PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Oscillations - CSIR NET Physics PYQs

Classical Mechanics . All PYQs (2015-2025) with answer key

23 questions . Answer key included

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Q1. [Dec 2015] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2015 Dec	3.5 M

The Lagrangian of a system is given by

$$L = \frac{1}{2}m\dot{q}_1^2 + 2m\dot{q}_2^2 - k\left(\frac{5}{4}q_1^2 + 2q_2^2 - 2q_1q_2\right)$$

where m and k are positive constants. The frequencies of its normal modes are

1. $\sqrt{\frac{k}{2m}}, \sqrt{\frac{3k}{m}}$
2. $\sqrt{\frac{k}{2m}}\left(13 \pm \sqrt{73}\right)$
3. $\sqrt{\frac{5k}{2m}}, \sqrt{\frac{k}{m}}$
4. $\sqrt{\frac{k}{2m}}, \sqrt{\frac{6k}{m}}$

Q2. [Dec 2015] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2015 Dec	5 M

For a dynamical system governed by the equation

$\frac{dx}{dt} = 2\sqrt{1 - x^2}$, with $|x| \leq 1$

1. $x = -1$ and $x = 1$ are both unstable fixed points
2. $x = -1$ and $x = 1$ are both stable fixed points
3. $x = -1$ is an unstable fixed point and $x = 1$ is a stable fixed points
4. $x = -1$ is a stable fixed point and $x = 1$ is a unstable fixed points

Q3. [June 2015] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2015 June	3.5 M

A particle of mass m moves in the one-dimensional potential $V(x) = \frac{\alpha}{3}x^3 + \frac{\beta}{4}x^4$ where $\alpha, \beta > 0$. One of the equilibrium points is $x = 0$. The angular frequency of small oscillations about the other equilibrium point is

1. $\frac{2\alpha}{\sqrt{3m\beta}}$
2. $\frac{\alpha}{\sqrt{m\beta}}$
3. $\frac{\alpha}{\sqrt{12m\beta}}$
4. $\frac{\alpha}{\sqrt{24m\beta}}$

Q4. [Dec 2016] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2016 Dec	3.5M

The parabolic coordinates (ξ, η) are related to the Cartesian coordinates (x, y) by $x = \xi\eta$ and $y = \frac{1}{2}(\xi^2 - \eta^2)$. The Lagrangian of a two-dimensional simple harmonic oscillator of mass m and angular frequency ω is

1. $\frac{1}{2}m\left[\dot{\xi}^2 + \dot{\eta}^2 - \omega^2(\xi^2 + \eta^2)\right]$
2. $\frac{1}{2}m(\xi^2 + \eta^2)\left[(\dot{\xi}^2 + \dot{\eta}^2) - \frac{1}{4}\omega^2(\xi^2 + \eta^2)\right]$
3. $\frac{1}{2}m(\xi^2 + \eta^2)\left(\dot{\xi}^2 + \dot{\eta}^2 - \frac{1}{2}\omega^2\xi\eta\right)$
4. $\frac{1}{2}m(\xi^2 + \eta^2)\left(\dot{\xi}^2 + \dot{\eta}^2 - \frac{1}{4}\omega^2\right)$

Q5. [Dec 2017] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2017 Dec	3.5M

A monoatomic gas 'of volume V is in equilibrium in a uniform vertical cylinder, the lower end of which is closed by a rigid wall and the other by a frictionless piston. The piston is pressed lightly and released. Assume that the gas is a poor conductor of heat and the cylinder and piston are perfectly insulating. If the cross-sectional area of the cylinder is A, the angular frequency of small oscillations of the piston about the point of equilibrium, is

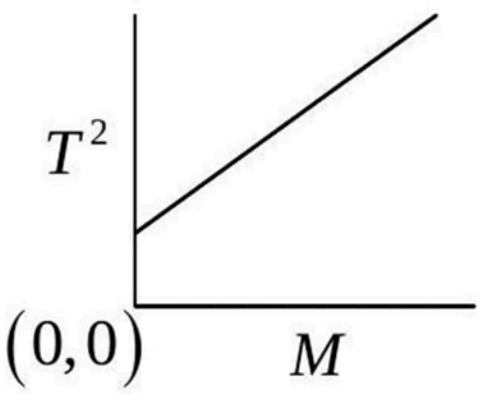
1. $\sqrt{5gA/(3V)}$
2. $\sqrt{4gA/(3V)}$
3. $\frac{5}{3}\sqrt{gA/V}$
4. $\sqrt{7gA/(5V)}$

Q6. [Dec 2017] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2017 Dec	3.5M

The spring constant k of a spring of mass m_s, is determined experimentally by loading the spring with mass M and recording the time period T, for a single oscillation. If the experiment is carried out for different masses, then the graph that correctly represents the result is

1.


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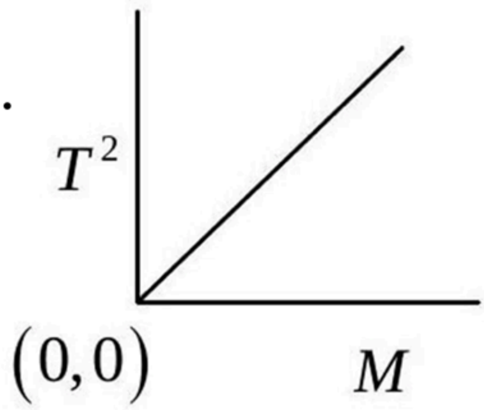

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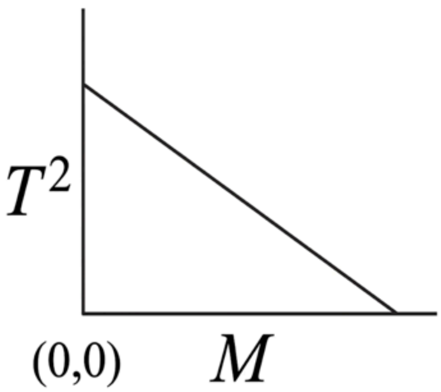

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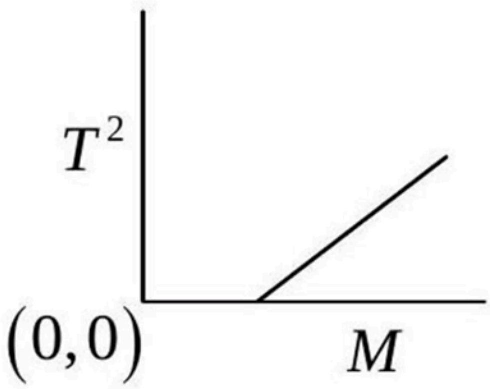


Q7. [June 2017] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2017 June	3.5M

A solid vertical rod, of length L and cross-sectional area A, is made of a material of Young's modulus Y. The rod is loaded with a mass M, and, as a result, extends by a small amount ΔL in the equilibrium condition. The mass is then suddenly reduced to $M/2$. As a result, the rod will undergo longitudinal oscillation with an angular frequency

1. $\sqrt{2YA/ML}$
2. $\sqrt{YA/ML}$
3. $\sqrt{2YA/M\Delta L}$
4. $\sqrt{YA/M\Delta L}$

Q8. [Dec 2018] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2018 Dec	3.5M

The time period of a particle of mass m, undergoing small oscillations around $x = 0$, in the potential $V = V_0 \cosh\left(\frac{x}{L}\right)$, is

1. $\pi\sqrt{\frac{mL^2}{V_0}}$

2. $2\pi\sqrt{\frac{mL^2}{2V_0}}$

3. $2\pi\sqrt{\frac{mL^2}{V_0}}$

4. $2\pi\sqrt{\frac{2mL^2}{V_0}}$

Q9. [June 2018] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2018 June	3.5M

A particle moves in the one-dimensional potential $V(x) = \alpha x^6$, where $a > 0$ is a constant. If the total energy of the particle is E, its time period in a periodic motion is proportional to

1. $E^{-1/3}$
2. $E^{-1/2}$
3. $E^{1/3}$
4. $E^{1/2}$

Q10. [June 2018] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2018 June	3.5M

A particle of mass m, kept in potential $V(x) = -\frac{1}{2}kx^2 + \frac{1}{4}\lambda x^4$ (where k and λ are positive constants), undergoes small oscillations about an equilibrium point. The frequency of oscillations is

1. $\frac{1}{2\pi}\sqrt{\frac{2\lambda}{m}}$

2. $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

3. $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$

4. $\frac{1}{2\pi}\sqrt{\frac{\lambda}{m}}$

Q11. [June 2019] . 3.5 marks
Classical Mechanics > Oscillations

CSIR NET	2019 June	3.5M

A particle of mass m moves in One dimension in the potential $V(x) = kx^4, (k > 0)$. at time $t = 0$ the particle starts from rest at $x = A$. For bounded motion, the time period of its motion is

1. proportional to $A^{-1/2}$
2. proportional to A^{-1}
3. independent of A
4. not well-defined (the system is chaotic)

Q12. [June 2019] . 5.0 marks
Classical Mechanics > Oscillations

CSIR NET	2019 June	5M

The equation of motion of a forced simple harmonic oscillator is $\ddot{x} + \omega^2 x = A\cos\Omega t$, where A is a constant. At resonance $\Omega = \omega$ the amplitude of oscillations at large times

1. saturates to a finite value
2. increases with time as $\sqrt{t}$
3. increases linearly with time
4. increases exponentially with time

Q13. [June 2020] . 3.5 marks
Classical Mechanics > Oscillations

CSIR NET	2020 June	3.5M

Two coupled oscillators in a potential $V(x,y) = \frac{1}{2}kx^2 + 2xy + \frac{1}{2}ky^2$ $(k > 2)$ can be decoupled into two independent harmonic oscillators (coordinates: x', y') by means of an appropriate transformation $\begin{pmatrix} x' \\ y' \end{pmatrix} = S \begin{pmatrix} x \\ y \end{pmatrix}$. The transformation matrix S is

1. $\begin{pmatrix} \frac{1}{\sqrt{2}} & 1 \\ 1 & -\frac{1}{\sqrt{2}} \end{pmatrix}$

2. $\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$

3. $\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$

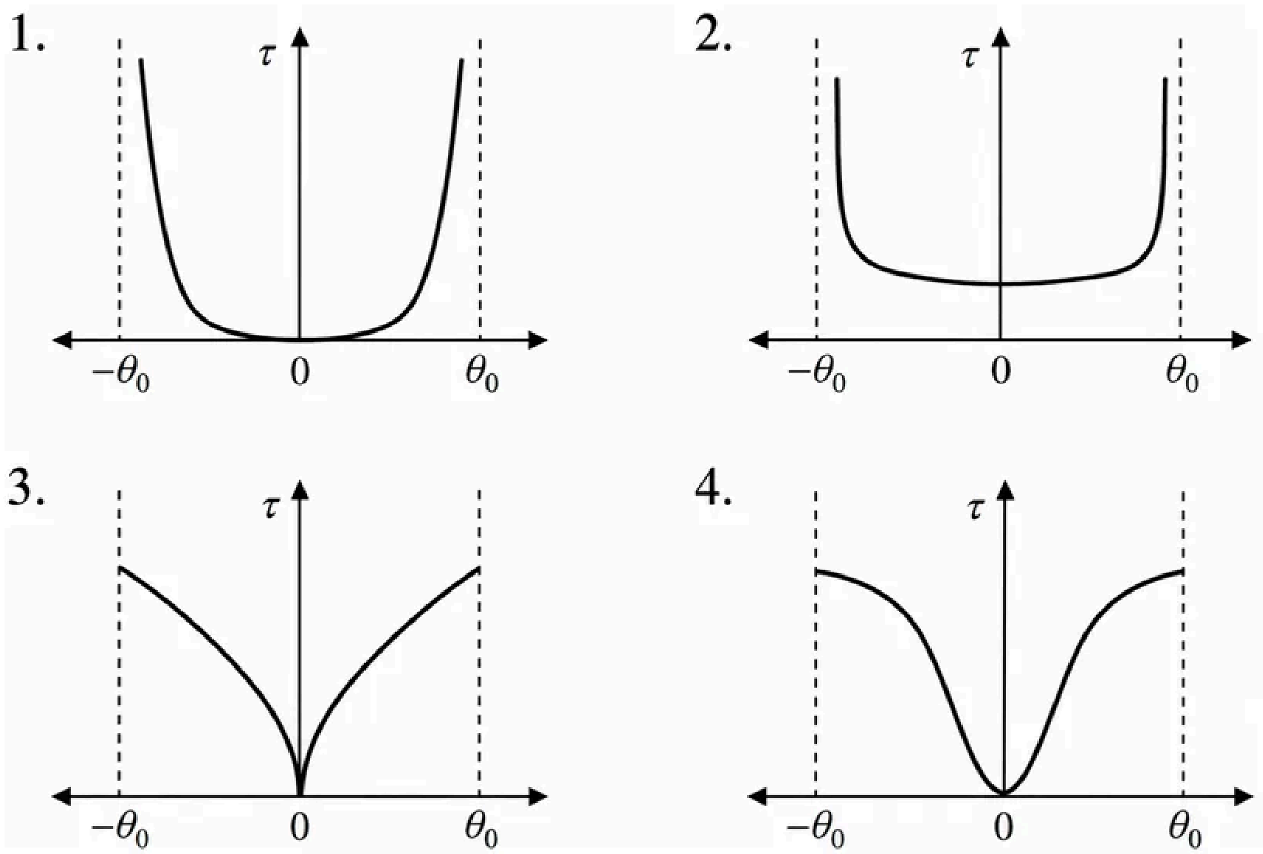
4. $\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$

Q14. [June 2020] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2020 June	5M

A pendulum executes small oscillations between angles $+\theta_0$ and $-\theta_0$. If $\tau(\theta)d\theta$ is the time spent between θ and $\theta + d\theta$, then $\tau(\theta)$ is best represented by



Q15. [June 2021] . 3.5 marks
Classical Mechanics > Oscillations

CSIR NET	2021 June	3.5M

A particle in one dimension executes oscillatory motion in a potential $V(x) = A|x|$, where $A > 0$ is a constant of appropriate dimension. If the time period T of its oscillation depends on the total energy E as E^a, then the value of a is

1. $1/3$
2. $1/2$
3. $2/3$
4. $3/4$

Q16. [June 2021] . 5.0 marks
Classical Mechanics > Oscillations

CSIR NET	2021 June	5M

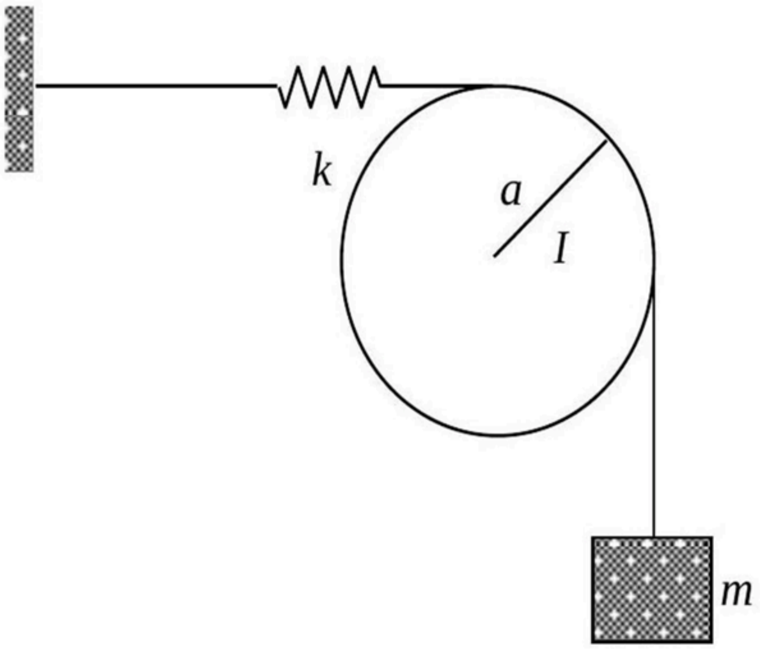
A particle of mass m moves in a potential that is $V = \frac{1}{2}m(\omega_1^2 x^2 + \omega_2^2 y^2 + \omega_3^2 z^2)$ in the coordinates of a non-inertial frame F. The frame F is rotating with respect to an inertial frame with an angular velocity $\hat{k}\Omega$, where $\hat{k}$ it is the unit vector along their common z-axis. The motion of the particle is unstable for all angular frequencies satisfying

1. $(\Omega^2 - \omega_1^2)(\Omega^2 - \omega_2^2) > 0$
2. $(\Omega^2 - \omega_1^2)(\Omega^2 - \omega_2^2) < 0$
3. $(\Omega^2 - (\omega_1 + \omega_2)^2)(\Omega^2 - |\omega_1 - \omega_2|^2) > 0$
4. $(\Omega^2 - (\omega_1 + \omega_2)^2)(\Omega^2 - |\omega_1 - \omega_2|^2) < 0$

Q17. [June 2022] . 3.5 marks
Classical Mechanics > Oscillations

CSIR NET	2022 June	3.5M

A wire, connected to a massless spring of spring constant k and a block of mass m, goes around a disc of radius a and moment of inertia I, as shown in the figure. Assume that the spring remains horizontal, the pulley rotates freely and there is no slippage between the wire and the pulley. The angular frequency of small oscillations of the disc is



1. $\sqrt{\frac{2ka^2}{ma^2+I}}$
2. $\sqrt{\frac{ka^2}{ma^2+I}}$
3. $\sqrt{\frac{ka^2}{ma^2+2I}}$
4. $\sqrt{\frac{ka^2}{2ma^2+I}}$

Q18. [June 2022] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2022 June	5M

The Lagrangian of system of two particles is

$$L = \frac{1}{2}\dot{x}_1^2 + 2\dot{x}_2^2 - \frac{1}{2}(x_1^2 + x_2^2 + x_1 x_2).$$

The normal frequencies are best approximated by

1. 1.2 and 0.7
2. 1.5 and 0.5
3. 1.7 and 0.5
4. 1.0 and 0.4

Q19. [Dec 2023] . 3.5 marks
Classical Mechanics > Oscillations

CSIR NET	2023 Dec	3.5 M

A particle of unit mass subjected to the 1-dimensional potential

$$V(x) = \frac{2\alpha}{x^3} - \frac{3\beta}{x^2}$$

executes small oscillations about its equilibrium position, where α and β are positive constants with appropriate dimensions. The time period of small oscillations is

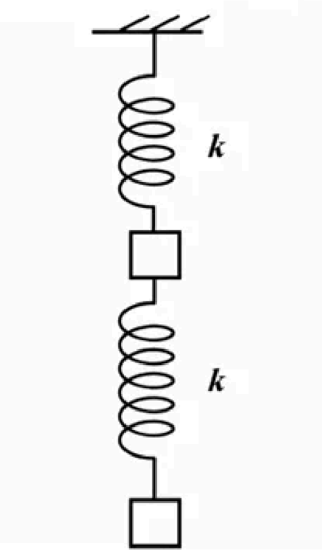
1. $\frac{\pi\alpha^2}{\sqrt{6\beta^5}}$
2. $\frac{\pi\alpha^2}{\sqrt{3\beta^5}}$
3. $\frac{2\pi\alpha^2}{\sqrt{3\beta^5}}$
4. $\frac{2\pi\alpha^2}{\sqrt{6\beta^5}}$

Q20. [June 2023] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2023 June	5M

A system of two identical masses connected by identical springs, as shown in the figure, oscillates along the vertical direction. The ratio of the frequencies of the normal modes is



1. $\sqrt{3-\sqrt{5}} : \sqrt{3+\sqrt{5}}$
2. $3-\sqrt{5} : 3+\sqrt{5}$
3. $\sqrt{5-\sqrt{3}} : \sqrt{5+\sqrt{3}}$
4. $5-\sqrt{3} : 5+\sqrt{3}$

Q21. [June 2024] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2024 June	5M

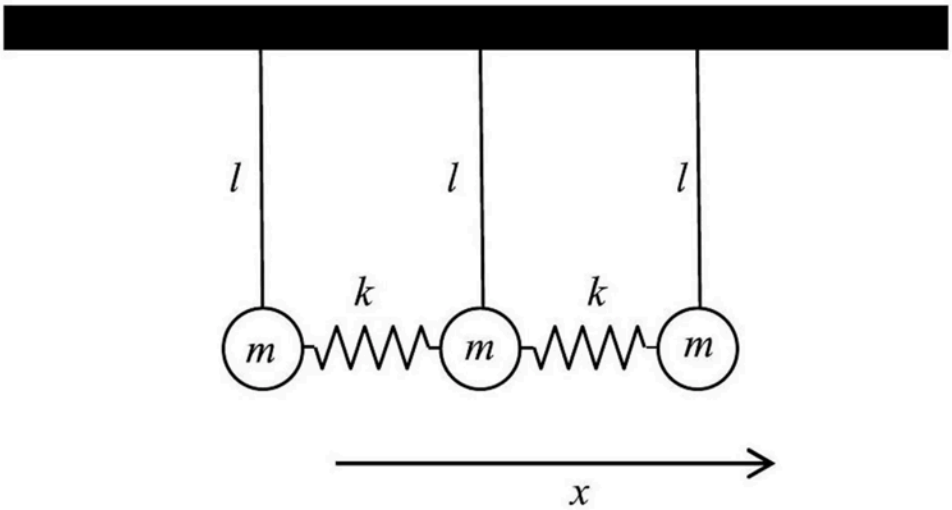
A linear molecule is modelled as two atoms of equal mass m placed at coordinates x_1 and x_2, connected by a spring of spring constant k. The molecule is moving in one dimension under an additional external potential $V(x_1, x_2) = \frac{1}{2}m\omega_0^2(x_1^2 + x_2^2)$. If one frequency of molecular vibration is ω_0, the other frequency is

1. $\sqrt{\omega_0^2 - \frac{k}{m}}$
2. $\sqrt{\omega_0^2 + \frac{k}{m}}$
3. $\sqrt{\omega_0^2 + \frac{2k}{m}}$
4. $\sqrt{\omega_0^2 - \frac{2k}{m}}$

Q22. [June 2024] . 5.0 marks
Classical Mechanics > Oscillations

CSIR NET	2024 June	5M

Three identical simple pendula (of mass m and equilibrium string length l) are attached together by springs of spring constant k, as shown in the figure.



The frequencies of small oscillations are given by $\sqrt{\frac{g}{l}}, \sqrt{\frac{k}{m}+\frac{g}{l}}, \sqrt{\frac{3k}{m}+\frac{g}{l}}$. The normal modes (without normalisation) corresponding to these frequencies respectively are

1. $(1,1,1), (1,0,1), (1,-2,1)$
2. $(1,1,1), (1,0,-1), (1,2,1)$
3. $(1,1,1), (1,0,-1), (1,-2,1)$
4. $(1,2,1), (1,0,-1), (1,1,1)$

Q23. [Dec 2025] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2025 Dec	5M	CM

The Lagrangian of a two-particle system is given by

$$L = \frac{1}{2}m(\dot{q}_1^2 + \dot{q}_2^2 + \dot{q}_1\dot{q}_2) - \frac{1}{2}m\omega^2\left(q_1^2 + q_2^2 + \frac{1}{2}q_1q_2\right).$$

The normal mode frequencies (in units of ω) are

1. $\sqrt{\frac{5}{3}}, \frac{1}{2}$
2. $\sqrt{\frac{5}{6}}, \sqrt{\frac{3}{2}}$
3. $\sqrt{\frac{6}{5}}, \sqrt{2}$
4. $\sqrt{\frac{5}{6}}, \sqrt{2}$

Answer Key

23 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Classical Mechanics	Oscillations	**1**
Q2	Classical Mechanics	Oscillations	**3**
Q3	Classical Mechanics	Oscillations	**2**
Q4	Classical Mechanics	Oscillations	**2**
Q5	Classical Mechanics	Oscillations	**1**
Q6	Classical Mechanics	Oscillations	**1**
Q7	Classical Mechanics	Oscillations	**1**
Q8	Classical Mechanics	Oscillations	**3**
Q9	Classical Mechanics	Oscillations	**1**
Q10	Classical Mechanics	Oscillations	**3**
Q11	Classical Mechanics	Oscillations	**2**
Q12	Classical Mechanics	Oscillations	**3**
Q13	Classical Mechanics	Oscillations	**2**
Q14	Classical Mechanics	Oscillations	**2**
Q15	Classical Mechanics	Oscillations	**2**
Q16	Classical Mechanics	Oscillations	**2**
Q17	Classical Mechanics	Oscillations	**2**
Q18	Classical Mechanics	Oscillations	**4**
Q19	Classical Mechanics	Oscillations	**4**
Q20	Classical Mechanics	Oscillations	**1**
Q21	Classical Mechanics	Oscillations	**3**
Q22	Classical Mechanics	Oscillations	**3**
Q23	Classical Mechanics	Oscillations	**2**

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