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

JEE (Main) 2021

Questions & Solutions

(Reproduced from memory retention)

Date : 25 February, 2021 (SHIFT-1) Time ; (9.00 am to 12.00 pm)

Duration : 3 Hours | Max. Marks : 300

SUBJECT : PHYSICS

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JEE-MAIN 2021 FEBRUARY ATTEMPT

PHYSICS

1. Time period of simple pendulum at a planet is 2 sec. Length of simple pendulum is 2 meter. Find the value of g at that planet (in m/s^2)

(1) $2\pi^2$ (2) $9.8\ m/s^2$ (3) $10\ m/s^2$ (4) $\frac{\pi^2}{2}\ m/s^2$

Ans. (1)

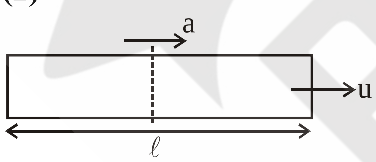
Sol. $T = 2\pi\sqrt{\frac{\ell}{g_{planet}}} \Rightarrow 2 = 2\pi\sqrt{\frac{2}{g_{planet}}}$

$\Rightarrow \frac{1}{\pi^2} = \frac{2}{g_{planet}} \Rightarrow g_{planet} = 2\pi^2\ m/sec^2$

2. A train passes by a pole with uniform acceleration 'a'. Its front end when passes by it has speed 'u' and its back end when passes by it has speed 'v'. Find speed of the middle part when it passes by the pole?

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

Ans. (2)



Sol.

$\therefore v^2 = u^2 + 2a\ell$

$\&\ v^2_{middle} = u^2 + 2a\,\frac{\ell}{2}$

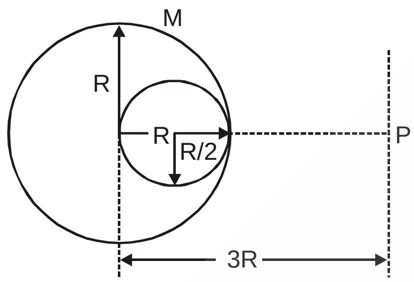
$\therefore\ v^2_{middle} = u^2 + al$

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

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

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

3. A sphere of mass M has gravitational field at point P is g_1. Now volume cavity of radius R is removed as shown. New gravitational field is g_2. Find $\left(\frac{g_1}{g_2}\right)$?



(1) $\frac{41}{50}$ (2) $\frac{50}{41}$ (3) $\frac{41}{42}$ (4) $\frac{40}{41}$

Ans. (2)

Sol. $g_1 = \frac{GM}{9R^2}$

$g_2 = \frac{GM}{9R^2} - \frac{G\left(M/8\right)}{\left(\frac{5R}{2}\right)^2}$

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

$= \frac{41}{50 \times 9}\left(\frac{GM}{R^2}\right)$

$\therefore \frac{g_1}{g_2} = \frac{50}{41}$

4. A screw gauge shows 8 division on circular scale below reference line when no object is placed. Number of division on circular scale is 100 and in one complete rotation it advanced by 1mm when a copper wire is measured with it, it complete one rotation and 72 division on circular scale. Find radius of copper wire.

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

Ans. (3)

Sol. least count = $\frac{1}{100}$mm.

+ve error = +0.08 mm.

Measured reading (Diameter) = 1mm + $\left(72 \times \frac{1}{100}\right)$mm.

Original (True reading) = 1.72 – 0.08 = 1.64 mm

So original radius = 0.82 mm.

5. Match the following dimensions:

(A) Kinetic energy	(P) $M^1L^1T^{-1}$
(B) Momentum	(Q) $M^1L^2T^{-2}$
(C) Plank Constant	(R) $M^1L^2T^{-2}C^{-1}$
(D) Electric potential	(S) $M^1L^2T^{-1}$

(1) $A\to Q$; $B\to P$; $C\to S$; $D\to R$ (2) $A\to P$; $B\to Q$; $C\to R$; $D\to S$

(3) $A\to Q$; $B\to P$; $C\to R$; $C\to S$ (4) $A\to R$; $B\to P$; $C\to S$; $C\to Q$

Ans. **(1)**

Sol. $KE = M^1L^2T^{-2}$

$P = M^1L^1T^{-1}$

$h = M^1L^2T^{-1}$

$v = M^1L^2T^{-2}C^{-1}$

6. A particle revolves in vertical circular motion attached to light string of fixed length 1m. Ratio of maximum to minimum tension is given as 5:1. Find minimum speed in the motion ?

(1) $\sqrt{\frac{5g\ell}{4}}$ (2) $\sqrt{\frac{5g\ell}{8}}$ (3) $\sqrt{\frac{5g\ell}{2}}$ (4) $\sqrt{\frac{5g\ell}{16}}$

Ans. **(3)**

Sol. $T_{max} = mg + \frac{mv^2}{\ell}$

& $T_{min} = \frac{m}{\ell}\left(v^2 - 4g\ell\right) - mg$

$$\therefore \frac{5}{1} = \frac{g + \frac{v^2}{\ell}}{\left(\frac{v^2}{\ell} - 5g\right)}$$

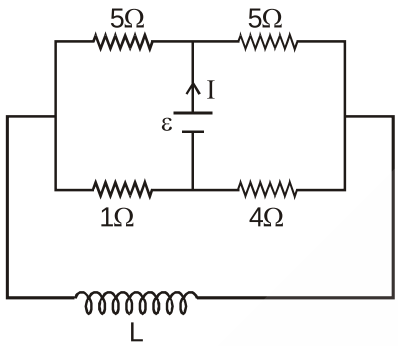
$$\frac{5v^2}{\ell} - 25g = g + \frac{v^2}{\ell}$$

$$\therefore \frac{4v^2}{\ell} = 26g$$

$$v^2 = \frac{13}{2}g\ell$$

$$\therefore V_{min}^2 = (5g\ell / 2)$$

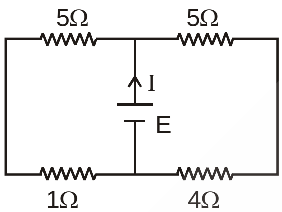
7. In given LR circuit, find out net current I at t = 0 and steady state.



(1) $\frac{5\varepsilon}{18}, \frac{10\varepsilon}{33}$ (2) $\frac{10\varepsilon}{33}, \frac{5\varepsilon}{18}$ (3) $\frac{5\varepsilon}{33}, \frac{10\varepsilon}{18}$ (4) $\frac{5\varepsilon}{18}, \frac{18\varepsilon}{5}$

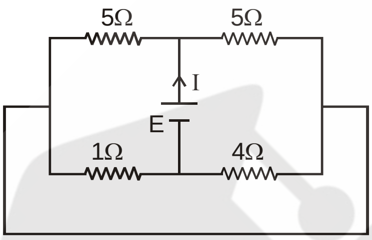
Ans. (1)

Sol. at t = 0



$I[t=0] = \frac{E \times 15}{6 \times 9} = \frac{5E}{18}$

at t = ∞



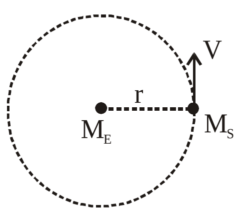
$I(t=\infty) = \frac{E}{\frac{5}{2}+\frac{4}{5}} = \frac{10E}{33}$

8. Two planets 1 and 2 of masses 400 kg and 600 kg respectively revolves around Earth (in circular orbit) which are at a height of 600 km and 1600 km above the Earth's surface respectively. Find $T_2 - T_1$. (T_1 = time period of revolution of planet -1, T_2 = Time period of revolution of planet -2, mass of Earth = 6×10^{24} kg, Radius of earth = 6400 km)

(1) 2887.15 sec (2) 2500.67 sec (3) 3000 sec (4) 2719.65 sec

Ans. **(1)**

Sol.



$$v = \sqrt{\frac{2GM_e}{r}}$$

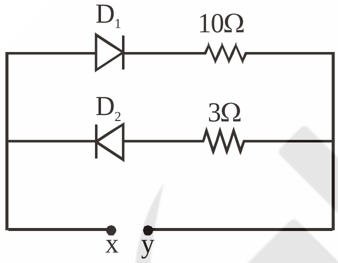
$$T = \frac{2\pi r}{\sqrt{\frac{2GM_e}{r}}} = 2\pi r\sqrt{\frac{r}{2GM_e}}$$

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

$$T_2 - T_1 = \sqrt{\frac{2\pi^2(8000\times10^3)^3}{G\times6\times10^{24}}} - \sqrt{\frac{2\pi^2(7000\times10^3)^3}{G\times6\times10^{24}}}$$

= 2887.15 sec

9. If we place a battery of 5 volt between x and y and terminal x is made positive then find current through cell. Diode is made from silicon.



(1) ≅ 0.43 amp (2) ≅ 0.73 amp (3) ≅ 1.5 amp (4) ≅ 0.3 amp

Ans. **(1)**

Sol. Since silicon diode is used so 0.7 volt is drop cross it. Only D_1 will conduct so current through cell

$$I = \frac{5-0.7}{10}$$

I = 0.43 Ans.

10. If pressure is constant in a thermodynamic process, then find ratio of dU : dQ : dW.

(Given $C_P = \frac{7}{2}R$, $C_V = \frac{5}{2}R$)

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

Ans. **(1)**

Sol. $dU = nC_V\Delta T = n\frac{5}{2}R\Delta T$

$dQ = nC_P\Delta T = n\times\frac{7}{2}R\Delta T$

$dW = nR\Delta T = nR\Delta T$

dU : dQ : dW

$\Rightarrow n\frac{5}{2}R\Delta T : n\frac{7}{2}R\Delta T : nR\Delta T$

5 : 7 : 2

11. An α-particle and proton are accelerated from rest under potential difference of 200V. Find ratio of their de-Broglie wavelength $\left(\frac{\lambda_P}{\lambda_\alpha}\right)$?

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

Ans. (2)

Sol. $\lambda = \frac{h}{\sqrt{2m(qV)}}$

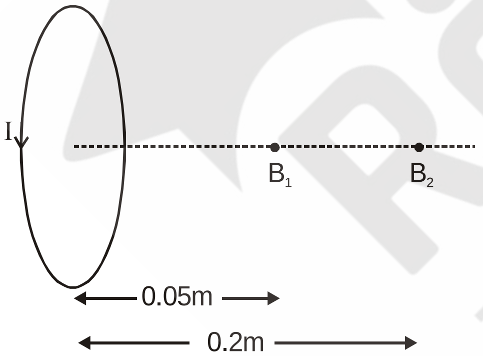
$\therefore \frac{\lambda_P}{\lambda_\alpha} = \sqrt{\frac{M_\alpha q_\alpha}{M_P q_P}} = 2\sqrt{2}$

12. Current I is flowing in a coil and two points B_1 and B_2 are on the axis of coil at a distance 0.05 m and 0.2 meter respectively. If ratio of magnetic field at point B_1 and B_2 are in 8 : 1, then find radius of coil.

(1) 0.1 m (2) 0.2 m (3) 0.7 m (4) 0.8 m

Ans. (1)

Sol.



$$B = \frac{\mu_0 NIR^2}{2(R^2+x^2)^{3/2}} \Rightarrow \frac{B_1}{B_2} = \frac{8}{1} = \frac{(R^2+x_2^2)^{3/2}}{(R^2+x_1^2)^{3/2}}$$

$$\left(\frac{R^2+x_2^2}{R^2+x_1^2}\right)^3 = 64 \Rightarrow \frac{R^2+x_2^2}{R^2+x_1^2} = 4$$

$$R^2 + x_2^2 = 4R^2 + 4x_1^2$$

$$3R^2 = x_2^2 - 4x_1^2$$

$= \left(\frac{2}{10}\right)^2 - 4\left(\frac{5}{100}\right)^2$

$= \frac{4}{100} - \frac{1}{100}$

$3R^2 = \frac{3}{100}$

$R = \frac{1}{10}$

$R = 0.1$ m

13. Electric field exists in space as $E = \frac{3}{5}E_0\hat{i} + \frac{4}{5}E_0\hat{j}$. Two planes P_1 and P_2, one in x-y plane of area 0.2 m^2 and other in x-z plane of Area 0.3 m^2 are considered. Find ratio of flux through them i.e. $\frac{\Phi_{P_1}}{\Phi_{P_2}}$ is $\frac{a}{b}$ (in lowest form). Find 'a'

Ans. (1)

Sol. $\Phi_{P_1} = \frac{3}{5}E_0(0.2)$

$\Phi_{P_2} = \frac{4}{5}E_0(0.3)$

$\therefore \frac{\Phi_{P_1}}{\Phi_{P_2}} = \frac{0.6}{1.2} = \frac{1}{2}$

14. A tuning fork of frequency 504 Hz is used as a sound source for resonance column tube experiment, tube is having a diameter of 6 cm, the zero of meter scale coincides with the top of tube, what is the reading of meter scale for first resonance to occur.

(Speed of sound in air is 336 m/sec)

(1) 14.86 cm (2) 15.5 cm (3) 18.6 cm (4) 13.5 cm

Ans. (1)

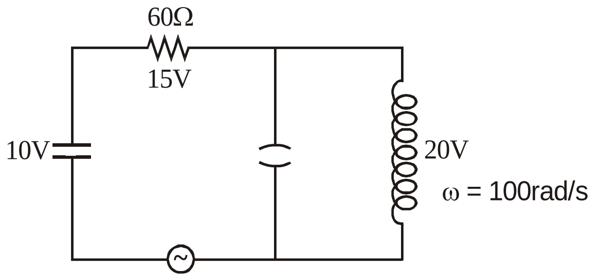
Sol. $\lambda = \frac{v}{f} = \frac{336}{504} = 66.66\text{cm}$

$\frac{\lambda}{4} = \ell + e = \ell + 0.3d = \ell + 1.8$

$16.66 = \ell + 1.8$ cm

$\ell = 14.86$ cm

15. Find values of L and C? (All given values are RMS)



(1) 0.8 H, 250 μF (2) 0.8 H, 500 μF

(3) 0.4 H, 250 μF (4) 1.33 H, 500 μF

Ans. **(1)**

Sol. Since key is open, circuit is series

$$15 = i_{RMS}(60)$$

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

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

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

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

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

16. Three particles proton (say 1), deuteron (say 2) and alpha particle (say -3) are having equal momentum. They are projected in a uniform magnetic field such that their velocity and magnetic field are perpendicular. Then the ratio of magnetic force acting on them $F_1 : F_2 : F_3$ is_______, and the ratio of their speed $V_1 : V_2 : V_3$ is _________

(1) 2 : 1 : 1, 4 : 2 : 1 (2) 2 : 2 : 1, 4 : 2 : 1 (3) 4 : 2 : 1, 2 : 1 : 1 (4) 4 : 1 : 1, 2 : 2: 1

Ans. (1)

Sol. $F = qVB = \frac{qPB}{m}$ $\quad V = \frac{P}{m}$

$F_1 = \frac{qPB}{m}$ $\quad V_1 = \frac{P}{m}$

$F_2 = \frac{qPB}{2m}$ $\quad V_2 = \frac{P}{2m}$

$F_3 = \frac{2qPB}{4m} = \frac{qPB}{2m}$ $\quad V_3 = \frac{P}{4m}$

$F_1 : F_2 : F_3 = 2 : 1 : 1$ $\quad V_1 : V_2 : V_3 = 4 : 2 : 1$

17. If ratio of intensity of two coherent light sources is given 2x, then find out value of $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

(1) $\frac{2\sqrt{2x}}{2x+1}$ (2) $\frac{\sqrt{2}\,x}{2x+1}$ (3) $\frac{2\sqrt{2}\,x}{2x-1}$ (4) $\left(\frac{2x}{2x+1}\right)$

Ans. **(1)**

Sol. $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

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

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

$$\frac{\frac{\left(\sqrt{2x}+1\right)^2}{\left(\sqrt{2x}-1\right)^2} - 1}{\frac{\left(\sqrt{2x}+1\right)^2}{\left(\sqrt{2x}-1\right)^2} + 1}$$

$$\Rightarrow \frac{2x+1+2\sqrt{2x}-2x-1+2\sqrt{2x}}{2x+1+2\sqrt{2x}+2x+1-2\sqrt{2x}} \Rightarrow \frac{4\sqrt{2x}}{4x+2} = \left(\frac{2\sqrt{2x}}{2x+1}\right)$$

18. The frequency of wave to be modulated is 2 kHz and of carrier wave is 1 MHz.

Assertion: The frequency range in which signal operates is 4 kHz.

Reason: The sideband frequencies are 998 kHz and 1002 kHz.

(1) Assertion is True, Reason is True; Reason is a correct explanation for Assertion.

(2) Assertion is True, Reason is True; Reason is NOT a correct explanation for Assertion

(3) Assertion is True, Reason is False

(4) Assertion is False, Reason is False

Ans. **(1)**

Sol. **Theoretical**

19. **Assertion :** A freely kept rod is heated and there will be no thermal stress generated in it.

Reason : When a rod is heated then it expands.

(1) Assertion is true, reason is true and reason is the correct explanation of assertion.

(2) Assertion is true, reason is true but reason is not the explanation of assertion.

(3) Assertion is true, reason is false

(4) Assertion is false, reason is false.

Ans. **(2)**

Sol. Stress is developed only if the expansion is hindered.

20. **Assertion :-** Two planets have same escape velocity but different masses.

Reason :- For same escape speed m_1R_1 must be equal to m_2R_2.

(1) Assertion is true, reason is true and reason is the correct explanation of assertion.

(2) Assertion is true, reason is true but reason is not the explanation of assertion.

(3) Assertion is true, reason is false

(4) Assertion is false, reason is false.

Ans. **(3)**

Sol. Theoretical.

21. Two radioactive substances x and y having N_1 and N_2 nuclei initially. The half life of x is half of the half life of Y. After a time of three half lives of Y, the number of undecayed nuclei of X and Y becomes equal. Then find the value of $\frac{N_1}{N_2}$.

Ans. 8

Sol. $T_x = \frac{T_Y}{2}$

$\frac{1}{\lambda_X} = \frac{1}{2\lambda_Y}$

$\lambda_x = 2\lambda_Y$

$t = 3T_Y$

$N_X = N_1 e^{-\lambda_X \times 3T_Y}$

$N_Y = N_2 e^{-\lambda_Y \times 3T_Y}$

$N_X = N_Y$

$$N_1 e^{-\lambda_X \times 3 \times \frac{\ell n 2}{\lambda_Y}} = N_2 e^{-\lambda_Y \times \frac{3\ell n 2}{\lambda_Y}}$$

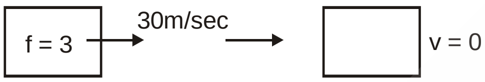
$$N_1 e^{-6\ell n 2} = N_2 e^{-3\ell n 2}$$

$$\frac{N_1}{N_2} = e^{3\ell n 2} = 8$$

22. A non-conducting container is moving with 30 m/sec, contains 1 mol of monoatomic gas inside it. Mass of gas inside container is 4U. If container suddenly stops then it's temperature change ΔT is $\frac{x}{3R}$ then what will be value of x

Ans. 3600

Sol.



$k_i + u_i = k_f + u_f$

$$\frac{1}{2} m_{gas} v^2 + \frac{f}{2} nRT_i = 0 + \frac{f}{2} nRT_f$$

$$\frac{3}{2} nR(T_f - T_i) = \frac{1}{2} m_{gas} v^2$$

$$\frac{3}{2}(1) R[\Delta T] = \frac{1}{2}(4)(30)^2$$

$$\Delta T = \frac{1200}{R} = \frac{x}{3R} \Rightarrow x = 3600$$

23. An object when placed at 10 cm from convex lens & when placed at 20 cm from it, image produced has same height. Find focal length of lens?

Ans. **15cm**

Sol. $m = \frac{f}{f+u} \Rightarrow \boxed{m_1 = -m_2}$

$$\therefore \frac{f}{f+(-10)} = \frac{-f}{f+(-20)}$$

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

$f - 10 = -f + 20$

$\therefore 2f = +30$

$\therefore f = +15$ cm

24. A transmitter circuit is used for transmission of EM waves having wavelength 960 meter. If capacitor used in circuit was of $2.56\ \mu F$, then the self inductance of the inductor coil used in the circuit such that resonance occurs, is $P \times 10^{-8}$ H. Find P ?

Ans. **10**

Sol. Since Resonance,

$$\omega_r = \frac{1}{\sqrt{LC}}$$

$$\therefore 2\pi f = \frac{1}{\sqrt{LC}}$$

$$\therefore 4\pi^2 \frac{c^2}{\lambda^2} = \frac{1}{LC}$$

$$\therefore 4\pi^2 \times \frac{9\times10^8\times10^8}{960\times960} = \frac{1}{L\times2.56\times10^{-6}}$$

$$L = \frac{375\times960}{10^{-6}\times4\times\pi^2\times9\times10^{16}} = \frac{10^3}{10^{10}}$$

$$= \boxed{10^{-7}H} = 10\times10^{-8}$$

25. In a thermodynamic process, pressure P and volume V is related as $P = kV^3$. If initial temperature of gas is 100º C and final temperature is 300º C, then if work done in the process is x(nR), then what will be the value of x: (n is number of mole, R is ideal gas constant)

Ans. **50**

Sol. $PV^{-3} = K$

$PV^x = K$

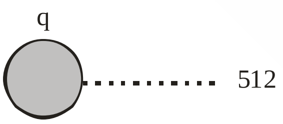
$X = -3$

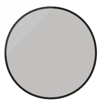
$$W = -\frac{nR\Delta T}{x-1} = -\left[\frac{nR(200)}{-3-1}\right] = 50\ (nR)$$

26. There are 512 mercury drops, initially each has a potential of 2 volt. Now all drops are combined to make a single drop, then find potential of single drop?

Ans. **128**

Sol.





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

$$\frac{v'}{2} = \frac{r(512)}{R}$$

$$\frac{v'}{2} = \frac{512}{8} = 128$$

v' = 128 volt

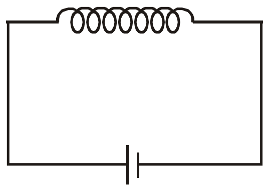
R, 512 q

$$v' = \frac{K(512)q}{R}$$

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

R = 8r

27. In the given circuit, find energy in J stored in circuit at t = 4 sec ? [At t = 0 s, circuit is closed]



Ans. 144 J

Sol. $\frac{Ldi}{dt} = 3t$

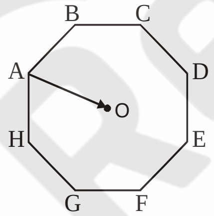
$\therefore \int Ldi = \int 3tdt$

$\therefore \; L\,i = \frac{3t^2}{2}$

$\therefore \; i = \frac{3t^2}{2L}$

So energy = $\frac{1}{2} \times L \times \left(\frac{3t^2}{2L}\right)^2 \quad = \frac{1}{2} \times \frac{9t^4}{4L} = \frac{9}{8} \times \frac{16 \times 16}{2} = 144J$

28. Figure shows the regular octagon ABCDEFGH. If $\overrightarrow{AO} = 2\hat{i} + 3\hat{j} - 4\hat{k}$ then find the value of $\overrightarrow{AB} + \overrightarrow{AC} + \overrightarrow{AD} + \overrightarrow{AE} + \overrightarrow{AF} + \overrightarrow{AG} + \overrightarrow{AH}$ is x times of $\overrightarrow{AO}$, then value of x is:



Ans. 8

Sol. $\frac{\vec{a} + \vec{b} + \vec{c} + \vec{d} + \vec{e} + \vec{f} + \vec{g} + \vec{h}}{8} = 0$

$\vec{b} + \vec{c} + \vec{d} + \vec{e} + \vec{f} + \vec{g} + \vec{h} = -\vec{a}$

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

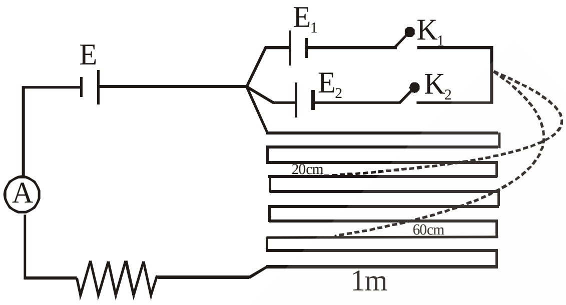
$\vec{b} - \vec{a} + \vec{c} - \vec{a} + \vec{d} - \vec{a} + \vec{e} - \vec{a} + \vec{f} - \vec{a} + \vec{g} - \vec{a} + \vec{h} - \vec{a}$

$(\vec{b} + \vec{c} + \vec{d} + \vec{e} + \vec{f} + \vec{g} + \vec{h}) - 7\vec{a}$

$\Rightarrow \; -\vec{a} - 7\vec{a}$

$= \quad -8\vec{a} = -8(\overrightarrow{OA}) = 8\overrightarrow{AO} \; = \; 8(\overrightarrow{AO})$

29. In given potentiometer experiment key K_1 is closed first keeping K_2 open and then K_2 is closed keeping K_1 open the figure shows the output, find $\frac{E_2}{E_1}$.



Ans. 2

Sol. $\frac{E_2}{E_1} = \frac{l_2}{l_1} = \frac{760}{380} = 2$

30. **Coming soon.**

Ans.

Sol.