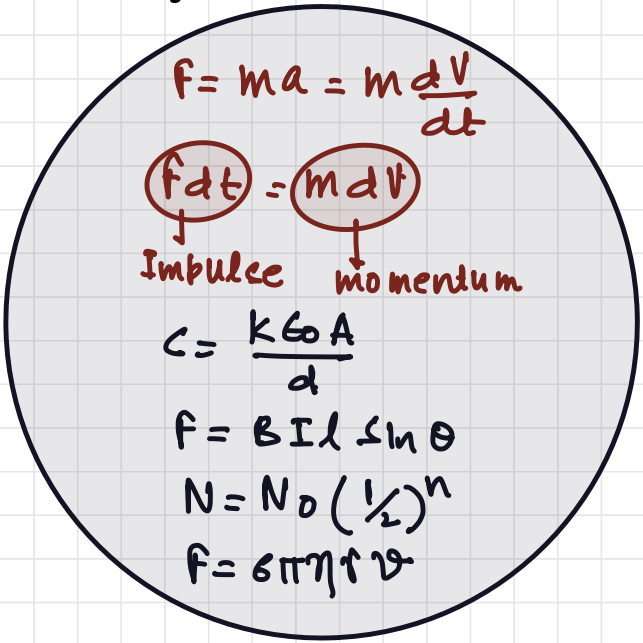
PHYSICS
JEE-MAIN (July-Attempt)
28 July (Shift-1)
Paper Solution



IIT JEE PHYSICS PAPER SOLUTION
28 JULY 2022
MORNING SHIFT
QUESTIONS BASED ON IMPULSE, FORCE EXPERIENCED BY CONDUCTOR IN MAGNETIC FIELD, INDUCTOR CURRENT LAG, SPRING, MI ARE TRICKY

KUMAR PHYSICS CLASSES
E 281 BASEMENT M BLOCK MAIN ROAD GREATER KAILASH 2 NEW DELHI
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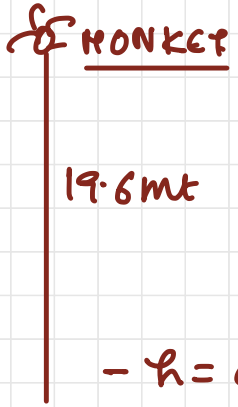
1. The dimensions of $\left(\frac{B^2}{\mu_0}\right)$ will be: (if μ_0 : permeability of free space and B : magnetic field)

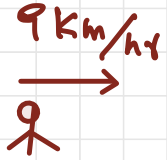
(A)[ML2 T-2]
(B)[MLT-2]
(C)[ML-1 T-2]
(D)[ML2 T-2 A-1]

$$\text{ENERGY DENSITY} = \frac{B^2}{2\mu_0}$$

$$\frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$$

2. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at height of 19.6 m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is :
(Given g = 9.8 m/s2)
(A) 5 m (B) 10 m (C) 19.8 m (D) 24.5 m





$-h = 0 - \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times19.6}{9.8}}$

$= 2$ second

└ Distance travelled by the cadet

$= v \times t$

$= 9 \times \frac{5}{18} \times 2$

$= 5$ m

3. In two different experiments, an objects of mass 5 kg moving with a speed of 25 ms-1 hits two different walls and comes to rest within (i) 3 second, (ii) 5 seconds, respectively. Choose the correct option out of the following:

(A) Impulse and average force acting on the object will be same for both the cases.

(B) Impulse will be same for both the cases but the average force will be different.

(C) Average force will be same for both the cases but the impulse will be different.

(D) Average force and impulse will be different for both the cases.

$$F = ma$$

$$F = m\frac{dv}{dt} = \frac{d(mv)}{dt} = \frac{dp}{dt}$$

$$F.dt = dp = m(\Delta v)$$

First case	Second case
Impulse $= 5(25-0)$	Impulse $= 5(25-0)$
$F_1 \Delta T = 125$ Ns	$F_2 \Delta T = 125$ Ns

$$F_1 = \frac{125}{\Delta T} = \frac{125}{3} N \qquad F_2 = \frac{125}{5} N$$

4. A balloon has mass 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If the balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne).
(A) 3 (B) 9 (C) 12 (D) 18

$$f = ma = m\frac{dv}{dt}$$

$$= v\frac{dm}{dt} = \left(\frac{4.5}{10}\frac{cm}{sec}\right)\left(\frac{10\,gm}{5\,sec}\right)$$

$$= 9\ dyne$$

5. If the radius of earth shrinks by 2% while its mass remains same. The acceleration due to gravity on the earth's surface will approximately:

(A) decrease by 2%
(B) decrease by 4%
(C) increase by 2%
(D) increase by 4%

$$g = \frac{GM}{R^2}$$

M → constant

$$\frac{\Delta g}{g} \times 100\% = 2\frac{\Delta R}{R} \times 100\%$$

$$= 2(2\%)$$

$$= 4\%$$

6. The force required to stretch a wire of cross-section 1 cm^2 to double its length will be : (Given Yung's modulus of the wire = 2×10^{11} N/m2)
(A) 1×10^7 N (B) 1.5×10^7 N (C) 2×10^7 N (D) 2.5×10^7 N

$$Y = \frac{F/A}{\Delta l/l}$$

$$F = Y A . \frac{\Delta l}{l}$$

$$= 2 \times 10^{11} \times 10^{-4} \frac{(2l - l)}{l}$$

$$= 2 \times 10^7 \text{ N}$$

7. A Carnot engine has efficiency of 50%. If the temperature of sink is reduced by 40° C, its efficiency increases by 30%. The temperature of the source will be:

(A) 166.7 K

(B) 255.1 K

(C) 266.7 K ✓

(D) 367.7 K

$$\eta = 1 - \frac{T_L}{T_H}$$

$$\frac{1}{2} = 1 - \frac{T_L}{T_H}$$

$$\frac{T_L}{T_H} = 1 - \frac{1}{2} = \frac{1}{2}$$

$$\frac{1}{2}(1.3) = 1 - \frac{T_L - 40}{T_H}$$

$$\frac{1.3}{2} = 1 - \frac{T_L}{T_H} - \frac{40}{T_H}$$

$$\frac{1.3}{2} = 1 - \frac{1}{2} + \frac{40}{T_H}$$

$$\frac{1.3}{2} - \frac{1}{2} = + \frac{40}{T_H}$$

$$\frac{0.3}{2} = + \frac{40}{T_H} \Rightarrow T_H = 266.7\,K$$

8. Given below are two statements:
Statement I : The average momentum of a molecule in a sample of an ideal gas depends on temperature.
Statement II : The rms speed of oxygen molecules in a gas in v If the temperature is doubled and the oxygen molecules dissociate into oxygen atoms, the rms speed will become $2v$.
In the light of the above statements, choose the correct answer from the options given below:

(A) Both Statement I and Statement II are true
(B) Both Statement I and Statement II are false
(C) Statement I is true but Statement II is false
(D) Statement I is false but Statement II is true

✓

$P_{avg} = 0$ (Due to random motion)

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$T_{NEW} = 2T$

$M_{NEW} = M/2$

$$\frac{V_{NEW}}{V} = \frac{\sqrt{\frac{2T}{M/2}}}{\sqrt{T/M}} = 2 \Rightarrow V_{NEW} = 2V$$

9. In the wave equation
$y = 0.5 \sin \frac{2\pi}{\lambda}(400\,t - x)$ m λ

The velocity of the wave will be:

(A) 200 m/s
(B) 200√2 m/s
(C) 400 m/s
(D) 400√2 m/s

$$y = 0.5 \sin\left[\frac{2\pi}{\lambda}(400t) - \frac{2\pi}{\lambda}x\right]$$

Compare with

$$y = a \sin\left[\frac{2\pi}{\lambda}vt - \frac{2\pi}{\lambda}x\right]$$

$$\frac{2\pi}{\lambda}vt = \frac{2\pi}{\lambda}(400t)$$

$$v = 400 \text{ m/s}$$

10. Two capacitors, each having capacitance 40 μ F are connected in series. The space between one of the capacitors is filled with dielectric material of dielectric constant K such that the equivalence capacitance of the system became 24 μ F. The value of K will be :

(A) 1.5 (B) 2.5 (C) 1.2 (D) 3

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$24 = \frac{(C)(KC)}{C + KC}$$

$$24 = \frac{K(40)}{K+1}$$

$$24K + 24 = 40K$$

$$24 = 16K \Rightarrow K = \frac{24^3}{16_2}$$

$$= 1.5$$

11. A wire of resistance R1 is drawn out so that its length is increased by twice of its original length. The ratio of new resistance to original resistance is:

(A) 9 : 1 (B) 1 : 9 (C) 4 : 1 (D) 3 : 1

$R_1 = \frac{\rho l_1}{A_1}$ | $R_2 = \frac{\rho l_2}{A_2}$

But volume remains constant

$A_1 l_1 = A_2 l_2$

$A_1 (l) = A_2 (3l) \Rightarrow \frac{A_1}{A_2} = 3$

$$\frac{R_1 = \frac{\rho l_1}{A_1}}{R_2 = \frac{\rho l_2}{A_2}} \Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1}$$

$$= \frac{l}{3l} \times \frac{1}{3}$$

$\frac{R_1}{R_2} = \frac{1}{9}$ ← $\frac{R_2}{R_1} = 9$

12. The current sensitivity of a galvanometer can be increases by
(A) Decreasing the number of turns
(B) Increasing the magnetic field
(C) Decreasing the area of the coil
(D) Decreasing the torsional constant of the spring

Choose the most appropriate answer from the options given below:
(A) (B) and (C) only
(B) (C) and (D) only
(C) (A) and (C) only
(D) (B) and (D) only ✓

$$NBIA = k\theta$$

$$I = \frac{k\theta}{NBA}$$

$$\frac{\Delta\theta}{\Delta I} = \frac{NBA}{k}$$

Current sensitivity can be increased only when $N\uparrow, B\uparrow, A\uparrow, k\downarrow$

13. As shown in the figure, a metallic rod of linear density 0.45 kg m-1 is lying horizontally on a smooth inclined plane which makes an angle of 45° with the horizontal. The minimum current flowing in the rod required to keep it stationary, when 0.15 T magnetic field is acting on it in the vertical upward direction, will be:

(A) 30 A

(B) 15 A

(C) 10 A

(D) 3 A

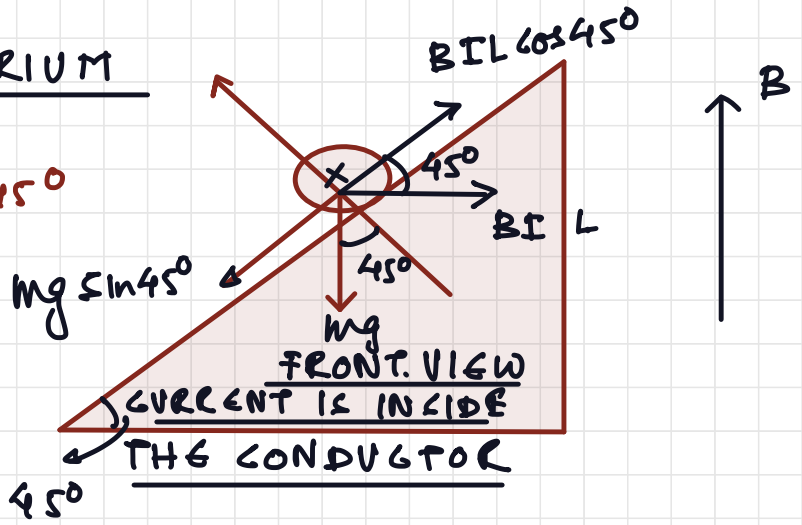
UNDER EQUILIBRIUM CONDITION

$mg \sin 45^\circ = BIL \cos 45^\circ$

$I = \left(\frac{m}{L}\right)\left(\frac{g}{B}\right)$

$= \frac{0.45 \times 10}{0.15}$

$= 30A$



14. The equation of current in a purely inductive circuit is $5 \sin(49\pi t - 30^\circ)$. If the inductance is 30 mH then the equation for the voltage across the inductor, will be :
{Let $\pi = 22/7$}

(A) $1.47 \sin(49\pi t - 30^\circ)$
(C) $23.1 \sin(49\pi t - 30^\circ)$
(B) $1.47 \sin(49\pi t + 60^\circ)$
(D) $23.1 \sin(49\pi t + 60^\circ)$

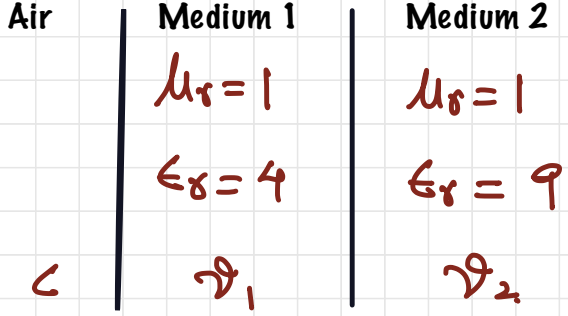
$V_0 = I_0 (X_L)$

$= 5(49)\pi (30 \times 10^{-3}) = 23.1$ Volt

Voltage leads to current by 90°.

$V = 23.1 \sin(49\pi t + 60^\circ)$

15. As shown in the figure, after passing through the medium 1. The speed of light v_2 in medium 2 will be :
(Given $c = 3 \times 10^8$ ms-1)



(A) 1.0×10^8 ms^{-1} (B) 0.5×10^8 ms^{-1} (C) 1.5×10^8 ms^{-1} (D) 3.0×10^8 ms^{-1}

$$\mu = \frac{v_a}{v_m} = \frac{\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r}}{\sqrt{\mu_0 \epsilon_0}}$$

$$\frac{c}{v} = \sqrt{\mu_r \epsilon_r}$$

$$\frac{c}{v} = \sqrt{(1)(9)}$$

$$v = c/3 = \frac{3 \times 10^8}{3} = 10^8 \text{ m s}^{-1}$$

16. In normal adjustment, for a refracting telescope, the distance between objective and eye piece is 30 cm. The focal length of the objective, when the angular magnification of the telescope is 2, will be :

(A) 20 cm (B) 30 cm (C) 10 cm (D) 15 cm

$$f_o + f_e = 30$$

$$m = \frac{f_o}{f_e} \Rightarrow 2 = \frac{f_o}{f_e} \Rightarrow f_o = 2f_e$$

$$f_o + \frac{f_o}{2} = 30$$

$$\frac{3f_o}{2} = 30$$

$$f_o = 20\,cm$$

17. The equation $\lambda = \frac{1.227}{x}$ nm can be used to find the de-Brogli wavelength of an electron. In this x equation x stands for:
Where
m = mass of electron
P = momentum of electron
K = Kinetic energy of electron
V = Accelerating potential in volts for electron

(A) $\sqrt{mK}$ (B) $\sqrt{P}$ (C) $\sqrt{K}$ (D) $\sqrt{V}$ ✓

$KE = \frac{1}{2} m v^2$

$v = \sqrt{\frac{2(KE)}{m}}$

$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2(KE)}{m}}}$

$= \frac{h}{\sqrt{2m(KE)}} = \frac{h}{\sqrt{2mqV}}$

$\lambda = \frac{12.27}{\sqrt{V}}$ Å

$= \frac{1.227}{\sqrt{V}}$ nm.

$x = \sqrt{V}$

18. The half life period of a radioactive substance is 60 days. The time taken for 7/8th of its original mass to disintegrate will be:

(A) 120 days (B) 130 days (C) 180 days (D) 20 days

7/8 → disintigrate

Left = 1/8 th

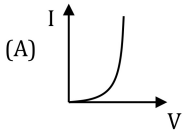
$N = N_0 \left(\frac{1}{2}\right)^n$

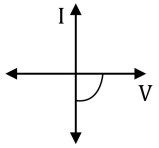
$\frac{1}{8} N_0 = N_0 \left(\frac{1}{2}\right)^n \Rightarrow n = 3$

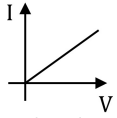
Total time $= n\,(T_{1/2})$

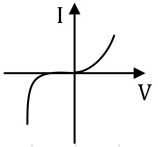
$= 3(60) = 180$ Days

19. Identify the solar cell characteristics from the following options:

(A) 

(B) 

(C) 

(D) 

20. In the case of amplitude modulation to avoid distortion the modulation index (μ) should be :
(A) $\mu \leq 1$ (B) $\mu \geq 1$ (C) $\mu = 2$ (D) $\mu = 0$

$$\mu = \frac{A_m}{A_c}$$

$\mu \leq 1$ to avoid distortion
because $\mu > 1$ will result in interference between carrier frequency & message frequency.

21. If the projection of $2\hat{i} + 4\hat{j} - 2k$ on $\hat{i} + 2\hat{j} + \alpha k$ is zero. Then, the value of α will be _____.

Sol. (5)

$$\vec{a} \cdot \vec{b} = 0$$

$$2(1) + 4(2) - 2\alpha = 0$$

$$2 + 8 - 2\alpha = 0$$

$$2\alpha = 10$$

$$\alpha = 5$$

22. A freshly prepared radioactive source of half life 2 hours 30 minutes emits radiation which is 64 times the permissible safe level. The minimum time, after which it would be possible to work safely with source, will be _____ hours.

$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$\frac{N_0}{64} = N_0 \left(\frac{1}{2}\right)^n$$

$$\left(\frac{1}{2}\right)^6 = \left(\frac{1}{2}\right)^n$$

$$n = 6$$

Total time $= n\,(T_{1/2})$

$= 6\,(2.5) = 15$-hours

23. In a Young's double slit experiment, a laser light of 560 nm produces an interference pattern with consecutive bright fringes' separation of 7.2 mm. Now another light is used to produce an interference pattern with consecutive bright fringes' separation of 8.1 mm. The wavelength of second light is _____ nm.

Sol. (630)

$$\beta = \frac{\lambda D}{d}$$

$$\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} \Rightarrow \beta_2 = \frac{\lambda_2}{\lambda_1}\beta_1$$

$$= \left(\frac{9}{8}\right) \times 500$$

$$= 630 \text{ nm}$$

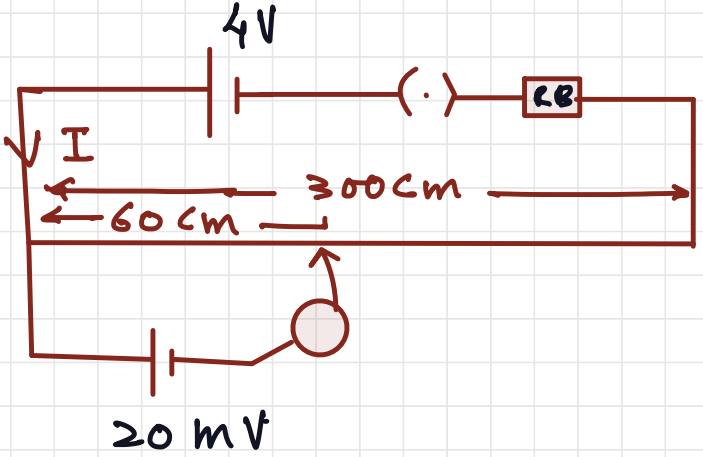
24. The frequencies at which the current amplitude in an LCR series circuit becomes $1/\sqrt{2}$ times its maximum value, are 212 rad s-1 and 232 rad s-1. The value of resistance in the circuit is R = 5Ω. The self inductance in the circuit is _____ mH.

Sol. (250)

$$\text{BAND WIDTH} = (232-212) = R/L$$

$$L = \frac{5}{20} = 250 \text{ mH}$$

25. As shown in the figure, a potentiometer wire of resistance 20 Ω and length 300 cm is connected with resistance box (R. B.) and a standard cell of emf 4 V. For a resistance 'R' of resistance box introduced into the circuit, the null point for a cell of 20 mV is found to be 60 cm. The value of 'R' is ____780____ Ω



300 cm ⟶ 20-ohm

60 cm ⟶ $\frac{20\times 60}{300} = 4$ ohm

$$I = \frac{4}{R_B + 20}$$

$$20\times 10^{-3} = \left(\frac{4}{R_B+20}\right)(4)$$

$$\frac{20}{1000} = \frac{16}{R_B+20} \Rightarrow 800 = R_B + 20$$

$$R_B = 780\text{-ohm}$$

26. The electric dipoles of dipole moments 1.2×10^{-30} Cm and 2.4×10^{-30} Cm are placed in two different uniform electric fields of strengths 5×10^{4} NC-1 and 15×10^{4} NC-1 respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is _____.

Sol. (6)

$$\tau = pE$$

$$\frac{\tau_1}{\tau_2} = \frac{p_1 E_1}{p_2 E_2} = \frac{1.2 \times 10^{-30} \times 5 \times 10^{4}}{2.4 \times 10^{-30} \times 15 \times 10^{4}} = \frac{1}{6}$$

$x = 6$

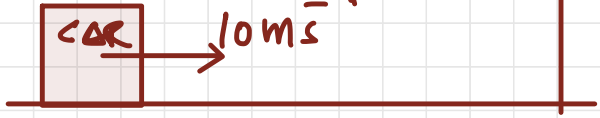
27-The frequency of echo will be ___340___ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km/h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330 m/s.

Sol. (340)

freq heard by the hill $\rightarrow f_1 = f\left(\frac{v}{v+v_s}\right)$

$= \left(\frac{330}{320}\right) \times 320 = 330\ Hz$

freq heard by car after reflection $= f_1\left(\frac{v+v_0}{v}\right)$



$= 330\left(\frac{330+10}{330}\right) = 340\ Hz$

28. The diameter of an air bubble which was initially 2 mm, rises steadily through a solution of density 1750 kg m-3 at the rate of 0.35 cms-1. The coefficient of viscosity of the solution is _____ poise (in nearest integer). (The density of air is negligible).

Sol. (1 1)

$$\frac{4}{3}\pi r^3 \rho g = 6\pi \eta r v$$

$$\frac{r^3 \rho g (4)}{3 \times 6 r v} = \eta.$$

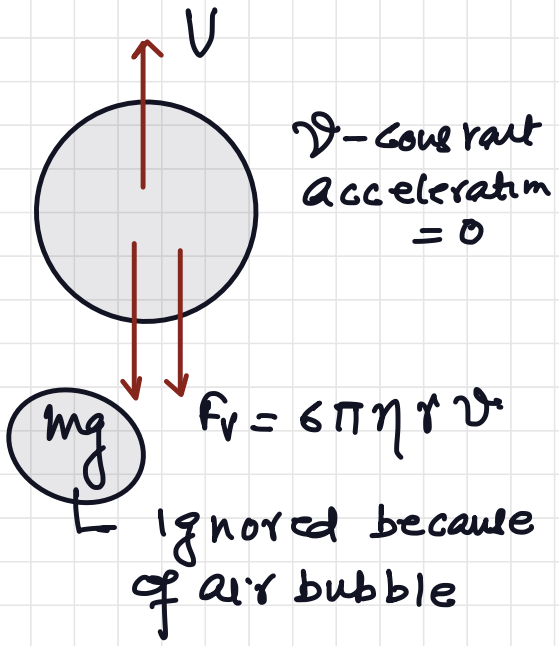
$r = 1 \times 10^{-3}$ mt

$\rho = 1.75 \times 10^3$ kg/mt^3

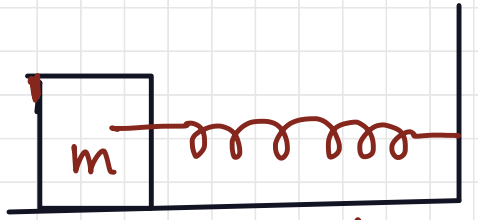
$v = 0.35 \times 10^{-2}$ mt/sec

$$\eta = \frac{10}{9} = 1.11 \text{ SI unit}$$

$= 11$ poise (CGS)



29. A block of mass 'm' (as shown in figure) moving with kinetic energy E compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be nE Nm^{-1} for n = ____24____.



$$W_{NET} = K_f - K_i$$

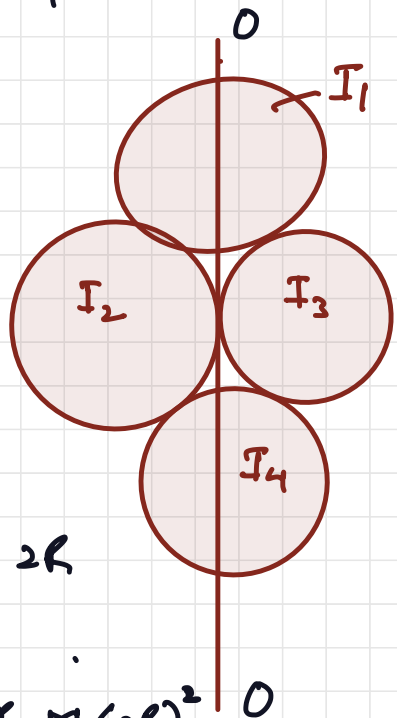
$$-\frac{1}{2}kx^2 = \frac{1}{2}m\left(\frac{V}{2}\right)^2 - \frac{1}{2}mV^2$$

$$k = \frac{3E}{2x^2}$$

$$k = \frac{3E}{2(1/4)^2} = 24E$$

$$n = 24$$

' 30. Four identical discs each of mass 'M' and diameter 'a' are arranged in a small plane as shown in figure. If the moment of inertia of the system about 00' is $\frac{x}{4} Ma^2$ Then, the value of x will be



$$I = I_1 + I_2 + I_3 + I_4$$

$$= (I_1 + I_4) + (I_2 + I_3)$$

$$= \left(\frac{MR^2}{4} \times 2\right) + 2\left(\frac{MR^2}{4} + MR^2\right)$$

$$= \frac{MR^2}{2} + 2\left(\frac{5MR^2}{4}\right)$$

$$= \frac{MR^2}{2} + \frac{5MR^2}{2} \qquad a = 2R$$

$$= 3MR^2 = \frac{x}{4} Ma^2 = \frac{x}{4} M(2R)^2$$

$$3MR^2 = \frac{x}{4} M(4R^2)$$

$x = 3$

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IIT JEE PHYSICS PAPER SOLUTION 28 JULY 2022 MORNING SHIFT

QUESTIONS BASED ON IMPULSE, FORCE EXPERIENCED BY CONDUCTOR IN MAGNETIC FIELD,INDUCTOR CURRENT LAG, SPRING,MI ARE TRICKY