Central University of Haryana

End Semester Examinations April 2022

Programme: **M.Sc. Physics** **Session: 2021-22**

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

Course Title: **Mathematical Methods in Physics** **Max. Marks: 70**

Course Code: **SBS PHY 01 101 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.

Q1.

a) Find the eigen values of orthogonal matrix $B=\frac{1}{3}\begin{bmatrix}1 & 2 & 2\\ 2 & 1 & -2\\ 2 & -2 & 1\end{bmatrix}$. 3.5

b) Prove that $\frac{\partial g^{pq}}{\partial x^m} = -g^{pn}\left(\frac{q}{mn}\right) - g^{qn}\left(\frac{p}{mn}\right)$. 3.5

c) Find the residue of $f(z) = \frac{z^3}{(z-1)^4(z-2)(z-3)}$ at its poles & hence evaluate $\oint_c f(z)dz$, where c is the circle |z|=2.5. 3.5

d) If $a_{ij}\, x^i x^j = 0$ where a_{ij} are constant then show that $a_{ij}+a_{ji}=0$.
3.5

e) Find the Taylor's expanson of $f(z) = \frac{2z^3+1}{z^2+z}$ about the point z=1. 3.5

f) State and prove Jordan's lemma. 3.5

g) What are Christoffel's symbols of first and second kind. 3.5

Q2.

a) Find the eigenvalues and eigenvectors of 3x3 matrix $A=\begin{bmatrix}3 & 1 & 4\\ 0 & 2 & 6\\ 0 & 0 & 5\end{bmatrix}$. 7

b) Find the Laurent expansion for $f(z) = \frac{7z-2}{(z^3-z^2-2z)}$

in the region *(i)* $1<|z+1|<3$ *(ii)* $0<|z+1|<1$. 7

c) Explain following with example for each

(i) Isolated singularity (ii) Removable singularity
(iii) Poles (iv) Essential singularity 7

Q3.

a) Prove Ricci's theorem where g^{ij} & g_{ij} are zero. 7

b) If $(ds)^2 = r^2(d\theta)^2 + r^2 sin^2(\theta)(d\phi)^2$ then find value of christooffel symbol

(a) [22,1] (b) [2,12] 7

c) Define covariant $\bar{A}_i$ and contravariant $\bar{A}^i$ vectors (Tensors of rank 1). Show that $\frac{\partial\phi}{\partial x_i}$ is a cavariant vector where ϕ is a scalar function. 7

Q4.

a) Use Cauchy's integral formula to evaluate

$f(z) = \frac{sinz}{zcosz} \oint_C \frac{z}{(z^2-3z+2)} dz$ where c is the circle |z-2|=0.5. 7

b) Find the sum of residues of at its poles inside the circle |z|=2. 7

c) State and prove Liouville's theorem. 7

Q5.

a) Use fourth order R-K for $u(0,2)$ of initial value problem $u'=-2tu^2$; $u(0)=1$ using $h=0.2$. 7

b) Compute the value of $\int_{0.2}^{1.4} (sinx - logx + e^x)\, dx$ using Simpsons's 3/8 rule. 7

c) Fit a Poisson distribution the set of observations

x :	0	1	2	3	4
f :	122	60	15	2	1

(Given: $e^{-0.5} = 0.61$) 7

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

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

Semester: I | **Session: 2021-22**

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

Course Code: SBS PHY03 105 GEC 3104 | **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 $f = 3x^2y^3z$.

(b) Three particles with masses $m_1 = 1$ kg, $m_2 = 2$ kg, and $m_3 = 3$ kg forms an equilateral triangle of edge length $a = 140$ cm. Locate centre-of-mass of the system.

(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 angular acceleration of the particle is a constant.

(d) Two objects of masses 20kg and 40kg are separated by a distance of 10m. Find the gravitational force at the mid-point of the line joining two masses.

(e) Calculate angular frequency and time period corresponding to a spring mass system having frequency of oscillations 5 MHz.

(f) Define Young's modulus (Y) and modulus of rigidity (η).

(g) Find the length of a meter rod, if it is (i) at rest, (ii) moving with speed 0.5c.

(4 × 3.5 = 14)

Q2. (a) Consider $\vec{A} = 3\hat{i} - 4\hat{j}$ and $\vec{B} = -2\hat{i} + 3\hat{k}$. Find the vector $\vec{C} = \vec{A} \times \vec{B}$. Prove that $\vec{C}$ is perpendicular to both $\vec{A}$ and $\vec{B}$.

(b) A block of mass 2 kg is sliding on a plane surface inclined at angle 30° with respect to the earth's surface. Calculate acceleration of the block.

(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) Show that the angular 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.

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

(c) Discuss the variation of acceleration due to gravity with distance from the centre of earth. Show that near to the surface of earth, its value is nearly constant and is given by $9.8\ m/s^2$.

(2 × 7 = 14)

Q4. (a) Find the expression for displacement $x(t)$ in a spring mass system, where a mass m is attached to a spring having spring constant k. Also, derive the expression for the potential energy of the system.

(b) Show that for a spring-mass system total energy is constant if there is no friction in the system.

(c) Draw and explain stress-strain graph for Hook's Law.

$(2 \times 7 = 14)$

Q5. (a) Discuss how do you determine modulus of rigidity of a fine wire using Torsion pendulum.

(b) Explain why moving clocks run slow.

(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 particle with respect to frame S? What will be velocity of 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

End Semester Examinations April 2022

Programme: M.Sc. (Physics) **Session: 2021-22**

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

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

Course Code: SBS PHY 01 103 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 Attempt any four parts - (4 x 3.5 = 14)

(a) A system is present in the following angular momentum eigenstates |l, m > ;

$$|\psi> = \frac{1}{\sqrt{7}}|1,-1> +A\,|1,0> + \frac{\sqrt{2}}{\sqrt{7}}|1,1>,$$

Where, A is a real constant.

(i) Calculate A so that $|\psi>$ is a normalized wave function.

(ii) Calculate the expectation values pf $\widehat{L_x}, \widehat{L_y}, \widehat{L_z}$ *and* $\widehat{L^2}$ in the state $|\psi>$.

(b) A charge particle of mass 2/3rd of the mass of a neutron is confined in a cubical box of side 2.5 Fermi. Evaluate (i) the energy of the particle and (ii) the energy of the photon emitted when the particle jumps from the first excited state to the ground state.

(c) For a quantum particle of mass 'm' the energy eigen value and the corresponding eigen function in one dimensional potential V(x) are given as –

$$E = 0 \quad \text{and} \quad \psi(x) = \frac{A}{x^2+a^2}$$

Find the potential V (x) involved in the system.

(d) Show that the matrix

$$A = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$$

is a unitary matrix. Also find its eigen values and the corresponding normalized eigen vectors.

(e) Prove the following relations –

$$\text{(i) } [\widehat{L_z}, \cos\phi] = i\hbar \sin\phi \quad and \quad (ii)[\widehat{J_x}\widehat{J_y}, \widehat{J_z}] + [\widehat{J_x}, \widehat{J_y}\widehat{J_z}] = i\hbar\,(\widehat{J_x^2} - 2\widehat{J_y^2} + \widehat{J_z^2})$$

(f) In a given harmonic oscillator problem, the creation (a^+) and annihilation operator (a) obey the relation -

$$a^+ a = \frac{H}{\hbar\omega} - \frac{1}{2}$$

Find the ground state energy and wave function in this case.

(g) Show that the expectation value of an observable, whose operator does not depend upon time explicitly, is a constant with zero uncertainty.

[Given ; Consider wave function as $\psi_n(\boldsymbol{r},t) = \psi_n(\boldsymbol{r})\exp(-\frac{iE_n t}{\hbar})$]

Q. 2 Attempt any two parts - (2 x 7 = 14)

(a) For a particle with spin s = 3/2, the Hamiltonian is given by –

$$\widehat{H} = \frac{\varepsilon_0}{\hbar^2}\left(\widehat{S_x^2} - \widehat{S_y^2}\right) - \frac{\varepsilon_0}{\hbar}\widehat{S_z}$$

Where, ε_0 is a constant having the dimensions of energy. Find the energy eigen values and eigen states of the particle at any time 't' if the system was initially in the eigen state $|\psi> = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}$.

(b) Consider the following Pauli matrices –

$$\sigma_x = \begin{pmatrix}0 & 1\\1 & 0\end{pmatrix}, \quad \sigma_y = \begin{pmatrix}0 & -i\\i & 0\end{pmatrix} \quad and \quad \sigma_z = \begin{pmatrix}1 & 0\\0 & 1\end{pmatrix}$$

Show that

(i) $\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = I$ and (ii) $e^{i\theta\sigma_y} = I\cos\theta + i\sigma_y\sin\theta$, where I is the unit matrix.

(c) What are Clebsh – Gordan coefficients ? Evaluate their values for a two particle system, with j_1 = ½ and j_2 = ½ ?

[Given : $<j_1, j_2 -1|j_1 + j_2 -1, j_1 + j_2 -1> = [j_1/(j_1+j_2)]^{1/2}$ and $<j_1 -1, j_2|j_1 + j_2 -1, j_1 + j_2 -1> = -[j_2/(j_1+j_2)]^{1/2}$]

Q. 3 Attempt any two parts - (2 x 7 = 14)

(a) A quantum particle is confined to move in the 1-D short range potential

$$V(x) = -V_0\,\delta(x), \qquad \text{for } V_0 > 0$$

Where δ (x) is the Dirac delta function. Find the energy of the system.

(b) The wave function of a particle confined to an infinite deep square well potential of width 'a' at time t = 0 is given by :

$$\psi(x,0) = \frac{3}{\sqrt{20}}\phi_0(x) + \frac{5}{\sqrt{30}}\phi_1(x) + \frac{3}{\sqrt{6}}\phi_4(x)$$

Where $\phi_n(x)$ is the wave function of the nth excited state. Find (i) the average energy of the system and (ii) the state wave function and average value of energy of the system at a later time 't'.

(c) A particle of mass 'm' is confined in the potential V (x, y, z) = V_1 (x, y) + V_2 (z) where,

$$V_1(x,y) = \frac{1}{2}m\,\omega^2(x^2+y^2) \qquad \text{and} \qquad (z) = \begin{cases} 0, & 0 \le z \le a, \\ +\infty, & elsewhere \end{cases}$$

Calculate (i) the energy and the wave function of the particle and (ii) the degeneracy associated with the 2nd energy level.

Q.4 : Attempt any two parts - (2 x 7 = 14)

(a) For a quantum system the dimensionless harmonic oscillator Hamiltonian is given by –

$$\hat{H} = \frac{1}{2}\widehat{P^2} + \frac{1}{2}\widehat{X^2}, \quad with \quad \hat{P} = -i\frac{d}{dx}$$

(i) show that the wave functions - $\psi_0(x) = e^{-\frac{x^2}{2}}$ and $\psi_1(x) = xe^{-\frac{x^2}{2}}$ are eigen functions of $\hat{H}$ with eigen values ½ and 3/2 respectively.

(ii) find the value of α, for which the wave function $\psi_2(x) = (1+\alpha x^2)e^{-\frac{x^2}{2}}$ is orthogonal to $\psi_0(x)$.

(b) The state of a quantum system is expressed in terms of a complete and orthonormal set of three vectors –

$$|\psi> = \frac{1}{\sqrt{19}}|\phi_2> + \sqrt{\frac{3}{19}}|\phi_2> + \sqrt{\frac{7}{19}}|\phi_3>$$

Where, $|\phi_n>$ are eigen states of the system's Hamiltonian - $\hat{H}|\phi_n> n\,\epsilon_0|\phi_n>$ with n = 1, 2 , 3 and ϵ_0 as dimensions of energy. Find the average energy of the system.

(c) The wave function of a particle in a state is –

$$\psi(x) = N\exp(-\frac{x^2}{2\alpha})\; where\; N = \left(\frac{1}{\pi\alpha}\right)^{\frac{1}{4}}.$$

Find the product of the uncertainties in the position and momentum operators.

Q.5: Attempt any two parts - (2 x 7 = 14)

(a) Consider the states –

$$|\psi> = 9i|\phi_1> + 2|\phi_2> \quad \text{and} \quad |\chi> = -\frac{1}{\sqrt{2}}|\phi_1> + \frac{1}{\sqrt{2}}|\phi_2>,$$

where the two vectors ϕ_1 and ϕ_2 form a complete and orthonormal basis. Calculate –

(i) $|\psi><\chi|$ (ii) $|\chi><\psi|$ (iii) $|\psi><\psi|$ and (iv) $|\chi><\chi|$

(b) The eigen state of a quantum system is given in terms of orthonormal vectors $|\phi_1>$, $|\phi_2>$ and $|\phi_3>$ as –

$$|\psi> = \frac{1}{\sqrt{15}}|\phi_1> + \frac{1}{\sqrt{3}}|\phi_2> + \frac{1}{\sqrt{5}}|\phi_3>$$

Where $|\phi_n>$ are eigen states of an operator $\hat{B}$ such that - $\hat{B}\,|\phi_n> = (3n^2 - 1)\,|\phi_n>$

Find the expectation value of $\hat{B}$ and $\hat{B}^2$ for the state $|\psi>$.

(c) For the matrix $A = \begin{pmatrix} 0 & i \\ -i & 0 \end{pmatrix}$ find

(i) eigen values and normalized eigen vectors.

(ii) Also, if a matrix U is formed from the normalized eigen vectors of matrix A, then show that U is Unitary and it satisfies –

$$U^{+} A\, U = \begin{pmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{pmatrix}$$

Where λ_1 and λ_2 are eigen values of A.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

Programme: Integrated B.Sc. - M.Sc. **Session: 2021-22**

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

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

Course Code: SBS PHY 03 101 4004

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) Show that $x\delta(x) = 0$ where $\delta(x)$ is Dirac delta function.

b) Bring out the fallacy, if any, in the following statement: " The mean of binomial distribution is 5 and its standard deviation is 3".

c) Find the slope of circle $x^2 + y^2 = 25$ at the point (3, -4).

d) Determine $\lim\limits_{x\to 0} \frac{sinx}{x}$.

e) If $\theta = t^n e^{-\frac{r^2}{4t}}$, find what value of n will make $\frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial\theta}{\partial r}) = \frac{\partial\theta}{\partial t}$.

f) Prove that for every field $\vec{V}$, div curl $\vec{V} = 0$.

g) Find the area of the parallelogram determined by the vectors $\hat{i} + 2\hat{j} + 3\hat{k}$ and $3\hat{i} - 2\hat{j} + \hat{k}$.

Q 2. (2X7=14)

a) Discuss Dirac delta function with its definition and properties. Also, explain its representation as limit of a rectangular function. Given Dirac delta function $\delta(x) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} e^{i\omega x} d\omega$. Find $\delta(x^2 - a^2)$.

b) If $\vec{f}$ is a vector point function of orthogonal curvilinear coordinates, then determine divergence and curl of $\vec{f}$.

c) Express $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ in spherical polar coordinates.

Q3. (2X7=14)

a) Verify Stoke's theorem for the function $\vec{F} = x^2\hat{i} - xy\hat{j}$ integrated round the square in the plane z=0 and bounded by the lines x=0, y=0, x=a, y=a.

b) State and prove Green's theorem for a plane.

c) Evaluate $\iint_S \vec{A}.\hat{n}ds$ where $\vec{A} = (x+y^2)\hat{i} - 2x\hat{j} + 2yz\hat{k}$ and S is the surface of the plane 2x+y+2z = 6 in the first octant.

Q 4. (2X7=14)

a) Show that the vectors $5\vec{a} + 6\vec{b} + 7\vec{c}, 7\vec{a} - 8\vec{b} + 9\vec{c}$ and $3\vec{a} + 20\vec{b} + 5\vec{c}$ are coplanar, $\vec{a}, \vec{b}, \vec{c}$ being three non-collinear vectors. Also, find the $\vec{a} \times (\vec{b} \times \vec{c})$.

b) If $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$, show that (a) $\nabla r = \frac{\vec{r}}{r}$ (b) $\nabla(\frac{1}{r}) = -\frac{\vec{r}}{r^3}$.

c) If $\vec{a}$ and $\vec{b}$ be the two unit vectors and the α be the angle between them, then find the value of α such that $\vec{a} + \vec{b}$ is a unit vector.

Q 5. (2X7=14)

a) If $y_1 = e^{2x}$, $y_2 = e^{3x}$ and $y'' - 5y' + 6y = 0$, then (a) Find Wronskian determinant, (b) Verify that the solutions satisfy the differential equation, (c) Show by Wronskian test the solutions are independent.

b) Describe Bernoulli equation. Solve: $r sin\theta - \frac{dr}{d\theta} cos\theta = r^2$.

c) Solve (a.) $\frac{dy}{dx} = \frac{2x + 9y - 20}{6x + 2y - 10}$, and (b.) $(x + 2y)(dx - dy) = dx + dy$.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

Programme: M.Sc. Physics **Session: 2021-22**

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

Course Title: Physics of Digital Photography **Max. Marks: 70**

Course Code: SBS PHY 01 103 GEC 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 does ISO stand for? How is it useful in digital photography?

b) Write down two equivalent exposures for f4@1/125 sec for ISO200.

c) What is the importance of the mirror in a DSLR camera?

d) Give one advantage and one disadvantage of a pin-hole camera.

e) What is the difference between refraction and diffraction of light?

f) Which camera will give a better image? 10 Mega pixels or 15 Mega pixels? Why?

g) What is the purpose of the white balance setting in a DSLR camera?

Q 2. (2X7=14)

a) Draw a diagram and explain the difference between diffuse reflection and specular reflection of light.

b) What is aperture? How is it useful in photography?

c) Draw a diagram and explain the concept of "depth of field". How is it useful in photography?

Q3. (2X7=14)

a) What are the differences between the CCD and CMOS sensors?

b) Define "colour temperature" of a light source.

c) What do you mean by pixel0? How is it important in digital photography?

Q 4. (2X7=14)

a) What is Shutter Priority Mode? When and how to use Shutter Priority Mode?

b) Discuss the importance of light and colours in photography.

c) What is the importance of mirror in a DSLR camera?

Q 5. (2X7=14)

a) Draw suitable diagram and explain rule of thirds.

b) Discuss the importance of Negative and Positive space in photography.

c) Discuss various genres of photography.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

Programme: **M.Sc. Physics** **Session: 2021-22**

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) Discuss the effect of temperature on the conductivity of semiconductors.

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 = 2kΩ and the input resistance R_i = 1 kΩ. If the current gain is 50, calculate the voltage gain of the amplifier.

f) Why is base of a transistor made thin?

g) Drive an expression for the voltage gain of a noninverting 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 with suitable diagrams the conduction band, valence band and forbidden energy gap.

Q3. (2X7=14)

a) Derive an expression for built in potential 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 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. It is required to obtain the sum of these signals without the change in magnitude and sign. Design a suitable circuit and explain its operation.

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

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

Programme: M.Sc. Physics
Semester: First
Course Title: Classical Mechanics
Course Code: SBS PHY 01 102 CC 3104

Session: 2021-22
Max. Time: 3 Hours
Max. Marks: 70

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) For sclerenomous constraints, what would be the structure of kinetic energy in terms of generalized coordinates?

b) Hamiltonian is the generator of the system motion. How?

c) Enlist various advantages of Variational Principle formulation.

d) List differences between Lagrangian and Hamiltonian formulation.

e) Prove that the fundamental Poisson's brackets are invariant under Canonical Transformation.

f) How is stable equilibrium position of a system distinguished from unstable equilibrium position?

g) Show that the moment of Inertia depends on the direction of axis of rotation.

Q 2. (2X7=14)

a) For a curve joining two points along which a particle falling from rest under the influence of gravity travels from higher to the lower point in the least time,

b) A bead slides without friction on a frictionless wire in a shape of cycloid with equations $x = a(\theta - \sin\theta)$; $y = a(1+\cos\theta)$ where $0 \leq \theta \leq 2\pi$. Find Lagrangian and hence equation of motion.

c) A particle of mass m is falling under the potential $V = -mgz$ (z= height) and describing the path (a) $z= gt^2/2$, (b) $z = ct$. Calculate the action for the paths and show that the minimum occurs for the path (a). The constant c in (b) is determined from the condition that the end points for path agree at $t = t_1$.

Q 3. (2X7=14)

a) For the Lagrangian $L = \frac{1}{2Z}\dot{q}^2 - \frac{1}{2}\left(X - \frac{Y^2}{Z}\right)q^2 - \frac{Y}{Z}q\dot{q}$ where X,Y,Z are time dependent, find the conjugate momentum and the Hamiltonian.

b) Identification of H as a constant of motion and as the total energy are two separate matters. The conditions sufficient for the one are not enough for the other. Explain the statement with an example of point mass m attached to a spring the other end of which is fixed on massless cart which is moved by external device with speed v_0.

c) Describe Routh's procedure and give its importance.

Q 4. (2X7=14)

a) What are generating functions Write their significance. Show that the transformation $Q = log\frac{\sin p}{q}$, $P = q\cot p$ is canonical and obtain the generating function.

b) What are action variables? Explain the adiabatic invariance of action variable.

c) Give physical significance of Hamilton's principal function and also show that it is the generator of Canonical Transformation to constant coordinate and momenta.

Q 5. (2X7=14)

a) Derive longitudinal normal modes of a linear symmetric triatomic molecule.

b) Explain the equivalent 1 D problem and classify the resultant orbits for a inverse square law force.

c) What are normal coordinates? Find the eigen frequencies and normal coordinates of a vibrating system characterized by a Lagrangian of three degrees of freedom, namely $L = \frac{1}{2}(\dot{\eta}_1^2 + \dot{\eta}_2^2 + \dot{\eta}_3^2) - \alpha^2(\eta_1^2 + \eta_2^2 + \eta_3^3 - \eta_1\eta_3)$.

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CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations April 2022

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

Semester: I | **Session: 2021-22**

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

Course Code: SBS PHY03 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) A block of mass 1 kg is sliding on a plane surface inclined at angle 60° with respect to the earth's surface. Calculate acceleration of the block.

(g) A block whose mass m is 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 frictionless 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) Discuss stable and unstable equilibrium by taking a typical potential energy curve in gravitational field. Also discuss, how force can be determined by this curve.

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

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

$(2 \times 7 = 14)$

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

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

(c) Show that the angular 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.

$(2 \times 7 = 14)$

Q4. (a) Find the expression for displacement $x(t)$ in a spring mass system, when the mass m is performing under-damping oscillations.

(b) State Kepler's laws of planetary orbits. Derive these laws from Newton's law of gravitation for a planet moving in a circular path.

(c) 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.

$(2 \times 7 = 14)$

Q5. (a) Derive the expression of velocity and acceleration in a rotating coordinate System and identify various fictitious forces in the rotating frame.

(b) Explain the phenomenon of time dilation.

(c) Stellar system Q1 moves away from us at a speed of 0.800c. Stellar system Q2, which lies in the same direction in space but is closer to us, moves away from us at speed 0.400c. What multiple of c gives the speed of Q2 as measured by an observer in the reference frame of Q1?

$(2 \times 7 = 14)$