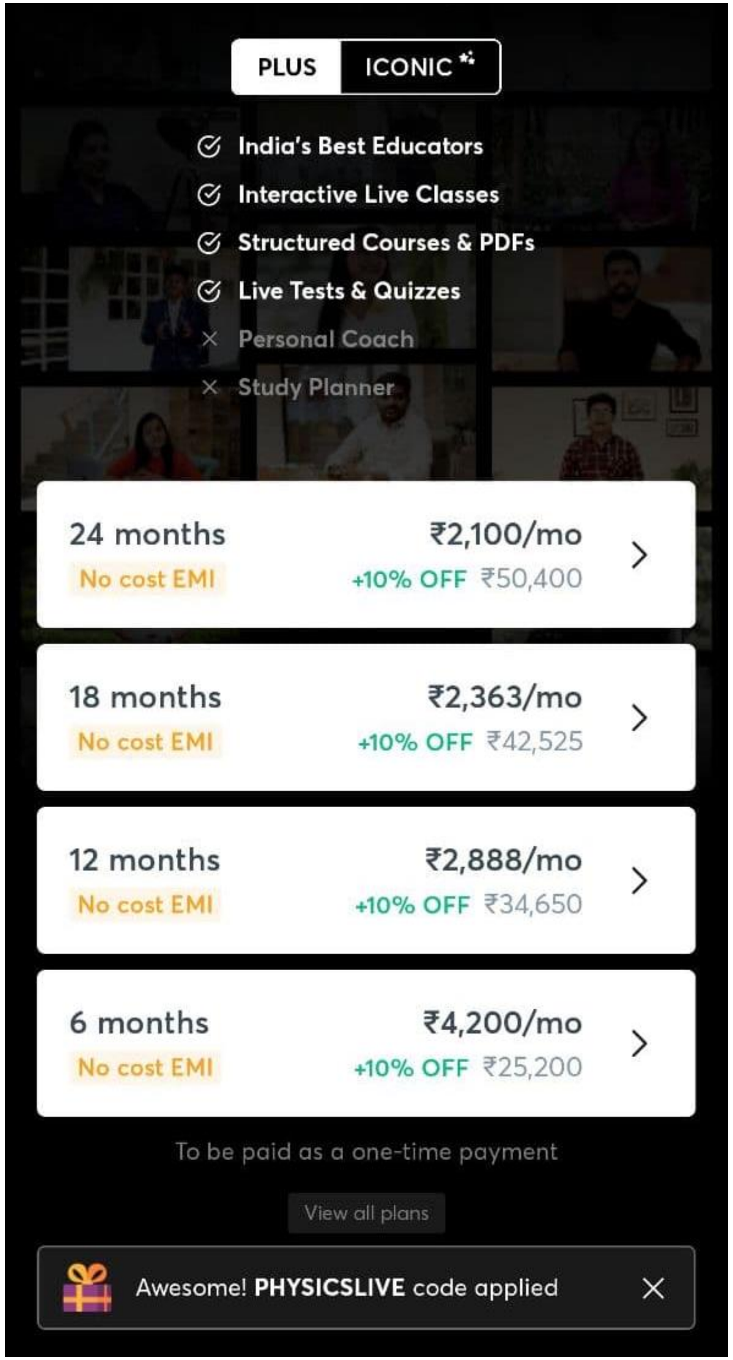
SIR PRATEEK JAIN

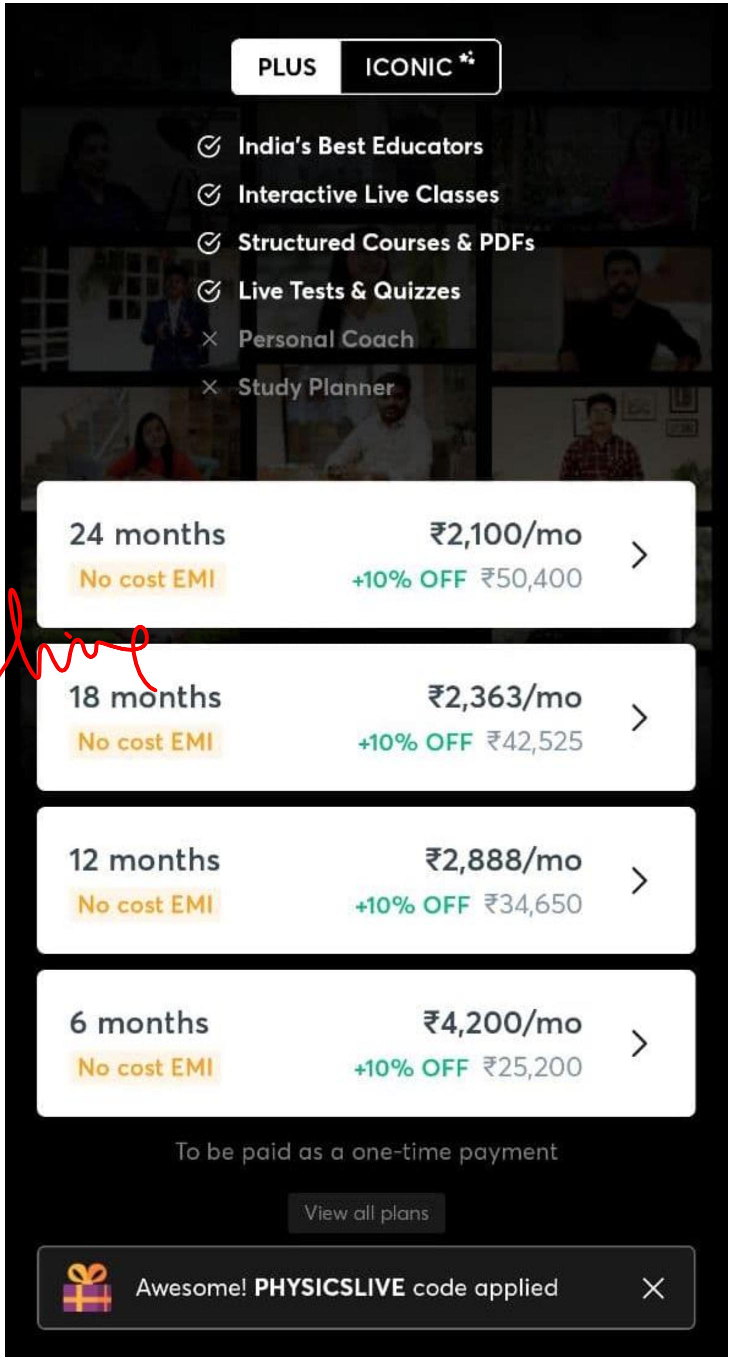
. Founder @Physicsaholics
. Top Physics Faculty on Unacademy (IIT JEE & NEET)
. 8+ years of teaching experience in top institutes like FIITJEE (Delhi, Indore) , CP (KOTA) etc.
. Produced multiple Top ranks.
. Research work with HC Verma sir at IIT Kanpur
. Interviewed by International media.



PHYSICSLIVE

Telegram Channel:-
@UnacademyPhysicslive

Use code PHYSICSLIVE to get 10% OFF on Unacademy PLUS and learn from India's Top Faculties.



For Video Solution of JEE Adv. 2021 Physics Paper-1 Click on below link

Solution on Website:- https://physicsaholics.com/home/courseDetails/69

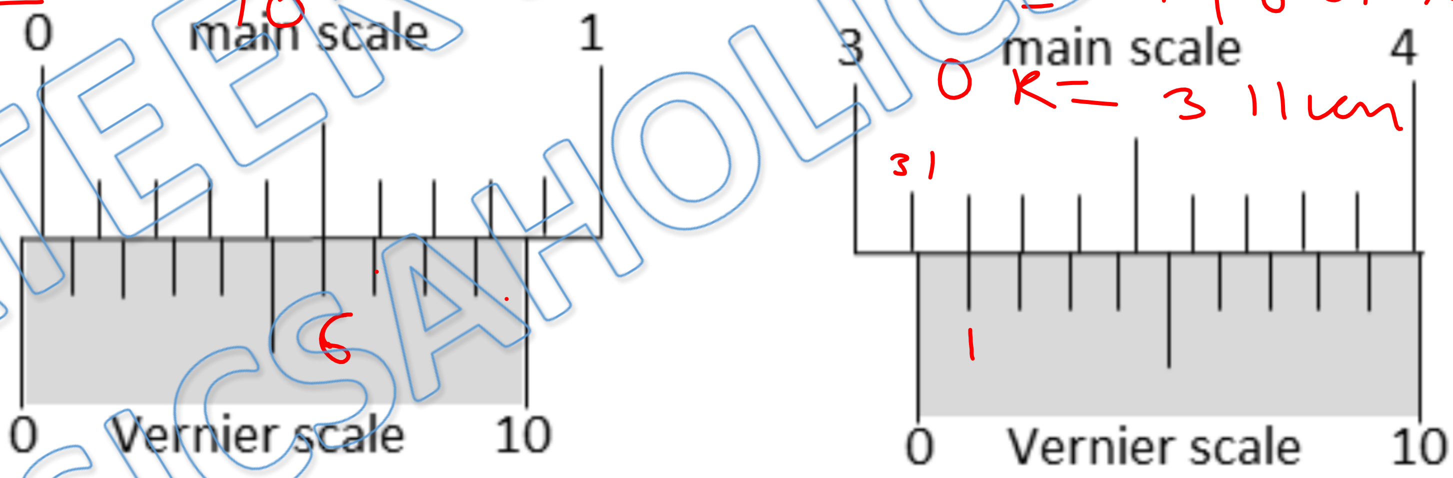
Solution on YouTube:- https://youtu.be/Z-iW5x0ikyk

JEE Advanced 2021
Paper - 1
Physics Answer Key & Solutions

By

PRATEEK JAIN SIR

Q1) The smallest division on the main scale of a Vernier calipers is 0.1 cm. Ten divisions of the Vernier scale correspond to nine divisions of the main scale. The figure below on the left shows the reading of this calipers with no gap between its two jaws. The figure on the right shows the reading with a solid sphere held between the jaws. The correct diameter of the sphere is



(A) 3.07 cm

(B) 3.11 cm

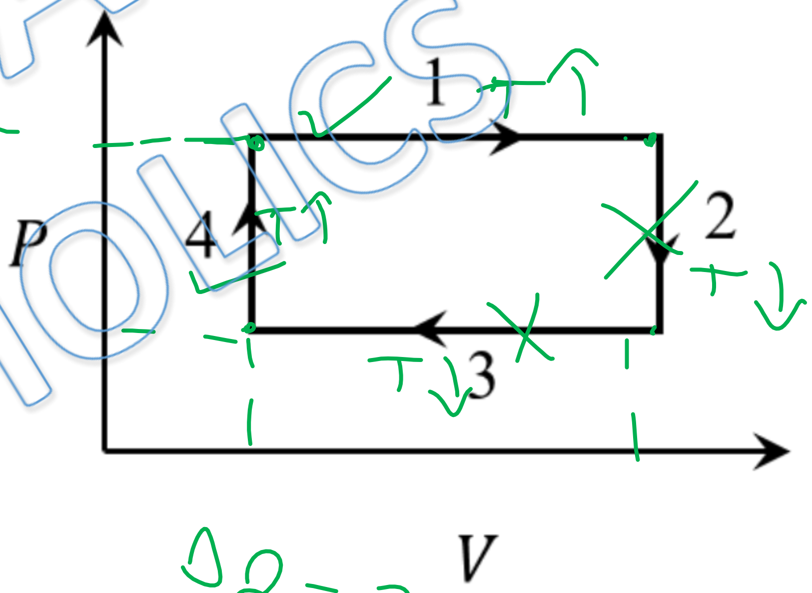
(C) 3.15 cm

(D) 3.17 cm

Difficulty Level: Easy

Ans. C

Q2) An ideal gas undergoes a four step cycle as shown in the $P - V$ diagram below. During this cycle, heat is absorbed by the gas in



(A) steps 1 and 2

(B) steps 1 and 3

(C) steps 1 and 4

(D) steps 2 and 4

Difficulty Level: Easy

Ans. C

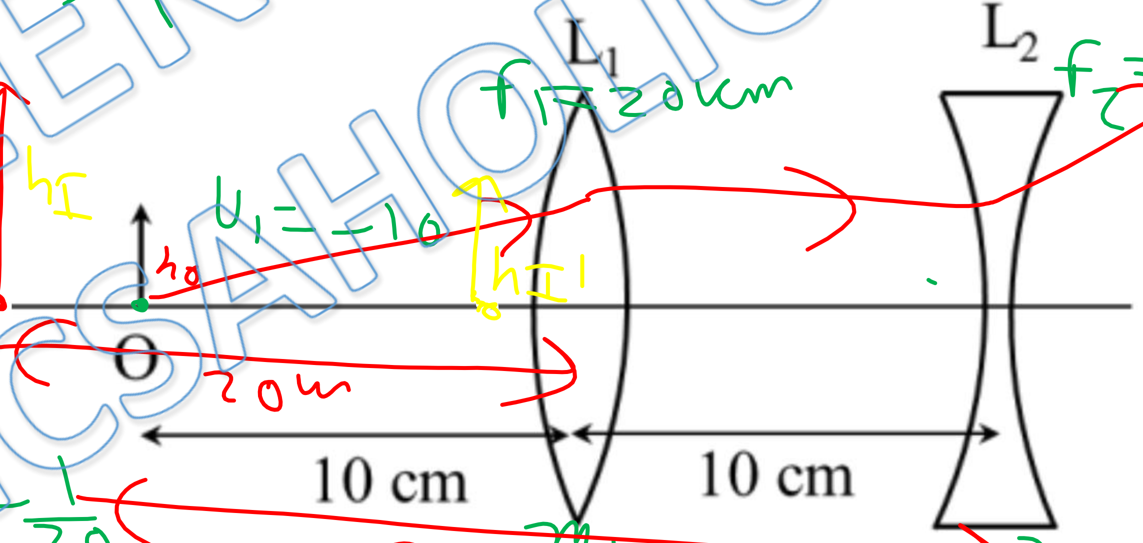
Q3) An extended object is placed at point O, 10 cm in front of a convex lens L_1 and a concave lens L_2 is placed 10 cm behind it, as shown in the figure. The radii of curvature of all the curved surfaces in both the lenses are 20 cm. The refractive index of both the lenses is 1.5. The total magnification of this lens system is

(A) 0.4

(B) 0.8

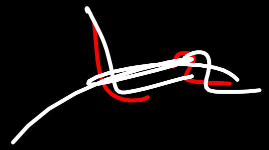
(C) 1.3

(D) 1.6



Difficulty Level: Easy

Ans. B



L_2

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_2}$$

$$\frac{1}{v_2} - \frac{1}{-30} = \frac{1}{-20}$$

$$\frac{1}{v_2} = -\frac{1}{20} - \frac{1}{30} = \frac{-50}{20 \times 30}$$

$$v_2 = -12\,cm$$

$m = hI$

$$m_2 = \frac{v_2}{u_2}$$

$$m_2 = \frac{+12}{+30} = \frac{2}{5}$$

Q4) A heavy nucleus Q of half-life 20 minutes undergoes alpha-decay with probability of 60% and beta-decay with probability of 40%. Initially, the number of Q nuclei is 1000. The number of alpha-decays of Q in the first one hour is

(A) 50

(B) 75

(C) 350

(D) 525

Difficulty Level: Easy

Ans. D

Question Stem for Question Nos. 5 and 6

A projectile is thrown from a point O on the ground at an angle 45° from the vertical and with a speed $5\sqrt{2}$ m/s. The projectile at the highest point of its trajectory splits into two equal parts. One part falls vertically down to the ground, 0.5 s after the splitting. The other part, t seconds after the splitting, falls to the ground at a distance x meters from the point O. The acceleration due to gravity $g = 10\ \text{m}/s^2$.

Q5) The value of t is ____.

Q6) The value of x is ____.

Difficulty Level: Moderate

Ans 5: 0.50

Ans 6: 7.50

$$S_y = u_y t + \frac{1}{2} a_y t^2$$

↓ +ve

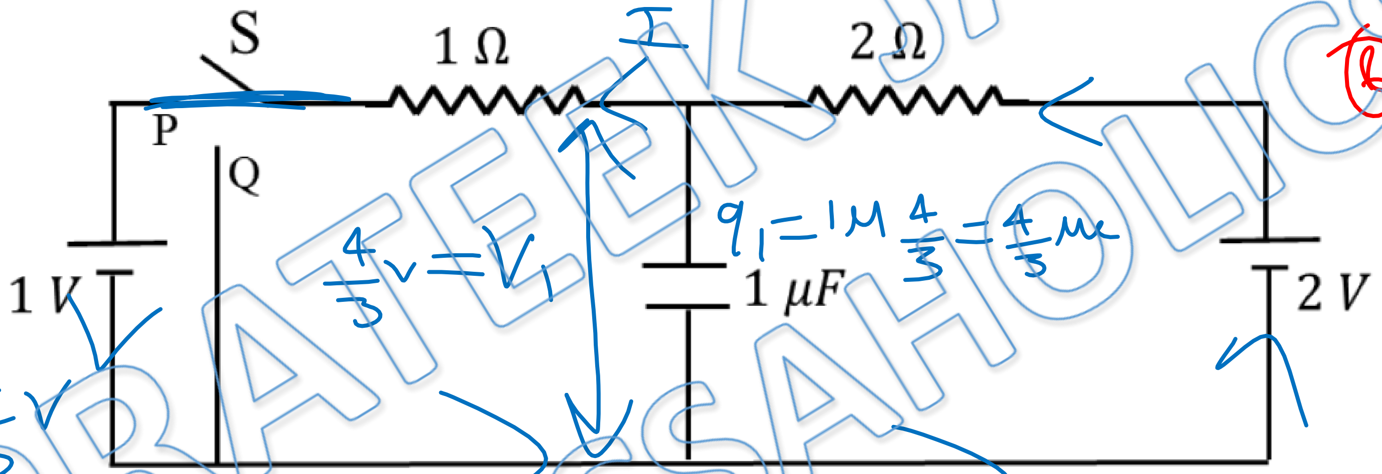
$$1.25 = v(0.5) + \frac{1}{2} 10 \times 0.25$$

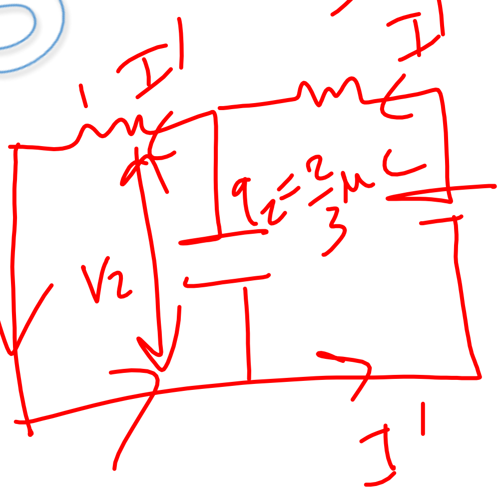
$$\cancel{1.25} = 0.5v + \cancel{1.25}$$

$$v = 0$$

Question Stem for Question Nos. 7 and 8

In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor becomes q_1 μC. Then S is switched to position Q. After a long time, the charge on the capacitor is q_2 μC.





Q7) The magnitude of q_1 is ____.

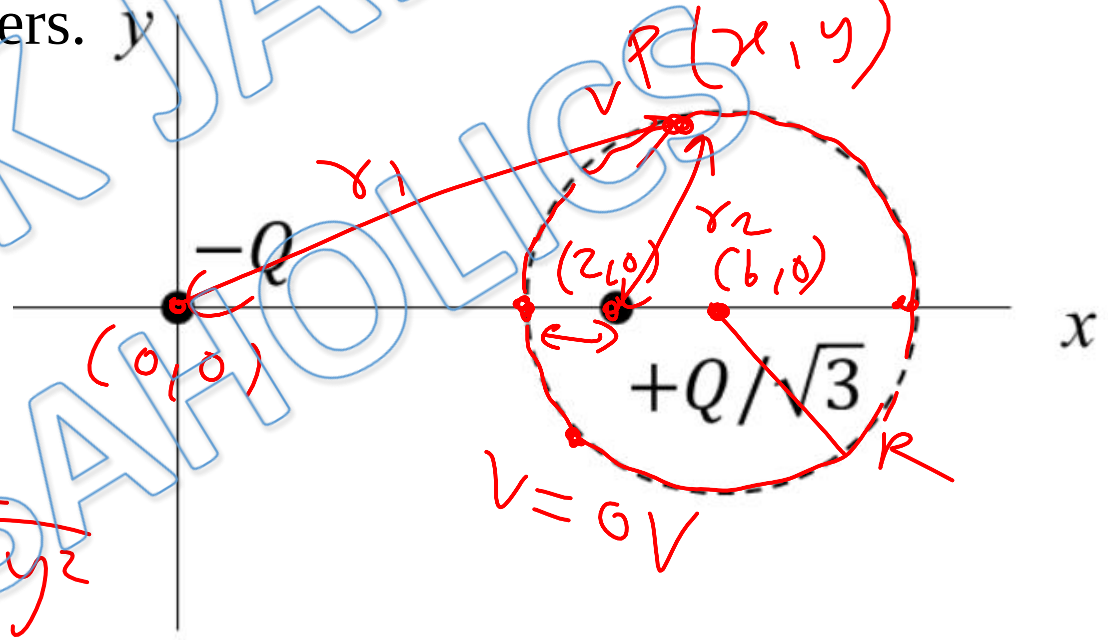
Q8) The magnitude of q_2 is ____.

Difficulty Level: Easy

Ans 7: 1.33
Ans 8: 0.67

Question Stem for Question Nos. 9 and 10

Two point charges $-Q$ and $+Q/\sqrt{3}$ are placed in the xy-plane at the origin (0, 0) and a point (2, 0), respectively, as shown in the figure. This results in an equipotential circle of radius R and potential $V = 0$ in the xy-plane with its center at (b, 0). All lengths are measured in meters.



Q9) The value of R is ___ meter.

Q10) The value of b is ___ meter.

Difficulty Level: Moderate

Ans 9: 1.73

Ans 10: 3.00

$$x^2+y^2+2gx+2fy+c=0$$

Centre :- $(-g, -f)$

$(3, 0)$

radius $r^2 = g^2+f^2-c$

$$r^2 = 9+0^2-6$$

$$r = \sqrt{3} = 1.73$$

$$\frac{1}{x^2+y^2} = \frac{1}{3(x^2+4-4x+y^2)}$$

$$3x^2+3y^2-12x+12 = x^2+y^2$$

$$2x^2+2y^2-12x+12=0$$

$$x^2+y^2-6x+6=0$$

$$2g=-6 \qquad f=0$$

$$g=-3$$

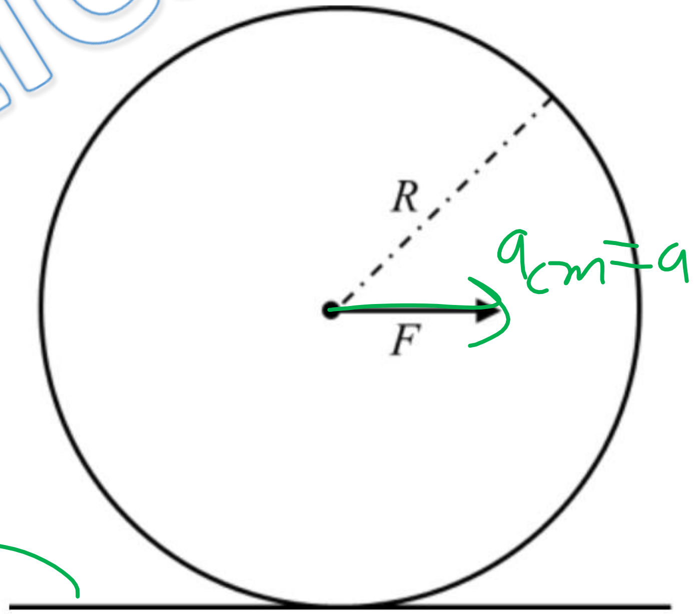
Q11) A horizontal force F is applied at the center of mass of a cylindrical object of mass m and radius R, perpendicular to its axis as shown in the figure. The coefficient of friction between the object and the ground is μ. The center of mass of the object has an acceleration a. The acceleration due to gravity is g. Given that the object rolls without slipping, which of the following statement(s) is(are) correct?

(A) For the same F, the value of a does not depend on whether the cylinder is solid or hollow

(B) For a solid cylinder, the maximum possible value of a is $2\mu g$

(C) The magnitude of the frictional force on the object due to the ground is always $\mu m g$

(D) For a thin-walled hollow cylinder, $a = \frac{F}{2m}$



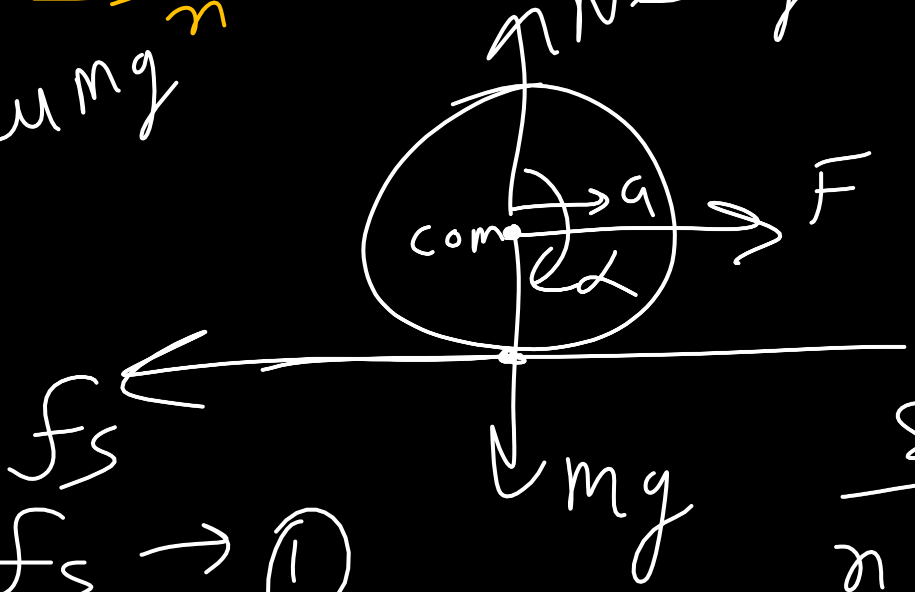
Difficulty Level: Moderate

$f_s \le f_{s,max}$ $\quad a \le \frac{\mu g}{n} \xrightarrow{s} a \le 2\mu g$

$n m a \le \mu m g$

Ans. B, D

$f_{s,max} = \mu N = \mu m g$



$a = \alpha R$

$I_{cm} = n m R^2$

solid	hollow
$n = \frac{1}{2}$	$n = 1$

$ma = F - f_s \rightarrow (1)$

$\tau_{cm} = I_{cm}\alpha$

$f_s R = n m R^2 \frac{a}{R}$

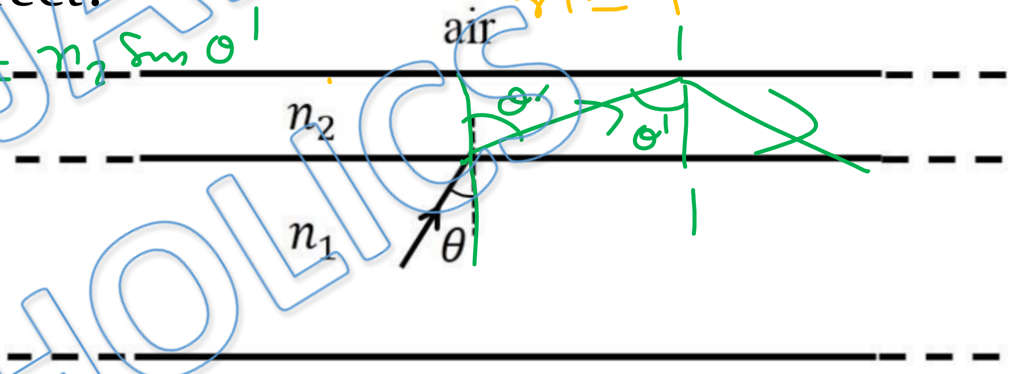
$f_s = n m a \rightarrow (2)$

$a = \frac{F}{m(1+n)} \xrightarrow[n=1]{h.c} a = \frac{F}{2m}$

JEE Adv. 2021 (P-1)

Q12) A wide slab consisting of two media of refractive indices n_1 and n_2 is placed in air as shown in the figure. A ray of light is incident from medium n_1 to n_2 at an angle θ, where $\sin\theta$ is slightly larger than $1/n_1$. Take refractive index of air as 1. Which of the following statement(s) is(are) correct?

HCV: Chapter – 18
Worked Out Examples
Q. 10



(A) The light ray enters air if $n_2 = n_1$

(B) The light ray is finally reflected back into the medium of refractive index n_1 if $n_2 < n_1$

(C) The light ray is finally reflected back into the medium of refractive index n_1 if $n_2 > n_1$

(D) The light ray is reflected back into the medium of refractive index n_1 if $n_2 = 1$

Difficulty Level: Moderate

Ans. B, C , D

Cond^n of TIR at Second boundary

$$\theta' > \theta_{c2}$$

$$\sin\theta' > \sin\theta_{c2}$$

$$\frac{n_1 \sin\theta}{n_2} > \frac{1}{n_2}$$

$$\sin\theta > \frac{1}{n_1}$$

JEE Adv. 2021 (P-1)

Q13) A particle of mass $M = 0.2$ kg is initially at rest in the xy-plane at a point ($x = -l$, $y = -h$), where $l = 10$ m and $h = 1$ m. The particle is accelerated at time $t = 0$ with a constant acceleration $a = 10\ m/s^2$ along the positive x-direction. Its angular momentum and torque with respect to the origin, in SI units, are represented by $\vec{L}$ and $\vec{\tau}$, respectively. $\hat{\imath}$, $\hat{\jmath}$ and $\hat{k}$ are unit vectors along the positive x, y and z-directions, respectively. If $\hat{k} = \hat{\imath} \times \hat{\jmath}$ then which of the following statement(s) is(are) correct?

(A) The particle arrives at the point ($x = l$, $y = -h$) at time $t = 2$ s

(B) $\vec{\tau} = 2\hat{k}$ when the particle passes through the point ($x = l$, $y = -h$)

(C) $\vec{L} = 4\hat{k}$ when the particle passes through the point ($x = l$, $y = -h$)

(D) $\vec{\tau} = \hat{k}$ when the particle passes through the point ($x = 0$, $y = -h$)

Difficulty Level: Easy

Ans. A, B, C

$m = 0.2\,kg$

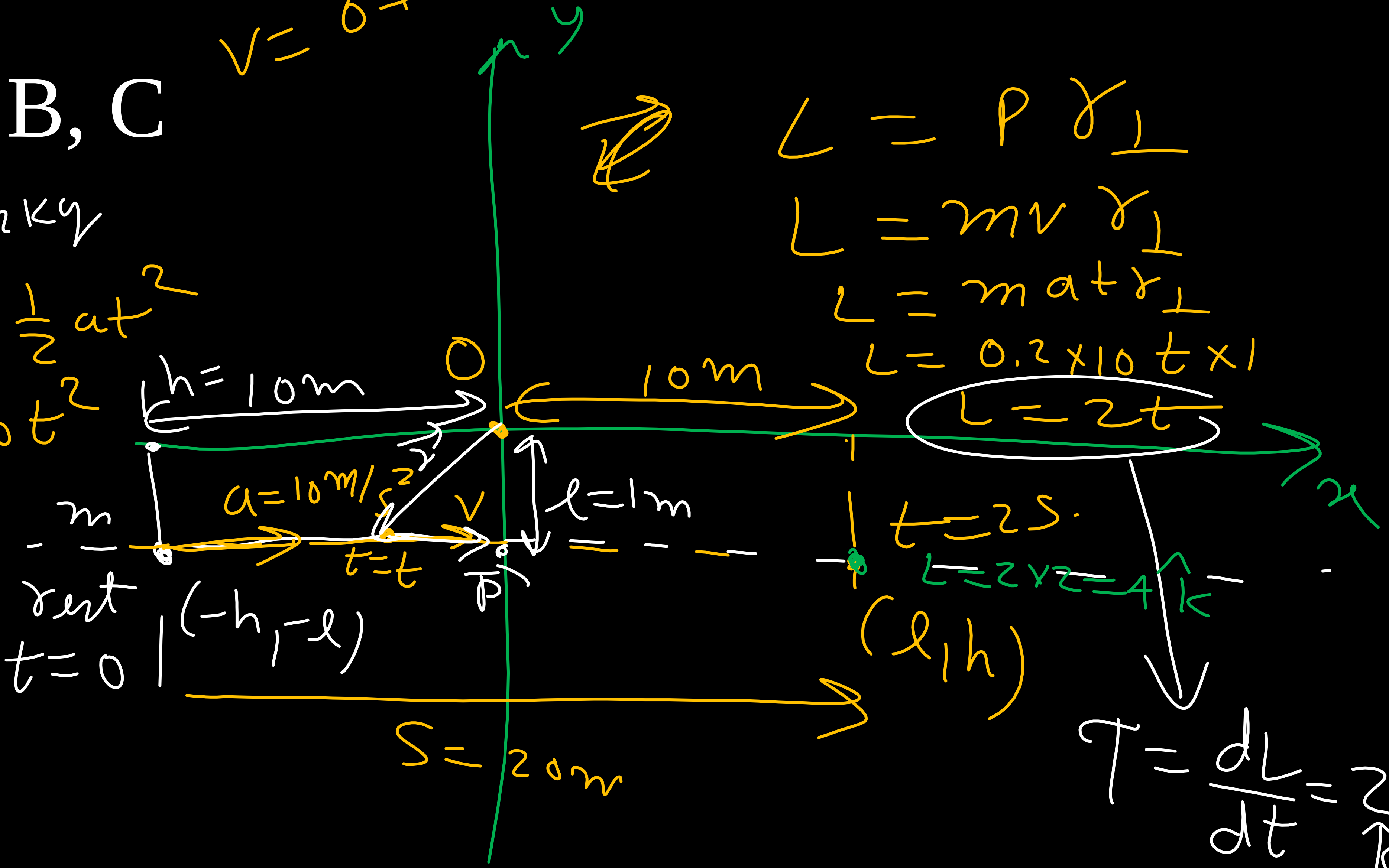
A) $S = ut + \frac{1}{2}at^2$

$20 = 0 + \frac{1}{2}10t^2$

$t^2 = 4$

$t = 2s$

$V = 0 + at$



$L = p r_\perp$

$L = mv r_\perp$

$L = mat r_\perp$

$L = 0.2 \times 10\, t \times 1$

$L = 2t$

$T = \frac{dL}{dt} = 2\,\hat{k}$

JEE Adv. 2021 (P-1)

Q14) Which of the following statement(s) is(are) correct about the spectrum of hydrogen atom?

(A) The ratio of the longest wavelength to the shortest wavelength in Balmer series is 9/5

(B) There is an overlap between the wavelength ranges of Balmer and Paschen series

(C) The wavelengths of Lyman series are given by $\left(1+\frac{1}{m^2}\right)\lambda_0$, where λ_0 is the shortest wavelength of Lyman series and m is an integer

(D) The wavelength ranges of Lyman and Balmer series do not overlap

Difficulty Level: Moderate

Ans. A, D

(C)

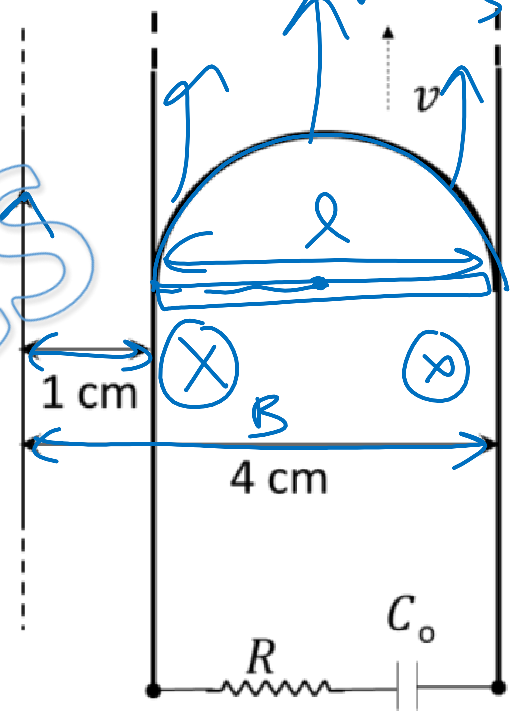
$$\frac{1}{\lambda} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\lambda = \lambda_0\left(\frac{n^2}{n^2-1}\right) \qquad \frac{1}{\lambda} = R\left(\frac{n^2-1}{n^2}\right) \Rightarrow \frac{1}{\lambda} = \left(\frac{n^2-1}{n^2}\right)\frac{1}{\lambda_0}$$

$$\frac{1}{\lambda_0} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R$$

JEE Adv. 2021 (P-1)

Q15) A long straight wire carries a current, $I = 2$ ampere. A semi-circular conducting rod is placed beside it on two conducting parallel rails of negligible resistance. Both the rails are parallel to the wire. The wire, the rod and the rails lie in the same horizontal plane, as shown in the figure. Two ends of the semi-circular rod are at distances 1 cm and 4 cm from the wire. At time $t = 0$, the rod starts moving on the rails with a speed $v = 3.0$ m/s (see the figure). A resistor $R = 1.4\ \Omega$ and a capacitor $C_0 = 5.0\ \mu F$ are connected in series between the rails. At time $t = 0$, C_0 is uncharged. Which of the following statement(s) is(are) correct? [$\mu_0 = 4\pi \times 10^{-7}$ SI units. Take $\ln 2 = 0.7$]



(A) Maximum current through R is 1.2×10^{-6} ampere

(B) Maximum current through R is 3.8×10^{-6} ampere

(C) Maximum charge on capacitor C_0 is 8.4×10^{-12} coulomb

(D) Maximum charge on capacitor C_0 is 2.4×10^{-12} coulomb

Difficulty Level: Moderate

Ans. A, C

$t = \infty,\ Q_{max} = C\varepsilon$

$= 5\mu \times 12 \times 1.4 \times 10^{-7}$

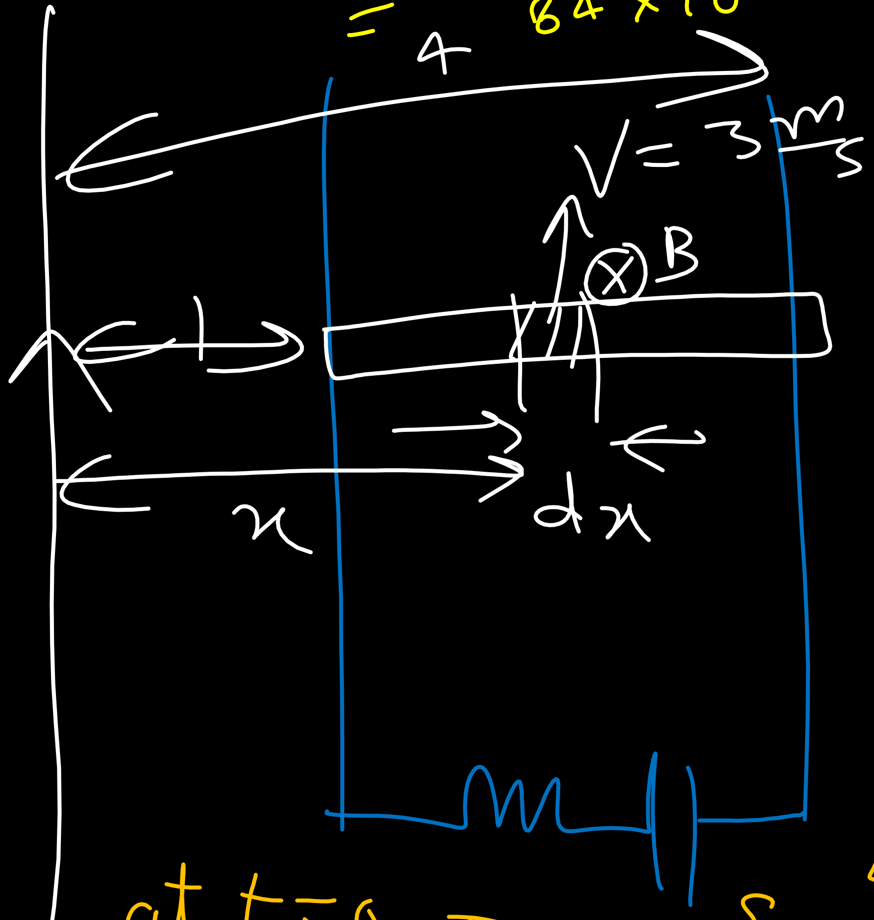
$= 84 \times 10^{-13}\ C$

$\ln 4 = \ln 2^2 = 2\ln 2 = 2 \times 0.7 = 1.4$

$d\varepsilon = B V dx$

$d\varepsilon = \frac{V \mu_0 I}{2\pi x} dx$

$\int d\varepsilon = \frac{V \mu_0 I}{2\pi} \int_1^4 \frac{dx}{x}$

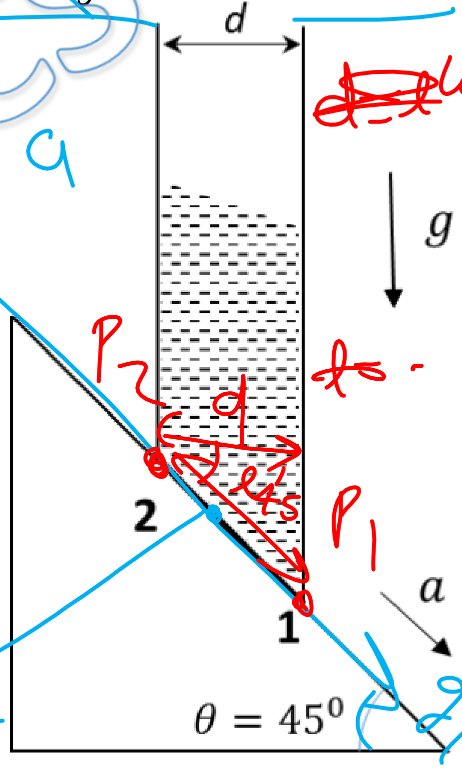


$\varepsilon = \frac{3 \times 4\pi \times 10^{-7} \times 2}{2\pi} \ln(4)$

$\varepsilon = 12 \times 10^{-7} \times 1.4\ V$

at $t = 0$, $I_{max} = \frac{\varepsilon}{R} = \frac{12 \times 1.4 \times 10^{-7}}{1.4} = 1.2 \times 10^{-6}\ A$

Q16) A cylindrical tube, with its base as shown in the figure, is filled with water. It is moving down with a constant acceleration a along a fixed inclined plane with angle $\theta = 45^0$. P_1 and P_2 are pressures at points 1 and 2, respectively, located at the base of the tube. Let $\beta = (P_1 - P_2)/(\rho g d)$, where ρ is density of water, d is the inner diameter of the tube and g is the acceleration due to gravity. Which of the following statement(s) is(are) correct?



(A) $\beta = 0$ when $a = g/\sqrt{2}$

(B) $\beta > 0$ when $a = g/\sqrt{2}$

(C) $\beta = \frac{\sqrt{2}-1}{\sqrt{2}}$ when $a = g/\sqrt{2}$

(D) $\beta = \frac{1}{\sqrt{2}}$ when $a = g/\sqrt{2}$

Difficulty Level: Difficult

Ans. A, C

$d = l \cos 45°$

$d = \frac{l}{\sqrt{2}}$

$l' = \sqrt{2} d$

$P_B = P_A + \rho g_{eff,AB} l'$

Q17) An α-particle (mass 4 amu) and a singly charged sulfur ion (mass 32 amu) are initially at rest. They are accelerated through a potential V and then allowed to pass into a region of uniform magnetic field which is normal to the velocities of the particles. Within this region, the α-particle and the sulfur ion move in circular orbits of radii r_α and r_S, respectively. The ratio (r_S/r_α) is 4.

$$r = \frac{m(vel)}{qB} = \frac{p}{qB} = \frac{\sqrt{2Km}}{qB} = \frac{\sqrt{2qVm}}{\sqrt{q}\,qB}$$

$$r = \sqrt{\frac{2Vm}{q}}\,\frac{1}{B} \propto \sqrt{\frac{m}{q}}$$

$$\frac{r_S}{r_\alpha} = \sqrt{\frac{m_S}{m_\alpha}}\sqrt{\frac{q_\alpha}{q_S}} = \sqrt{\frac{32}{4} \times \frac{2}{1}} = 4$$

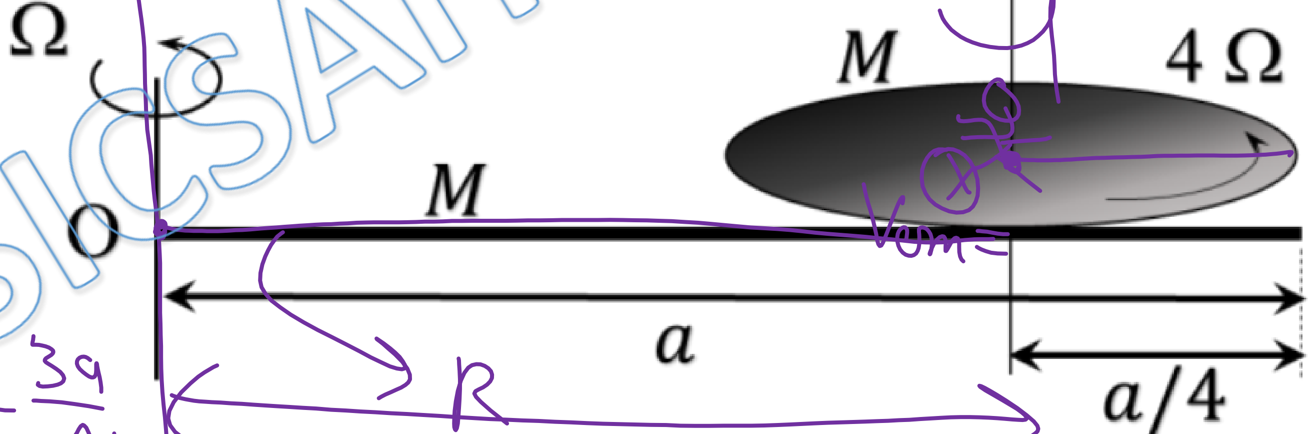
Difficulty Level: Easy

Ans. 4

JEE Adv. 2021 (P-1)

Q18) A thin rod of mass M and length a is free to rotate in horizontal plane about a fixed vertical axis passing through point O. A thin circular disc of mass M and of radius $a/4$ is pivoted on this rod with its center at a distance $a/4$ from the free end so that it can rotate freely about its vertical axis, as shown in the figure. Assume that both the rod and the disc have uniform density and they remain horizontal during the motion. An outside stationary observer finds the rod rotating with an angular velocity Ω and the disc rotating about its vertical axis with angular velocity 4Ω. The total angular momentum of the system about the point O is $\left(\frac{Ma^2\Omega}{48}\right)n$.

The value of n is ____.



Difficulty Level: Moderate

Ans. 49

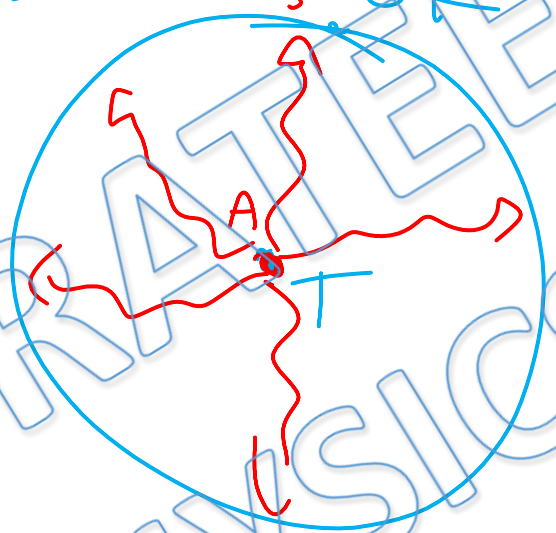
$$L_d = ma^2\Omega\left(\frac{2}{16}+\frac{9}{16}\right) = ma^2\Omega\frac{11}{16}$$

$$L_{sys} = L_s + L_d$$

$$= ma^2\Omega\left(\frac{1}{3}+\frac{11}{16}\right) = ma^2\Omega\left(\frac{16+33}{48}\right)$$

$$= \frac{49}{48}ma^2\Omega$$

Q19) A small object is placed at the center of a large evacuated hollow spherical container. Assume that the container is maintained at 0 K. At time $t = 0$, the temperature of the object is 200 K. The temperature of the object becomes 100 K at $t = t_1$ and 50 K at $t = t_2$. Assume the object and the container to be ideal black bodies. The heat capacity of the object does not depend on temperature. The ratio (t_2/t_1) is ____.



Difficulty Level: Moderate

Ans. 9

$$\frac{t_2}{t_1} = \frac{1 - \frac{1}{64}}{\frac{8}{8\times 8} - \frac{1}{64}}$$

$$= \frac{63/64}{7/64}$$

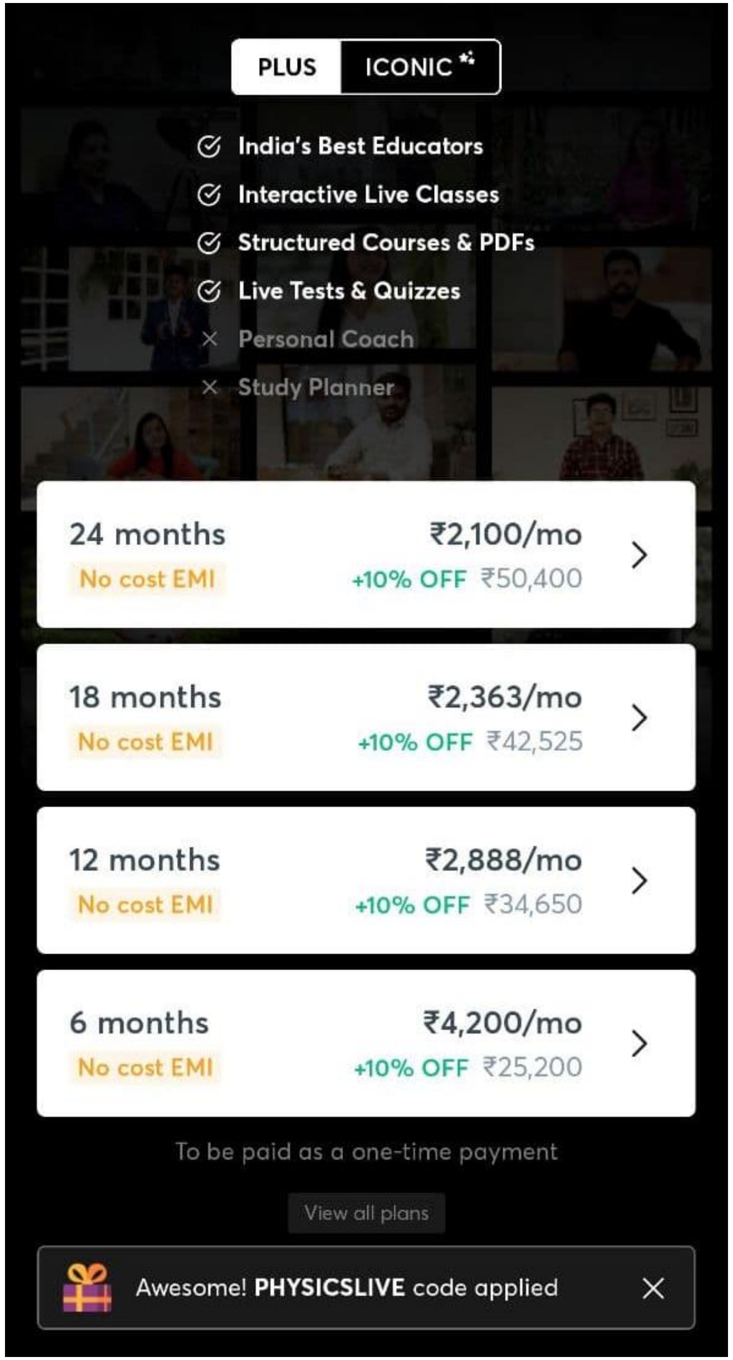
$$\frac{t_2}{t_1} = 9$$

$$\frac{1}{3}\left[\frac{1}{T^3}\right]_{200}^{T} = kt$$

$$\frac{1}{T^3} - \frac{1}{200^3} = 3kt$$

$$\frac{1}{100^3} - \frac{1}{200^3} = 3kt_1 = \frac{1}{50^3}\left(\frac{1}{2^3} - \frac{1}{4^3}\right)$$

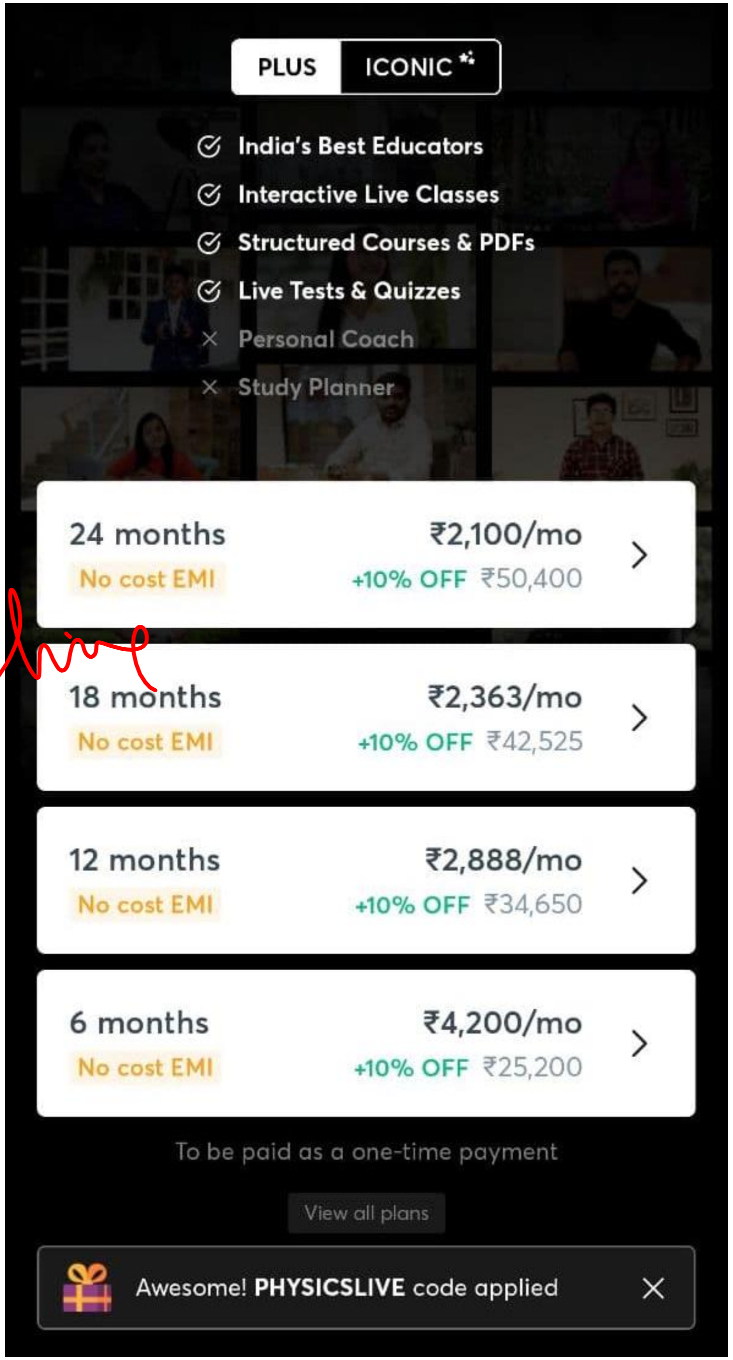
$$\frac{1}{50^3} - \frac{1}{200^3} = 3kt_2 = \frac{1}{50^3}\left(\frac{1}{1^3} - \frac{1}{4^3}\right)$$



PHYSICSLIVE

Telegram Channel:-
@UnacademyPhysicslive

Use code PHYSICSLIVE to get 10% OFF on Unacademy PLUS and learn from India's Top Faculties.



For Video Solution of JEE Adv. 2021 Physics Paper-1
Click on below link

Solution on Website:- https://physicsaholics.com/home/courseDetails/69

Solution on YouTube:- https://youtu.be/Z-iW5x0ikyk

SUBSCRIBE

@Physicsaholics

@Physicsaholics_prateek

@IITJEE_Physics
@NEET_Physics

physicsaholics.com

Unacademy

CLICK

Links are also in the description of the video.

Chalo Niklo