

JEE Main 2021 Paper

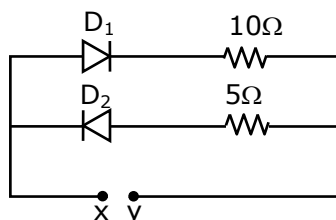


Date: 25th February 2021 (Shift-1)

Subject: Physics

Section - A

1. Match 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) ~ 0.86 A

(2) ~ 0.5 A

(3) ~ 0.43 A

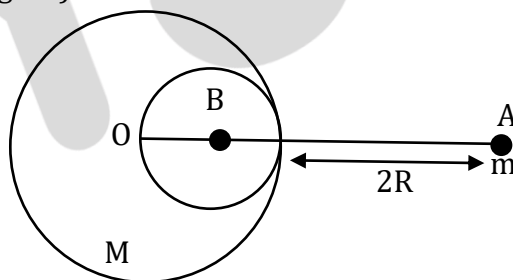
(4) ~ 1.5 A

Ans. (3)

Sol. Since silicon diode is used so 0.7 Volt is drop across it, only D_1 will conduct so current through cell

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

2. 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) 41 : 50

(2) 36 : 25

(3) 50 : 41

(4) 25 : 36

Ans. (1)

Sol. Gravitational field intensity $g_1 = \frac{GM}{(3R)^2} = \frac{GM}{9R^2}$... (1)

$$\text{Gravitational field intensity } g_2 = \frac{GM}{9R^2} - \frac{G\left(\frac{M}{8}\right)}{\left(3R - \frac{R}{2}\right)^2} = \frac{GM}{9R^2} - \frac{GM}{R^2 50} = \frac{41}{9 \times 50} \frac{GM}{R^2} \dots (2)$$

$$\text{Implies, } \frac{g_1}{g_2} = \frac{41}{50}$$

$$\Rightarrow \frac{F_1}{F_2} = \frac{mg_1}{mg_2} = \frac{41}{50}$$

3. 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 metre 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) 14.8 cm
(3) 16.6 cm (4) 18.4 cm

Ans. (2)

Sol. $\lambda = \frac{v}{f} = \frac{336}{504} = 66.66\text{cm}$

$$\frac{\lambda}{4} = l + e = l + 0.3d$$

$$= l + 1.8$$

$$16.66 = l + 1.8 \text{ cm}$$

$$l = 14.86 \text{ cm}$$

4. 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) 3 : 7 : 2 (2) 5 : 7 : 2
(3) 5 : 7 : 3 (4) 3 : 5 : 2

Ans. (2)

Sol. Since the gas is diatomic in nature and the process is isobaric, we have

$$C_p = \frac{7}{2}R, \quad C_v = \frac{5}{2}R$$

$$dU = nC_v dT$$

$$dQ = nC_p dT$$

$$dW = nR dT$$

$$dU : dQ : dW$$

$$C_v : C_p : R$$

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

$$5 : 7 : 2$$

5. Given below are two statements:

Statement I: A speech signal of 2 kHz is used to modulate a carrier signal of 1 MHz. The bandwidth 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) Both statement I and statement II are false
(2) Statement I is false but statement II is true
(3) Statement I is true but statement II is false
(4) Both statement I and statement II are true

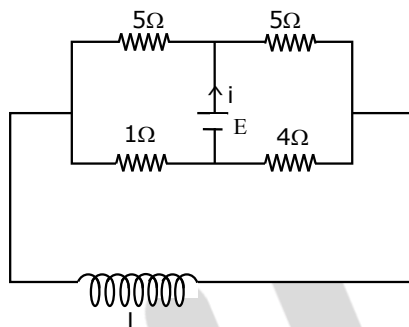
Ans. (4)

JEE Main 2021 Paper



Sol. Side band = $(f_c - f_m)$ to $(f_c + f_m)$
 = $(1000 - 2)$ kHz to $(1000 + 2)$ kHz
 = 998 kHz to 1002 kHz
 Band width = $2f_m$
 = 2×2 kHz
 = 4 kHz
 Both statements are true.

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



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

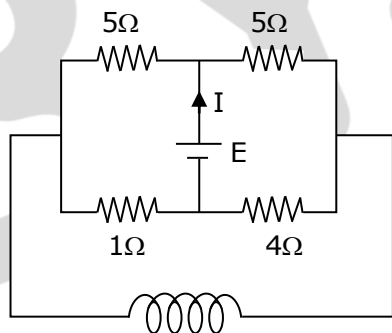
(2) $\frac{5E}{18}, \frac{18E}{55}$

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

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

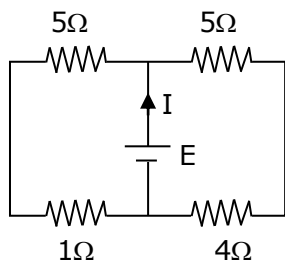
Ans. (3)

Sol.



at $t = 0$, inductor is open

Initial- state equivalent of the circuit shown in figure -1 is

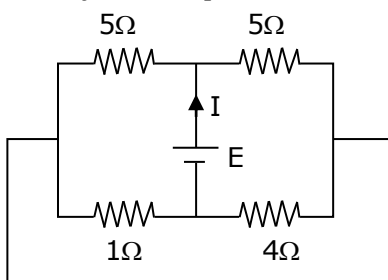


$$R_{eq} = \frac{6 \times 9}{6+9} = \frac{54}{15}$$

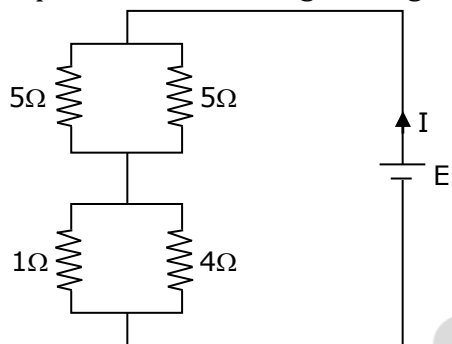
$$I(t=0) = \frac{E \times 15}{54} = \frac{5E}{18}$$

at $t = \infty$, For steady state inductor is replaced by plane wire

Steady state equivalent of the circuit shown in figure-1 is



Equivalent circuit diagram is given by

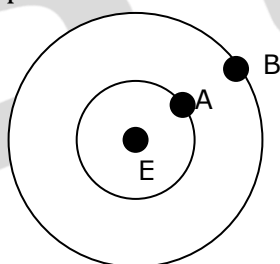


$$R_{eq} = \frac{1 \times 4}{1+4} + \frac{5 \times 5}{5+5}$$

$$= \frac{4}{5} + \frac{5}{2} = \frac{8+25}{10} = \frac{33}{10}$$

$$I = \frac{E}{R_{eq}} = \frac{10E}{33}$$

7. Two satellites A and B of masses 200 kg and 400 kg 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 = 6400 km, mass of earth = 6×10^{24} kg]

(1) 4.24×10^2 s

(2) 3.33×10^2 s

(3) 1.33×10^3 s

(4) 4.24×10^3 s

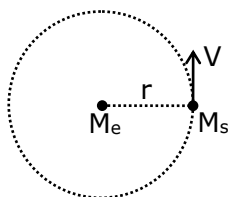
Ans. (3)

Sol.

$$V = \sqrt{\frac{GM_e}{r}}$$

$$T = \frac{2\pi r}{\sqrt{\frac{GM_e}{r}}} = 2\pi r \sqrt{\frac{r}{GM_e}}$$

$$T = \sqrt{\frac{4\pi^2 r^3}{GM_e}} = \sqrt{\frac{4\pi^2 r^3}{GM_e}}$$



JEE Main 2021 Paper

B

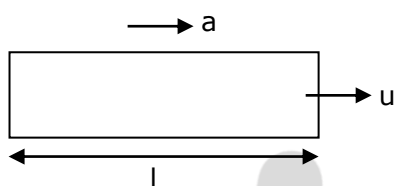
$$T_2 - T_1 = \sqrt{\frac{4\pi^2(8000 \times 10^3)^3}{G \times 6 \times 10^{24}}} - \sqrt{\frac{4\pi^2(7000 \times 10^3)^3}{G \times 6 \times 10^{24}}} \\ \cong 1.33 \times 10^3 \text{ s}$$

8. 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) $\sqrt{\frac{v^2 + u^2}{2}}$ (4) $\frac{u + v}{2}$

Ans. (3)

Sol.



a = uniform acceleration

u = velocity of first compartment

v = velocity of last compartment

l = length of train

$v^2 = u^2 + 2as$ (3rd equation of motion)

$$v^2 = u^2 + 2al \quad \dots(1)$$

$$v_{\text{middle}}^2 = u^2 + 2a \frac{l}{2}$$

$$\therefore v_{\text{middle}}^2 = u^2 + al \quad \dots(2)$$

From equation (1) and (2)

$$v_{\text{middle}}^2 = u^2 + \left(\frac{v^2 - u^2}{2}\right)$$

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

$$\therefore v_{\text{middle}} = \sqrt{\frac{v^2 + u^2}{2}}$$

9. A proton, a deuteron and an α particle are moving with the same momentum in a uniform magnetic field. The ratio of magnetic forces acting on them is _____ and their speeds are in the ratio _____.

(1) 2 : 1 : 1 and 4 : 2 : 1

(2) 1 : 2 : 4 and 2 : 1 : 1

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

(4) 4 : 2 : 1 and 2 : 1 : 1

Ans. (1)

Sol. As $v = \frac{p}{m}$ & $F = qvB$
 $\therefore F = \frac{qp}{m} B$
 $F_1 = \frac{qpB}{m}, v_1 = \frac{p}{m}$
 $F_2 = \frac{qpB}{2m}, v_2 = \frac{p}{2m}$
 $F_3 = \frac{2qpB}{4m}, v_3 = \frac{p}{4m}$
 $F_1 : F_2 : F_3 \quad \& \quad V_1 : V_2 : V_3$
 $1 : \frac{1}{2} : \frac{1}{4} \quad \& \quad 1 : \frac{1}{2} : \frac{1}{4}$
 $2 : 1 : 1 \quad \& \quad 4 : 2 : 1$

- 10.** Given below are two statements: 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) A is true but R is false
- (2) Both A and R are true and R is the correct explanation of A
- (3) Both A and R are true but R is NOT the correct explanation of A
- (4) A is false but R is true

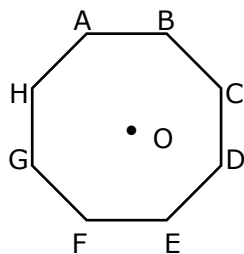
Ans. (3)

Sol. If a rod is free and it is heated then there is no thermal stress produced in it. The rod will expand due to increase in temperature. So, both A & R are true.

- 11.** In an octagon ABCDEFGH of equal side, what is the sum of

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

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



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

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

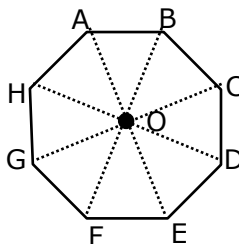
(2) $-16\hat{i} - 24\hat{j} - 32\hat{k}$

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

Ans. (1)

Sol.

$$\begin{aligned} \overline{AO} + \overline{OB} &= \overline{AB} \\ \overline{AO} + \overline{OC} &= \overline{AC} \\ \overline{AO} + \overline{OD} &= \overline{AD} \\ \overline{AO} + \overline{OE} &= \overline{AE} \\ \overline{AO} + \overline{OF} &= \overline{AF} \\ \overline{AO} + \overline{OG} &= \overline{AG} \\ \overline{AO} + \overline{OH} &= \overline{AH} \end{aligned}$$



$$\begin{aligned} 8 \overline{AO} &= (\overline{AB} + \overline{AC} + \overline{AD} + \overline{AE} + \overline{AF} + \overline{AG} + \overline{AH}) \\ &= 8(2\hat{i} + 3\hat{j} - 4\hat{k}) \\ &= 16\hat{i} + 24\hat{j} - 32\hat{k} \end{aligned}$$

- 12.** 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, numbers of nuclei of both are equal. The ratio $\frac{N_1}{N_2}$ will be equal to:

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

Ans. (1)

Sol. After n half-life no of nuclei undecayed = $\frac{N_0}{2^n}$

Given, $\left(t_{\frac{1}{2}x}\right) = \frac{\left(t_{\frac{1}{2}y}\right)}{2}$

So, 3 half life of y = 6 half-life of x

Given, $N_x = N_y \left(\text{after } 3 \left(t_{\frac{1}{2}y}\right)\right)$

$$\frac{N_1}{2^6} = \frac{N_2}{2^3}$$

$$\frac{N_1}{N_2} = \frac{2^6}{2^3} = 2^3 = \frac{8}{1}$$

- 13.** Match List-I with List-II:

List-I

- (a) h (Planck's constant)
- (b) E (Kinetic energy)
- (c) V (Electric potential)
- (d) P (Linear momentum)

List-II

- (i) [MLT⁻¹]
- (ii) [ML²T⁻¹]
- (iii) [ML²T⁻²]
- (iv) [ML²I⁻¹T⁻³]

JEE Main 2021 Paper

B

Choose the correct answer from the options given below:

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

Ans. (1)

Sol. K.E. = $[ML^2T^{-2}]$

P (Linear momentum) = $[MLT^{-1}]$

h (Planck's constant) = $[ML^2T^{-1}]$

V (Electric potential) = $[ML^2T^{-3}I^{-1}]$

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

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

Ans. (3)

Sol. Least count. = $\frac{\text{pitch}}{\text{no. of div.}} = \frac{1 \text{ mm}}{100} = 0.01 \text{ mm}$

+ve zero error = $8 \times \text{L.C.} = +0.08 \text{ mm}$

Measured reading = $1 \text{ mm} + 72 \times \text{L.C.}$

= $1 \text{ mm} + 0.72 \text{ mm}$

= 1.72 mm

True reading = $1.72 - 0.08$

= 1.64 mm

Radius = $\frac{1.64}{2} = 0.82 \text{ mm}$

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

- (1) $2\pi^2 \text{ ms}^{-2}$ (2) 16 m/s^2
(3) 9.8 ms^{-2} (4) $\pi^2 \text{ ms}^{-2}$

Ans. (1)

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

$$T^2 = \frac{4\pi^2 l}{g}$$

$$g = \frac{4\pi^2 l}{g}$$

$$= \frac{4\pi^2 \times 2}{(2)^2} = 2\pi^2 \text{ ms}^{-2}$$

16. An α particle and a proton are accelerated from rest by a potential difference of 200 V. After this, their de Broglie wavelengths are λ_α and λ_p respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$ is:

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

Ans. (2)

Sol. $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$
 $\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}} = \sqrt{\frac{4 \times 2}{1 \times 1}}$
 $= 2\sqrt{2} = 2.8$

17. 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 masses.
Reason R: The product of their masses and radii 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

Ans. (2)

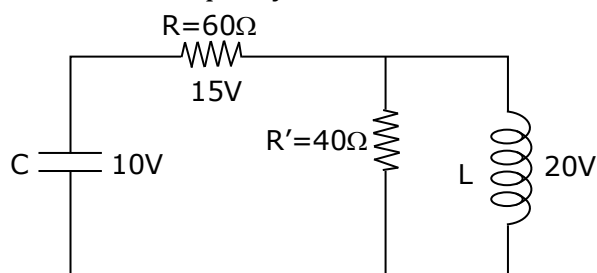
Sol. $V_e =$ escape velocity

$$V_e = \sqrt{\frac{2GM}{R}}$$

$$\text{so, for same } v_e, \frac{M_1}{R_1} = \frac{M_2}{R_2}$$

A is true but R is false.

18. 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.



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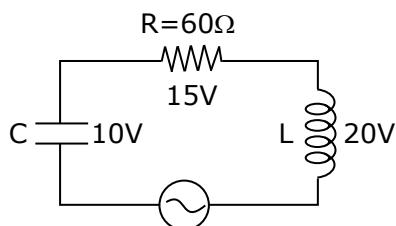


- (1) 0.8 H and 250 μ F
 (3) 1.33 H and 250 μ F

- (2) 0.8 H and 150 μ F
 (4) 1.33 H and 150 μ F

Ans. (1)

Sol.



Since key is open, circuit is series L-C-R circuit

$$15 = i_{\text{rms}} (60)$$

$$\therefore i_{\text{rms}} = \frac{1}{4} \text{ A}$$

$$\text{Now, } 20 = \frac{1}{4} X_L = \frac{1}{4} (\omega L)$$

$$\therefore L = \frac{4}{5} = 0.8 \text{ H}$$

$$\& 10 = \frac{1}{4} \frac{1}{(100C)}$$

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

19. Two coherent light sources having intensities 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) $\frac{2\sqrt{2x}}{2x+1}$

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

Ans. (3)

Sol. Let $I_1 = 2x$

$$I_2 = 1$$

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

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

$$\frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}} + I_{\text{min}}} = \frac{(\sqrt{2x}+1)^2 - (\sqrt{2x}-1)^2}{(\sqrt{2x}+1)^2 + (\sqrt{2x}-1)^2}$$

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

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

(1) 0.15 m

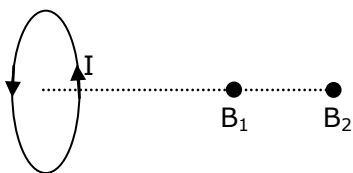
(2) 0.2 m

(3) 0.1 m

(4) 1.0 m

Ans. (3)

Sol.



$$B = \frac{\mu_0 NiR^2}{2(R^2+x^2)^{\frac{3}{2}}}$$

$$\text{at } x_1 = 0.05\text{m, } B_1 = \frac{\mu_0 NiR^2}{2(R^2+(0.05)^2)^{\frac{3}{2}}}$$

$$\text{at } x_2 = 0.2\text{m, } B_2 = \frac{\mu_0 NiR^2}{2(R^2+(0.2)^2)^{\frac{3}{2}}}$$

$$\frac{B_1}{B_2} = \frac{(R^2+0.04)^{\frac{3}{2}}}{(R^2+0.0025)^{\frac{3}{2}}}$$

$$\left(\frac{8}{1}\right)^{\frac{2}{3}} = \frac{R^2+0.04}{R^2+0.0025}$$

$$4(R^2 + 0.0025) = R^2 + 0.04$$

$$3R^2 = 0.04 - 0.01$$

$$R^2 = \frac{0.03}{3} = 0.01$$

$$R = \sqrt{0.01} = 0.1 \text{ m}$$

Section - B

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

Ans. (15)

Sol. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$... (1)

$$m = \frac{v}{u} \quad \dots (2)$$

from (1) and (2) we get

$$m = \frac{f}{f+u}$$

given conditions

$$m_1 = -m_2$$

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

$$f - 20 = -f + 10$$

$$2f = 30$$

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

2. The electric field in a region is given by $\vec{E} = \left(\frac{3}{5}E_0\hat{i} + \frac{4}{5}E_0\hat{j}\right)\frac{N}{C}$. The ratio of flux of reported field through the rectangular surface of area 0.2 m^2 (parallel to y-z plane) to that of the surface of area 0.3 m^2 (parallel to x-z plane) is a : 2, where a = _____

JEE Main 2021 Paper



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

Ans. (1)

Sol. $\phi = \vec{E} \cdot \vec{A}$

$$\vec{A}_a = 0.2\hat{i}$$

$$\vec{A}_b = 0.3\hat{j}$$

$$\phi_a = \left(\frac{3}{5}E_0\hat{i} + \frac{4}{5}E_0\hat{j}\right) \cdot 0.2\hat{i}$$

$$\phi_a = \frac{3}{5}E_0 \times 0.2$$

$$\phi_b = \left(\frac{3}{5}E_0\hat{i} + \frac{4}{5}E_0\hat{j}\right) \cdot 0.3\hat{j}$$

$$\phi_b = \frac{4}{5}E_0 \times 0.3$$

$$\frac{a}{b} = \frac{\phi_a}{\phi_b} = \frac{\frac{3}{5}E_0 \times 0.2}{\frac{4}{5}E_0 \times 0.3} = \frac{6}{12} = \frac{1}{2}$$

Therefore, $a = 1$

3. 512 identical drops of mercury are charged to a potential of 2 V each. The drops are joined to form a single drop. The potential of this drop is ___ V.

Ans. (128)

Sol. Let charge on each drop = q

Radius = r

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

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

Radius of bigger

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

$$R = 8r$$

$$V = \frac{k(512)q}{R} = \frac{512}{8} \frac{kq}{r} = \frac{512}{8} \times 2$$

$$= 128 \text{ V}$$

4. 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, a and b are positive constants.

The equilibrium distance between two atoms will $\left(\frac{2\alpha}{\beta}\right)^{\frac{a}{b}}$. Where $a =$ _____

Ans. (1)

Sol. $F = -\frac{dU}{dr}$

$$F = -\left[-\frac{10\alpha}{r^{11}} + \frac{5\beta}{r^6}\right]$$

for equilibrium, $F = 0$

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

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

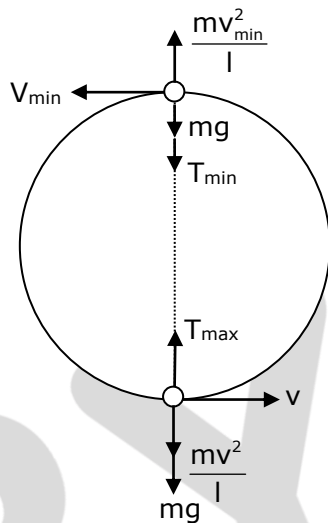
$$r = \left(\frac{2\alpha}{\beta}\right)^{\frac{1}{5}}$$

$$a = 1$$

5. A small bob tied at one end of a thin string of length 1m 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 highest position is _____ m/s. (take $g=10 \text{ m/s}^2$)

Ans. (5)

Sol.



By conservation of energy,

$$v_{\min}^2 = V^2 - 4gl \quad \dots(1)$$

$$T_{\max} = mg + \frac{mv^2}{l} \quad \dots(2)$$

$$T_{\min} = \frac{mv_{\min}^2}{l} - mg \quad \dots(3)$$

from equation (1) and (3)

$$T_{\min} = \frac{m}{l} (v^2 - 4gl) - mg$$

$$\frac{T_{\max}}{T_{\min}} = \frac{\frac{v^2}{l} + g}{\frac{v^2}{l} - 5g}$$

$$\frac{5}{1} = \frac{\frac{v^2}{l} + 10}{\frac{v^2}{l} - 50}$$

$$5v^2 - 250 = v^2 + 10$$

$$v^2 = 65 \quad \dots(4)$$

from equation (4) and (1)

$$v_{\min}^2 = 65 - 40 = 25$$

$$V_{\min} = 5 \text{ m/s}$$

JEE Main 2021 Paper

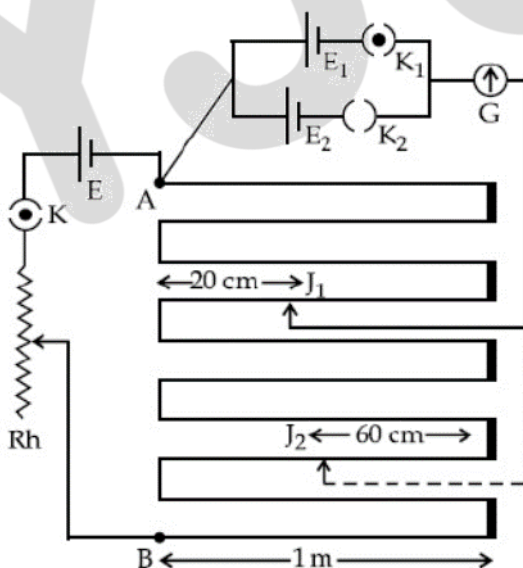


6. In a certain thermodynamic process, the pressure of a gas depends on its volume as kV^3 . The work done when the temperature changes from 100°C to 300°C will be ___ nR, where n denotes number of moles of a gas.

Ans. (50)

Sol. $P = kV^3$
 $pV^{-3} = k$
 $x = -3$
 $W = \frac{nR(T_1 - T_2)}{x - 1}$
 $= \frac{nR(100 - 300)}{-3 - 1}$
 $= \frac{nR(-200)}{-4}$
 $= 50nR$

7. In the given circuit of potentiometer, the potential difference E across AB (10 m 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 galvanometer in the. Now the first battery (E_1) is replaced by the second battery (E_2) for working by making K_1 open and E_2 closed. The galvanometer gives then null deflection at J_2 . The value of $\frac{E_1}{E_2}$ is the smallest fraction of $\frac{a}{b}$, Then the value of a is ___.



Ans. (1)

Sol. $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
 $= \frac{3 \times 100 \text{ cm} + (100 - 20) \text{ cm}}{7 \times 100 \text{ cm} + 60 \text{ cm}}$
 $= \frac{380}{760} = \frac{1}{2} = \frac{a}{b}$
 $a = 1$

8. A monoatomic gas of mass 4.0 u is kept in an insulated container. Container is moving with a 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 _____.

Ans. (3600)

Sol. $\Delta K_E = \Delta U$
 $\Delta U = nC_V\Delta T$
 $\frac{1}{2}mv^2 = \frac{3}{2}nR\Delta T$
 $\frac{mv^2}{3nR} = \Delta T$
 $\frac{4 \times (30)^2}{3 \times 1 \times R} = \Delta T$
 $\Delta T = \frac{4 \times (30)^2}{3 \times 1 \times R}$
 $\frac{x}{3R} = \frac{1200}{R}$
 $x = 3600$

9. A coil of inductance 2 H 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 4 s is _____ J.

Ans. (144)

Sol. $L \frac{di}{dt} = \epsilon$
 $= 3t$
 $L \int di = 3 \int t dt$
 $Li = \frac{3t^2}{2}$
 $i = \frac{3t^2}{2L}$
 Energy stored in the coil, $E = \frac{1}{2}Li^2$
 $= \frac{1}{2}L \left(\frac{3t^2}{2L} \right)^2$
 $= \frac{1}{2} \times \frac{9t^4}{4L}$
 $= \frac{9}{8} \times \frac{(4)^4}{4 \times 2} = 144 \text{ J}$

10. A transmitting station releases waves of wavelength 960 m. A capacitor of 256 μF is used in the resonant circuit. The self inductance of coil necessary for resonance is _____ $\times 10^{-8}\text{H}$.

Ans. (10)

Sol. At resonance
 $\omega_r = \frac{1}{\sqrt{Lc}}$

$$\begin{aligned}\therefore 2\pi f &= \frac{1}{\sqrt{Lc}} \\ \therefore 4\pi^2 \frac{c^2}{\lambda^2} &= \frac{1}{Lc} \\ \therefore \frac{4\pi^2 \times 3 \times 10^8 \times 3 \times 10^8}{960 \times 960} &= \frac{1}{L \times 2.56 \times 10^{-6}} \\ L &= \frac{375 \times 960}{10^{-6} \times 4 \times \pi^2 \times 9 \times 10^{16}} = \frac{10^3}{10^{10}} \\ &= 10^{-7} \text{ H} \\ &= 10 \times 10^{-8} \text{ H}\end{aligned}$$

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