

JEE-MAIN EXAMINATION – JANUARY 2025(HELD ON WEDNESDAY 29th JANUARY 2025)

TIME : 3 : 00 PM TO 6 : 00 PM

PHYSICS**TEST PAPER WITH SOLUTION****SECTION-A**

26. The difference of temperature in a material can convert heat energy into electrical energy. To harvest the heat energy, the material should have
 (1) low thermal conductivity and low electrical conductivity
 (2) high thermal conductivity and high electrical conductivity
 (3) low thermal conductivity and high electrical conductivity
 (4) high thermal conductivity and low electrical conductivity

Ans. (3)**Sol.** See-back effect

- Low thermal conductivity
 High electrical conductivity
 Ans. (3)

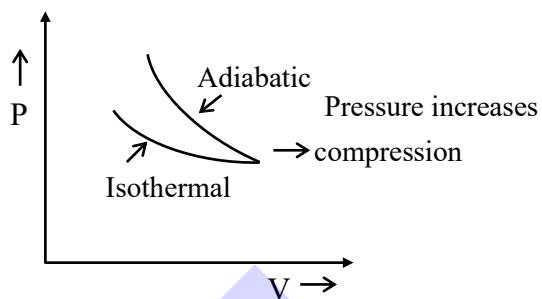
27. Given below are two statements. One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A) : With the increase in the pressure of an ideal gas, the volume falls off more rapidly in an isothermal process in comparison to the adiabatic process.

Reason (R) : In isothermal process, $PV = \text{constant}$, while in adiabatic process $PV^\gamma = \text{constant}$. Here γ is the ratio of specific heats, P is the pressure and V is the volume of the ideal gas.

In the light of the above statements, choose the **correct** answer from the options given below :

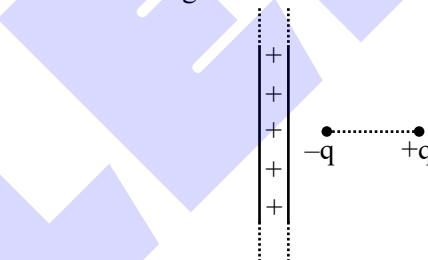
- (1) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
 (2) (A) is true but (R) is false
 (3) Both (A) and (R) are true and (R) is the correct explanation of (A).
 (4) (A) is false but (R) is true

NTA Ans. (4)**Allen Ans.(3)****Sol.**

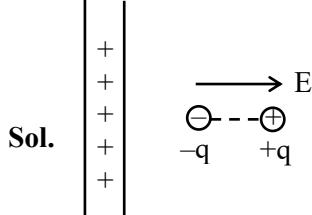
$$\left(\frac{dP}{dV}\right)_{\text{Adiabatic}} > \left(\frac{dP}{dV}\right)_{\text{Isothermal}}$$

Ans. (3)

28. An electric dipole is placed at a distance of 2 cm from an infinite plane sheet having positive charge density σ_0 . Choose the correct option from the following.



- (1) Torque on dipole is zero and net force is directed away from the sheet.
 (2) Torque on dipole is zero and net force acts towards the sheet.
 (3) Potential energy of dipole is minimum and torque is zero.
 (4) Potential energy and torque both are maximum

Ans. (3)

$$\text{Here } E = \frac{\sigma}{2\epsilon_0}, \vec{\tau} = \vec{P} \times \vec{E}$$

$$\vec{\tau} = 0$$

$$U = -\vec{P} \cdot \vec{E} \quad U \rightarrow \text{minimum}$$

Ans. (3)

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29. In an experiment with photoelectric effect, the stopping potential.

- increases with increase in the wavelength of the incident light
- increases with increase in the intensity of the incident light
- is $\left(\frac{1}{e}\right)$ times the maximum kinetic energy of the emitted photoelectrons
- decreases with increase in the intensity of the incident light

Ans. (3)

Sol. $\frac{hc}{\lambda} = W + eV_s$

$$\frac{hc}{\lambda} = W + (K_{\max})$$

$$\therefore V_s = \frac{K_{\max}}{e}$$

Ans. (3)

30. A point charge causes an electric flux of $-2 \times 10^4 \text{ Nm}^2 \text{C}^{-1}$ to pass through a spherical Gaussian surface of 8.0 cm radius, centred on the charge.

The value of the point charge is :

(Given $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{N}^{-1} \text{m}^{-2}$)

$$(1) -17.7 \times 10^{-8} \text{ C}$$

$$(3) 17.7 \times 10^{-8} \text{ C}$$

$$(2) -15.7 \times 10^{-8} \text{ C}$$

$$(4) 15.7 \times 10^{-8} \text{ C}$$

Ans. (1)

Sol. $\phi = -2 \times 10^4 \frac{\text{Nm}^2}{\text{C}}$

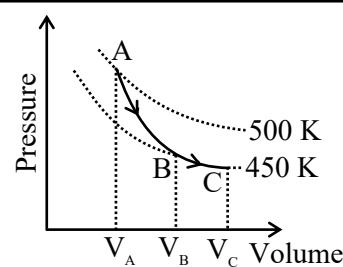
$$r = 8.0 \text{ cm}$$

$$\phi = \frac{q}{\epsilon_0} \Rightarrow q = \epsilon_0 \phi$$

$$= (8.85 \times 10^{-12}) \times (-2 \times 10^4)$$

$$q = -17.7 \times 10^{-8} \text{ C}$$

31.



A poly-atomic molecule ($C_V = 3R$, $C_P = 4R$, where R is gas constant) goes from phase space point A ($P_A = 10^5 \text{ Pa}$, $V_A = 4 \times 10^{-6} \text{ m}^3$) to point B ($P_B = 5 \times 10^4 \text{ Pa}$, $V_B = 6 \times 10^{-6} \text{ m}^3$) to point C ($P_C = 10^4 \text{ Pa}$, $V_C = 8 \times 10^{-6} \text{ m}^3$). A to B is an adiabatic path and B to C is an isothermal path.

The net heat absorbed per unit mole by the system is :

- $500R(\ln 3 + \ln 4)$
- $450R(\ln 4 - \ln 3)$
- $500R \ln 2$
- $400R \ln 4$

Ans. (2)

Sol. $\Delta Q_{AB} = 0$ adiabatic

$$\Delta Q_{BC} = \Delta W_{BC}$$

$$= nRT \ell \ln \left(\frac{V_C}{V_B} \right) = 450R \ell \ln \left(\frac{8 \times 10^{-6}}{6 \times 10^{-6}} \right)$$

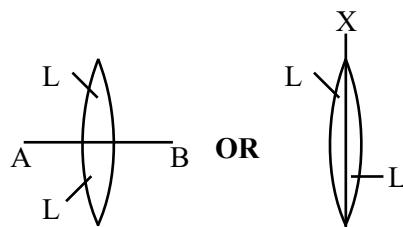
$$= 450R \ell \ln \left(\frac{4}{3} \right) = 450R (\ln 4 - \ln 3)$$

$$\therefore \Delta Q = \Delta Q_{AB} + \Delta Q_{BC}$$

$$\Delta Q = 450 R (\ln 4 - \ln 3)$$

Note : Solution is based on direct data. B and C are not satisfying the condition of isothermal process.

32. Two identical symmetric double convex lenses of focal length f are cut into two equal parts L_1, L_2 by AB plane and L_3, L_4 by XY plane as shown in figure respectively. The ratio of focal lengths of lenses L_1 and L_3 is



$$(1) 1 : 4$$

$$(3) 2 : 1$$

$$(2) 1 : 1$$

$$(4) 1 : 2$$



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36. Given below are two statements. One is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A) : $\frac{v_A = 5}{v_B = 2} \quad \frac{v_B = 2}{v_C = 4}$

Three identical spheres of same mass undergo one dimensional motion as shown in figure with initial velocities $v_A = 5 \text{ m/s}$, $v_B = 2 \text{ m/s}$, $v_C = 4 \text{ m/s}$. If we wait sufficiently long for elastic collision to happen, then $v_A = 4 \text{ m/s}$, $v_B = 2 \text{ m/s}$, $v_C = 5 \text{ m/s}$ will be the final velocities.

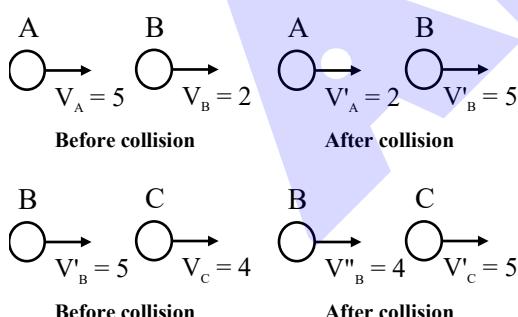
Reason (R) : In an elastic collision between identical masses, two objects exchange their velocities.

In the light of the above statements, choose the **correct** answer from the options given below :

- (1) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
- (2) (A) is true but (R) is false
- (3) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (4) (A) is false but (R) is true

Ans. (4)

Sol. In elastic collision for same mass, velocities interchange



$$V'_A = 2 \text{ m/s} \quad V''_B = 4 \text{ m/s} \quad V'_C = 5 \text{ m/s}$$

37. A sand dropper drops sand of mass $m(t)$ on a conveyer belt at a rate proportional to the square root of speed (v) of the belt, i.e. $\frac{dm}{dt} \propto \sqrt{v}$. If P is the power delivered to run the belt at constant speed then which of the following relationship is true ?
- (1) $P^2 \propto v^3$
 - (2) $P \propto \sqrt{v}$
 - (3) $P \propto v$
 - (4) $P^2 \propto v^5$

Ans. (4)

$$\text{Sol. Power} = \vec{F} \cdot \vec{V}$$

$$F = \frac{dp}{dt} [p = mv]$$

$$F = \left(\frac{dm}{dt} \right) v = C(\sqrt{v})v$$

$$F = Cv^{3/2}$$

$$\text{Power} = C(v^{3/2})v = Cv^{5/2}$$

$$P^2 \propto v^5$$

Ans. (4)

38. A convex lens made of glass (refractive index = 1.5) has focal length 24 cm in air. When it is totally immersed in water (refractive index = 1.33), its focal length changes to

- (1) 72 cm
- (2) 96 cm
- (3) 24 cm
- (4) 48 cm

Ans. (2)

$$\text{Sol. } \frac{1}{8} = \left(\frac{\mu_\ell - 1}{\mu_s} \right) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]$$

$$\frac{1}{24} = (1.5 - 1) \left[\frac{2}{R} \right] \quad \dots (i)$$

$$\frac{1}{f'} = \left(\frac{1.5}{1.33} - 1 \right) \left(\frac{2}{R} \right)$$

$$\frac{1}{f'} = \left(\frac{1.5 \times 3}{4} - 1 \right) \frac{2}{R} \quad \dots (ii)$$

(i) divided by (ii)

$$\frac{f'}{24} = 4$$

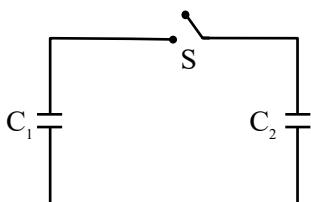
$$f' = 96 \text{ cm}$$



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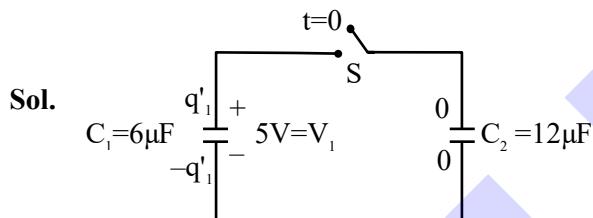
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39. A capacitor, $C_1 = 6\mu F$ is charged to a potential difference of $V_0 = 5V$ using a 5V battery. The battery is removed and another capacitor, $C_2 = 12\mu F$ is inserted in place of the battery. When the switch 'S' is closed, the charge flows between the capacitors for some time until equilibrium condition is reached. What are the charges (q_1 and q_2) on the capacitors C_1 and C_2 when equilibrium condition is reached.



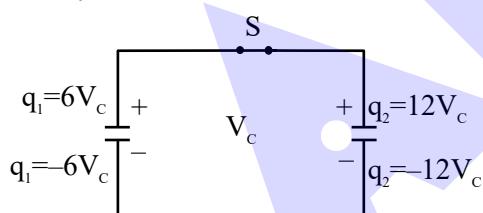
- (1) $q_1 = 15 \mu C, q_2 = 30 \mu C$
 (2) $q_1 = 30 \mu C, q_2 = 15 \mu C$
 (3) $q_1 = 10 \mu C, q_2 = 20 \mu C$
 (4) $q_1 = 20 \mu C, q_2 = 10 \mu C$

Ans. (3)



$$q'_1 = 6 \times 5 = 30 \mu C$$

Finally



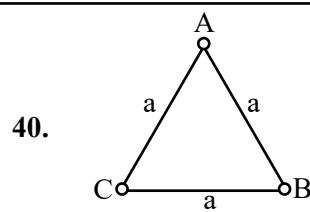
$$6V_c + 12V_c = 30 + 0$$

$$18V_c = 30$$

$$V_c = \frac{30}{18} = \frac{5}{3} \text{ Volt}$$

$$\Rightarrow q_1 = \frac{6 \times 5}{3} = 10 \mu C$$

$$\Rightarrow q_2 = \frac{12 \times 5}{3} = 20 \mu C$$

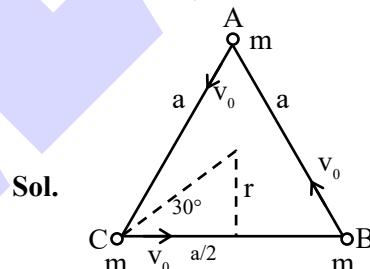


Three equal masses m are kept at vertices (A, B, C) of an equilateral triangle of side a in free space. At $t = 0$, they are given an initial velocity $\vec{V}_A = V_0 \vec{AC}$, $\vec{V}_B = V_0 \vec{BA}$ and $\vec{V}_C = V_0 \vec{CB}$.

Here, \vec{AC}, \vec{CB} and \vec{BA} are unit vectors along the edges of the triangle. If the three masses interact gravitationally, then the magnitude of the net angular momentum of the system at the point of collision is :

- (1) $\frac{1}{2} a m V_0$ (2) $3 a m V_0$
 (3) $\frac{\sqrt{3}}{2} a m V_0$ (4) $\frac{3}{2} a m V_0$

Ans. (3)



$$\tan 30^\circ = \frac{2r}{a} = \frac{1}{\sqrt{3}}$$

$$r = \frac{a}{2\sqrt{3}}$$

$$L = (mv_{r\perp}) \times 3$$

$$= mv_0 \frac{a}{2\sqrt{3}} \times 3$$

$$= \frac{\sqrt{3}}{2} mv_0 a$$



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41. Match List-I with List-II.

	List-I		List-II
(A)	Young's Modulus	(I)	$ML^{-1}T^{-1}$
(B)	Torque	(II)	$ML^{-1}T^{-2}$
(C)	Coefficient of Viscosity	(III)	$M^{-1}L^3T^{-2}$
(D)	Gravitational Constant	(IV)	ML^2T^{-2}

Choose the **correct** answer from the options given below :

- (1) (A)-(I), (B)-(III), (C)-(II), (D)-(IV)
- (2) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)
- (3) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)
- (4) (A)-(II), (B)-(IV), (C)-(I), (D)-(III)

Ans. (4)

Sol. (A) $[Y] = \frac{F}{A(\frac{\Delta\ell}{\ell})} \Rightarrow \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$ (II)

(B) Torque ($\vec{\tau}$) = $\vec{r} \times \vec{F}$

$$(\vec{\tau}) = L \times MLT^{-2} = ML^2T^{-2}$$
 (IV)

(C) Coefficient of viscosity $\Rightarrow F = \eta A \frac{dV}{dt}$

$$\eta \rightarrow \text{Pa}\cdot\text{sec}$$

$$[\eta] = \frac{MLT^{-2}}{L^2} \times T = ML^{-1}T^{-1}$$
 (I)

(D) Gravitational constant (G)

$$F = \frac{GM_1M_2}{r^2}$$

$$[G] = \frac{F \cdot r^2}{m_1 m_2} = \frac{MLT^{-2} \times L^2}{M^2} = M^{-1}L^3T^{-2}$$
 (III)

42. Match List-I with List-II.

	List-I		List-II
(A)	Magnetic induction	(I)	Ampere meter ²
(B)	Magnetic intensity	(II)	Weber
(C)	Magnetic flux	(III)	Gauss
(D)	Magnetic moment	(IV)	Ampere meter

Choose the **correct** answer from the options given below :

- (1) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
- (2) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)
- (3) (A)-(I), (B)-(II), (C)-(III), (D)-(IV)
- (4) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)

Ans. (2)

Sol. (A) Magnetic induction \rightarrow Gauss (III)

(B) Magnetic intensity

$$\left(H = \frac{B}{\mu} \right) \rightarrow \text{Ampere / meter}$$
 (IV)

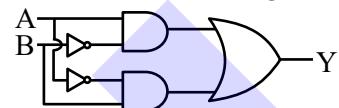
(C) Magnetic flux \rightarrow Weber (Wb) (II)

(D) Magnetic moment \rightarrow Ampere-meter²

$$(\vec{M} = i\vec{A})$$

Note : None of the option(s) are correct but if we need to choose most appropriate option then the answer is (2)

43. The truth table for the circuit given below :



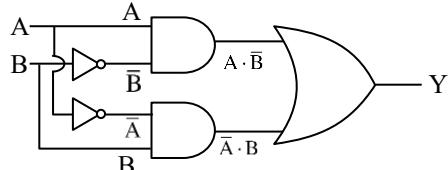
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

A	B	Y
0	0	0
1	0	0
1	1	0
0	1	1

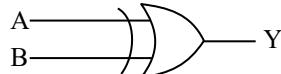
A	B	Y
0	0	0
1	0	1
0	1	0
1	1	0

A	B	Y
0	0	0
1	1	1
1	0	1
0	1	1

Ans. (1)



$$Y = A \cdot \bar{B} + \bar{A} \cdot B$$



XOR (Exclusive OR)



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44. A cup of coffee cools from 90°C to 80°C in t minutes when the room temperature is 20°C . The time taken by the similar cup of coffee to cool from 80°C to 60°C at the same room temperature is :

$$\begin{array}{ll} (1) \frac{13}{5}t & (2) \frac{10}{13}t \\ (3) \frac{13}{10}t & (4) \frac{5}{13}t \end{array}$$

Ans. (1)

Sol. By using average form of Newton's law of cooling

$$\frac{90-80}{t} = k \left(\frac{90+80}{2} - 20 \right) \quad \dots \text{(i)}$$

$$\frac{80-60}{t'} = k \left(\frac{80+60}{2} - 20 \right) \quad \dots \text{(ii)}$$

(i)/(ii)

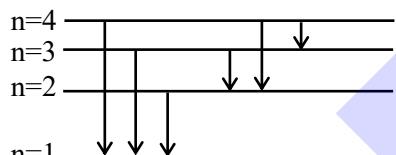
$$\frac{10 \times t'}{t \times 20} = \frac{65}{50}$$

$$t' = \frac{65}{50} \times 2t = \frac{65}{25}t = \frac{13}{5}t$$

45. The number of spectral lines emitted by atomic hydrogen that is in the 4^{th} energy level, is

$$\begin{array}{ll} (1) 6 & (2) 0 \\ (3) 3 & (4) 1 \end{array}$$

Ans. (1)



Total possible transition = 6

SECTION-B

46. The magnetic field inside a 200 turns solenoid of radius 10 cm is 2.9×10^{-4} Tesla. If the solenoid carries a current of 0.29 A, then the length of the solenoid is _____ π cm.

Ans. (8)

Sol. Assuming long solenoid

$$\begin{aligned} B &= \mu_0 \left(\frac{N}{\ell} \right) i \\ \ell &= \frac{\mu_0 N i}{B} = \frac{(4\pi \times 10^{-7})(200)(0.29)}{2.9 \times 10^{-4}} \text{ m} \\ &= 8\pi \text{ cm} \end{aligned}$$

47. A parallel plate capacitor consisting of two circular plates of radius 10 cm is being charged by a constant current of 0.15 A. If the rate of change of potential difference between the plates is 7×10^8 V/s then the integer value of the distance between the parallel plates is –

$$\left(\text{Take, } \epsilon_0 = 9 \times 10^{-12} \frac{\text{F}}{\text{m}}, \pi = \frac{22}{7} \right) \text{ _____ } \mu\text{m.}$$

Ans. (1320)

$$\text{Sol. } V = \frac{Q}{C} = \frac{it}{\left(\frac{\epsilon_0 A}{d} \right)} = \frac{itd}{\epsilon_0 (\pi r^2)}$$

$$\Rightarrow d = \frac{\epsilon_0 (\pi r^2)}{i} \left(\frac{V}{t} \right)$$

$$= \frac{\left(9 \times 10^{-12} \right) \left(\frac{22}{7} \right) (0.1)^2}{0.15} (7 \times 10^8) \text{ m}$$

$$d = 1320 \mu\text{m}$$

48. A physical quantity Q is related to four observables

$$a, b, c, d \text{ as follows : } Q = \frac{ab^4}{cd}$$

where, $a = (60 \pm 3)\text{Pa}$; $b = (20 \pm 0.1)\text{m}$; $c = (40 \pm 0.2) \text{ Nsm}^{-2}$ and $d = (50 \pm 0.1)\text{m}$,

then the percentage error in Q is $\frac{x}{1000}$,

where $x = \text{_____}$.

NTA Ans. (77)

Allen Ans. (7700)

$$\text{Sol. } Q = \frac{ab^4}{cd}$$

$$\Rightarrow \frac{\Delta Q}{Q} \times 100 = \left[\frac{\Delta a}{a} + 4 \frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d} \right] \times 100$$

$$\Rightarrow \frac{x}{1000} = \left[\frac{3}{60} + 4 \left(\frac{0.1}{20} \right) + \left(\frac{0.2}{40} \right) + \frac{0.1}{50} \right] \times 100$$

$$\Rightarrow x = 7700$$

49. Two planets, A and B are orbiting a common star in circular orbits of radii R_A and R_B , respectively, with $R_B = 2R_A$. The planet B is $4\sqrt{2}$ times more massive than planet A. The ratio $\left(\frac{L_B}{L_A} \right)$ of angular momentum (L_B) of planet B to that of planet A (L_A) is closest to integer _____.

Ans. (8)



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Sol. $L = mv_0 R = m\sqrt{\frac{GM}{R}}R = m\sqrt{GMR}$

here M is mass of star

$$\frac{L_B}{L_A} = \frac{m_B}{m_A} \sqrt{\frac{R_B}{R_A}}$$

$$= 4\sqrt{2} \sqrt{\frac{2}{1}}$$

$$\frac{L_B}{L_A} = 8$$

50. Two cars P and Q are moving on a road in the same direction. Acceleration of car P increases linearly with time whereas car Q moves with a constant acceleration. Both cars cross each other at time $t = 0$, for the first time. The maximum possible number of crossing(s) (including the crossing at $t = 0$) is _____.

Ans. (3)

Sol. $a_p = kt$, k is constant

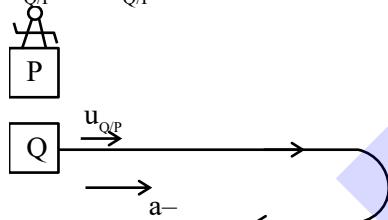
$a_q = a$, a is constant

$$a_{Q/P} = a_q - a_p = a - kt$$

as initial velocities are not mentioned in question, so will have to assume two cases.

Case-I

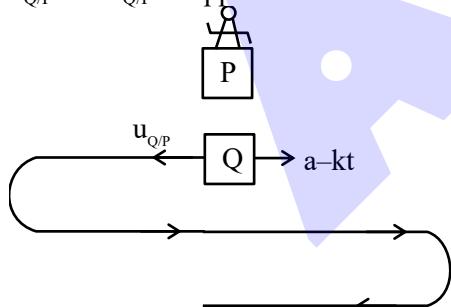
$u_{Q/P}$ and $a_{Q/P}$ in same direction



Total number of crossing = 2

Case-II

$u_{Q/P}$ and $a_{Q/P}$ in opposite direction



Total number of crossing = 3



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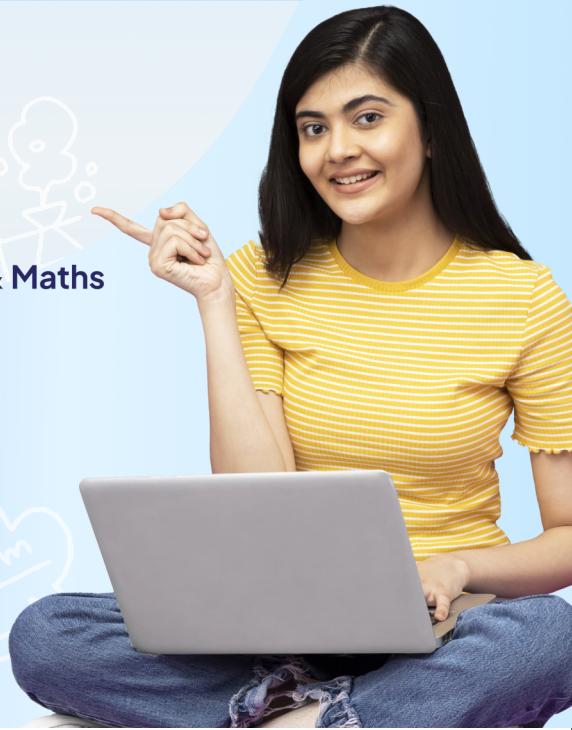


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