# PHYSICS
# JEE-MAIN (August-Attempt)
# 26 August (Shift-1) Paper
# Solution

**SECTION - A**

Q.1 An inductor coil stores 64 J of magnetic field energy and dissipates energy at the rate of 640 W when a current of 8A is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit in seconds:

(1) 0.4 (2) 0.8 (3) 0.125 (4) 0.2

Sol. (4)

Energy inside an inductor $= \frac{1}{2} L I^2$

$$64 = \frac{1}{2} L \times 8^2$$

$L = 2H$

Power Dissipation across inductor $= I^2R$

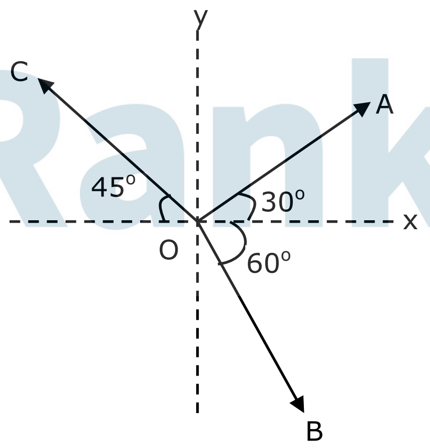
$$640 = (8)^2R$$

$R = R = 10\Omega$

Time Constant $= \tau = \frac{L}{R} = \frac{2}{10} = \frac{1}{5}$

$= 0.2$ sec

Q.2 The magnitude of vectors $\overrightarrow{OA}$, $\overrightarrow{OB}$ and $\overrightarrow{OC}$ in the given figure are equal. The direction of $\overrightarrow{OA} + \overrightarrow{OB} - \overrightarrow{OC}$ with x-axis will be :




(1) $\tan^{-1}\frac{\left(1+\sqrt{3}-\sqrt{2}\right)}{\left(1-\sqrt{3}-\sqrt{2}\right)}$ (2) $\tan^{-1}\frac{\left(\sqrt{3}-1+\sqrt{2}\right)}{\left(1-\sqrt{3}+\sqrt{2}\right)}$

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

**Sol. (4)**

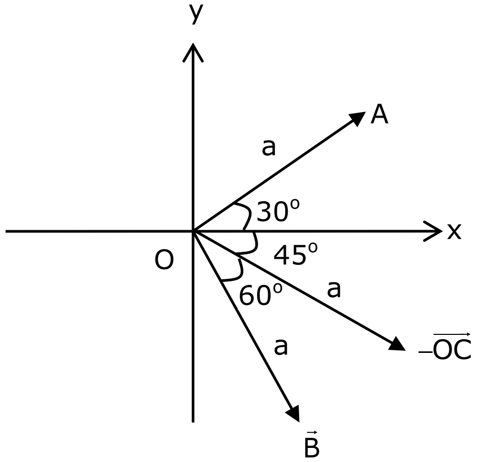
$\overrightarrow{OA} + \overrightarrow{OB} - \overrightarrow{OC} = \vec{R}$

$|OA| = |OB| = |OC| = a$

Component of $\vec{R}$
in x-direction

$$a\cos 30^\circ\,\hat{i} + a\cos 45^\circ\,\hat{j} + a\cos 60^\circ\,\hat{i}$$

$$\vec{R} = \left(a\cos 30\hat{i} + a\cos 45\hat{i} + a\cos 60\hat{i}\right) + \left(a\sin 30\hat{j} - a\sin 45\hat{j} - a\sin 60\hat{j}\right)$$




$$\vec{R} = \hat{i}\left(\frac{a\sqrt{3}}{2} + \frac{a1}{\sqrt{2}} + \frac{a}{2}\right) + \hat{j}\left(\frac{a}{2} - \frac{a}{\sqrt{2}} - \frac{a\sqrt{3}}{2}\right)$$

$$\vec{R} = a\hat{j}\left(\frac{\sqrt{3}}{2} + \frac{1}{\sqrt{2}} + \frac{1}{2}\right) + a\hat{j}\left(\frac{1}{2} - \frac{1}{\sqrt{2}} - \frac{\sqrt{3}}{2}\right)$$

$$\vec{R} = a\hat{i}\left(\frac{\sqrt{6} + 2\sqrt{2}}{2\sqrt{2}}\right) + a\hat{j}\left(\frac{\sqrt{2} - 2 - \sqrt{6}}{2\sqrt{2}}\right)$$

$$\vec{R} = x\hat{i} + y\hat{j}$$

direction of $\vec{R} = \tan^{-1}\left(\frac{y}{x}\right)$

$$\text{direction} = \tan\theta = \frac{a\left(\frac{\sqrt{2} - 2 - \sqrt{6}}{2\sqrt{2}}\right)}{a\left(\frac{\sqrt{6} + 2 + \sqrt{2}}{2\sqrt{2}}\right)} = \frac{\sqrt{2} - 2 - \sqrt{6}}{\sqrt{6} + 2 + \sqrt{2}} = \frac{\sqrt{2}\left(1 - \sqrt{2} - \sqrt{3}\right)}{\sqrt{2}\left(\sqrt{3} + \sqrt{2} + 1\right)}$$

$$\tan\theta = \frac{1 - \sqrt{2} - \sqrt{3}}{1 + \sqrt{3} + \sqrt{2}}$$

$$\theta = \tan^{-1}\left(\frac{1 - \sqrt{3} - \sqrt{2}}{1 + \sqrt{3} + \sqrt{2}}\right)$$

Q.3 A series LCR circuit deriven by 300 V at a frequency of 50 Hz contains a resistance R = $3k\Omega$, an inductor of inductive reactance $X_L = 250\pi\Omega$ and an unknown capacitor. The value of capacitance to maximize the average power should be:

(1) 4 $\mu$F (2) 25 $\mu$F (3) 40 $\mu$F (4) 400 $\mu$F

Sol. (1)

V = 300 V

f = 50 Hz $\Rightarrow$ $\omega = 2\pi f$

R = $3k\Omega$

$X_L = 250\pi\Omega$

Power maximum at Resonance

$X_L = X_C$

$\omega L = \frac{1}{\omega C}$

$\frac{1}{\omega c} = 250\pi$

$C = \frac{1}{\omega \times 250\pi} = \frac{1}{2\pi \times 50 \times 250\pi} = \frac{1}{25000}$

$= 0.04 \times 10^{-4}$

$= 4 \times 10^{-6}$

$= 4\mu F$

Q.4 In a Screw Gauge, fifth division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation the reading on the main scale is 5 mm and the 20th division of the circular scale coincides with reference line. Calculate the true reading.

(1) 5.00 mm (2) 5.20 mm (3) 5.15 mm (4) 5.25 mm

Sol. (3)

Least count (L.C) $= \frac{0.5}{50}$

True reading $= 5 + \frac{0.5}{50} \times 20 - \frac{0.5}{50} \times 5$

$= 5 + \frac{0.5}{50}(15) = 5.15\text{mm}$

Q.5 If E, L, M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $P = EL^2M^{-5}G^{-2}$ are:

(1) $[M^0\ L^1\ T^0]$ (2) $[M^{-1}\ L^{-1}\ T^2]$ (3) $[M^0\ L^0\ T^0]$ (4) $[M^1\ L^1\ T^{-2}]$

Sol. (3)

E = energy = $[ML^2T^{-2}]$

L = angular momentum = $[ML^2T^{-1}]$

M = Mass = [M]

G = Gravitaional constant = $[M^{-1}L^3T^{-2}]$

P = $EL^2\ M^{-5}G^{-2}$

$[P] = [ML^2T^{-2}][ML^2T^{-1}]^2[M]^{-5}[M^{-1}L^3T^{-2}]^{-2}$

$= [ML^2T^{-2}\ M^2L^4T^{-2}\ M^{-5}\ M^{+2}\ L^{-6}\ T^{+4}]$

$= [M^0\ L^0\ T^0]$

Q.6 **Statement I:**

By doping silicon semiconductor with pentavalent material, the electrons density increases.

**Statement II:**

The n-type semiconductor has net negative charge.

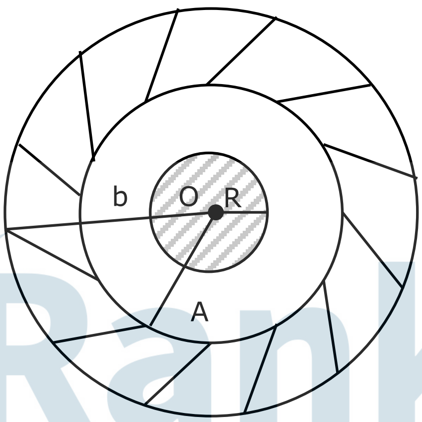
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both Statement I and Statement II are true.
(2) Statement I is true but Statement II is false.
(3) Both Statement I and Statement II are false.
(4) Statement I is false but Statement II true.

Sol. (2)

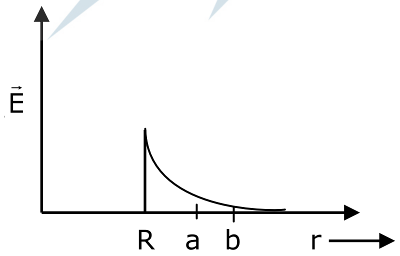
⇒ As each pentavalent impurity atom donets one electron the pentavalent impurities are called donor impurities

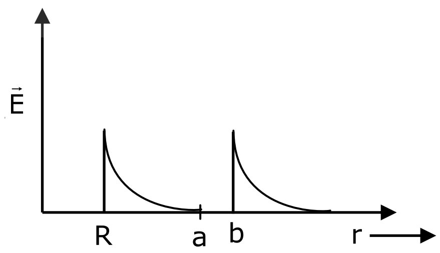
⇒ The net charge of the semiconductor will be zero.

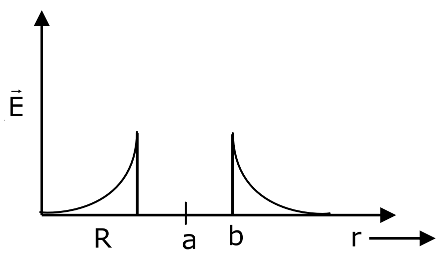
Q.7 A solid metal sphere of radius R having charge q is enclosed inside the concentric spherical shell of inner radius a and outer radius b as shown in figure. the approximate veriation electric field $\vec{E}$ as a function of distance r from centre O is given by:

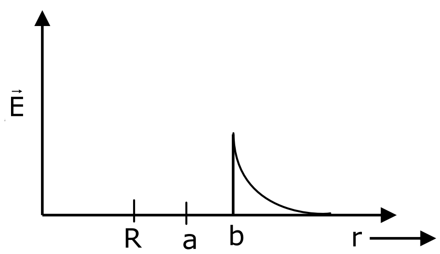





(1) 


(2) 


(3) 

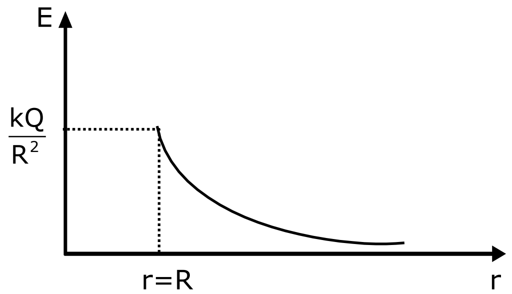

(4) 


Sol. NTA Offical (2)
Motion (1) or (2)
Considering outer spherical shell is non-conducting

Electric field inside a metal sphere is zero.

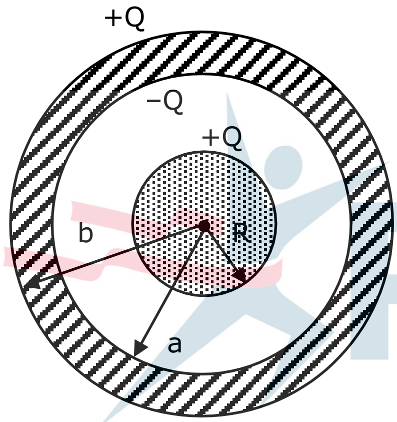
$r < R \Rightarrow E = 0$

$r > R \Rightarrow E = \frac{kQ}{r^2}$



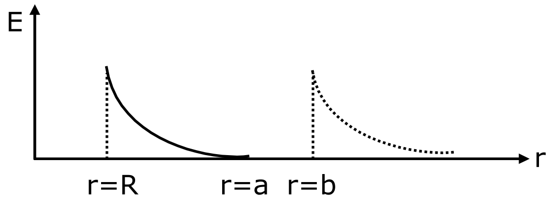

Option (2)

Considering outer spherical shell is conducting




r < R, E = 0

| | |
|---|---|
| $R \le r < a$ | $E = \frac{kQ}{r^2}$ |
| $a \le r < b$, | $E = 0$ |
| $r \ge b$ | $E = \frac{kQ}{r^2}$ |

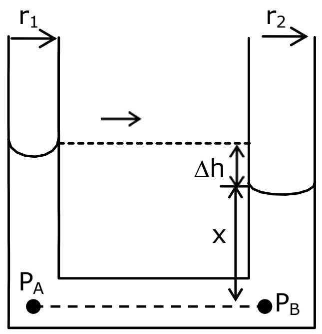


Q.8 Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.

[Take surface tension of water T = $7.3\times10^{-2}Nm^{-1}$, angle of contact = 0, g = 10 $ms^{-2}$ and density of water = $1.0\times10^{3}kg\,m^{-3}$]

(1) 5.34 mm (2) 4.97 mm (3) 2.19 mm (4) 3.62 mm

Sol. (3)




We have $P_A = P_B$ .[Points A & B at same horizontal level]

$$\therefore\ P_{atm} - \frac{2T}{r_1} + \rho g\left(x+\Delta h\right) = P_{atm} - \frac{2T}{r_2} + \rho g x$$

$$\therefore\ \rho g \Delta h = 2T\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$= 2\times7.3\times10^{-2}\left[\frac{1}{2.5\times10^{-3}} - \frac{1}{4\times10^{-3}}\right]$$

$$\therefore\ \Delta h = \frac{2\times7.3\times10^{-2}\times10^{3}}{10^{3}\times10}\left[\frac{1}{2.5} - \frac{1}{4}\right]$$

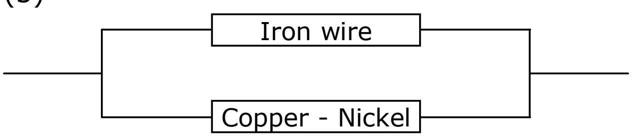
$$= 2.19\times10^{-3}m = 2.19mm$$

Q.9 What equal length of an iron wire and a copper-nickel alloy wire, each of 2 mm diameter connected parallel to give an equivalent resistance of 3 $\Omega$?

(Given resistivities of iron and copper-nickel alloy wire are 12 $\mu\Omega$ cm and 51 $\mu\Omega$ cm respectively)

(1) 82 m (2) 110 m (3) 97 m (4) 90 m

Sol. (3)




$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{3} = \frac{A_1}{\rho_1 \ell} + \frac{A_2}{\rho_1 \ell}$$

$$\ell = 3\left[\frac{A}{\rho_1} + \frac{A}{\rho_2}\right]$$

$$\ell = 3A\left[\frac{\rho_1+\rho_2}{\rho_1\rho_2}\right] = 3\times\pi\times10^{-6}\left[\frac{12+51}{12\times51}\right] = 97m$$

Q.10 The rms speeds of the molecules of Hydrogen, Oxygen and Carbondioxide at the same temperature are $V_H$, $V_O$ and $V_C$ respectively then:

(1) $V_H = V_O > V_C$ (2) $V_C > V_O > V_H$ (3) $V_H > V_O > V_C$ (4) $V_H = V_O = V_C$

Sol. (3)

$$(V_{rms})_H = V_H = \sqrt{\frac{3RT}{M_H}} = \sqrt{\frac{3RT}{1}}$$

$$V_0 = \sqrt{\frac{3RT}{M_O}} \qquad V_C = \sqrt{\frac{3RT}{M_C}}$$

$M_H = 1$
$M_O = 16$
$M_C = 44$

$$V_O = \sqrt{\frac{3RT}{16}} \qquad V_C = \sqrt{\frac{3RT}{44}}$$

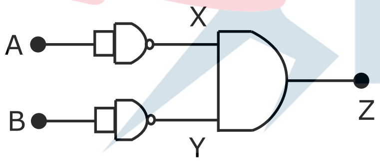
$V_H : V_O : V_C$

$$\sqrt{\frac{3RT}{1}} : \sqrt{\frac{3RT}{16}} : \sqrt{\frac{3RT}{44}}$$

$$1 : \frac{1}{4} : \frac{1}{\sqrt{44}}$$

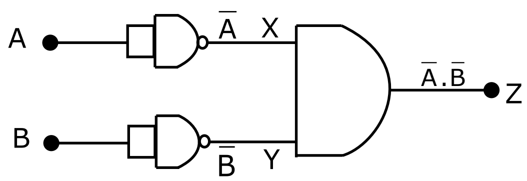
$\boxed{V_H > V_O > V_C}$

Q.11 Identify the logic operation carried out by the given circuit:




(1) NOR (2) OR (3) NAND (4) AND

Sol. (1)




| A | B | $\bar{A}.\bar{B}$ | $\overline{A+B}$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 |

Output = $\bar{A}.\bar{B} = \overline{A+B}$

<u>NOR gate</u>

Q.12 Car B overtakes another car A at a relative speed of 40 $ms^{-1}$. How fast will the image of car B appear to move in the mirror of focal length 10 cm fitted in car A, when the car B is 1.9 m away from the car A?

(1) 0.1 $ms^{-1}$ (2) 0.2 $ms^{-1}$ (3) 4 $ms^{-1}$ (4) 40 $ms^{-1}$

Sol. (1)


Mirror used is convex mirror (rear-view mirror)

$\therefore V_{1/m} = -m^2 V_{O/m}$

Given,

$V_{O/m} = 40 m/s$

$m = \frac{f}{f-u} = \frac{10}{10+190} = \frac{10}{200}$

$\therefore V_{1/m} = -\frac{1}{400} \times 40 = -0.1 m/s$

$\therefore$ Car will appear to move with speed 0.1 m/s

Q.13 Inside a uniform spherical shell:

(a) the gravitational field is zero.

(b) the gravitational potential is zero.

(c) the gravitational field is same everywhere.

(d) the gravitational potential is same everywhere.

(e) all of the above.

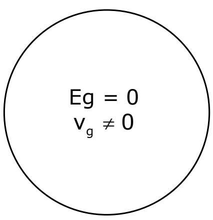
Choose the **most appropriate** answer from the options given below:

(1) (a), (c) and (d) only (2) (e) only

(3) (b), (c) and (d) only (4) (a), (b) and (c) only

Sol. (1)

Gravitational Potential is not zero.




a, c, d correct

Q.14 In a photoelectric experiment ultraviolet light of wavelength 280 nm is used with lithium cathode having work function $\phi = 2.5 eV$. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential. ($h = 6.63 \times 10^{-34} Js$, $c = 3 \times 10^8 ms^{-1}$)

(1) 1.9 V (2) 1.1 V (3) 1.3 V (4) 0.6 V

Sol. (3)

$\lambda_1 \Rightarrow$

$E = \frac{1240}{280} ev = 4.42eV$

$(eV_s)_1 = E - \phi = 4.42eV - 2.5ev$

$= 1.92ev$

$\lambda_2 \Rightarrow$

$E = \frac{1240}{400} = 3.1eV$

$(eV_s)_2 = E - \phi = (3.1 - 2.5) ev$

$= 0.6$ eV

$Vs_1 - Vs_2 = 1.92 - 0.6 = 1.3V$

Q.15 A particular hydrogen like ion emits radiation of frequency $2.92 \times 10^{15}$Hz when it makes transition from n = 3 to n = 1. The frequency in Hz of radiation emitted in transition from n = 2 to n = 1 will be:

(1) $0.44 \times 10^{15}$ (2) $4.38 \times 10^{15}$ (3) $6.57 \times 10^{15}$ (4) $2.46 \times 10^{15}$

Sol. (4)

$\frac{1}{\lambda} = Rz^2 \left( \frac{1}{n_1} - \frac{1}{n_2} \right)$

$\frac{1}{\lambda} = Rz^2 \left( \frac{1}{1} - \frac{1}{9} \right)$

$\frac{1}{\lambda'} = Rz^2 \left( \frac{1}{1} - \frac{1}{4} \right)$

$\frac{\lambda'}{\lambda} = \frac{8}{9} \times \frac{4}{3} = \frac{32}{27}$

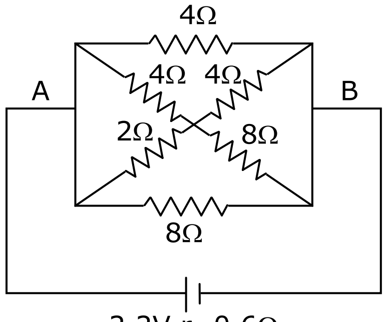
$\frac{f}{f'} = \frac{32}{27}$

$f' = \left( \frac{27}{32} \right) f$

$f' = \frac{27}{32} \times 2.92 \times 10^{15}Hz$

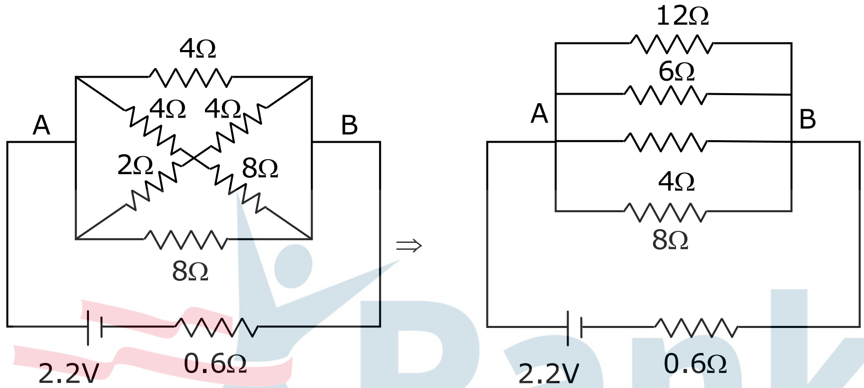
$= 2.46 \times 10^{15}Hz$

Q.16 In the given figure, the emf of the cell is 2.2 V and if internal resistance is $0.6\Omega$. Calculate the power dissipated in the whole circuit:




(1) 2.2 W (2) 1.32 W (3) 0.65 W (4) 4.4 W

Sol. (1)




$$\frac{1}{R_{AB}} = \frac{1}{12} + \frac{1}{6} + \frac{1}{4} + \frac{1}{8}$$

$$R_{AB} = \frac{48}{30}$$

$$R_{eq} = \frac{48}{30} + 0.6 \Rightarrow \frac{66}{30} = 2.2\Omega$$

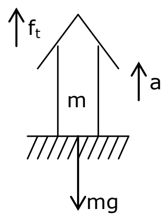
$$\text{Power} = \frac{V^2}{R} = \frac{(2.2)^2}{2.2} = 2.2W$$

Q.17 The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of 20 $ms^{-2}$. The gases comes out at a relative speed of 500 ms–1 with respect to the rocket:
[Use g = 10 $m/s^2$]

(1) 60 kg $s^{-1}$ (2) 10 kg $s^{-1}$ (3) $6.0 \times 10^2$ kg $s^{-1}$ (4) 500 kg $s^{-1}$

Sol. (1)

$F_t - mg = ma$



$$\frac{dm}{dt}V_r - mg = ma$$

$$\frac{dm}{dt} = \frac{m(g+a)}{V_r} = \frac{1000(10+20)}{500}$$

$$\frac{dm}{dt} = 2\times 30 = 60\,kgs^{-1}$$

Q.18 The fractional change in the magnetic field intensity at a distance 'r' from centre on the axis of current carrying coil of radius 'a' to the magnetic field intensity at the centre of the same coil is:(Take r < a).

(1) $\frac{3}{2}\frac{r^2}{a^2}$ (2) $\frac{3}{2}\frac{a^2}{r^2}$ (3) $\frac{2}{3}\frac{a^2}{r^2}$ (4) $\frac{2}{3}\frac{r^2}{a^2}$

Sol. (1)

$$B_{axis} = \frac{\mu_0 i R^2}{2\left(R^2+x^2\right)^{3/2}}$$

$$B_{centre} = \frac{\mu_0 i}{2R}$$

$$\therefore B_{centre} = \frac{\mu_0 i}{2a}$$

$$\therefore B_{axis} = \frac{\mu_0 i a^2}{2\left(a^2+r^2\right)^{3/2}}$$

$\therefore$ fractional change in magnetic field =

$$\frac{\frac{\mu_0 i}{2a} - \frac{\mu_0 i a^2}{2\left(a^2+r^2\right)^{3/2}}}{\frac{\mu_0 i}{2a}} = 1 - \frac{1}{\left[1+\left(\frac{r^2}{a^2}\right)\right]^{3/2}}$$

$$\approx 1 - \left[1 - \frac{3}{2}\frac{r^2}{a^2}\right] = \frac{3}{2}\frac{r^2}{a^2}$$

Note: $\left(1+\frac{r^2}{a^2}\right)^{-3/2} \approx \left(1 - \frac{3}{2}\frac{r^2}{a^2}\right)$

[True only if r<<a]

Q.19 An electric appliance supplies 6000 J/min heat to the system. If the system delivers a power of 90 W. How long it would take to increase the internal energy by $2.5\times10^3$ J?

(1) $4.1 \times 10^1$s (2) $2.4 \times 10^3$s (3) $2.5 \times 10^2$s (4) $2.5 \times 10^1$s

Sol. (3)

$$\Delta Q = \Delta U + \Delta W$$

$$\frac{\Delta Q}{\Delta t} = \frac{\Delta U}{\Delta t} + \frac{\Delta W}{\Delta t}$$

$$\frac{600}{60}\frac{J}{sec} = \frac{2.5\times10^3}{\Delta t} + 90$$

$$\Delta t = 250\,sec.$$

Q.20 The material filled between the plates of a parallel plate capacitor has resistivity $200\,\Omega m$. The value of capacitance of the capacitor is 2pF. If a potential difference of 40 V is applied across the plates of the capacitor, then the value of leakage current flowing out of the capacitor is: (given the value of relative permitivity of material is 50)

(1) 9.0 $\mu$A (2) 0.9 $\mu$A (3) 9.0 mA (4) 0.9 mA

Sol. (4)

$\rho = 200\ \Omega m$

$C = 2 \times 10^{-12}$ F

V = 40 V

K = 56

$$i = \frac{q}{\rho k \varepsilon_0} = \frac{q_0}{\rho k \varepsilon_0} e^{-\frac{t}{\rho k \varepsilon_0}}$$

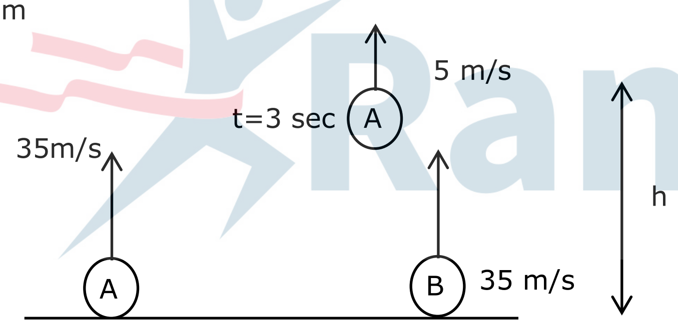
$$i_{max} = \frac{2 \times 10^{-12} \times 40}{200 \times 50 \times 8.85 \times 10^{-12}}$$

$$= \frac{80}{10^4 \times 8.85} = 903\mu A = 0.9mA$$

## Section B

Q.1 Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3 s with the same initial velocity of 35 m/s, then these balls collide at a height of ___________m. (take $g = 10\ m/s^2$)

Sol. 50 m




$V_A = u_A - gt$

$= 35 - 10 \times 3$

$= 5$ m/s

$\overline{V_{BA}} = \vec{V_B} - \vec{V_A} = 35 - 5 = 30m/s$

$\overline{a_{BA}} = \vec{a_B} - \vec{a_A} = -g - (-g) = 0$

$h = u_A t + \frac{1}{2} a_A t^2$

$= 35 \times 3 - \frac{1}{2} \times 10 \times 3^2$

$= 105 - 45 = 60m$

collide time = t = 60/30 = 2sec.

height $= 35 \times 2 - \frac{1}{2} \times 10 \times 4$

$= 70 - 20 = 50m$

Q.2 A source and a detector move away from each other in absence of wind with a speed of 20 m/s with respect to the ground.. if the detector detects a frequency of 1800 Hz of the sound coming from the source, then the original frequency of source considering speed of sound in air 340 m/s will be __________ Hz.

Sol. 2025


$V_S$ = 20 m/s $\quad$ $V_O$ = 20 m/s

$$f' = f\left(\frac{C - V_0}{C + V_S}\right)$$

$$1800 = f\left(\frac{340 - 20}{340 + 20}\right)$$

$$f = 2025\,\text{Hz}$$

Q.3 White light is passed through a double slit and interference observed on a screen 1.5 m away. The separation between the slits is 0.3 mm. The first violet and red fringes are formed 2.0 mm and 3.5 mm away from the central white fringes. The difference in wavelengths of red and voilet light is _________ nm.

Sol. 300 nm

$$y_{red} = \frac{\lambda_{red} D}{d} \quad .....(1)$$

$$y_{voilet} = \frac{\lambda_{voilet} D}{d} \quad .....(2)$$

$$\frac{d}{D}\left(y_{red} - Y_{voilet}\right) = \left(\lambda_{red} - \lambda_{voilet}\right)$$

$$\frac{0.3}{1.5 \times 10^{-3}}(3.5 - 2) = \left(\lambda_{red} - \lambda_{voilet}\right)$$

$$\left(\lambda_{red} - \lambda_{voilet}\right) = 0.3 \times 10^{-3}\,\text{mm}$$

$$= 0.3 \times 10^{-3} \times 10^{6}\,\text{nm}$$

$$= 300 \text{ nm}$$

Q.4 An amplitude modulated wave is represented by $C_m(t)$ = 10 (1 + 0.2 cos 12560t) sin (111×$10^4$t) volts. The modulating frequency in kHz will be __________.

Sol. 2 kHz

$C_m(t)$ = 10 (1 + 0.2 cos 12560t) sin (111×$10^4$t)V

$$C_m = A_C\left(1 + \frac{A_C}{A_m}\cos\left(2\pi f_m t\right)\right)$$

$$2\pi f_m = 12560$$

$$f_m = \frac{12560}{2 \times 3.14} = 2000$$

$$= 2 \text{ kHz}$$

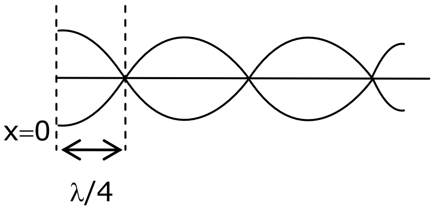
Q.5 Two travelling waves produces a standing wave represented by equation.
$y = 1.0 \text{ mm} \cos(1.57 \text{ cm}^{-1})x \sin(78.5 \text{ s}^{-1})t$. the node closest to the orgin in the region $x > 0$ will be at x = ________ cm.

Sol. 1

$y = 1.0 \text{ mm} \cos(1.57 \text{ cm}^{-1})x \sin(78.5 \text{ s}^{-1})t$

$y = 2A \cos kx \sin \omega t$

$R = 2A \cos kx$

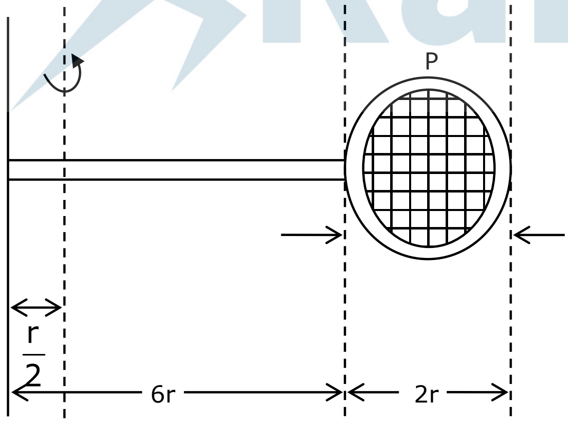



$k = \frac{1.57}{cm} = \frac{2\pi}{\lambda}$

$\Delta x = \lambda/4$

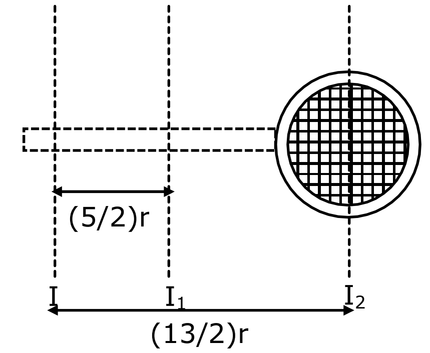
$= 4/4 = 1\text{cm}$

Q.6 Consider a badminton racket with length scales as shown in the figure.




If the mass of the linear and circular portions of the badminton racket are same (M) and the mass of the threads are negligible, the moment of inertia of the racket about an axis perpendicular to the handle and in the plane of the ring at, $\frac{r}{2}$ distance from the end A of the handle will be __________ $Mr^2$.

Sol. 52




$$I = \left[I_1 + M\left(\frac{5}{2}r\right)^2\right] + \left[I_2 M\left(\frac{13r}{2}\right)^2\right]$$

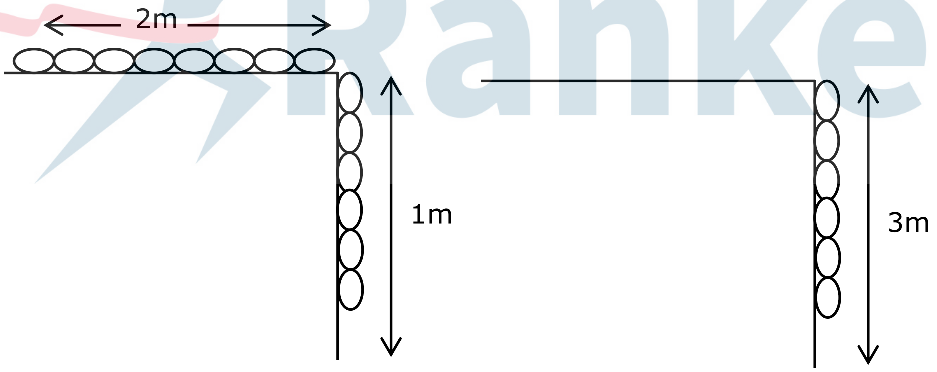
$$= \left[\frac{M(36r^2)}{12} + \frac{M(25r^2)}{4}\right] + \left[\frac{Mr^2}{2} + \frac{169Mr^2}{4}\right]$$

$= 52\ Mr^2$

$= 52.00$

Q.7 A uniform chain of length 3 meter and mass 3 kg overhangs a smooth table with 2 meter laying on the table. If k is the kinetic energy of the chain in joule as it completely slips off the table, then value of k is __________. (Take g = 10 m/s$^2$)

Sol. 40




$k = U_f - U_i$

$k = [m_2gh_2] - (m_1gh_1)$

$= \left[3 \times g \times \frac{3}{2}\right] - \left(1 \times g \times \frac{1}{2}\right)$

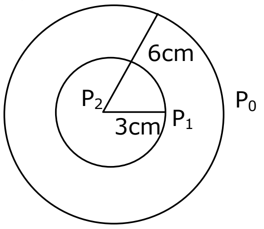
= 45 – 5 = 40 J

mass of 3 m = 3 kg

mass of 1 m = 1 kg

Q.8 A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is _________ cm.

Sol. 2 cm




$P_1 - P_0 = 4T/6$

$P_2 - P_1 = 4T/3$

$P_2 - P_0 = \frac{4T}{6} + \frac{4T}{3}$

$P_2 - P_0 = \frac{4T}{R}$

$\frac{4T}{R} = \frac{4T}{6} + \frac{4T}{3}$

$\frac{1}{R} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2}$

$R = 2cm$

Q.9 The electric field in a plane electromagnetic wave is given by

$\vec{E} = 200\cos\left[\left(\frac{0.5\times10^3}{m}\right)x - \left(1.5\times10^{11}\frac{rad}{s}\times t\right)\right]\frac{V}{m}\hat{j}$

If the wave falls normally on a perfectly reflecting surface having an area of 100 $cm^2$. If the radiation pressure exerted by the E.M. wave on the surface during a 10 minute exposure is $\frac{x}{10^9}\frac{N}{m^2}$. Find the value of x.

Sol. 354

$E_0 = 200$

$I = \frac{1}{2}\varepsilon_0 E_0^2 .C$

Radiation pressure

$P = \frac{2I}{C}$

$= \left(\frac{2}{C}\right)\left(\frac{1}{2}\varepsilon_0 E_0^2 C\right)$

$= \varepsilon_0 E_0^2$

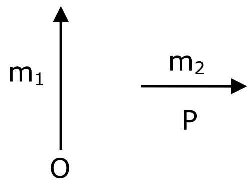
$= 8.85\times10^{-12}\times200^2$

$= 8.85\times10^{-8}\times4$

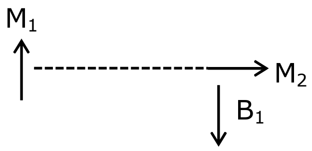
$= \frac{354}{10^9}$

= 354.0

Q.10 Two short magnetic dipoles $m_1$ and $m_2$ each having magnetic moment of 1 $Am^2$ are placed at point O and P respectively. The distance between OP is 1 meter. The torque experienced by the magnetic dipole $m_2$ due to the presence of $m_1$ is __________ $\times 10^{-7}$ Nm.




Sol. 1




$$\vec{\tau} = \vec{M}_2 \times \vec{B}_1$$

$$\tau = M_2 B_1 \sin 90^\circ$$

$$= 1 \times \frac{\mu_0}{4\pi} \frac{M_1}{(1)^3} 1$$

$$= 10^{-7} N.m$$

= 1.00