FINAL JEE–MAIN EXAMINATION – APRIL, 2023
Held On Thursday 06th April, 2023
TIME : 03:00 PM to 06:00 PM

SECTION - A

31. The temperature of an ideal gas is increased from 200 K to 800 K. If r.m.s. speed of gas at 200 K is v_0. Then, r.m.s. speed of the gas at 800 K will be:

(1) $4v_0$ (2) $2v_0$ (3) v_0 (4) $\frac{v_0}{4}$

Sol. **(2)**

using $v_{rms} = \sqrt{\frac{3RT}{m}}$

$v_0 = \sqrt{\frac{3R\times 200}{m}}$ ….(1)

$(v') = \sqrt{\frac{3R\times 800}{m}}$ ….(2)

dividing (2) by (1)

$\frac{v'}{v_0} = \sqrt{\frac{800}{200}} = \sqrt{4} = 2$

or $v' = 2v_0$

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

Assertion A : The phase difference of two light wave change if they travel through different media having same thickness, but different indices of refraction

Reason R : The wavelengths of waves are different in different media.

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

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

Sol. **(1)**

Both the statements are true

As we know speed of light in a medium

$v = \frac{c}{\mu}$ or $f\lambda = \frac{c}{\mu}$

therefore $\lambda \propto \frac{1}{\mu}$

when light will travel through two different mediums their phase difference will change

$\Delta Q = \frac{2\pi}{\lambda}\Delta x$

and R is correction explanation

33. For an amplitude modulated wave the minimum amplitude is 3 V, while the modulation index is 60%. The maximum amplitude of the modulated wave is :

(1) 10 V (2) 12 V (3) 15 V (4) 5 V

Sol. **(2)**

Given, modulation index = 60% = 0.6

$\frac{A_m}{A_c} = \frac{0.6}{1}$

Using componendo – dividendo, we can write

$\frac{A_m + A_c}{A_m - A_c} = \frac{0.6+1}{0.6-1} = \frac{1.6}{-0.4}$

$A_m + A_c = \frac{1.6}{-0.4} \times (A_m - A_c)$

$= \frac{1.6}{-0.4} \times (-3) = 12$ V

34. The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is :

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

Sol. **(4)**

Using $v = \sqrt{\frac{\gamma RT}{m}}$

$$\frac{U_{H_2}}{v_{O_2}} = \sqrt{\frac{m_{O_2}}{m_{H_2}}} = \sqrt{\frac{32}{2}} = \sqrt{\frac{16}{1}} = 4:1$$

(since both hydrogen and oxygen are di-atomic, γ will be same)

35. A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass 'm' of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance 'l'. If the dipole is placed in a uniform electric field '$\bar{E}$'; in such a way that dipole axis makes a very small angle with the electric field, '$\bar{E}$'. The angular frequency of the oscillations of the dipole when released is given by :

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

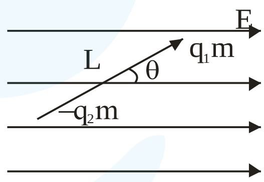
Sol. **(1)**

In this case, since masses of both charges are not same, therefore, we need to find center of mass (COM), about which dipole will oscillate and then we will find moment of Inertia about this axis, to find torque & hence ω.

As we know, COM will divide length in the inverse ratio of the masses, therefore, COM will be at a distance of $\frac{L}{3}$ from 2m & $\frac{2L}{3}$ from m.

MI about this axis

$$I = 2m\left(\frac{L}{3}\right)^2 + \left(\frac{2L}{3}\right)^2$$



$$\text{Or } I = \frac{2mL^2}{a} + \frac{4mL^2}{a} = \frac{6mL^2}{a} = \frac{2mL^2}{3}$$

$$\text{Using } \omega = \frac{2mL^2}{3} \text{ \& } p = qL$$

$$\omega = \sqrt{\frac{qLE}{\frac{2L^2}{3}}} = \sqrt{\frac{3qE}{2mL}}$$

None of these given option is correct. **(BONUS)**

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

Assertion A : When you squeeze one end of a tube to get toothpaste out from the other end. Pascal's principle is observed.

Reason R : A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.

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

(1) A is correct but R is not correct

(2) Both A and R are correct and R is the correct explanation of A

(3) A is not correct but R is correct

(4) Both A and R are correct but R is NOT the correct explanation of A

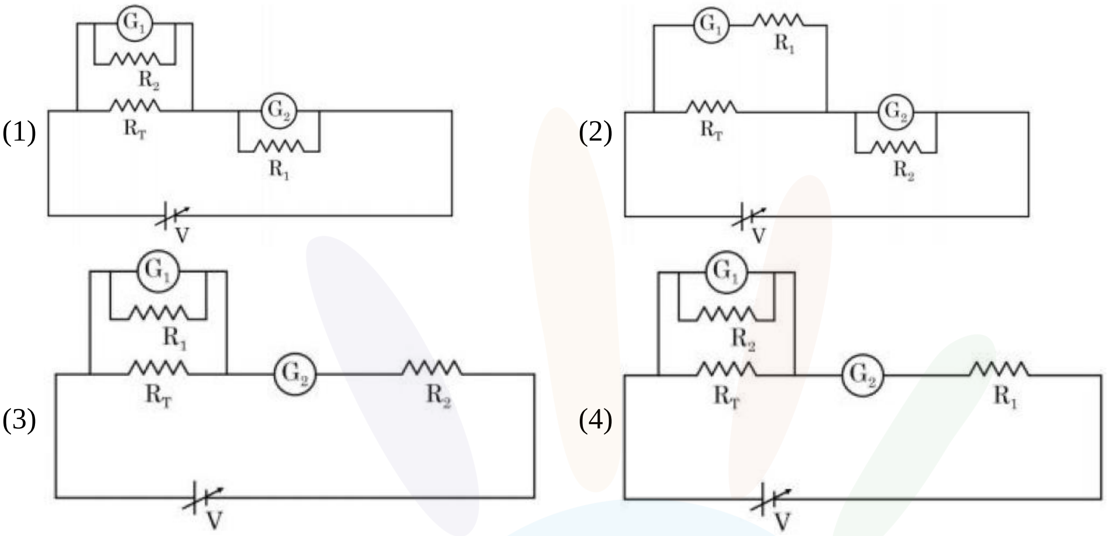
Sol. **(2)**

As per pascal's law, when we apply pressure to an ideal liquid it is equally distributed in the entire liquid and to the walls as well.

Since due to applied pressure, every morning, the tooth paste does not get compressed and we can safely consider it on incompressible liquid.

Therefore both statements are true and R is correct explanation of A.

37. A student is provided with a variable voltage source V, a test resistor $R_T = 10\Omega$, two identical galvanometers G_1 and G_2 and two additional resistors, $R_1 = 10M\Omega$ and $R_2 = 0.001\Omega$. For conducting an experiment to verify ohm's law, the most suitable circuit is :



Sol. **(2)**
This question is based on the conceptual clarity that we should connect ammeter in series and voltmeter in parallel to measure current and potential difference, respectively
Also, when we use a galvanometer to create an ammeter, shunt resistance should be very small and should be in parallel.
When we create a voltemeter shunt should be large and in series with galvanometer.
All these criteria are satisfied in option (2)

38. A body cools in 7 minutes from $60^\circ C$ to $40^\circ C$. The temperature of the surrounding is $10^\circ C$. The temperature of the body after the next 7 minutes

(1) $30^\circ C$ (2) $34^\circ C$ (3) $32^\circ C$ (4) $28^\circ C$

Sol. **(4)**
Method-1
Using exact law of cooling
$T - T_s = (T_0 - T_s)\, e^{-Kt}$
Case-I: $(40 - 10) = (60 - 10)\, e^{-7K}$
$30 = 50e^{-7K}$ ….(1)
Case-II: $(T - 10) = (40 - 10)\, e^{-7K}$ or $T - 10 = 30\, e^{-7K}$
Dividing (2) by (1)

$$\frac{T-10}{30} = \frac{30}{50}$$

$$\Rightarrow T - 10 = \frac{30 \times 30}{50} = 18$$

or T = 28 °C
Methode-2
Using newton's average law of cooling

$$\frac{T_i - T_f}{t} = k\left(\frac{T_i + T_f}{2} - T_s\right)$$

Case-I:- $\frac{60-40}{7} = R\left[\frac{60+40}{2} - 10\right] \Rightarrow \frac{20}{7} = k\,[40]$ ….(i)

Case-II:- $\frac{40-T}{7} = R\left[\frac{20+T}{2}\right]$ ….(2)

Dividing (2) by (1)

$$\frac{40-T}{20}=\frac{20+T}{80}$$

160 – 4T = 20 + T

5T = 140

T = 28 °C

39. The energy density associated with electric field $\bar{E}$ and magnetic field $\bar{B}$ of an electromagnetic wave in free space is given by $(\varepsilon_0 - \text{permittivity of free space}, \mu_0 - \text{permeability of free space})$

(1) $U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{B^2}{2\mu_0}$ (2) $U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{\mu_0 B^2}{2}$

(3) $U_E = \frac{E^2}{2\epsilon_0}, U_B = \frac{B^2}{2\mu_0}$ (4) $U_E = \frac{\epsilon_0 E^2}{2}, U_B = \frac{\mu_0 B^2}{2}$

Sol. **(1)**

By theory of electromagnetic waves

$U_E = \frac{1}{2}\varepsilon_0 E^2$ and

$U_B = \frac{1}{2}\frac{B^2}{\mu_0}$

40. The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth, equal to one-fourth the radius of the earth is :

(1) 64 N (2) 25 N (3) 100 N (4) 50 N

Sol. **(1)**

using newton's formula $F = \frac{GMm}{r^2}$

at surface of earth, $100 = \frac{GM_e m}{Re^2}$ ….(1)

at $r = R_e + \frac{R_e}{4} = \frac{5}{4}R_e$

$$F' = \frac{GM_e m}{\left(\frac{5}{4}R_e\right)^2} = \frac{16}{25}\times\frac{GM_e m}{R_e^2}$$

$F' = \frac{16}{25}\times 100 = 64$ N

41. A capacitor of capacitance 150.0 μF is connected to an alternating source of emf given by E = 36 sin(120πt) V. The maximum value of current in the circuit is approximatively equal to :

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

Sol. **(4)**

Given alternating AC source E = 36 sin (120 πt) v & capacitor C = 150 μF

using Q = CV

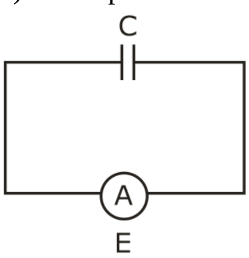
we can write $Q = (CE_0 \sin \omega t)$

Current $i = \frac{dQ}{dt} = (CE_0\,\omega \cos \omega t)$

max. value of current $i_0 = CE_0\,\omega$

or $i_0 = 150 \times 10^{-6} \times 36 \times 120\pi$

= 2.03 A



42. A 2 meter long scale with least count of 0.2 cm is used to measure the locations of objects on an optical bench. While measuring the focal length of a convex lens, the object pin and the convex lens are placed at 80 cm mark and 1 m mark., respectively. The image of the object pin on the other side of lens coincides with image pin that is kept at 180 cm mark. The % error in the estimation of focal length is :

(1) 0.51 (2) 1.02 (3) 0.85 (4) 1.70

Sol. **(4)**

Based on the data provided

U = 100 – 80 = 20 cm

V = 180 – 100 = 80 cm

Using $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ or $f=\frac{uv}{u+v}=\frac{20\times 80}{20+80}$ or f = 16 cm

For error analysis,

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$$

Differentiating

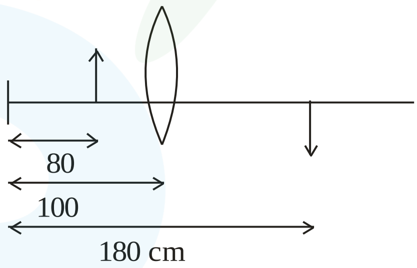
$$-\frac{Df}{f^2}=-\frac{Dv}{v^2}-\frac{\Delta u}{u^2}$$

To calculate Δu & Δv

U = (100 ± 2) – (80 ± 0.2) = (20 ± 0.4) cm

Therefore Δu = 0.4 cm,

Similarly Δv = 0.4 cm.



Now $\frac{\Delta f}{f}=f\left[\frac{\Delta v}{v^2}+\frac{\Delta u}{u^2}\right]$

$$\frac{\Delta f}{f}=16\left[\frac{0.4}{(80)^2}+\frac{0.4}{(20)^2}\right]$$

(Note: every data is in cm)

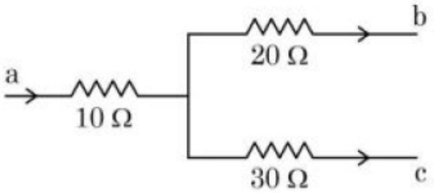
$$\frac{\Delta f}{f}=\frac{16\times 0.4}{(20)^2}\left[\frac{1}{4^2}+1\right]$$

$$=\frac{16\times 0.4}{20^2}\times\frac{17}{16}=\frac{17\times 0.4}{400}$$

% Error : $\frac{\Delta f}{f}\times 100=\frac{17\times 0.4}{400}\times 1000$

= 1.7

43. Figure shows a part of an electric circuit. The potentials at points a, b and c are 30 V, 12 V and 2 V respectively. The current through the 20 Ω resistor will be



(1) 1.0 A (2) 0.2 A (3) 0.4 A (4) 0.6 A

Sol. **(3)**

Let potential of the junction be x volts

using junction law $i_i + i_2 + i_3 = 0$

or $\frac{x-30}{10}+\frac{x-12}{20}+\frac{x-2}{30}=0$

or $\frac{1}{60}[6x-180+3x-36+2x-4]=0$

or $\frac{1}{60}[11x-220]=0$

or $x = \frac{220}{11} = 20V$

current through 20 Ω is = $\frac{x-12}{20}$

$i_2 = \frac{20-12}{20} = 0.4A$

44. A small particle of mass m moves in such a way that its potential energy $U = \frac{1}{2}m\omega^2 r^2$ where ω is constant and r is the distance of the particle from origin. Assuming Bohr's quantization of momentum and circular orbit, the radius of n^{th} orbit will be proportional to,

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

Sol. **(4)**

Given U = $\frac{1}{2}$ $m\omega^2r^2$, to find radius r as f (n), where n is orbit

Using Bohr's postulate : angular momentum L = mvr = $\frac{nh}{2\pi}$

or $mr\omega^2 = \frac{nh}{2\pi}$

$\Rightarrow r \propto \sqrt{n}$

45. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**
Assertion A : Diffusion current in a p-n junction is greater than the drift current in magnitude if the junction is forward biased.
Reason R: Diffusion current in a p-n junction is from the n-side to the p-side if the junction is forward biased.
In the light of the above statements, choose the most appropriate answer from the options given below
(1) A is not correct but R is correct
(2) Both A and R are correct and R is the correct explanation of A
(3) Both A and R are correct but R is NOT the correct explanation of A
(4) A is correct but R is not correct

Sol. **(4)**
Statement A is correct and Statement R is wrong as per the theory of p-n junction.

46. Choose the incorrect statement from the following :
(1) The linear speed of a planet revolving around the sun remains constant.
(2) The speed of satellite in a given circular orbit remains constant.
(3) When a body falls towards earth, the displacement of earth towards the body is negligible.
(4) For a planet revolving around the sun in an elliptical orbit, the total energy of the planet remains constant.

Sol. **(1)**
Since planets revolve around the sun in an elliptical orbit its linear speed is not constant, hence option 1 not correct (and right choice).
Other statement are correct as per theory.

47. A child of mass 5 kg is going round a merry-go-round that makes 1 rotation in 3.14 s. The radius of the merry-go-round is 2 m. The centrifugal force on the child will be
(1) 40 N (2) 100 N (3) 80 N (4) 50 N

Sol. **(1)**

Given, m = 5kg, R = 2 m

time t for 1 rev = 3.14 sec or π sec

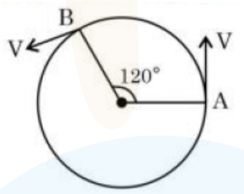
θ for 1 rev = 2 π rad

Therefore $\omega = \frac{\theta}{t} = \frac{2\pi}{\pi} = 2$ rad/s

centrifugal force $F = mR\omega^2$

or $F = 5 \times 2 \times 2^2 = 40$ N

48. As shown in the figure, a particle is moving with constant speed π m/s. Considering its motion from A to B, the magnitude of the average velocity is :



(1) $\pi\,\text{m/s}$ (2) $2\sqrt{3}\,\text{m/s}$ (3) $\sqrt{3}\,\text{m/s}$ (4) $1.5\sqrt{3}\,\text{m/s}$

Sol. **(4)**

Given speed v = π m/s

or $R\omega = \pi$

or $\omega = \frac{\pi}{R}\,\text{rad/s}$

angular displacement $\theta = 120°$ or $\frac{2\pi}{3}$

uising $\theta = \omega t$

$t = \frac{\theta}{\omega} = \frac{2\pi/3}{\pi/R} = \frac{2R}{3}$

linear displacement d = 2 R sin (θ/2)

$d = 2R \sin\left(\frac{120}{2}\right)$

$= 2R \times \sin 60 = 2R \times \frac{\sqrt{3}}{2}$

$= R\sqrt{3}$

average velocity $= \frac{d}{t} = \frac{R\sqrt{3}}{2R/3} = \frac{3\sqrt{3}}{2}$

49. The work functions of Aluminium and Gold are 4.1 eV and and 5.1 eV respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is

(1) 1 (2) 2 (3) 1.24 (4) 1.5

Sol. **(1)**

Using $KE_{max} = eV_s = hf - \phi_0$

where ϕ_0 is work function, V_s is stopping potential and f is frequency

or $V_s = \frac{h}{e}f - \frac{\phi_0}{e}$

therefore the slope m will be same for all graphs and will be independent of ϕ_0.

50. A particle starts with an initial velocity of 10.0 ms^{-1} along x-direction and accelerates uniformly at the rate of 2.0 ms^{-2}. The time taken by the particle to reach the velocity of 60.0 ms^{-1} is __________.

(1) 3s (2) 6s (3) 25s (4) 30s

Sol. **(3)**

Using Ist equation of motion

$$t = \frac{v-u}{a}$$

$$t = \frac{60-10}{2} = \frac{50}{2} = 25 \text{ sec}$$

SECTION - B

51. A simple pendulum with length 100 cm and bob of mass 250 g is executing S.H.M. of amplitude 10 cm. The maximum tension in the string is found to be $\frac{x}{40}$ N. The value of x is __________.

Sol. **(99)**

For pendulum

$$T_{max} = mg + \frac{mv^2}{L} \qquad \ldots(1)$$

Given $m = \frac{1}{4}$ kg, L = 1m, g = 9.8 m/s^2

and amplitude $A = \frac{1}{10}$ m

For SHM, $KE_{max} = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2A^2$

using $\omega = \sqrt{\frac{g}{L}}$

$$mv^2 = m\left(\sqrt{\frac{g}{L}}\right)^2 A^2 = \frac{mgA^2}{L} \qquad \ldots(2)$$

using (2) in (1)

$$T_{max} = 2\,mg + \frac{mgA^2}{L^2}$$

$$= mg\left[1+\frac{1}{10^2}\right] = \frac{1}{4} \times 9.8 \times \frac{101}{100}$$

or $T_{max} = \frac{98.98}{40}$

Therefore x = 99

52. Experimentally it is found that 12.8 eV energy is required to separate a hydrogen atom into a proton and an electron. So the orbital radius of the electron in a hydrogen atom is $\frac{9}{x}\times10^{-10}$ m. The value of the x is : _______.

(1 eV = 1.6 × 10^{-19} J, $\frac{1}{4\pi\epsilon_0} = 9\times10^9\,Nm^2/C^2$ and electronic charge = 1.6 × 10^{-19} C)

Sol. **(16)**

Using $E = \frac{ke^2}{2r}$

$r = \frac{Re^2}{2E}$

Given E = 12.8 eV = 12.8 × e Joule

$r = \frac{9\times10^9 e^2}{2\times12.8e} = \frac{9\times10^9\times1.6\times10^{-19}}{2\times12.8}$

$r = \frac{9\times10^{-10}}{(2\times12.8/1.6)} = \frac{9\times10^{-10}}{10}\,m$

Therefore x = 16

53. A beam of light consisting of two wavelengths 7000 Å and 5500 Å is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the place of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is n × 10^{-5} m. The value of n is ______.

Sol. **(462)**

Let n_1 maxima of 7000 Å coincides with n_2 maxima of 5500 Å

therefore $n_1\beta_1 = n_2\beta_2$

or $\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{5500}{7000} = \frac{11}{14}$

therefore 11th maxima of 7000 Å will coincide with 14th maximum of 5500 Å

To find the least distance of this

$y = n_1\beta_1$

or $y = \frac{n_1\lambda_1 D}{d} = \frac{11\times7000\times10^{-10}\times150\times10^{-2}}{2.5\times10^{-3}}$

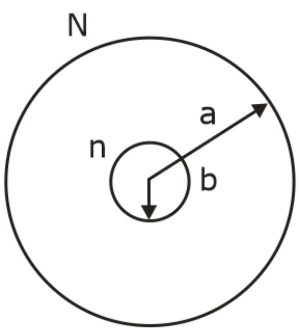
$= \frac{11\times7\times5}{2.5}\times10^{-5}$ m

or y = 462 × 10^{-5} m

therefore n = 462

54. Two concentric circular coils with radii 1 cm and 1000 cm, and number of turns 10 and 200 respectively are placed coaxially with centers coinciding. The mutual inductance of this arrangement will be _______ × 10^{-8} H. (Take, $\pi^2 = 10$)

Sol. **(4)**



Given

a = 1000 cm

b = 1 cm

or b << a

we will take larger coil as primary

$B = \frac{\mu_0 i_p N}{2a}$

flux $\phi_s = BA = \frac{\mu_0 i_p N}{2a} \times \pi b^2 \times n$

Mutual inductance $M = \frac{\phi_s}{i_p}$

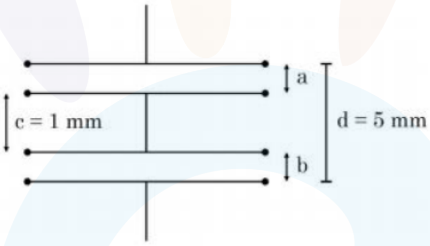
$M = \frac{\mu_0 N n \pi b^2}{2 \times a}$

or $M = \frac{4\pi \times 10^{-7} \times 200 \times 10 \times \pi \times 1 \times 10^{-4}}{2 \times 1000 \times 10^{-2}}$

$= 4\pi^2 \times 10^{-9}$

or $M = 4 \times 10^{-8}$ (using $\pi^2 = 10$)

55. As shown in the figure, two parallel plate capacitors having equal plate area of 200 cm^2 are joined in such a way that $\alpha \neq b$. The equivalent capacitance of the combination is $x \in_0$ F. The value of x is ________.



Sol. **(5)**

As per the arrangement given, distance between the capacitor plates are a and b and $a \neq b$

using the diagram we can write

$b = 5 - a - 1 = (4 - a)$ in mm

as we know capacitance of capacitor $C = \frac{\varepsilon_0 A}{d}$

and in series arrangement

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{a}{\varepsilon_0 A} + \frac{4-a}{\varepsilon_0 A} = \frac{4(\text{in mm})}{\varepsilon_0 A}$$

or $C_{eq} = \frac{\varepsilon_0 A}{4(\text{mm})}$

Given $A = 200$ cm^2

$C_{eq} = \frac{\varepsilon_0 \times 200 \times 10^{-4}}{4 \times 10^{-3}}$

$= \varepsilon_0\ 50 \times 10^{-1}$

or $C_{eq} = 5\varepsilon_0$ farad

therefore n =5

56. A proton with a kinetic energy of 2.0 eV moves into a region of uniform magnetic field of magnitude $\frac{\pi}{2} \times 10^{-3}$T. The angle between the direction of magnetic field and velocity of proton is 60°. The pitch of the helical path taken by the proton is ______ cm.

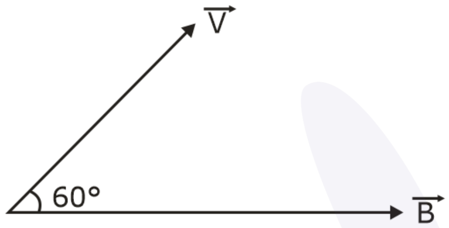
(Take, mass of proton = 1.6×10^{-27} kg and Charge on proton = 1.6×10^{-19} C).

Sol. **(40)**

$B = \frac{\pi}{2} \times 10^{-3}$

$K.E. = \frac{1}{2}mV^2$

$\Rightarrow V = \sqrt{\frac{2KE}{m}}$



PItch = v cos 60° × time period of one rotation

$= v \cos 60° \times \frac{2\pi m}{eB}$

$= \sqrt{\frac{2\times2\times1.6\times10^{-9}}{1.6\times10^{-27}}} \times \cos 60° \times \frac{2\pi\times1.6\times10^{-27}}{1.6\times10^{-19}\times\frac{\pi}{2}\times10^{-3}}$

$= 2 \times 10^4 \times \frac{1}{2} \times 4 \times 10^{-5}$

$= 4 \times 10^{-1}$ m = 40 cm

57. A body is dropped on ground from a height 'h_1' and after hitting the ground, it rebounds to a height 'h_2'. If the ratio of velocities of the body just before and after hitting ground is 4, then percentage loss in kinetic energy of the body is $\frac{x}{4}$. The value of x is ________.

Sol. **(375)**

Let u and v be speeds, just before and after body strikes the ground.

Given $\frac{u}{v} = \frac{4}{1}$

loss in KE: $\Delta KE = \frac{\frac{1}{2}mu^2 = \frac{1}{2}mv^2}{\frac{1}{2}mu^2}$

$\Delta KE = 1 - \left(\frac{v}{u}\right)^2 = 1 - \frac{1}{16} = \frac{15}{16}$

Percentage loss $= \frac{15}{16} \times 100 = 375$

58. A ring and a solid sphere rotating about an axis passing trough their centers have same radii of gyration. The axis of rotation is perpendicular to plane of ring. The ratio of radius of ring to that of sphere is $\sqrt{\frac{2}{x}}$. The value of x is ______.

Sol. **(5)**

Given radius of gyration is same for ring and solid sphere

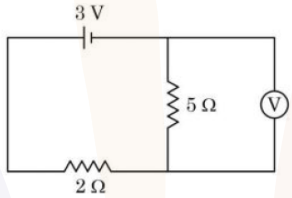
$K_R = K_{ss}$

$R_R = \sqrt{\frac{2}{5}} R_{ss}$

or $\frac{R_R}{R_{ss}} = \sqrt{\frac{2}{5}}$

therefore x = 5

59. As shown in the figure, the voltmeter reads 2 V across 5 Ω resistor. The resistance of the voltmeter is ___ Ω .

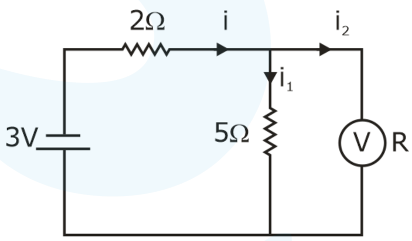


Sol. **(20)**

Method-I:

$R_{eq} = 2 + \frac{5R}{5+R} = \frac{10+7R}{5+R}$

$i = \frac{3}{R_{eq}} = \frac{3(5+R)}{10+7R}$



$i_1 = \frac{2}{5}, i_2 = \frac{2}{R}$

$i = i_1 + i^2$

$\frac{3(5+R)}{10+7R} = \frac{2}{5} + \frac{2}{R} = \frac{2(5+R)}{5R}$

$15R (5 + R) = 2 (5 + R) (10 + 7R)$

$75R + 15R^2 = 2 (50 + 35R + 10R + 2R^2)$

$15R^2 + 75R = 14R^2 + 90R + 100$

$R^2 – 15 R – 100 = 0$

$R = \frac{15\sqrt{225 \times 1 \times 100}}{2}$

$= \frac{15 \pm \sqrt{625}}{2} = \frac{15 \pm 25}{2}$

$R = 20\ \Omega$

Method-II:

Given potential across 5Ω and voltmeter is 2V. To find resistance R of voltmeter.

Let current in 5Ω be i_1, and in R i_2.

$i_1 = \frac{2}{5}$ and $i_2 = \frac{2}{R}$

V across 2Ω will be 1 volt and $i = \frac{1}{2}$A.

Using junction law: $i = i_1 + i_2$

$\frac{1}{2} = \frac{2}{5} + \frac{2}{R}$

$\frac{2}{R} = \frac{1}{2} - \frac{2}{5} = \frac{1}{10}$

R = 20Ω

60. A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is 7×10^5 Nm^{-2}. The value of mass m is _____kg.

(Take, $g = 9.8\ ms^{-2}$ and $\pi = \frac{22}{7}$)

Sol. 11

Using stress $= \frac{\text{force}}{\text{area}} = \frac{mg}{A}$

$\Rightarrow m = \frac{S \times A}{g} = \frac{7 \times 10^5 \times \pi R^2}{g}$

$= \frac{7 \times 10^5 \times \frac{22}{7} \times (7 \times 10^{-3})^2}{9.8}$ (Note: 14 mm is diameter)

$= 11$ kg