

**FINAL JEE-MAIN EXAMINATION – FEBRUARY, 2021**

(Held On Thursday 25<sup>th</sup> February, 2021) TIME : 9 : 00 AM to 12 : 00 NOON

**PHYSICS**

**TEST PAPER WITH ANSWER & SOLUTIONS**

**SECTION-A**

1. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : When a rod lying freely is heated, no thermal stress is developed in it.

Reason R : On heating the length of the rod increases.

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 false but R is true  
 (3) A is true but R is false  
 (4) Both A and R are true and R is the correct explanation of A

**Official Ans. by NTA (1)**

**Sol.** A and R are true but R is not the correct explanation of A.

2. A student is performing the experiment of resonance column. The diameter of the column tube is 6 cm. The frequency of the tuning fork is 504 Hz. Speed of the sound at the given temperature is 336 m/s. The zero of the meter scale coincides with the top end of the resonance column tube. The reading of the water level in the column when the first resonance occurs is:

- (1) 13 cm                      (2) 16.6 cm  
 (3) 18.4 cm                    (4) 14.8 cm

**Official Ans. by NTA (4)**

**Sol.**  $d = 6\text{cm}$ ,  $f = 504$ ,  $v = 336\text{ m/s}$   
 $e = 0.3d$

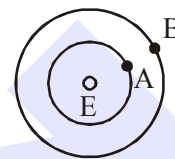
$$l + e = \frac{\lambda}{4} = \frac{v}{4f}$$

$$l = 16.66 - 0.3 \times 6$$

$$l = 14.866\text{ cm}$$

$$l = 14.8\text{ cm}$$

3. Two satellites A and B of masses 200kg and 400kg are revolving round the earth at height of 600 km and 1600 km respectively. If  $T_A$  and  $T_B$  are the time periods of A and B respectively then the value of  $T_B - T_A$ :



[Given : radius of earth = 6400km, mass of earth =  $6 \times 10^{24}\text{ kg}$ ]

- (1)  $1.33 \times 10^3\text{ s}$                       (2)  $3.33 \times 10^2\text{ s}$   
 (3)  $4.24 \times 10^3\text{ s}$                       (4)  $4.24 \times 10^2\text{ s}$

**Official Ans. by NTA (1)**

**Sol.**  $T = 2\pi \sqrt{\frac{r^3}{GM}}$

$$T_A = 2\pi \sqrt{\frac{(6400+600) \times 10^3}{GM}}$$

$$T_A = 2\pi \times 10^9 \sqrt{\frac{7^3}{GM}}$$

$$T_B = 2\pi \times 10^9 \sqrt{\frac{8^3}{GM}}$$

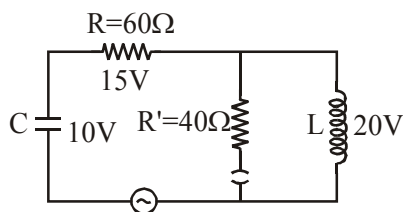
$$T_B - T_A = \frac{2\pi 10^9}{\sqrt{GM}} [8\sqrt{8} - 7\sqrt{7}]$$

$$= 314 \times 4.107$$

$$= 1289.64$$

$$= 1.289 \times 10^3\text{ s}$$

4. The angular frequency of alternating current in a L-C-R circuit is 100 rad/s. The components connected are shown in the figure. Find the value of inductance of the coil and capacity of condenser.



- (1) 0.8 H and 150  $\mu$ F  
 (2) 0.8 H and 250  $\mu$ F  
 (3) 1.33 H and 250  $\mu$ F  
 (4) 1.33 H and 150  $\mu$ F

Official Ans. by NTA (2)

Sol. Current through 60 $\Omega$  resistance =  $\frac{15}{60} = \frac{1}{4}$  A

thus capacitor current =  $\frac{1}{4}$  A

$\therefore V_C = I X_C$

$10 = \frac{1}{4} \times \frac{1}{\omega C}$

$\therefore C = \frac{1}{40\omega} = \frac{1}{4000} = 250 \mu\text{F}$

Now,

current through 40 $\Omega$  resistance =  $\frac{20}{40} = \frac{1}{2}$  A

thus current through inductor =  $\frac{1}{2} - \frac{1}{4} = \frac{1}{4}$  A

$V_L = I X_L = \frac{1}{4} \times \omega L$

$20 = \frac{1}{4} \times 100 \times L$

$\Rightarrow L = 0.8$  H

5. A proton, a deuteron and an  $\alpha$  particle are moving with same momentum in a uniform magnetic field. The ratio of magnetic forces acting on them is \_\_\_\_ and their speed is \_\_\_\_ in the ratio.

- (1) 1 : 2 : 4 and 2 : 1 : 1  
 (2) 2 : 1 : 1 and 4 : 2 : 1  
 (3) 4 : 2 : 1 and 2 : 1 : 1  
 (4) 1 : 2 : 4 and 1 : 1 : 2

Official Ans. by NTA (2)

Sol.  $F = q(\vec{v} \times \vec{B}) = \frac{q}{m}(\vec{P} \times \vec{B})$

$\Rightarrow F \propto \frac{q}{m}$

thus  $F_1 : F_2 : F_3 = \frac{q_1}{m_1} : \frac{q_2}{m_2} : \frac{q_3}{m_3}$

$= \frac{e}{m_p} : \frac{e}{2m_p} : \frac{2e}{4m_p}$

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

$= 2 : 1 : 1$

Now for speed calculation

$P = \text{constant} \Rightarrow v \propto \frac{1}{m}$

thus  $v_1 : v_2 : v_3 = \frac{1}{m_p} : \frac{1}{2m_p} : \frac{1}{4m_p}$

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

$= 4 : 2 : 1$

6. Given below are two statement :

Statement-I: A speech signal of 2 kHz is used to modulate a carrier signal of 1 MHz. The band width requirement for the signal is 4 kHz.

Statement-II : The side band frequencies are 1002 kHz. and 998 kHz.

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

- (1) Statement I is true but Statement II is false  
 (2) Statement I is false but Statement II is true  
 (3) Both Statement I and Statement II are true  
 (4) Both Statement I and Statement II are false

**Official Ans. by NTA (3)**

**Sol.**  $f_m = 2\text{kHz}$

$f_c = 1\text{MHz} = 1000\text{ kHz}$

Band width =  $2f_m = 4\text{kHz}$

$\therefore$  Side frequencies will be

$$= f_c \pm f_m$$

$$= (1000 \pm 2)\text{ kHz}$$

$$= 998\text{ kHz} \ \& \ 1002\text{ kHz}$$

So statement-I & statement-II both are correct.

7. If the time period of a two meter long simple pendulum is 2s, the acceleration due to gravity at the place where pendulum is executing S.H.M. is :

(1)  $\pi^2\text{ms}^{-2}$                       (2)  $9.8\text{ ms}^{-2}$

(3)  $2\pi^2\text{ms}^{-2}$                       (4)  $16\text{ m/s}^2$

**Official Ans. by NTA (3)**

**Sol.**  $T = 2\pi \sqrt{\frac{l}{g}}$

$$2 = 2\pi \sqrt{\frac{2}{g}}$$

$$\Rightarrow g = 2\pi^2$$

8. The pitch of the screw gauge is 1mm and there are 100 divisions on the circular scale. When nothing is put in between the jaws, the zero of the circular scale lies 8 divisions below the reference line. When a wire is placed between the jaws, the first linear scale division is clearly visible while 72<sup>nd</sup> division on circular scale coincides with the reference line. The radius of the wire is

- (1) 1.64 mm                      (2) 0.82 mm  
 (3) 1.80 mm                      (4) 0.90 mm

**Official Ans. by NTA (2)**

**Sol.** Least count =  $\frac{1\text{mm}}{100} = 0.01\text{mm}$

zero error =  $+ 8 \times \text{LC} = + 0.08\text{ mm}$

True reading (Diameter)

$$= (1\text{ mm} + 72 \times \text{LC}) - (\text{Zero error})$$

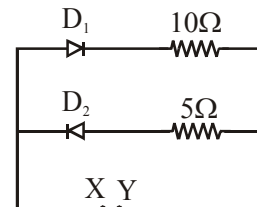
$$= (1\text{mm} + 72 \times 0.01\text{mm}) - 0.08\text{ mm}$$

$$= 1.72\text{ mm} - 0.08\text{ mm}$$

$$= 1.64\text{ mm}$$

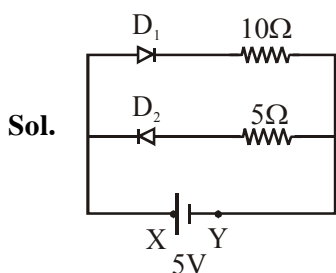
therefore, radius =  $\frac{1.64}{2} = 0.82\text{ mm}$ .

9. A 5V battery is connected across the points X and Y. Assume  $D_1$  and  $D_2$  to be normal silicon diodes. Find the current supplied by the battery if the +ve terminal of the battery is connected to point X.



- (1)  $\sim 0.5\text{ A}$                       (2)  $\sim 1.5\text{ A}$   
 (3)  $\sim 0.86\text{ A}$                       (4)  $\sim 0.43\text{ A}$

**Official Ans. by NTA (4)**



Here only  $D_1$  will work and we know for silicon diode, potential drop on  $D_1$  will be 0.7V

$$I = \frac{5 - 0.7}{10} = 0.43 \text{ A}$$

10. An  $\alpha$  particle and a proton are accelerated from rest by a potential difference of 200 V. After this, their de Broglie wavelengths are  $\lambda_\alpha$  and

$\lambda_p$  respectively. The ratio  $\frac{\lambda_p}{\lambda_\alpha}$  is :

- (1) 3.8      (2) 8      (3) 7.8      (4) 2.8

Official Ans. by NTA (4)

Sol.

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}} = \sqrt{\frac{4m_p \times 2e}{m_p \times e}} = \sqrt{8} = 2\sqrt{2}$$

$$= 2\sqrt{2}$$

$$\frac{\lambda_p}{\lambda_\alpha} = 2 \times 1.4 = 2.8$$

11. A diatomic gas, having  $C_p = \frac{7}{2}R$  and

$C_v = \frac{5}{2}R$ , is heated at constant pressure. The

ratio  $dU : dQ : dW$  :

- (1) 5 : 7 : 3      (2) 5 : 7 : 2  
 (3) 3 : 7 : 2      (4) 3 : 5 : 2

Official Ans. by NTA (2)

Sol.  $dU = nC_v dT$

$$dQ = nC_p dT$$

$$dW = PdV = nRdT \text{ (isobaric process)}$$

$$dU : dQ : dW : C_v : C_p : R$$

$$= \frac{5R}{2} : \frac{7R}{2} : R = 5 : 7 : 2$$

12. An engine of a train, moving with uniform acceleration, passes the signal-post with velocity  $u$  and the last compartment with velocity  $v$ . The velocity with which middle point of the train passes the signal post is:

(1)  $\sqrt{\frac{v^2 + u^2}{2}}$       (2)  $\frac{v - u}{2}$

(3)  $\frac{u + v}{2}$       (4)  $\sqrt{\frac{v^2 - u^2}{2}}$

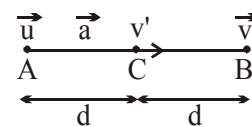
Official Ans. by NTA (1)

Sol.  $(v')^2 = u^2 + 2ad$

$$v^2 = (v')^2 + 2ad$$

solving, we get

$$v' = \sqrt{\frac{v^2 + u^2}{2}}$$



13. Match List-I with List-II :

List-I	List-II
(a) $h$ (Planck's constant)	(i) $[M L T^{-1}]$
(b) $E$ (kinetic energy)	(ii) $[M L^2 T^{-1}]$
(c) $V$ (electric potential)	(iii) $[M L^2 T^{-2}]$
(d) $P$ (linear momentum)	(iv) $[M L^2 I^{-1} T^{-3}]$

Choose the correct answer from the options given below :

- (1) (a)→(iii), (b)→(iv), (c)→(ii), (d)→(i)  
 (2) (a)→(ii), (b)→(iii), (c)→(iv), (d)→(i)  
 (3) (a)→(i), (b)→(ii), (c)→(iv), (d)→(iii)  
 (4) (a)→(iii), (b)→(ii), (c)→(iv), (d)→(i)

Official Ans. by NTA (2)

Sol. By dimensional analysis.

14. Magnetic fields at two points on the axis of a circular coil at a distance of 0.05m and 0.2 m from the centre are in the ratio 8 : 1. The radius of coil is \_\_\_\_.

- (1) 0.2 m (2) 0.1 m  
(3) 0.15 m (4) 1.0 m

Official Ans. by NTA (2)

- Sol. We know, the magnetic field on the axis of a current carrying circular ring is given by

$$B = \frac{\mu_0}{4\pi} \frac{2NIA}{(R^2 + x^2)^{3/2}}$$

$$\therefore \frac{B_1}{B_2} = \frac{8}{1} = \left[ \frac{R^2 + (0.2)^2}{R^2 + (0.05)^2} \right]^{3/2}$$

$$4[R^2 + (0.05)^2] = [R^2 + (0.2)^2]$$

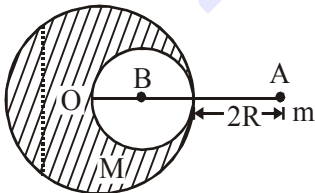
$$4R^2 - R^2 = (0.2)^2 - 4 \times (0.05)^2$$

$$4R^2 - R^2 = (0.2)^2 - (0.1)^2$$

$$3R^2 = 0.3 \times 0.1$$

$$R^2 = (0.1)^2 \Rightarrow R = 0.1$$

15. A solid sphere of radius R gravitationally attracts a particle placed at 3R from its centre with a force  $F_1$ . Now a spherical cavity of radius  $\left(\frac{R}{2}\right)$  is made in the sphere (as shown in figure) and the force becomes  $F_2$ . The value of  $F_1 : F_2$  is :

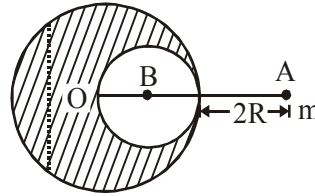


- (1) 25 : 36 (2) 36 : 25  
(3) 50 : 41 (4) 41 : 50

Official Ans. by NTA (3)

- Sol. Let initial mass of sphere is  $m'$ . Hence mass of removed portion will be  $m'/8$

$$F_1 = m.E. = \frac{m.Gm'}{9R^2}$$



$$F_2 = m \left[ \frac{G.m'}{(3R)^2} - \frac{G.m'/8}{(5R/2)^2} \right]$$

$$= \frac{Gm'}{9R^2} - \frac{Gm' \times 4}{8 \times 25}$$

$$= \left( \frac{1}{9} - \frac{1}{50} \right) \frac{Gm'}{R^2}$$

$$F_2 = \frac{41}{50 \times 9} \cdot \frac{Gm'}{R^2}$$

$$\frac{F_1}{F_2} = \frac{1}{9} \times \frac{50 \times 9}{41} = \frac{50}{41}$$

16. Two radioactive substances X and Y originally have  $N_1$  and  $N_2$  nuclei respectively. Half life of X is half of the half life of Y. After three half lives of Y, number of nuclei of both are equal.

The ratio  $\frac{N_1}{N_2}$  will be equal to :

- (1)  $\frac{1}{8}$  (2)  $\frac{3}{1}$   
(3)  $\frac{8}{1}$  (4)  $\frac{1}{3}$

Official Ans. by NTA (3)

- Sol.  $T_x = t ; T_y = 2t$

$$3T_y = 6t,$$

$$N_1' = N_2'$$

$$N_1 e^{-\lambda_1 6t} = N_2 e^{-\lambda_2 6t}$$

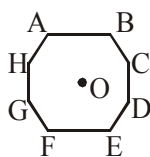
$$\frac{N_1}{N_2} = e^{(\lambda_1 - \lambda_2)6t} = e^{\ln 2 \left( \frac{1}{t} - \frac{1}{2t} \right) \times 6t} = e^{(\ln 2) \times 3} = e^{\ln 8} = 8$$

$$\frac{N_1}{N_2} = \frac{8}{1}$$

17. In an octagon ABCDEFGH of equal side, what is the sum of

$$\overline{AB} + \overline{AC} + \overline{AD} + \overline{AE} + \overline{AF} + \overline{AG} + \overline{AH}$$

if,  $\overline{AO} = 2\hat{i} + 3\hat{j} - 4\hat{k}$



(1)  $-16\hat{i} - 24\hat{j} + 32\hat{k}$

(2)  $16\hat{i} + 24\hat{j} - 32\hat{k}$

(3)  $16\hat{i} + 24\hat{j} + 32\hat{k}$

(4)  $16\hat{i} - 24\hat{j} + 32\hat{k}$

**Official Ans. by NTA (2)**

**Sol.** We know,

$$\therefore \overline{OA} + \overline{OB} + \overline{OC} + \overline{OD} + \overline{OE} + \overline{OF} + \overline{OG} + \overline{OH} = \vec{0}$$

By triangle law of vector addition, we can write

$$\overline{AB} = \overline{AO} + \overline{OB} ; \overline{AC} = \overline{AO} + \overline{OC}$$

$$\overline{AD} = \overline{AO} + \overline{OD} ; \overline{AE} = \overline{AO} + \overline{OE}$$

$$\overline{AF} = \overline{AO} + \overline{OF} ; \overline{AG} = \overline{AO} + \overline{OG}$$

$$\overline{AH} = \overline{AO} + \overline{OH}$$

Now

$$\overline{AB} + \overline{AC} + \overline{AD} + \overline{AE} + \overline{AF} + \overline{AG} + \overline{AH}$$

$$= (7 \overline{AO}) + \overline{OB} + \overline{OC} + \overline{OD} + \overline{OE} + \overline{OF} + \overline{OG} + \overline{OH}$$

$$= (7 \overline{AO}) + \vec{0} - \overline{OA}$$

$$= (7 \overline{AO}) + \overline{AO}$$

$$= 8 \overline{AO} = 8(2\hat{i} + 3\hat{j} - 4\hat{k})$$

$$= 16\hat{i} + 24\hat{j} - 32\hat{k}$$

18. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : The escape velocities of planet A and B are same. But A and B are of unequal mass.

Reason R : The product of their mass and radius must be same,  $M_1 R_1 = M_2 R_2$

In the light of the above statements, choose the most appropriate answer from the options given below :

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

**Official Ans. by NTA (2)**

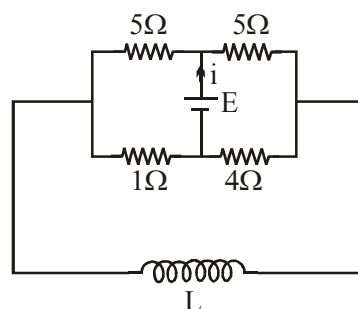
**Sol.**  $V_e = \sqrt{\frac{2GM}{R}}$

$$\frac{M_1}{R_1} = \frac{M_2}{R_2}$$

$$M_1 R_2 = M_2 R_1$$

Hence reason R is not correct.

19. The current (i) at time  $t = 0$  and  $t = \infty$  respectively for the given circuit is :



(1)  $\frac{18E}{55}, \frac{5E}{18}$

(2)  $\frac{10E}{33}, \frac{5E}{18}$

(3)  $\frac{5E}{18}, \frac{18E}{55}$

(4)  $\frac{5E}{18}, \frac{10E}{33}$

**Official Ans. by NTA (4)**

**Sol.** At  $t = 0$ , current through inductor is zero,

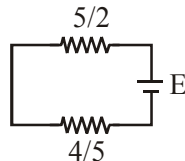
$$\text{hence } R_{\text{eq}} = (5+1) \parallel (5+4) = \frac{18}{5}$$

$$i_1 = \frac{E}{18/5} = \frac{5E}{18}$$

At  $t = \infty$ , inductor becomes a simple wire and now the circuit will be as shown in figure

$$\text{hence } R_{\text{eq}} = (5 \parallel 5) + (4 \parallel 1) = \frac{33}{10}; (\parallel \Rightarrow \text{parallel})$$

$$i_2 = \frac{E}{33/10} = \frac{10E}{33}$$



**20.** Two coherent light sources having intensity in the ratio  $2x$  produce an interference pattern.

The ratio  $\frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}} + I_{\text{min}}}$  will be :

(1)  $\frac{2\sqrt{2x}}{x+1}$                       (2)  $\frac{\sqrt{2x}}{2x+1}$

(3)  $\frac{\sqrt{2x}}{x+1}$                       (4)  $\frac{2\sqrt{2x}}{2x+1}$

**Official Ans. by NTA (4)**

**Sol.** Given that,  $\frac{I_1}{I_2} = 2x$

We know,

$$I_{\text{max}} = (\sqrt{I_1} + \sqrt{I_2})^2 \quad \& \quad I_{\text{min}} = (\sqrt{I_1} - \sqrt{I_2})^2$$

$$\therefore \frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}} + I_{\text{min}}} = \frac{2\sqrt{I_1 I_2}}{I_1 + I_2} = \frac{2\sqrt{I_1/I_2}}{\frac{I_1}{I_2} + 1} = \frac{2\sqrt{2x}}{2x+1}$$

### SECTION-B

**1.** A transmitting station releases waves of wavelength 960 m. A capacitor of  $2.56 \mu\text{F}$  is used in the resonant circuit. The self inductance of coil necessary for resonance is  $\_\_\_\_ \times 10^{-8}$  H.

**Official Ans. by NTA (10)**

**Sol.**  $\lambda = 960$  m

$$C = 2.56 \mu\text{F} = 2.56 \times 10^{-6} \text{ F}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$L = ?$$

$$\text{Now at resonance, } \omega_0 = \frac{1}{\sqrt{LC}}$$

[Resoant frequency]

$$2\pi f_0 = \frac{1}{\sqrt{LC}}$$

$$\text{On substituting } f_0 = \frac{c}{\lambda}, \text{ we have } 2\pi \frac{c}{\lambda} = \frac{1}{\sqrt{LC}}$$

$$\text{Squaring both sides : } 4\pi^2 \frac{c^2}{\lambda^2} = \frac{1}{LC}$$

$$= \frac{4 \times 10 \times (3 \times 10^8)^2}{(960)^2} = \frac{1}{L \times 2.56 \times 10^{-6}}$$

$$\Rightarrow \frac{1}{L} = \frac{4 \times 10 \times 9 \times 10^{16} \times 2.56 \times 10^{-6}}{960 \times 960}$$

$$\Rightarrow L = 10 \times 10^{-8} \text{ H}$$

**2.** The electric field in a region is given

$$\vec{E} = \left( \frac{3}{5} E_0 \hat{i} + \frac{4}{5} E_0 \hat{j} \right) \frac{N}{C}. \text{ The ratio of flux of}$$

reported field through the rectangular surface of area  $0.2 \text{ m}^2$  (parallel to  $y - z$  plane) to that of the surface of area  $0.3 \text{ m}^2$  (parallel to  $x - z$  plane) is  $a : b$ , where  $a = \_\_\_\_.$

[Here  $\hat{i}, \hat{j}$  and  $\hat{k}$  are unit vectors along  $x, y$  and  $z$ -axes respectively]

**Official Ans. by NTA (1)**

**Sol.**  $\vec{E} = \left( \frac{3E_0}{5} \hat{i} + \frac{4E_0}{5} \hat{j} \right) N$

$A_1 = 0.2 \text{ m}^2$  [parallel to  $y - z$  plane]

$= \vec{A}_1 = 0.2 \text{ m}^2 \hat{i}$

$A_2 = 0.3 \text{ m}^2$  [parallel to  $x - z$  plane]

$\vec{A}_2 = 0.3 \text{ m}^2 \hat{j}$

Now  $\phi_a = \left[ \frac{3E_0}{5} \hat{i} + \frac{4E_0}{5} \hat{j} \right] \cdot [0.2 \hat{i}] = \frac{3 \times 0.2}{5} E_0$

&  $\phi_b = \left[ \frac{3E_0}{5} \hat{i} + \frac{4E_0}{5} \hat{j} \right] \cdot [0.3 \hat{j}] = \frac{4 \times 0.3}{5} E_0$

Now  $\frac{\phi_a}{\phi_b} = \frac{0.6}{1.2} = \frac{1}{2} = \frac{a}{b}$

$\Rightarrow a : b = 1 : 2$

$\Rightarrow a = 1$

3. In a certain thermodynamical process, the pressure of a gas depends on its volume as  $kV^3$ . The work done when the temperature changes from  $100^\circ\text{C}$  to  $300^\circ\text{C}$  will be  $\_\_\_ nR$ , where  $n$  denotes number of moles of a gas.

**Official Ans. by NTA (50)**

**Sol.**  $P = kV^3$

$T_i = 100^\circ\text{C}$  &  $T_f = 300^\circ\text{C}$

$\Delta T = 300 - 100$

$\Delta T = 200^\circ\text{C}$

$P = kV^3$

now  $PV = nRT$

$\therefore kV^4 = nRT$

now  $4kV^3 dV = nRdT$

$\therefore PdV = nRdT/4$

$\therefore \text{Work} = \int PdV = \int \frac{nRdT}{4} = \frac{nR}{4} \Delta T$

$= \frac{200}{4} \times nR = 50nR$

4. A small bob tied at one end of a thin string of length  $1\text{m}$  is describing a vertical circle so that the maximum and minimum tension in the string are in the ratio  $5 : 1$ . The velocity of the bob at the height position is  $\_\_\_\_\_ \text{ m/s}$ .

(Take  $g = 10 \text{ m/s}^2$ )

**Official Ans. by NTA (5)**

- Sol.** Let the speed of bob at lowest position be  $v_1$  and at the highest position be  $v_2$ .

Maximum tension is at lowest position and minimum tension is at the highest position.

Now, using, conservation of mechanical energy,

$\frac{1}{2}mv_1^2 = \frac{1}{2}mv_2^2 + mg \cdot 2l$

$\Rightarrow v_1^2 = v_2^2 + 4gl \dots (1)$

Now  $T_{\max} - mg = \frac{mv_1^2}{l}$

$\Rightarrow T_{\max} = mg + \frac{mv_1^2}{l}$

&  $T_{\min} + mg = \frac{mv_2^2}{l}$

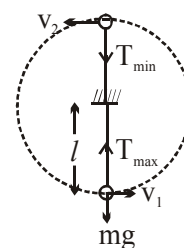
$\Rightarrow T_{\min} = \frac{mv_2^2}{l} - mg$

$\frac{T_{\max}}{T_{\min}} = \frac{5}{1}$

$\Rightarrow \frac{mg + \frac{mv_1^2}{l}}{\frac{mv_2^2}{l} - mg} = \frac{5}{1}$

$\Rightarrow mg + \frac{mv_1^2}{l} = \left[ \frac{mv_2^2}{l} - mg \right] 5$

$\Rightarrow mg + \frac{m}{l} [v_1^2 + 4gl] = \frac{5mv_2^2}{l} - 5mg$





$$\Rightarrow mg + \frac{mv_2^2}{l} + 4mg = \frac{5mv_2^2}{l} - 5mg$$

$$\Rightarrow 10mg = \frac{4mv_2^2}{l}$$

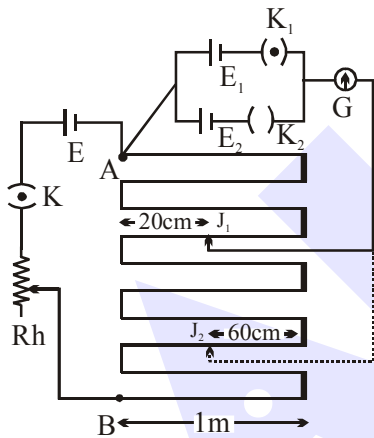
$$v_2^2 = \frac{10 \times 10 \times 1}{4}$$

$$\Rightarrow v_2^2 = 25 \Rightarrow v_2 = 5 \text{ m/s}$$

Thus, velocity of bob at highest position is 5 m/s.

5. In the given circuit of potentiometer, the potential difference  $E$  across  $AB$  (10m length) is larger than  $E_1$  and  $E_2$  as well. For key  $K_1$  (closed), the jockey is adjusted to touch the wire at point  $J_1$  so that there is no deflection in the galvanometer. Now the first battery ( $E_1$ ) is replaced by second battery ( $E_2$ ) for working by making  $K_1$  open and  $K_2$  closed. The galvanometer gives then null deflection at  $J_2$ .

The value of  $\frac{E_1}{E_2}$  is  $\frac{a}{b}$ , where  $a = \underline{\hspace{1cm}}$ .



**Official Ans. by NTA (1)**

**Sol.** Length of  $AB = 10 \text{ m}$

For battery  $E_1$ , balancing length is  $l_1$

$l_1 = 380 \text{ cm}$  [from end A]

For battery  $E_2$ , balancing length is  $l_2$

$l_2 = 760 \text{ cm}$  [from end A]

Now, we know that  $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

$$\Rightarrow \frac{E_1}{E_2} = \frac{380}{760} = \frac{1}{2} = \frac{a}{b}$$

$\therefore a = 1$  &  $b = 2$ .

$a = 1$

6. The same size images are formed by a convex lens when the object is placed at 20cm or at 10cm from the lens. The focal length of convex lens is \_\_\_\_\_ cm.

**Official Ans. by NTA (15)**

**Sol.**  $m = \frac{f}{u+f}$

$$+m = \frac{f}{-10+f} \dots (1)$$

$$-m = \frac{f}{-20+f} \dots (2)$$

(1) / (2)

$$-1 = \frac{f-20}{f-10}$$

$$10 - f = f - 20$$

$$30 = 2f$$

$$f = 15 \text{ cm}$$

7. 512 identical drops of mercury are charged to a potential of 2V each. The drops are joined to form a single drop. The potential of this drop is \_\_\_\_\_ V.

**Official Ans. by NTA (128)**

**Sol.**  $Q = 512q$

$$\text{Volume}_i = \text{Volume}_f$$

$$512 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$$

$$2^9 r^3 = R^3$$

$$R = 8r$$

$$2 = \frac{kq}{r}$$

$$V = \frac{kQ}{R} = \frac{k \cdot 512q}{8r}$$

$$V = 128.$$

8. A coil of inductance 2H having negligible resistance is connected to a source of supply whose voltage is given by  $V = 3t$  volt. (where  $t$  is in second). If the voltage is applied when  $t = 0$ , then the energy stored in the coil after 4s is \_\_\_\_\_ J.

**Official Ans. by NTA (144)**

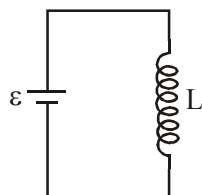
**Sol.**  $\epsilon = \frac{LdI}{dt}$

$$3 \int_0^4 t \, dt = 2 \int_0^I dI$$

$$\frac{3}{2} \times 16 = 2I$$

$$I = 12$$

$$V = \frac{1}{2}LI^2 = \frac{1}{2} \times 2(12)^2 = 144 \text{ J}$$



9. A monoatomic gas of mass 4.0 u is kept in an insulated container. Container is moving with velocity 30 m/s. If container is suddenly stopped then change in temperature of the gas

( $R =$  gas constant) is  $\frac{x}{3R}$ . Value of  $x$  is \_\_\_\_.

**Official Ans. by NTA (3600)**

- Sol.** Given that mass of gas is 4u hence its molar mass  $M$  is 4g/mol

$$\therefore \frac{1}{2}mv^2 = nC_v\Delta T$$

$$\frac{1}{2}m \times (30)^2 = \frac{m}{M} \times \frac{3R}{2} \times \Delta T$$

$$\therefore \Delta T = \frac{3600}{3R}$$

10. The potential energy ( $U$ ) of a diatomic molecule is a function dependent on  $r$  (interatomic distance) as

$$U = \frac{\alpha}{r^{10}} - \frac{\beta}{r^5} - 3$$

where,  $\alpha$  and  $\beta$  are positive constants. The equilibrium distance between two atoms will be

$$\left(\frac{2\alpha}{\beta}\right)^{\frac{a}{b}}, \text{ where } a = \text{____.}$$

**Official Ans. by NTA (1)**

- Sol.** For equilibrium

$$\frac{dU}{dr} = 0$$

$$\frac{-10\alpha}{r^{11}} + \frac{5\beta}{r^6} = 0$$

$$\frac{5\beta}{r^6} = \frac{10\alpha}{r^{11}}$$

$$r^5 = \frac{2\alpha}{\beta}$$

$$r = \left(\frac{2\alpha}{\beta}\right)^{\frac{1}{5}}$$

$$a = 1$$