

09/01/25
[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1365

I

Unique Paper Code : 2222011101

Name of the Paper : Mathematical Physics – I

Name of the Course : B.Sc. (Hons) Physics

Semester : I

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all including.
3. Q. No. 1 which is compulsory.
4. **All** questions carry equal marks.

1. (a) Determine the linear dependence (or independence) of set of the functions

$$-1, \sin^2 x, \cos^2 x$$

P.T.O.

(b) Solve the differential equation :

$$\left[y \left(1 + \frac{1}{x} \right) + \cos y \right] dx + [x + \log x - x \sin y] dy = 0$$

(c) Using index notation, verify that

$$\vec{a} \cdot (\vec{b} \times \vec{c}) = \vec{c} \cdot (\vec{a} \times \vec{b}) = \vec{b} \cdot (\vec{c} \times \vec{a})$$

(d) A certain student population, consisting of 70% from the government schools, selects 15 representatives to attend an international student meet. Find the mean representation of the students from government schools in the sample and calculate its standard deviation.

(e) Evaluate $\iint \vec{r} \cdot \hat{n} dS$, where S is a closed surface.

(f) Find the unit vector normal to the surface

$$x^2 + y^2 + z^2 = 4 \text{ at the point } (1, \sqrt{2}, -1).$$

(3×6=18)

2. (a) Solve : $\frac{dy}{dx} - y \tan x = -y^2 \sec x$. (6)

(b) Solve the differential equation $\frac{d^2y}{dx^2} + \frac{g}{l}x = \frac{g}{l}L$

where g , l and L are constants subject to the conditions $x = a$, $\frac{dx}{dt} = 0$ at $t = 0$. (6)

(c) Evaluate $\vec{\nabla} \cdot \left[r \vec{\nabla} \left(\frac{1}{r^3} \right) \right]$ where $r = \sqrt{x^2 + y^2 + z^2}$. (6)

3. (a) Solve by the method of Undetermined coefficient

$$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + 2y = e^x + x. \quad (10)$$

(b) Verify $\vec{\nabla} \times \vec{B} = \vec{\nabla}(\vec{\nabla} \cdot \vec{A}) - \vec{\nabla}^2 \vec{A}$

where the vector $\vec{B}$ is defined as $\vec{B} = \vec{\nabla} \times \vec{A}$. (8)

4. (a) Solve the given differential equation using Variation of Parameters

$$\frac{d^2y}{dx^2} + y = x - \cot x \quad (8)$$

(b) Verify that a scalar product of vectors $\vec{A}$ and $\vec{B}$ is invariant under rotation. (6)

- (c) Using Green' theorem, show that the area enclosed by the curve C is

$$\frac{1}{2} \int_C (x dy - y dx) \quad (4)$$

5. (a) Obtain the expression for the mean and variance of the poisson distribution. (8)

- (b) Verify Stokes' theorem for the vector field (10)

$\vec{F} = y^2 \hat{i} - (x+z) \hat{j} + yz \hat{k}$ over the unit square bounded by $0 \leq x \leq 1, 0 \leq y \leq 1, 0 \leq z \leq 1$.

6. (a) Show that the vector field

$$\vec{F} = 2x(y^2 + z^3) \hat{i} - 2x^2 y \hat{j} + 3x^2 z^2 \hat{k}$$

is conservative. Find the corresponding scalar potential and compute the work done in moving the particle from $(-1, 2, 1)$ to $(2, 3, 4)$. (8)

- (b) Find Talyor expansion of $f(x) = \ln(1 + v)$ near $x = 0$ and approximate $f(x = -0.1)$ by taking first four terms of the series. (4)

- (c) Solve : $x^2 \frac{d^2 y}{dx^2} + 4x \frac{dy}{dx} + 2y = e^x$. (6)

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Your Roll No.....

Sr. No. of Question Paper : 1384

I

Unique Paper Code

: 222211102

(2222011102)

Name of the Paper

: Mechanics

Name of the Course

: B.Sc. Hons. – (Physics)_NEP: UGCF-2022

Semester

: I

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **five** questions in all. Question no **one** is compulsory.

1. Attempt any **six** from the following :

(a) Three freight trucks of mass m each are pulled with force F by a locomotive in horizontal direction towards right. Considering the friction is negligible. Find the forces on each car and the direction of force. (3)

(b) Define moment of Inertia of a body rotating about an axis and explain its physical significance.

(c) Find the work done in moving a particle in the force field

$$\vec{F} = 3x^2\hat{i} + (2xz - y)\hat{j} + z\hat{k} \text{ along the straight line from } (0,0,0) \text{ to } (2,1,3).$$

(d) What would be the effective weight of an astronaut normally weighing 70 kg when his rocket moves vertically upward with 5 g acceleration?

P.T.O.

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- (e) A block of mass M slides along a horizontal table with speed V_0 . At $x = 0$ it hits a spring with spring constant k and begins to experience a friction force (see figure 1 given below). The coefficient of friction is variable and is given by $\mu = bx$, where b is a constant. Find the loss in mechanical energy when the block has first come momentarily to rest.

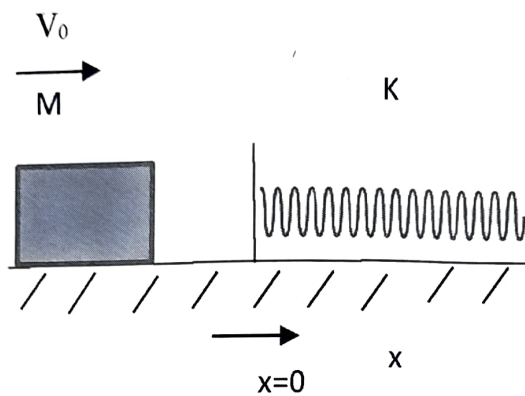


Figure 1

- (f) A uniform sphere of mass M and radius R and a uniform cylinder of mass M and radius R , are released simultaneously from rest at the top of an inclined plane. Which body reaches the bottom first if they both roll without slipping?
- (g) An observer sees two spaceships flying apart with speed $0.99c$. What is the speed of one spaceship as viewed by the other?
2. (a) Does the Center of mass of a solid body necessarily lie within the body? Give example. (2)
- (b) A bomb-shell is thrown obliquely in air. It explodes during its flight & fragments fly off in various directions. Show that the Center of mass of the fragments continues to move along the same path which the unexploded shell would have followed. Neglect the air resistance. (6)

- (c) A rocket starts from rest with an initial mass ' M_0 ' & reaches a final velocity ' V_f ' at burn out when its mass is ' M_f '. Show that $\frac{M_f}{M_0} = e^{-\left(\frac{V_f}{u}\right)}$, Where u = exhaust velocity. (10)

3. (a) What are the fictitious forces? Give examples. (3)

- (b) What is the importance of a potential energy curve? Define turning point and points of equilibrium on potential energy curve of a particle. (3)

- (c) State the Kepler's first and second law of planetary motion. Derive the expression for the velocity of a satellite in circular orbit around the earth. (12)

4. (a) The acceleration due to gravity measured in an earthbound coordinate system is denoted by g . However, because of the earth's rotation, g differs from the true acceleration due to gravity g_0 . Assuming that the earth is perfectly round, with radius R , and angular velocity Ω , find g as a function of latitude λ . (10)

- (b) A constant torque $4\hat{i} + 4\hat{j} + 6\hat{k}$ Nm acts on a particle. At time $t = 0$, the angular momentum of the particle is $2\hat{i} + 7\hat{j} + 8\hat{k}$ kg m²/s, find its angular momentum after 6 seconds. (6)

- (c) Find the moment of inertia of a uniform cube of side a about an axis passing through its center and parallel to one of the faces. (2)

5. (a) Mass m_1 slides along a frictionless table and suffers a one-dimensional elastic collision with a stationary mass $m_2 = 3m_1$. If the speed of the center of mass of the system is 3 m/s before collision, what are the speeds of the center of mass and mass m_2 after collision? (7)

- (b) The position vector of a moving particle at any time t is given by $\mathbf{R} = a \cos(\omega t) \hat{i} + b \sin(\omega t) \hat{j}$; where a and b are constant. Show that the force acting on the particle is conservative. (3)
- (c) What do you understand by the concept of angular momentum of a system of n -number of particles? How its angular momentum varies in the absence of any external torque? (8)
6. (a) Calculate the length and orientation of a meter rod in a frame of reference which is moving with velocity equal to $0.6c$, in a direction making an angle of 30° with the rod. Taking velocity of light as c . (5)
- (b) Explain why particle cannot move faster than light. (3)
- (c) Obtain Einstein formula for addition of velocities. If the kinetic energy of a particle is 3 times its rest mass energy, then what will be its resultant velocity? (10)

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Your Roll No.....

Sr. No. of Question Paper : 1403

I

Unique Paper Code

: 222211103

(2222011103)

Name of the Paper

: Waves and Oscillation

Name of the Course

: B.Sc. Hons. -(Physics)_NEP:
UGCF-2022

Semester

: I

Duration : 2 Hours

Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all.
3. Question No. 1 is compulsory.

1. Attempt any **five** questions.

(a) The displacement y of a particle executing periodic motion is given by,

P.T.O.

$$y = 4 \cos^2 \left(\frac{1}{2} t \right) \sin(1000 t)$$

Show that this expression may be a result of the superposition of three independent harmonic motions.

- (b) Explain the conditions for obtaining a straight line as a Lissajous figure on an oscilloscope.
- (c) A particle of mass 3 moves along the axis attracted toward origin by a force whose magnitude is numerically equal to $12x$. The particle is also subjected to a damping force whose magnitude is numerically equal to 12 times the instantaneous speed. If it is initially at rest at $x = 10$, find the position and the velocity of the particle at any time.
- (d) Explain qualitatively the normal coordinates and normal modes of a coupled oscillatory system.
- (e) Distinguish between stationary and progressive waves.
- (f) Find the quality factor Q for the damped oscillations of an object with a frequency of 1 Hz, and whose amplitude of vibration gets halved in 5 s.

$$(3 \times 5 = 15)$$

2. (a) A uniform spring of spring constant K and a finite mass ' m_s ' is loaded with a mass ' M '. If ' m_s ' is not negligible compared to ' M ', show that the period of oscillations of mass spring system is,

$$T = 2\pi \sqrt{\frac{M + \frac{m_s}{3}}{K}}.$$

- (b) Two vibrations at right angles to each other are described by the equations $x = 10 \cos(5\pi t)$, $y = 10 \cos(10\pi t - \pi/4)$. Draw graphically the Lissajous figure of the resulting motion. (10,5)

3. (a) Two collinear simple harmonic motions of nearly equal frequencies and different amplitude are superimposed on each other. Find out resultant equation and explain the formation of beats.

- (b) An alternating emf of peak-to-peak value 40 volts is applied across the series combination of an inductor of inductance 100 mH, capacitor of capacitance 1pF and resistance 100 Ω . Determine resonance frequency, quality factor and bandwidth.

(10,5)

4. (a) Show that for a forced and damped harmonic oscillator in steady state, the average power is equal to the average power dissipated by system.

- (b) Two identical masses of mass ' M ' are connected with three identical springs of same spring constant ' K ' and placed on a smooth surface as shown in Fig. 1. Find out the normal mode frequencies and corresponding configuration/shapes. (10,5)

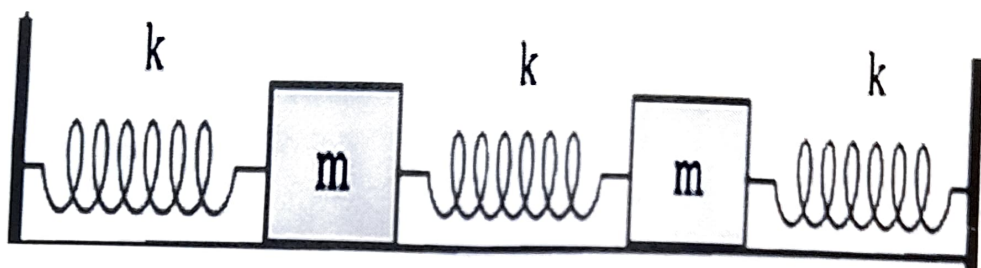


Fig. 1

5. (a) Find the expression for the normal mode of vibration and displacement for a string fixed at both the ends having tension T and mass per unit length μ .
- (b) A string of length $l = 0.5$ m and mass per unit length 0.01 kg/m has a fundamental frequency of 250 Hz. What is the tension in the string? (10,5)