Solution

PHYSICS

JEE main - Physics

PHYSICS (Section-A)

1.

(b) $ML^{-1}T^{-2}$

Explanation:

The quantity $\frac{B^2}{2\mu_0}$ is the energy density of magnetic field.

$\Rightarrow [\frac{B^2}{2\mu_0}] = \frac{Energy}{Volume} = \frac{Force \times displacement}{(displacement)^3}$

$= [\frac{ML^2T^{-2}}{L^3}] = ML^{-1}T^{-2}$

2.

(b) 570 Ω

Explanation:

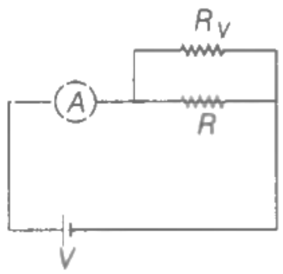
Measured value of R = 5% less than actual value of R.

Actual values of R = 30 Ω

So, measured value of R is R' = 30 - (5% of 30) = 30 - $\frac{5}{100} \times 30$

$\Rightarrow$R' = 28.5 Ω ...(i)

Now, let us assume that internal resistance of voltmeter Rv. Replacing voltmeter with its internal resistance, we get following circuit.



It is clear that the measured value, R' should be equal to parallel combination of R and R_V . Mathematically,

$R' = \frac{RR_V}{R+R_V} = 28.5\Omega$

Given, R = $30\Omega \Rightarrow \frac{30R_V}{30+R_V}$ = 28.5

$\Rightarrow 30R_V = (28.5 \times 30) + 28.5 R_V$

$\Rightarrow 1.5R_V = 28.5 \times 30$

$\Rightarrow R_V = \frac{28.5 \times 30}{1.5} = 19 \times 30$ or $R_V = 570\ \Omega$

3.

(c) $\sqrt{\frac{2v^2h}{g} + h^2}$

Explanation:

Time of fall of packet

$t = \sqrt{\frac{2h}{g}}, x = \sqrt{\frac{2h}{g}}v$

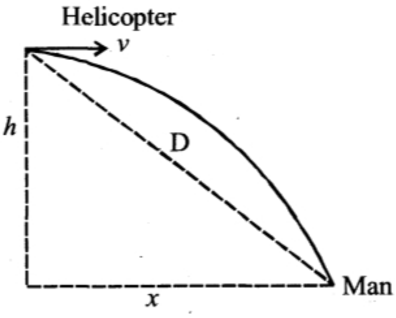
Horizontal range (x) - time $\times$ horizontal component of velocity (v)

$\therefore$ Required distance

$D = \sqrt{x^2 + h^2}$

$= \sqrt{\left(\sqrt{\frac{2h}{g}}v\right)^2 + h^2}$

or, $D = \sqrt{\frac{2hv^2}{g} + h^2}$

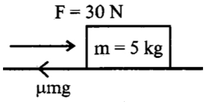


4.

(c) 0.50

Explanation:

From equation of motion



$S = ut + \frac{1}{2}at^2$

$\Rightarrow 50 = 0 + \frac{1}{2} \times a \times 100$

a - 1m/s^2; F - μmg = ma

$\Rightarrow 30 - \mu \times 50 = 5 \times 1 \;\Rightarrow 50\mu = 25; \mu = \frac{1}{2}$

5.

(c) 6×10^{-2}

Explanation:

As the particles moving in circular orbits, So

$\frac{mv^2}{r} = \frac{16}{r} + r^2$

Kinetic energy, $KE_0 = \frac{1}{2}mv^2 = \frac{1}{2}\left[16 + r^4\right]$

For first particle, r = 1, $K_1 = \frac{1}{2}\ m(16 + 1)$

Similarly, for second particle, r = 4, $K_2 = \frac{1}{2}\ m(16 + 256)$

$\therefore \frac{K_1}{K_2} = \frac{\frac{16+1}{2}}{\frac{16+256}{2}} = \frac{17}{272} = 6 \times 10^{-2}$

6. **(a)** $\frac{4MR^2}{9\sqrt{3}\pi}$

Explanation:

Maximum possible volume of cube will occur when

$\sqrt{3}a$ = 2R (a = side of cube)

$\therefore a = \frac{2}{\sqrt{3}}R$

Now, density of sphere, $\rho = \frac{M}{\frac{4}{3}\pi R^3}$

Mass of cube, m = (volume of cube)(ρ) = (a^3)(ρ)

= $\left[\frac{2}{\sqrt{3}}R\right]^3 \left[\frac{m}{\frac{4}{3}\pi R^3}\right] = \left(\frac{2}{\sqrt{3}\pi}\right) M$

Now, moment of inertia o f the cube about the said axis is

$I = \frac{ma^2}{6} = \frac{\left(\frac{2}{\sqrt{3}\pi}\right)M\left(\frac{2}{\sqrt{3}}R\right)^2}{\sigma}$

$= \frac{4MR^2}{9\sqrt{3}\pi}$

7.

(c) 17.8 m/s

Explanation:

Apply Bernoulli's theorem between Piston and hole

$P_A + \rho gh = P_0 + \frac{1}{2}\rho v_e^2$

Assuming there is no atmospheric pressure on piston

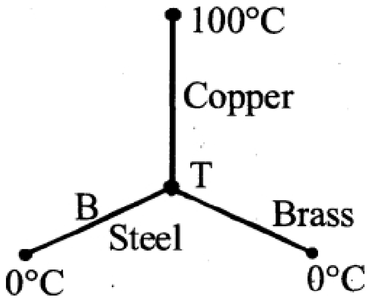
$\frac{5\times10^5}{\pi} + 10^3 \times 10 \times 10 = 1.01 \times 10^5 + \frac{1}{2} \times 10^3 \times v_e^2$

$\Rightarrow v_e$ = 1.78m/s

8.

(d) 4.8 cal/s

Explanation:



Here, heat flow per second through the copper rod is divided into two parts at the junction and that flow in two different rods made up of brass and steel as shown in the figure.

$Q = Q_1 + Q_2$

$\Rightarrow \frac{100-T}{R_C} = \frac{T-0}{R_B} + \frac{T-0}{R_S}$

where $R = \frac{l}{K_4}$, A is equal in each case

$\Rightarrow (100 - T)\frac{K_C}{L_C} = T\left(\frac{K_B}{l_B} + \frac{K_S}{l_S}\right)$

$\Rightarrow (100 - T)\frac{0.92}{46} = T\left(\frac{0.26}{13} + \frac{0.12}{12}\right)$

$\Rightarrow T = 40^oC$

$\therefore Q = \frac{(100-40)}{l_C} K_C A$

$Q = \frac{60\times0.92\times4}{46} = 4.8$ cal s^{-1}

9.

(b) 12.6×10^6 J

Explanation:

$\eta = \frac{W}{Q_{ahsorbed}} \Rightarrow W = \eta Q_{absorbed}$

$= \left(1 - \frac{T_{sink}}{T_{source}}\right) Q_{absorbed} = \left(1 - \frac{400}{1000}\right) 5000\text{Kcal}$

$= \frac{6}{10} \times 5000\text{Kcal}$ = 3000 Kcal

$= 3000 \times 10^3 \times 4.2$ J [$\because$ 1 cal = 4.2 J] = 12.6×10^6J

10.

(c) 10^{-3} rad/s

Explanation:

We know that time period of a pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$

So, angular frequency $\omega = \frac{2\pi}{T} = \sqrt{\frac{g}{l}}$ ...(i)

Now, differentiate both side w.r.t g

$\therefore \frac{d(\omega)}{dg} = \frac{1}{2\sqrt{g}\sqrt{l}}$

$d\omega = \frac{dg}{2\sqrt{g}\sqrt{l}}$ ...(ii)

By dividing Eq. (ii) by Eq. (i), we get $\frac{d\omega}{\omega} = \frac{dg}{2g}$ or we can write $\frac{\Delta\omega}{\omega} = \frac{\Delta g}{2g}$ ...(iii)

As Δg is due to oscillation of support

$\therefore \Delta g = 2\omega^2 A$

($\omega_1 \to$ 1 rad/s, support)

Putting value of Δg in Eq. (iii) we get

$\frac{\Delta\omega}{\omega} = \frac{1}{2} \cdot \frac{2\omega_1^2 A}{g} = \frac{\omega_1^2 A}{g}$; (A = 10^{-2} m^2)

$\Rightarrow \quad \frac{\Delta\omega}{\omega} = \frac{1\times10^{-2}}{10}$ = 10^{-3} rad/s

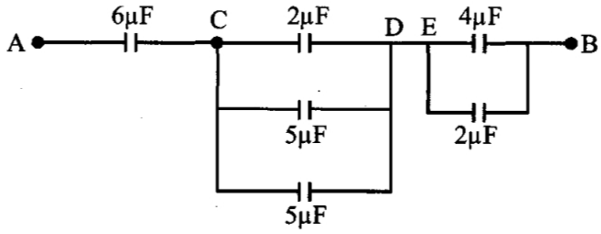
11.

(d) 2.4 μF

Explanation:

The simplified circuit of the circuit given in question as follows:

The equivalent capacitance between C & D capacitors of 2μF, 5μF and 5 μF are in parallel.



$\therefore$ C_{CD} = 2 + 5 + 5 = 12 μF ($\because$ In parallel grouping C_{eq} = C_1 + C_2 + ...+ C_n)

Similarly equivalent capacitance between E & BC_{EB} = 4 + 2 = 6 μF

Now equivalent capacitance between A & B $\frac{1}{C_{eq}}$ = $\frac{1}{6} + \frac{1}{12} + \frac{1}{6} = \frac{5}{12}$

$\Rightarrow$ C_{eq} = $\frac{12}{5}$ = 2.4 μF ($\because$ In series grouping, $\frac{1}{C_{eq}}$ = $\frac{1}{C_1} + \frac{1}{C_2}$ + ... + $\frac{1}{C_n}$)

12. **(a)** 2.8 $\times$ 10^6 Hz

Explanation:

f = $\frac{1}{T}$ = $\frac{eB}{2\pi m}$ $\left[\because \mathrm{T} = \frac{2\pi \mathrm{m}}{\mathrm{qB}}\right]$

= $\frac{1.6\times10^{-19}\times10^{-4}}{2\pi\times9\times10^{-31}}$ = 2.8 $\times$ 10^6Hz

13.

(c) 2600 A/m

Explanation:

Coercivity, $\mathrm{H} = \frac{\mathrm{B}}{\mu_0}$ and $B = \mu_0 ni \left(n = \frac{N}{\ell}\right)$

or, $\mathrm{H} = \frac{\mathrm{N}}{\ell}\mathrm{i} = \frac{100}{0.2} \times 5.2$ = 2600 A/m

14.

(b) At t = 0.5 direction of I_R reverses and V_R is zero

Explanation:

According to question,

I(t) = I_0t(1 - t)

$\therefore$ I = I_0t - I_0t^2

ϕ = B.A

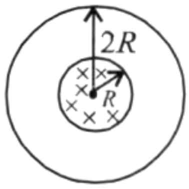
ϕ = (μ_0nI) $\times$ (πR^2)

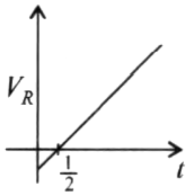
($\because$ B = μ_0nI and A = πR^2)

V_R = $\frac{-d\phi}{dt}$

V_R = $\mu_0 n\pi R^2$(I_0 - 2I_0t)

$\Rightarrow$ V_R = 0 at t = $\frac{1}{2}$s



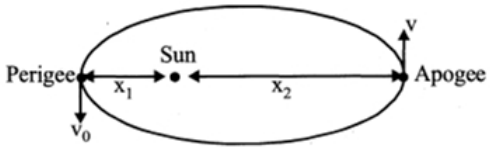


15.

(b) $\frac{v_0 x_1}{x_2}$

Explanation:

When distance of the planet from the sun is maximum i.e., x at apogee so velocity is minimum and vice-versa.



By angular momentum conservation

$mv_0x_1 = mvx_2$

$\Rightarrow v = \frac{v_0x_1}{x_2}$

16.

(b) 4 .0 $\times$ 10^{-5} s

Explanation:

$V = \frac{E_0}{B_0} = \frac{2.25}{1.5\times10^{-8}} = \frac{2.25\times10^8}{1.5} = 1.5 \times 10^8 \text{ m/s}$

$t = \frac{\text{Total distance}}{\text{velocity of work}} = \frac{6\times10^8}{1.5\times10^8} = 4 \times 10^{-5}\text{sec}$

17.

(b) Frequency

Explanation:

According to Einstein’s photoelectric equation,

K_{max} = hv - $\phi_0 \Rightarrow$ eV_0 = hv - ϕ

Where, V_0 = Stopping potential,

ϕ = Work function,

v = Frequency of incident light

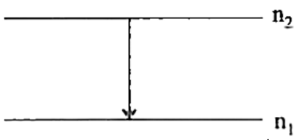
$\therefore$ Stopping potential depends on frequency.

18.

(d) 4

Explanation:

A hydrogen atom makes a transition from n = 2 to n = 1



Then wavelength = $\mathrm{Rcz}^2\left|\frac{1}{n_1^2} - \frac{1}{n_2^2}\right|$ = $\mathrm{Rc}(1)^2\left|1 - \frac{1}{4}\right|$

$\lambda = \mathrm{Rc}\left|\frac{3}{4}\right|$ ...(1)

For ionized lithium

$\lambda = \text{Rc}(3)^2 \left|\frac{1}{n^2}\right| = \text{Rc}\,9\left|\frac{1}{n^2}\right|$ ...(2)

$\text{Rc}\left[\frac{3}{4}\right] = \text{Rc}\,9\left[\frac{1}{n^2}\right] \Rightarrow \frac{3}{4} = \frac{9}{n^2} \Rightarrow n = \sqrt{12} = 2\sqrt{3}$

$\therefore$ The least quantum number must be 4.

19.

(b) 60 MW

Explanation:

Power output of the reactor,

$P = \frac{\text{energy}}{\text{time}}$

$= \frac{2}{235} \times \frac{6.023\times10^{26}\times200\times1.6\times10^{-19}}{30\times24\times60\times60} \simeq 60$ MW

20. **(a)** 0.4 A and 0.2 A

Explanation:

When positive terminal connected to A then diode D_1 is forward biased, current, $I = \frac{2}{5} = 0.4A$

When positive terminal connected to B then diode D_2 is forward biased, current, $I = \frac{2}{10} = 0.2A$

PHYSICS (Section-B)

21. 640.0

Explanation:

Flux through surface x = 0, y = 0, y = 20 cm, z = 0 and z = 20 cm

will be zero as for these surface $\vec{E} \perp \vec{A}$

Flux through surface (x = 0.2 m) = 4000 $\times$ $0.2^2 \times 0.2^2$ = 6.4 Vm = 640 Vcm

22. 242.0

Explanation:

When voltage is minimum, current is maximum.

So, circuit is purely inductive i.e. R = 0

So, $Z = X_L$ Then, $i_0 = \frac{V_0}{X_L}$

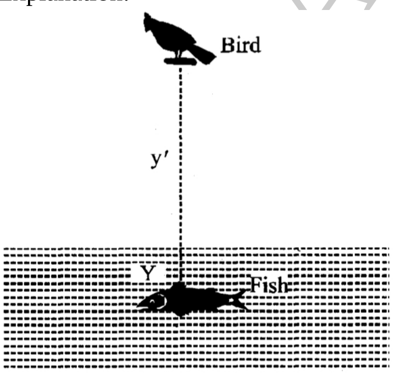
$\Rightarrow i_0 = \frac{V_0}{2\pi fL} \Rightarrow i_0 = \frac{\sqrt{2}V_{rms}}{2\pi fL}$

$\Rightarrow i_0 = \frac{\sqrt{2}\times220}{2\pi\times50\times0.2} = \frac{220\sqrt{2}}{20\pi} = \frac{11\sqrt{2}}{\pi} = \frac{\sqrt{242}}{\pi}$

$\because$ a = 242

23. 3

Explanation:



Effective height of the bird as seen by the fish, $Y = y + \mu y'$

Differentiating both sides w.r.t.t

$\frac{dY}{dt} = \frac{dy}{dt} + \mu\frac{dy'}{dt}$

Given $\frac{dY}{dt} = 12\ ms^{-1}$;

$\frac{dy}{dt} = 8\ ms^{-1}$

$\therefore 12 = 8 + \frac{4}{3}\frac{dy}{dt}$

$\therefore \frac{dy'}{dt} = \frac{4\times3}{4} = 3\ ms^{-1}$

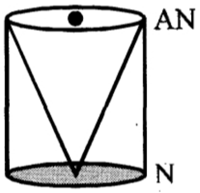
24. 50.0

Explanation:

If we don't ignore the word fundamental mode, you cannot observe resonance once again whatever be the height of water in column.

$\lambda=\frac{V}{f}=\frac{340}{340}=1 \text{ m}$

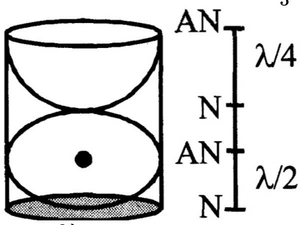
In first resonance



$\lambda = 4L_1$

$L_1=\frac{\lambda}{4}=25 \text{ cm}$

In second resonance $\lambda=\frac{4L}{3}$



$L=\frac{3\lambda}{4}=75 \text{ cm}$

In third resonance

$\lambda=\frac{4L}{5}\ L=\frac{\lambda}{2}+\frac{\lambda}{4}=\frac{4\lambda}{3}$

$L=\frac{5\lambda}{4}=125 \text{ cm}$, So, mode of vibration is $L=\frac{5\lambda}{4}$

Now, if 50 cm of water is added, it will vibrate in second resonance mode.

So, height of water required = (125 - 75) cm = 50 cm

25. 2.0

Explanation:

As $\Delta l=\frac{F\cdot l}{Y\cdot\pi r^2}\Rightarrow\Delta l\propto\frac{l}{r^2}$

$\Delta l_2=\left(\frac{l_2}{l_1}\right)\left(\frac{r_1}{r_2}\right)^2\Delta l_1=(2)\left(\frac{1}{2}\right)^2(0.04)\text{m} = 2 \text{ cm}.$