt}{5+3t}$ with 5 subintervals using Simpson's 3/8 rule. Compare with exact solution.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations March 2023

Programme: Integrated B.Sc. M.Sc. (Physics)

Semester: I | **Session: 2022-23**

Course Title: Mechanics | **Max. Time: 3 Hours**

Course Code: SBS PHY 03 102 CC 4004 | **Max. Marks: 70**

Instructions:

- Question no. 1 has seven parts and students need to answer any four. Each part carries three and half marks.
- Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.
- The use of a personal non-programmable calculator is allowed.

Q1. (a) The state of rest and state of motion are relative. Explain using appropriate example.

(b) In an inelastic collision, two particles of masses 3 kg and 2kg, coming from opposite direction with speed 20 ms^{-1} and 30 ms^{-1} respectively, collided to form a single composite particle. Calculate the speed of composite particle?

(c) The angular position $\theta(t)$ of a circular disk rotating about its central axis is given by $\theta(t) = 3.00 + 5.00t + 0.50t^2$. Calculate the speed of an object, with negligible mass, at one edge of the disk at t = 3 s if radius of the disk is 5.0 m.

(d) Four particles with masses $m_1 = 1$ kg, $m_2 = 2$ kg, $m_3 = 3$ kg, and $m_4 = 4$ kg are placed on four corners of a square with length $a = 20$ cm. Calculate the value of gravitational potential at the point, where two diagonals of the square intersect each other.

(e) A spaceship passes Earth at 9:00 AM with a uniform relative speed of 0.8c. If the clocks of the spaceship and the earth are synchronized at the time of passage at 9:00 AM, what will be the time in spacecraft clock at the moment when the clock on earth shows the time 01:00 PM in the same day?

(f) Discuss briefly how the fate of a particle of mass m moving under the influence of a force $\vec{F}$ can be predicted using Newton's second law: $\vec{F} = m\vec{a}$?

(g) A block having mass $m = 500$ g is fastened to a spring whose spring constant k is 50 N/m. The block is pulled a distance (x) 11 cm from its equilibrium position at $x = 0$ on a friction-less surface and released from rest at $t = 0$. Calculate the value of kinetic energy and potential energy at equilibrium position and extreme position for the mass m in resulting simple harmonic motion?

($4 \times 3.5 = 14$)

Q2. (a) Show that the final velocity of a rocket in free-space is independent of rate at which fuel is expelled.

(b) Solve Newton's Law to find the expression for total energy of a spring mass system.

(c) What are conservative forces? Prove that the gravitational force between two point masses m_1 and m_2 ($\vec{F} = \frac{Gm_1m_2}{r^3}\vec{r}$) is a conservative force.

(2 × 7 = 14)

Q3. (a) Calculate moment of inertia of a hollow cylinder around the axis passing though its centre of mass and perpendicular to its length.

(b) Explain Hook's Law of elasticity and draw stress-strain graph.

(c) Show that the centripetal acceleration of an object performing a uniform circulation motion is v^2/r, where r is radius of circular path and $\vec{v}$ is tangential velocity. Show by a velocity diagram that the centripetal acceleration is acting always towards the centre of the circular path.

(2 × 7 = 14)

Q4. (a) Discuss how sun captures a comet by using the concepts of central force motion.

(b) Show that the total energy of a planet moving in a bounded curve in the gravitational field is negative and equal to its kinetic energy.

(c) Derive the expression of velocity and acceleration in a rotating coordinate System and identify various fictitious forces in the rotating frame.

(2 × 7 = 14)

Q5. (a) Stellar system Q1 moves away from us at a speed of 0.90c. Stellar system Q2, which lies in the same direction in space but is closer to us, moves away from us at speed 0.60c. What multiple of c gives the speed of Q2 as measured by an observer in the reference frame of Q1?

(b) Discuss Doppler effect of light. Also, find to what frequency must Earth receivers be tuned to receive the report from a spaceship, which is moving away from Earth at a speed of 0.900c, and sending signals back to earth by transmitting at a frequency (measured in the spaceship frame) of 100 MHz?

(c) Explain the phenomenon of time dilation.

(2 × 7 = 14)

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations March 2023

Programme: Integrated BSc-MSc Physics | **Session: 2022-23**

Semester: 1st | **Max. Time: 3 Hours**

Course Title: Mathematical Physics-I | **Max. Marks: 70**

Course Code: SBS PHY 03 101 CC 4004

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Explain physical significance of gradient and divergence.

b) Find a unit vector perpendicular to the surface $x^2 + y^2 - z^2 = 11$ at point (4,2,3).

c) Solve the differential equation: $(D-1)^3 y = 16e^{3x}$

d) What do you understand by exact differential equation? Solve the differential equation: $(5x^4 + 3x^2y^2 - 2xy^3)dx + (2x^3y - 3x^2y^2 - 5y^4)dy = 0$

e) Calculate the scale factors for spherical polar coordinates.

f) Write and sketch the form of Dirac delta function.

g) The probability of horse A winning the race is 1/5 and the probability of horse B winning the race is 1/6. What is the probability that one of the horses win?

Q 2. (2X7=14)

a) What do you understand by homogenous differential equation? Solve the differential equation: $\frac{dy}{dx} = \frac{x+2y-3}{2x+y-3}$

b) Construct a differential equation for the motion of a simple pendulum and solve it to calculate displacement and period of oscillation.

c) Solve the differential equation: $\frac{d^2y}{dx^2} + 3\frac{dy}{dx} + 2y = e^{2x}\text{Sin}x$

Q3. (2X7=14)

a) For a position vector, $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, calculate (i) $Curl\left(\frac{\hat{k}}{r}\right)$, and (ii) $Curl\left(\frac{\vec{r}}{r^3}\right)$ (iii) Show that $div.(r^n r) = (3+n)r^n$

b) Prove that Curl (grad Ø) = 0 using Stokes' theorem.

c) Explain Gauss divergence theorem and hence evaluate: $\iint (x^3dydz + y^3dzdx + z^3dxdy)$, over a surface S of the sphere $x^2 + y^2 + z^2 = a^2$

Q 4. (2X7=14)

a) Derive an expression for length element in orthogonal curvilinear coordinates. Why curvilinear coordinates need not be lengths?

b) Explain cyllindrical coordinate system and calculate the value of scale factors in this system. Express gradient, divergence and curl in cyllindrical coordinate system.

c) (i) Show that the vector field $V = \frac{-x\hat{\imath}-y\hat{\jmath}}{\sqrt{x^2+y^2}}$ is a sink.

(ii) Find a, b and c such that $\vec{F} = (6xy + az^3)\hat{\imath} + (bx^2 - z)\hat{\jmath} + (3xz^2 + cy)\hat{k}$ is irrorational.

Q 5. (2X7=14)

a) Explain binomial distribution and Poission's distribution. Discuss their importance in Physics.

b) Find the mean deviation from the mean and standard deviation of the series: A, a+d, a+2d,……………, (a+2nd). Also show that the standard deviation is greater than this mean deviation.

c) Show by Wronskian that if $b \neq 0$, the functions $e^{ax} \cos bx,\ e^{ax} \sin bx$ are linearly independent over reals.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations March 2023

Programme: M.Sc. **Session: 20222-23**
Semester: Ist **Max. Time: 3**
Hours
Course Title: Classical Mechanics
Max. Marks: 70
Course Code: SBS PHY 01 102 CC3104

Instructions:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) What are cyclic coordinates? How are they related to general conservation Theorem?
b) State D'Alembert's Principle? Give its significance.
c) What are Legendre Transformations?
d) What are canonical variables?
e) Show that the Poisson bracket of any two constants of the motion is also a constant of motion.
f) Define modified Hamilton's principle.
g) What are normal Coordinates

Q 2. (2X7=14)

a) Using principle of virtual work, derive D' Alembert's principle. How does it get modified for virtual displacement of generalized coordinates?
b) Construct the Lagrangian and hence derive corresponding equations of motion for a double pendulum.
c) State Hamilton's principle and use it to derive Lagrange's equation of motion.

Q3. (2X7=14)

a) What are Legendre Transformations? Use them to establish Hamilton equations of motion.
b) Derive Hamilton's canonical equation from Hamilton's variational principle.
c) What are cyclic coordinates? How they are related to Conservation Theorems?

Q 4. (2X7=14)

a) Use Canonical transformations to solve the problem of Simple Harmonic Oscillator
b) Show that the transformation $Q = \log(\frac{1}{q}\, sinp),\ P = q\ cotp$ is canonical.
c) Obtain Hamilton Jacobi equation and establish adiabatic invariance of action variable

Q 5. (2X7=14)

a) Derive longitudinal normal modes of a linear symmetric triatomic molecule.
b) Determine the eigenvalues equation for small oscillation. How will you obtain eigen values (ω^2) and eigenvectors from this equation?
c) Determine Eigenvalues of Inertia Tensor and hence define the Principal axis of transformation.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations March 2023

Programme: Integrated B.Sc. M.Sc. (Physics) **Session: 2022-23**

Semester: First **Max. Time: 3 Hours**

Course Title: Renewable Energy and Energy Harvesting **Max. Marks: 35**

Course Code: SBS PHY 03 102 SE 2002

Instructions:

1. Question no. 1 has four parts and students need to answer any two parts. Each part carries three and half Marks.

2. Question no. 2 to 5 have two parts each and student need to answer any one part of each question. Each part carries seven marks.

Q 1. (2X3.5=07)

a) Discuss about fossil fuels and their limitations.
b) What do you understand by wind energy harvesting?
c) Differentiate between conventional and non-conventional energy sources.
d) What are linear generators?

Q 2. (1X7=07)

a) Explain solar energy, its importance and how can we store it.
b) How can you define a photovoltaic device? What are two major factors that can affect the efficiency of a photovoltaic device?

Q3. (1X7=07)

a) Discuss various types of wind turbines.
b) Based on frequency, discuss the types of tides.

Q 4. (1X7=07)

a) What is geothermal technology? How can we use geothermal energy efficiently?
b) Discuss environmental impacts of hydropower sources with suitable examples.

Q 5. (1X7=07)

a) Discuss the physics and characteristics of piezoelectric effect.
b) What are renewable sources of energy?

Central University of Haryana
Term End Examinations, March 2023 B.Tech. Programmes

Course Code: : BT PHY 117 A
Branch: CSE
Max Time: 70
Course Title: Semiconductor Physics

Instructions:
Question Number **one (PART-I)** is compulsory and carries total 14 marks (Each sub Question carries two Marks).
Question Numbers 2(two) to 5(five) carry fourteen marks each with internal choice.

PART -I

Q. No.1

(a) What is Laser?
(b) Describe the differences between Stimulated Emission and Spontaneous Emission
(c) what are the important applications of solar cells
(d) what are the main drawbacks of free electron theory
(e)What are the differences between intrinsic and extrinsic semiconductor
(f) Define fermi energy
(g) What is the need to achieve population inversion?

PART –II

Q. No.2 Discuss in detail the Kronig – Penny model for a linear lattice. How does it lead to the formation of energy band in solids?

OR
Q. No.2
The Fermi energy of copper is 7 eV. Calculate (a) The Fermi momentum of electron in copper. (b) de Broglie wavelength of the electron and (c) the Fermi Energy

Q. No.3
Discuss the effect of donor and acceptor impurities in semiconductors. Explain the action of a P-N junction diode and mention its important applications.
OR
Q. No 3
Mobilities of electron and holes in a sample of intrinsic germanium at room temperature are 0.37 $m^2/V.s$ and 0.18 $m^2/V.s$, respectively. If each electron and hole densities is equal to $2.5X10^{19}/m^3$, calculate the electrical conductivity and the resistivity of germanium.

Q. No.4
What is Hall effect? Explain the terms, mobility of charge carriers and Hall effect. Obtain the expression of Hall coefficient in terms of current density and electronic charges.
OR
Q. No .4
Explain Fermi-Dirac distribution function. Plot this function for various temperatures including 0K. Determine the resistivity by Four Probe Method.

Q. No.5

Describe the density of states for 3D, 2D, 1D and 0D systems.

OR

Q. No.5

Describe the Quantum Wells/Dots and Nanowires and its application in Nanoscience.

Central University of Haryana
Term End Examination March 2023
B.Tech. Programmes
Branch: Civil Engineering

Course Code: BT PHY 113A | **Max Time: 3 hrs**
Course Title: Mechanics | **Max Marks: 70**

Instructions:
Question Number **one (PART-I)** is compulsory and carries total 14 marks (Each sub Question carries two Marks).
Question Numbers 2(two) to 5(five) carry fourteen marks each with internal choice.

PART -I

Q. No.1

a) What is the difference between scalar and vector transformations?
b) What is an inertial frame of reference, and how is it used in physics?
c) What is the form invariance of Newton's Second Law?
d) What is the difference between polar coordinates and Cartesian coordinates?
e) A particle moves in a potential field with a potential energy function $V(x) = -x^3$. Calculate the force acting on the particle if it is located at x = -1 m.
f) A satellite of mass m is in orbit around a planet with a radius r, and a speed v. Calculate the angular momentum of the satellite.
g) A box of mass m is pushed up a ramp with an angle θ from the horizontal by a constant force F. Calculate the work done by the force

PART –II

Q. No.2 What is a three-dimensional coordinate frame of reference, and how is it used to represent the position and orientation of objects in space through three mutually perpendicular axes?

OR

Q. No.2 How do scalars and vectors transform under rotations, and what is the relationship between the magnitude and direction of the vector before and after the rotation transformation?

Q. No.3 What is the mathematical formulation of the Kepler problem in terms of central forces, and how can it be used to describe the motion of celestial bodies?

OR

Q. No 3 What is a damped harmonic oscillator, and how does it differ from a simple harmonic oscillator in energy dissipation?

Q. No.4 What is the relationship between the angular velocity vector and moment of inertia tensor in describing the three-dimensional motion of a rigid body?

OR

Q. No .4 What are fictitious forces in a noninertial frame of reference, and how do they arise due to the acceleration of the frame and affect the motion of objects within the frame?

Q. No.5 What is a free body diagram, and how is it used to model the forces and moments acting on a body due to typical supports and joints, such as pin joints, roller joints, and fixed supports, in the analysis of mechanical systems? Can you provide a specific example to illustrate the concept?

OR

Q. No.5 What is the principle of invariance of Newton's second law of motion, and how does it demonstrate that the law remains valid in all inertial frames of reference, regardless of their relative motion or orientation?

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations March 2023

Programme: M.Sc. Physics **Session: 2022-23**
Semester: First **Max. Time: 3 Hours**

Course Title: Semiconductor Devices **Max. Marks: 70**

Course Code: SBS PHY 01 104 CC 3104

Instructions:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) What do you understand by a semiconductor? Discuss some important properties of semiconductors.

b) Define density of states (DOS) and derive its expression for a 3-dimensional system

c) What is a ripple factor? What is its value for a half-wave and full-wave rectifier?

d) Why is LED not made of silicon or germanium?

e) For a single stage transistor amplifier, the collector load is $R_C = 2k\Omega$ and the input resistance $R_i = 1\ k\Omega$. If the current gain is 50, calculate the voltage gain of the amplifier.

f) Out of Emitter, Base and collector which portion of a transistor is heavily doped and why?

g) Drive an expression for the voltage gain of an inverting amplifier.

Q 2. (2X7=14)

a) In intrinsic GaAs, the electron and hole mobilities are 0.85 and 0.04 m^2/Vs, respectively and the corresponding effective masses are 0.068 m_0 and 0.5 m_0, respectively where m_0 is the rest mass of an electron. Given the energy band gap at 300 K as 1.43 eV, determine the intrinsic carrier concentration and conductivity.

b) Distinguish between direct and indirect band gap semiconductors with examples.

c) Explain and derive the expression for the variation in conductivity with change in temperature for an extrinsic semiconductor.

Q3. (2X7=14)

a) Derive an expression for the width of the depletion region for a p-n junction.

b) Sketch the flat band diagram in metal-semiconductor contact and explain it.

c) Discuss the difference between shunt and series clippers.

Q 4. (2X7=14)

a) Explain the construction and working of D-MOSFET.

b) A certain p-channel E-MOSFET has a V_{GS} [threshold] = – 2V. If V_{GS} = 0V, then find out the drain current.

c) How will you draw DC load line on the output characteristics of a transistor? What is its importance?

Q 5. (2X7=14)

a) What do you mean by slew rate and how does it affect the maximum operating frequency of an OP-amp?

b) There are three voltage sources V_1, V_2, V_3 and an average of these signals is required. Design a suitable circuit and explain it's operation.

c) Explain how an OP-amp can be used as a differentiator and integrator. Derive expressions for output voltages.