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PAPER-1 (B.E./B. TECH.)

JEE (Main) 2020

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 04 September, 2020 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT : PHYSICS

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PART : PHYSICS

SECTION – 1 : (Maximum Marks : 80)

Straight Objective Type (सीधे वस्तुनिष्ठ प्रकार)

This section contains **20 multiple choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

इस खण्ड में **20 बहु–विकल्पी प्रश्न** हैं। प्रत्येक प्रश्न के 4 विकल्प (1), (2), (3) तथा (4) हैं, जिनमें से **सिर्फ एक सही** है।

1. A small bar magnet is placed with its axis at 30° with an external magnetic field of 0.06 T experiences a torque of 0.018 Nm. The minimum work required to rotate it from its stable to unstable equilibrium position is:

(1) 9.2×10^{-3} J (2) 11.7×10^{-3} J (3) 6.4×10^{-2} J (4) 7.2×10^{-2} J

Ans. **(4)**

Sol. $\tau = MB\sin\theta = 0.18$

$$M = \frac{0.018}{B\sin\theta} = \frac{0.018}{0.06 \times 0.5} = 0.6A - m^2$$

$\omega = \Delta U = U_f - U_i$

$= -MB\cos180° - (-MB\cos0°)$

$= 2MB$

$= 2 \times 0.6 \times 0.06$

$= 0.072$ J

2. On the x-axis and at a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{(x^2+a^2)^{3/2}}$ in the x-direction. The magnitude of the gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity is:

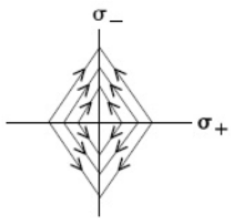
(1) $\frac{A}{(x^2+a^2)^{3/2}}$ (2) $A(x^2 + a^2)^{3/2}$ (3) $A(x^2 + a^2)^{1/2}$ (4) $\frac{A}{(x^2+a^2)^{1/2}}$

Ans. **(4)**

Sol. $V_x = -\int_{\infty}^{x} \frac{Ax}{(A^2+x^2)^{3/2}}(-dx)$

$$V_x = -\frac{A}{\sqrt{A^2+x^2}}$$

3. Two charged thin infinite plane sheets of uniform charge density σ_+ and σ_-, where $|\sigma_+| > |\sigma_-|$, intersect at the right angle. Which of the following best represents the electric field lines for the system:

(1)


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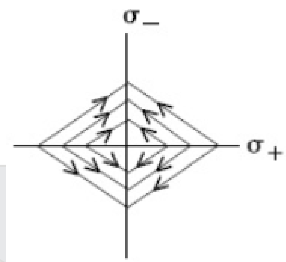

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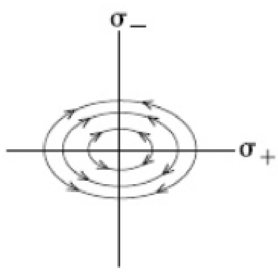

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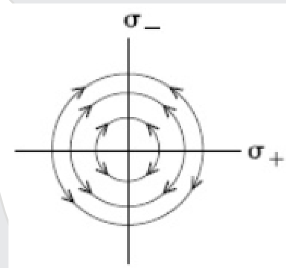


Ans. **(2)**

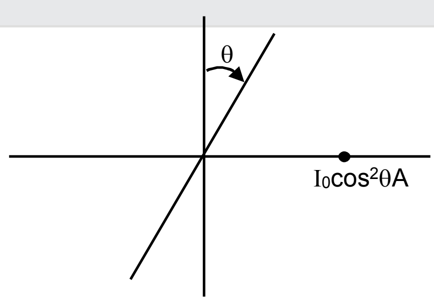
Sol. The electric field intensity due to each uniformly charged infinite plane is uniform. The electric field intensity at points A, B, C and D due to plane 1, plane 2 and both planes are given by E_1, E_2 and E as shown in figure 1. Hence the electric lines of forces are as given in figure 2.

4. A beam of plane polarised light of large cross-sectional area and uniform intensity of 3.3 Wm^{-2} falls normally on a polariser(cross sectional area 3×10^{-4} m^2) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to:

(1) 1.0×10^{-4} J (2) 5.0×10^{-4} J (3) 1.0×10^{-5} J (4) 1.5×10^{-4} J

Ans. **(1)**

Sol.



Average energy = $I_0A < \cos^2\theta >$

$$= \frac{3.3 \times 3 \times 10^{-4}}{2} = \frac{9.9}{2} \times 10^{-4} = 4.95 \times 10^{-4}$$

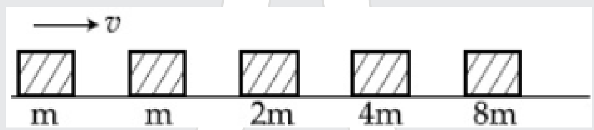
5. Choose the correct option relating wavelengths of different parts of electromagnetic wave spectrum:

(1) $\lambda_{\text{radio waves}} > \lambda_{\text{micro waves}} > \lambda_{\text{visible}} > \lambda_{\text{x-rays}}$
(2) $\lambda_{\text{visible}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{x-rays}}$
(3) $\lambda_{\text{visible}} > \lambda_{\text{x-rays}} > \lambda_{\text{radio waves}} > \lambda_{\text{micro waves}}$
(4) $\lambda_{\text{x-rays}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{visible}}$

Ans. **(1)**

Sol. Theory based

6. Blocks of masses m, 2m, 4m and 8m are arranged in a line of a frictionless floor. Another block of mass m, moving with speed υ along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. Bt the time the last block of mass 8m starts moving the total energy loss is p% of the original energy. Value of 'p' is close to :



(1) 87 (2) 37 (3) 77 (4) 94

Ans. **(4)**

Sol.

Inelastic collision

mv = 16 mv[1]

$$v^1 = \frac{v}{16}$$

$$\Delta K \text{ loss} = \frac{1}{2}mv^2 - \frac{1}{2}(16M)\left(\frac{v}{16}\right)^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}M\frac{v^2}{16}$$

$$= \frac{1}{2}mv^2\left(\frac{15}{16}\right)$$

$$\% \Delta K \text{ loss} = \frac{\frac{1}{2}mv^2\left(\frac{15}{16}\right)}{\frac{1}{2}MV^2} \times 100 = \frac{15}{16} \times 100 = 93.75\%$$

7. A particle of mass $m_A = m/2$ moving along the x-axis with velocity v_0 collides elastically with another particle B at rest having mass $m_B = m/e$. If both the particles move along the x-axis after the collision, the change $\Delta\lambda$ in the wavelength of the particle A, in terms of its de-Broglie wavelength (λ_0) before the collision is :

(1) $\Delta\lambda = 2\lambda_0$ (2) $\Delta\lambda = 4\lambda_0$ (3) $\Delta\lambda = \frac{3}{2}\lambda_0$ (4) $\Delta\lambda = \frac{5}{2}\lambda_0$

Ans. **(2)**

Sol. [m/2] → v [m/3] = [m/2] → V_1 [m/3] → V_2

rest

$$v_1 = \frac{2(m/3)0}{\left(\frac{m}{2}+\frac{m}{3}\right)} + \frac{\left(\frac{m}{2}-\frac{m}{3}\right)v}{\left(\frac{m}{2}+\frac{m}{3}\right)} = \frac{v}{5}$$

For particle A,

Initial de-Broglie wavelength

$$\lambda_0 = \frac{h}{\frac{m}{2}v} = \frac{2h}{mv}$$

Final de-Broglie wavelength after collision.

$$\lambda_1 = \frac{h}{\frac{m}{2}\frac{v}{5}} = \frac{10h}{mv} = 5\lambda_0$$

Change in De-Broglie wavelength $\Delta\lambda = \lambda_1 - \lambda_0 = 4\lambda_0$

8. A battery of 3.0 V is connected to a resistor dissipating 0.5 W of power. If the terminal voltage of the battery is 2.5 V, the power dissipated within the internal resistance is :

(1) 0.125 W (2) 0.50 W (3) 0.10 W (4) 0.072 W

Ans. **(3)**

Sol. E = 3V

$V_R = 2.5V$

By KVL

$V_r + V_R = E$

$V_r + 2.5 = 3$

$V_r = 0.5$

$$\frac{V_R}{V_r} = \frac{IR}{Ir} = \frac{2.5}{0.5} = 5 \quad \text{......(1)}$$

$\frac{R}{r} = 5$

$\frac{P_R}{P_r} = \frac{I^2R}{I^2r} = \frac{R}{r}$

$\frac{P_R}{P_r} = 5$

$P_r = \frac{P_R}{5} = \frac{0.5}{5} = 0.1\,\text{watt}$

9. The specific heat of water = 4200 J-kg^{-1} K^{-1} and the latent heat of ice = 3.4 × 10^5 J-kg^{-1}.100 grams of ice at 0ºC is placed in 200 g of water at 25ºC. The amount of ice that will melt as the temperature of water reaches 0ºc is close to (in grams)

(1) 61.7 (2) 69.3 (3) 64.6 (4) 63.8

Ans. **(1)**

Sol. $MS\Delta T = M\ell$

$\frac{200}{1000} \times 4200 \times 25 = m \times 340 \times 10^3$

m = 61.7

10. Match the C_p/C_v ratio for ideal gases with different type of molecules:

Molecule Type	C_p / C_v
(A) Monoatomic	(I) 7/5
(B) Diatomic rigid molecules	(II) 9/7
(C) Diatomic non-rigid molecules	(III) 4/3
(D) Triatomic rigid molecules	(IV) 5/3

(1) (A) – (III), (B) – (IV), (C) – (II), (D) – (I)

(2) (A) – (IV), (B) – (I), (C) – (II), (D) – (III)

(3) (A) – (IV), (B) – (II), (C) – (I), (D) – (III)

(4) (A) – (II), (B) – (III), (C) – (I), (D) – (IV)

Ans. **(2)**

Sol. $\gamma = 1 + 2/f$

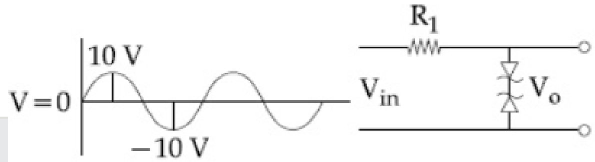
For A ; f = 3 ; $\gamma = 1 + \frac{2}{3} = \frac{5}{3}$

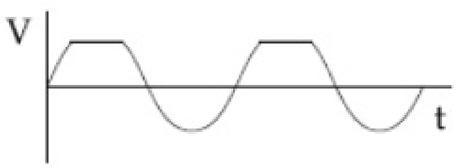
For B ; f = 5 ; $\gamma = 1 + \frac{2}{5} = \frac{7}{5}$

For C ; f = 7 ; $\gamma = 1 + \frac{2}{7} = \frac{9}{7}$

For D ; f = 6 ; $\gamma = 1 + \frac{2}{6} = \frac{4}{3}$

11. Take the breakdown voltage of the zener diode used in the given circuit as 6V. For the input voltage shown in the figure below, the time variation of the output voltage is : (Graphs drawn are schematic and not to the scale)



(1)


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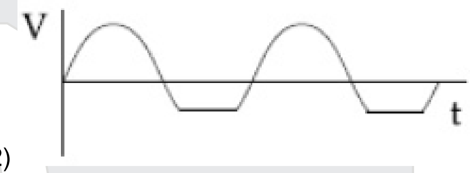

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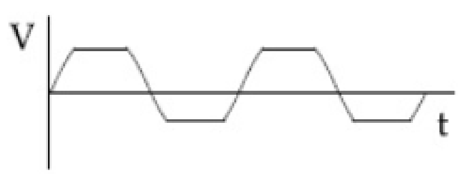

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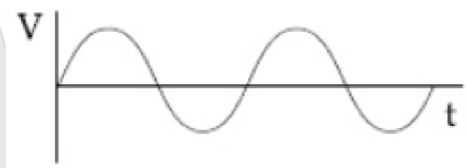


Ans. **(3)**

Sol. Based on Theory

12. A air bubble of radius 1 cm in water has an upward acceleration of 9.8 cms^{-2}. The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is (g = 980 cm/s^2).

(1) 4.15 gm (2) 1.52 gm (3) 4.51 gm (4) 3.15 gm

Ans. **(1)**

Sol. $F_b - mg = ma$

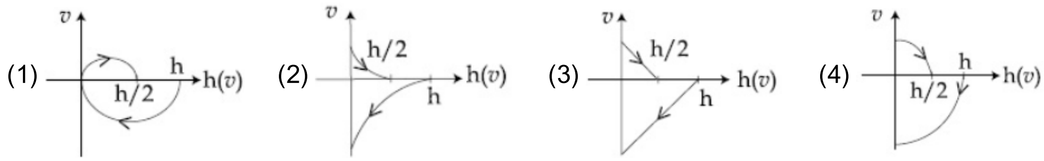
$F_b = m(g + a)$

$= \frac{4}{3}\pi r^3 \rho g = m(g + a)$

$m = \frac{4}{3}\pi(1)g = m(980 + 9.8)$

m = 4.15

13. A tennis ball is released from a height h and after freely on a wooden floor it rebounds and reaches height h/2. The velocity versus height of the ball during its motion may be represented graphically by : (graphs are drawn schematically and on not to scale)



Ans. **(4)**

Sol. (i) For uniformly accelerated / deaccelerated motion

$v^2 = u^2 \pm 2gh$

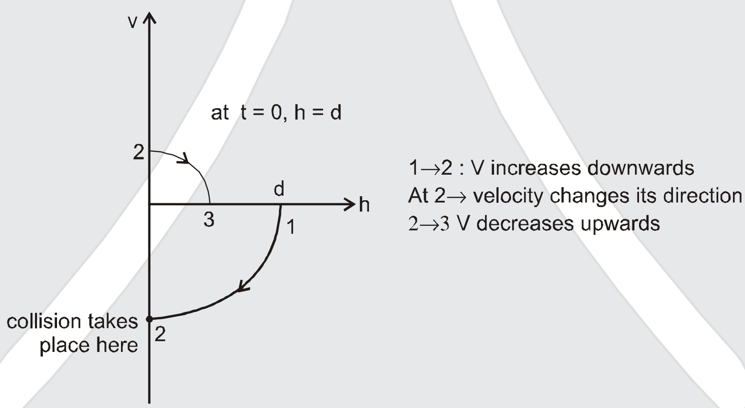
i.e. v-h graph will be a parabola (because equation is quadratic).

(ii) Initially velocity is downwards (-ve) and then after collision it reverses its direction with lesser magnitude. i.e. velocity is upwards (+ve). Graph (A) satisfies both these conditions.

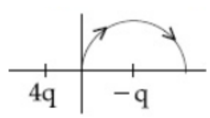
Therefore, correct answer is (A)

Note that time t = 0 corresponds to the point on the graph where h = d

Next time collision takes place at 3.



14. A two point charges 4q and –q are fixed on the x-axis at x = -d/2 and x= d/2, respectively. If the third point charge 'q' is taken from the origin to x= d along the semicircle as shown in the figure, the energy of the charge will :



(1) Increase by $\frac{2q^2}{3\pi \in_0 d}$ (2) Increase by $\frac{2q^2}{4\pi \in_0 d}$

(3) decrease by $\frac{q^2}{4\pi \in_0 d}$ (4) decrease by $\frac{4q^2}{3\pi \in_0 d}$

Ans. **(4)**

Sol. Potential at O,

$$\Rightarrow \quad V_0 = \frac{K4q}{\frac{d}{2}} + \frac{K(-q)}{\frac{d}{2}} = \frac{6Kq}{d}$$

Potential at P,

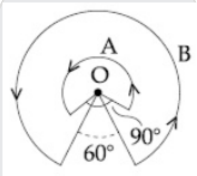
$$\Rightarrow \quad V_P = \frac{K4q}{\frac{3d}{2}} + \frac{K(-q)}{\frac{d}{2}} = \frac{2Kq}{3d}$$

Change in potential energy of a charge q = $q\Delta V = q(V_f - V_i)$

$= q(V_P - V_O)$

$$q\left(\frac{2Kq}{3d} - \frac{6Kq}{d}\right) = -\frac{16q^2}{4\pi\varepsilon_0 3d} = -\frac{4q^2}{3\pi\varepsilon_0 d}$$

15. A wire A, bent in the shape of an arc of a circle, carrying a current of 2A and having radius 2 cm and another wire B, also bent in the shape of an arc of a circle, carrying a current of 3A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires A and B at the common centre O is :



(1) 6 : 5 (2) 6 : 4 (3) 2 : 5 (4) 4 : 6

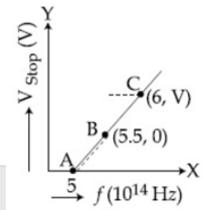
Ans. **(1)**

Sol. $B_C = \frac{\mu_0 I}{4\pi R}(\theta)$ (θ angle substance at centre)

$$\frac{B_{large}}{B_{small}} = \frac{i_1}{i_2} \times \frac{R_2}{R_1}\frac{(2\pi - \pi/2)}{(2\pi - \pi/3)}$$

$$= \frac{2}{2} \times \frac{2}{3} \times \frac{3\pi}{2} \times \frac{3}{5\pi} = \frac{6}{5}$$

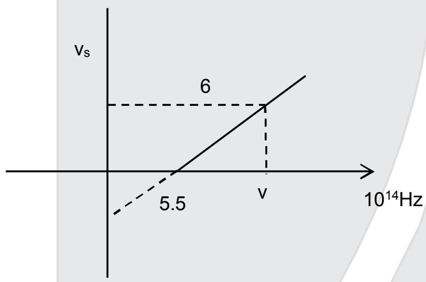
16. Given figure shows few data points in a photo-electric effect experiment for a certain metal. The minimum energy for ejection of electrons from its surface is : (Planck's constant h = 6.62 × 10^{-34} J-s)



(1) 2.10 eV (2) 2.59 eV (3) 1.93 eV (4) 2.27 eV

Ans. **(4)**

Sol.



Threshold Energy = hv

= 6.62 × 10^{-34} × 5.5 × 10^{14} J

Work friction $= \frac{6.62 \times 5.5 \times 10^{-20}}{1.6 \times 10^{-19}}$ eV = 2.27 eV

17. For a transvers wave travelling, along a straight line, the distance between two peaks (crests) is 5m, while the distance between one crest and one trough is 1 : 5 m. The possible wavelengths (in m) of the waves are :

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

Ans. **(3)**

Sol. Trough to crest distance

$$1.5 = (2n_1 + 1)\frac{\lambda}{2} \quad \ldots(1)$$

Trough to trough distance

$$5 = (n_2\lambda) \quad \ldots(2)$$

from (1) and (2)

$$\frac{1.5}{5} = \frac{2n_1 + 1}{2(n_2)}$$

$3n_2 = 10n_1 + 5$

n_1 and n_2 are integer

(1) $n_1 = 1$, $n_2 = 5$, $\lambda = 1$

(2) $n_1 = 4$, $n_2 = 15$, $\lambda = 1/3$

(3) $n_1 = 7$. $n_2 = 25$, $\lambda = 1/5$

18. Standing from the origin at time t = 0, with initial velocity $5\hat{j}\,ms^{-1}$, a particle moves in the x-y plane with a constant acceleration of $(10\,\hat{i} + 4\,\hat{j})\,ms^{-2}$. At time t, its coordinates are (20m, y_0 m). The values of t and y_0 are, respectively :

(1) 4s and 52 m (2) 2s and 24 m (3) 2s and 18 m (4) 5s and 25 m

Ans. **(3)**

Sol. Equation (1)

$S_x = \frac{1}{2}a_x t^2$

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

t = 2

Equation (2)

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

$y = 5(2) + \frac{1}{2}(4)(2)^2$

y = 18

19. Dimensional formula for thermal conductivity is (here K denotes the temperature) :

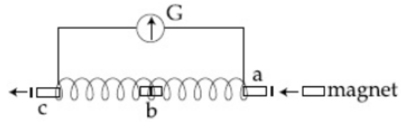
(1) $MLT^{-2}\,K$ (2) $MLT^{-3}\,K^{-1}$ (3) $MLT^{-3}\,K$ (4) $MLT^{-2}\,K^{-2}$

Ans. **(2)**

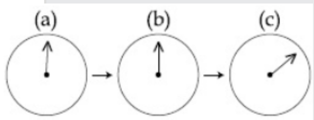
Sol. $k = \frac{(Q/t)\Delta x}{A\Delta T}$

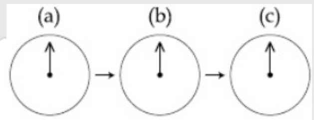
$= \frac{M^1L^2T^{-2}(L)}{L^2K(T)} = M^1L^1T^{-3}K^{-1}$

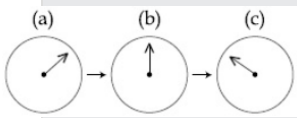
20. A small bar magnet is moves through a coil at constant speed from one end to the other. Which of the following series of observations will be seen on the galvanometer G attached across the coil ?

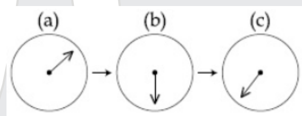


Three positions shown describe : (a) the magnet's entry (b) magnet is completely inside and (c) magnet's exit.

(1) 

(2) 

(3) 

(4) 

Ans. **(3)**

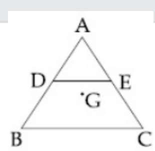
Sol. Theory Based

Numerical Value Type (संख्यात्मक प्रकार)

This section contains **5 Numerical value type questions.**

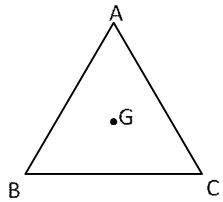
इस खण्ड में **5 सख्यात्मक प्रकार के प्रश्न** हैं।

21. ABC is a plane lamina of the shape of an equilateral triangle. D, E are mid-points of AB, AC and G is the centroid of the lamina. Moment of inertia of the lamina about a axis passing through G and perpendicular to the plane ABC is I_0. If part ADE is removed, the moment of inertia of the remaining part about the same axis is $\frac{NI_0}{16}$ where N is an integer. Value of N is :



Ans. 11

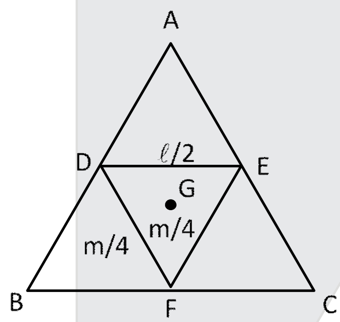
Sol.



Let mass of lamina = m, and length of side = ℓ, then moment of inertia of lamina about an axis passing through G and perpendicular to the plane.

$I_0 \propto m\ell^2$

$I_0 = km\ell^2$



Let moment of inertia of DEF = I_1 about G

then, $I_1 \propto \left(\frac{m}{4}\right)\left(\frac{\ell}{2}\right)^2 \propto \frac{m\ell^2}{16}$

$I_1 = \frac{I_0}{16}$

Let $I_{ADE} = I_{BDF} = I_{EFC} = I_2$

then, $3I_2 + I_1 = I_0$

$3I_2 + \frac{I_0}{16} = I_0 \quad \Rightarrow I_2 = \frac{5I_0}{16}$

So, Moment of inertia of DECB = $2I_2 + I_1 = 2\left(\frac{5I_0}{16}\right) + \left(\frac{I_0}{16}\right) = \frac{11 I_0}{16}$

22. In a compound microscope, the magnified virtual image is formed at a distance of 25 cm from the eye-piece. The focal length of its objective lens is 1cm. If the magnification is 100 and the tube length of the microscope is 20 cm, then the focal length of the eye-piece lens (in cm) is ________

Ans. **NTA answer is 5 and Reso answer is 6.25**

Sol. $M = \frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)$

$M = \frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$

$100 = \frac{20}{(1)}\left(1+\frac{25}{f_e}\right)$; $5 = 1+\frac{25}{f_e}$

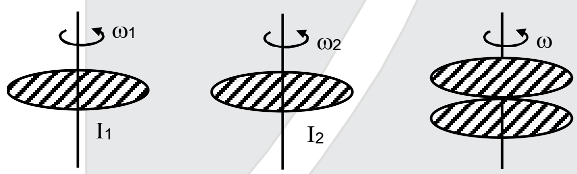
$4 = \frac{25}{f_e}$; $f_e = \frac{25}{4}$ = 6.25 cm

{ It is not mentioned that the answer should be an integer so better answer should be 6.25}

23. A circular disc of mass M and radius R is rotating about its axis with angular speed ω_1. If another stationary disc having radius $\frac{R}{2}$ and same mass M is dropped co-axially on to the rotating disc. Gradually both discs attain constant angular speed ω_2. The energy lost in the process is p% of the initial energy. Value of p is ___________

Ans. **20**

Sol.



Angular momentum conservation

$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2) \times \omega_f$

$\frac{MR^2}{2} \times \omega + 0 = \left(\frac{MR^2}{2}+\frac{MR^2}{8}\right)\omega_f$

$\omega_f = \frac{4}{5}\omega$

Final K.E., $K_f = \frac{1}{2}\left(\frac{MR^2}{2}+\frac{MR^2}{8}\right)\frac{16}{25}\omega^2$

$K_f = \frac{MR^2\omega^2}{5}$; $K_i = \frac{1}{2}\left(\frac{MR^2}{2}\right)\omega^2 = \frac{MR^2\omega^2}{4}$

Percentage loss in kinetic energy % loss = $\frac{\frac{MR^2\omega^2}{4}-\frac{MR^2\omega^2}{5}}{\frac{MR^2\omega^2}{4}} \times 100$ = 20%

24. A closed vessel contains 0.1 mole of a monoatomic ideal gas at 200 K. If 0.05 mole of the same gas at 400 K is added to it, the final equilibrium temperature (in K) of the gas in the vessel will be close to_______

Ans. **NTA answer is 266 and Reso answer is 266.67 ≈ 267**

Sol. (0.1) (200) + (0.05) (400) = (0.15)T

$$T = \frac{20+20}{0.15} = \frac{800}{3} = 266.67$$

= 266.67 **{It is not mentioned that answer should be in integer, so 266.67 will be better answer}**

25. In the line spectra of hydrogen atom, difference between the largest and the shortest wavelengths of the Lyman series is 305 Å. The corresponding difference for the Paschan series in Å is :________

Ans. **NTA answer is 10553 and Reso answer is 10553.14**

Sol. **Lyman ;** $\frac{1}{\lambda_{min}} = R(1) = R$; n = ∞ to 1

$$\frac{1}{\lambda_{max}} = R\left\{1-\frac{1}{4}\right\} = \frac{3R}{4} \text{ ; n = 2 to 1}$$

$$\Rightarrow \lambda_{max} - \lambda_{min} = \frac{4}{3R} - \frac{1}{R}$$

$$304 = \frac{1}{3R} \quad \text{...(a)}$$

Paschen : $Y_{\lambda'_{min}} = R\left(\frac{1}{9}\right)$ and $Y_{\lambda'_{max}} = R\left(\frac{1}{9}-\frac{1}{16}\right) = \frac{7R}{16\times 9}$

$$\lambda'_{max} - \lambda'_{min} = \frac{16\times 9}{7R} - \frac{9}{R} = \frac{81}{7R} \quad \text{....(b)}$$

$$\frac{(b)}{(a)} = \frac{x}{3\times 304} = \frac{81}{7} \quad \Rightarrow \quad x = 10553.14$$

{ It is not mentioned that the answer should be an integer so better answer should be 10553.14}