PART 1 - PHYSICS

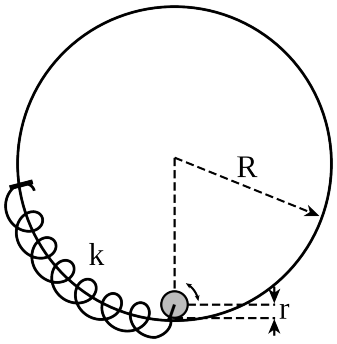
Topic : Oscillations, System of particles and rotational motion

SECTION–1 : (Maximum Marks : 12)

- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks	: +3	If ONLY the correct option is chosen;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

1. The center of a disk of radius r and mass m is attached to a spring of spring constant k, inside a ring of radius R > r as shown in the figure. The other end of the spring is attached on the periphery of the ring. Both the ring and the disk are in the same vertical plane. The disk can only roll along the inside periphery of the ring, without slipping. The spring can only be stretched or compressed along the periphery of the ring, following the Hooke's law. In equilibrium, the disk is at the bottom of the ring. Assuming small displacement of the disc, the time period of oscillation of center of mass of the disk is written as $T = \frac{2\pi}{\omega}$. The correct expression for ω is (g is the acceleration due to gravity): [JEE Advanced 2025 Paper 1]



(A) $\sqrt{\frac{2}{3}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$ (B) $\sqrt{\frac{2g}{3(R-r)}+\frac{k}{m}}$ (C) $\sqrt{\frac{1}{6}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$ (D) $\sqrt{\frac{1}{4}\left(\frac{g}{R-r}+\frac{k}{m}\right)}$

Scan or tap for the full solution

2. As shown in the figures, a uniform rod OO' of length l is hinged at the point O and held in place vertically between two walls using two massless springs of same spring constant. The springs are connected at the midpoint and at the top-end (O') of the rod, as shown in Fig. 1 and the rod is made to oscillate by a small angular displacement. The frequency of oscillation of the rod is f_1. On the other hand, if both the springs are connected at the midpoint of the rod, as shown in Fig. 2 and the rod is made to oscillate by a small angular displacement, then the frequency of oscillation is f_2. Ignoring gravity and assuming motion only in the plane of the diagram, the value of $\frac{f_1}{f_2}$ is: [JEE Advanced 2025 Paper 2]

Space for Rough Work

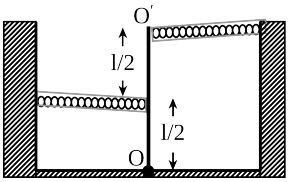


Fig. 1

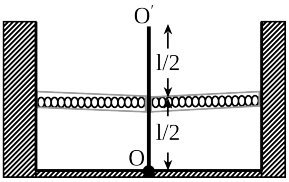


Fig. 2

(A) 2 (B) $\sqrt{2}$ (C) $\sqrt{\frac{5}{2}}$ (D) $\sqrt{\frac{2}{5}}$

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3. Two beads, each with charge q and mass m, are on a horizontal, frictionless, non-conducting, circular hoop of radius R. One of the beads is glued to the hoop at some point, while the other one performs small oscillations about its equilibrium position along the hoop. The square of the angular frequency of the small oscillations is given by

[ε_0 is the permittivity of free space.] [JEE Advanced 2024 Paper 1]

(A) $q^2/(4\pi\varepsilon_0 R^3 m)$ (B) $q^2/(32\pi\varepsilon_0 R^3 m)$ (C) $q^2/(8\pi\varepsilon_0 R^3 m)$ (D) $q^2/(16\pi\varepsilon_0 R^3 m)$

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4. A block of mass 5 kg moves along the x-direction subject to the force F = (−20x + 10) N, with the value of x in metre. At time t = 0 s, it is at rest at position x = 1 m. The position and momentum of the block at t = (π/4) s are [JEE Advanced 2024 Paper 1]

(A) −0.5 m, 5 kg m/s (B) 0.5 m, 0 kg m/s (C) 0.5 m, −5 kg m/s (D) −1 m, 5 kg m/s

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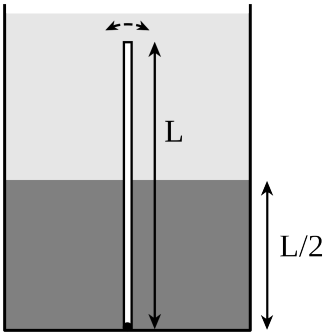
Space for Rough Work

SECTION–2 : (Maximum Marks : 12)

- This section contains **ONE** paragraph.
- Based on each paragraph, there are **THREE** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value of the answer (in decimal notation, truncated / rounded-off to the **SECOND DECIMAL PLACE**; e.g. 6.25, 7.00, −0.33, −.30, 30.27, −127.30) in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks : +4 If ONLY the correct answer is entered;
Zero Marks : 0 In all other cases.

5. A tank contains two immiscible liquids of densities 6ρ and 2ρ. The higher density liquid is filled up to a height L/2 from the bottom. A thin rod of density ρ and length L is fully immersed and hinged at the bottom so that it can oscillate freely, as shown in the figure. If the rod is slightly disturbed from its equilibrium, the time period of small oscillations is $\frac{2\pi}{n}\sqrt{\frac{L}{g}}$, where g is the acceleration due to the gravity. The value of n is: [JEE Advanced 2026 Paper 1]



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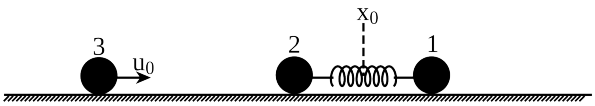
Paragraph for Questions 6 and 7

Two particles, 1 and 2, each of mass m, are connected by a massless spring, and are on a horizontal frictionless plane, as shown in the figure. Initially, the two particles, with their center of mass at x_0, are oscillating with amplitude a and angular frequency ω. Thus, their positions at time t are given by $x_1(t) = (x_0 + d) + a\sin\omega t$ and $x_2(t) = (x_0 - d) - a\sin\omega t$, respectively, where d > 2a. Particle 3 of mass m moves towards this system with speed $u_0 = a\omega/2$, and undergoes instantaneous elastic collision with particle 2, at time t_0. Finally, particles 1 and 2 acquire a center of mass speed v_{cm} and oscillate with amplitude b and the same angular frequency ω.



6. If the collision occurs at time $t_0 = 0$, the value of $v_{cm}/(a\omega)$ will be _____. [JEE Advanced 2024 Paper 2]

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7. If the collision occurs at time $t_0 = \pi/(2\omega)$, then the value of $4b^2/a^2$ will be _____.

[JEE Advanced 2024 Paper 2]

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Space for Rough Work

JEE ADVANCED OSCILLATIONS — PYQS

Test Pattern : **JEE (Advanced)**

ANSWER KEY

SECTION–1

Ques.	1	2	3	4																									
Ans.	**A**	**C**	**B**	**C**																									

SECTION–2

Ques.	5	6	7									
Ans.	**1.70 to 1.75**	**0.75**	**4.25**									