JEE MAIN 2024 SESSION-2
Paper with Solution

PHYSICS | 04th April 2024 _ Shift-2

MOTION

PRE-ENGINEERING JEE (Main+Advanced) | PRE-MEDICAL NEET | FOUNDATION (Class 6th to 10th) Olympiads/Boards

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SECTION – A

31. A charge q is placed at the center of one of the surface of a cube. The flux linked with the cube is -

(1) $\frac{q}{2\in_0}$ (2) $\frac{q}{4\in_0}$ (3) $\frac{q}{8\in_0}$ (4) zero

Sol. 1

$$\phi = \frac{q_{en}}{\varepsilon_0}$$

$$q_{en} = \frac{q}{2}$$

$$\phi = \frac{q}{2\varepsilon_0}$$

32. A sample of gas at temperature T is adiabatically expanded to double its volume. Adiabatic constant for the gas is $\gamma = 3/2$. The work done by the gas in the process is : (μ = 1 mole)

(1) $RT[1-2\sqrt{2}]$ (2) $RT[2\sqrt{2}-1]$ (3) $RT[\sqrt{2}-2]$ (4) $RT[2-\sqrt{2}]$

Sol. 4

PV = nRT

$$P = \frac{nRT}{V}$$

Also, PV^{γ} = constant

$$\frac{nRT}{V}V^{\gamma} = \text{constant}$$

$TV^{\gamma-1}$ = constant

$$TV^{\gamma-1} = T_2 \cdot (2V)^{\gamma-1}$$

$$T_2 = T\cdot\left(\frac{1}{2}\right)^{1/2} = \frac{T}{\sqrt{2}}$$

$$W = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

$$= 2nR\left(T - \frac{T}{\sqrt{2}}\right)$$

$$= RT(2-\sqrt{2})$$

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

Assertion A : Number of photons increases with increase in frequency of light.

Reason R : Maximum kinetic energy of emitted electrons increases with the frequency of incident radiation

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 not the correct explanation of A

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

(3) A is correct but R is not correct

(4) A is not correct but R is correct.

Sol. 4

Number of photons remains unchanged with increase in frequency.

By relation

$h\nu = \phi_0 + k_{max}$

if ν increases, then k_{max} increases.

34. The width of one of the two slits in a Young's double slit experiment is 4 times that of the other slit. The ratio of the maximum of the minimum intensity in the interference pattern is -

(1) 1 : 1 (2) 16 : 1 (3) 9 : 1 (4) 4 : 1

Sol. 3

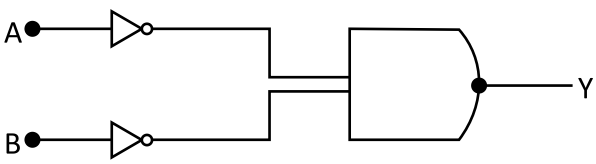
$I_1 = I_0$

$I_2 = 4I_0$

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

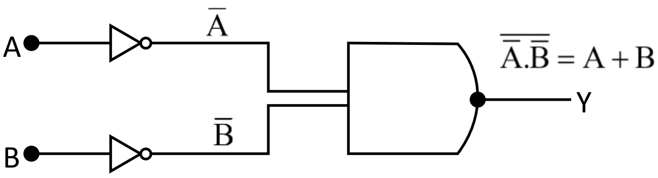
$$= \frac{9I_0^{\,2}}{I_0^{\,2}} = 9$$

35. Identify the logic gate given in the circuit :



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

Sol. 3



y = A + B ⟹ OR gate

36. Given below are two statements :

Statement-I: The contact angle between a solid and a liquid is a property of the material of the solid and liquid as well.

Statement-II: The rise of a liquid in a capillary tube does not depend on the inner radius of the tube.

In the light of the above statements, choose the correct answer from the options given below :

(1) Statement I is false but Statement II is true.

(2) Both Statement I and Statement II are false.

(3) Both Statement I and Statement II are true.

(4) Statement I is true but Statement II is false.

Sol. 4

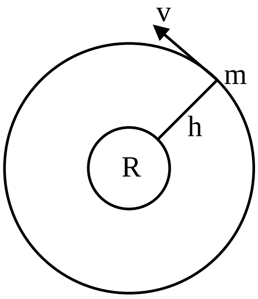
$$h = \frac{2T\cos\theta}{\rho rg}$$

here, r is radius of tube.

37. Correct formula for height of a satellite from earths surface is -

(1) $\left(\frac{T^2R^2g}{4\pi^2}\right)^{1/3}-R$ (2) $\left(\frac{T^2R^2g}{4\pi}\right)^{1/2}-R$ (3) $\left(\frac{T^2R^2}{4\pi^2g}\right)^{1/3}-R$ (4) $\left(\frac{T^2R^2g}{4\pi^2}\right)^{-1/3}+R$

Sol. **1**



$$\frac{mv^2}{(R+h)}=\frac{GMm}{(R+h)^2}$$

$$\Rightarrow v=\sqrt{\frac{GM}{R+h}}$$

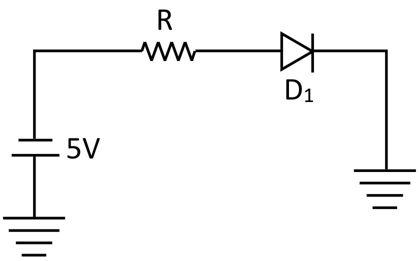
$$\text{Now } T=\frac{2\pi(R+h)}{\sqrt{\frac{GM}{R+h}}}$$

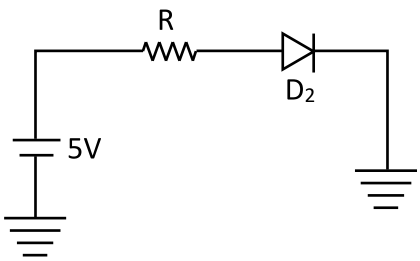
$$\Rightarrow T=\frac{2\pi(R+h)^{3/2}}{\sqrt{GM}}=\frac{2\pi(R+h)^{3/2}}{R\sqrt{g}}$$

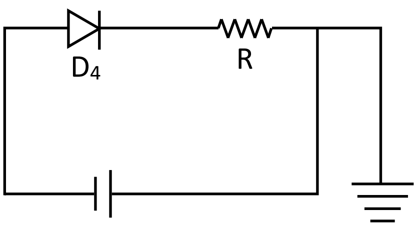
$$\Rightarrow T^2R^2g=4\pi^2(R+h)^3$$

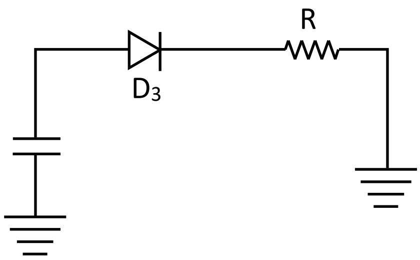
$$\Rightarrow \left(\frac{T^2R^2g}{4\pi^2}\right)^{1/3}-R=h$$

38. Which of the diode circuit shows correct biasing used for the measurement of dynamic resistance of p-n junction diode –

(1)


(2)


(3)


(4)


Sol. **2**

For conduction of current diode must be in forward biased mode.
which is only in option (2).
So, option (2) is correct.

39. An electric bulb rated 50 W – 200 V is connected across a 100 V supply. The power dissipation of the bulb is -

(1) 12.5 W (2) 25 W (3) 100 W (4) 50 W

Sol. **1**

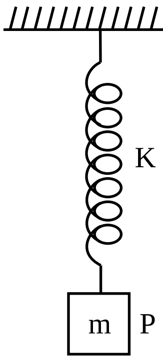
Resistance

$$R = \frac{V^2}{P} = \frac{(200)^2}{50} = 800\Omega$$

Power dissipated $= \frac{V_1^2}{R}$

$$= \frac{(100)^2}{800} = \frac{100}{8} = 12.5\,W$$

40. In simple harmonic motion, the total mechanical energy of given system is E. If mass of oscillating particle P is doubled then the new energy of the system for same amplitude is –



(1) $E\sqrt{2}$ (2) E (3) 2E (4) $E/\sqrt{2}$

Sol. **2**

E = KE + PE

$$E = \frac{1}{2}m\omega^2\left(A^2 - x^2\right) + \frac{1}{2}m\omega^2x^2$$

also, $\omega = \sqrt{\frac{k}{m}}$

If m is doubled, $\omega' = \frac{\omega}{\sqrt{2}}$

Here, value of $m\omega^2$ remains constant

41. A 90 kg body placed at 2R distance from surface of earth experiences gravitational pull of –
(R = Radius of earth, g = 10 ms^{-2})

(1) 100 N (2) 300 N (3) 120 N (4) 225 N

Sol. 1

g at height h from earth's surface

$$g_h = \frac{GM}{(R+h)^2}$$

$$g_h = \frac{GM}{9R^2} = \frac{g}{9} (\because h = 2R)$$

gravitational pull

$= mg_h$

$$= 90 \times \frac{g}{9}$$

$= 10\ g = 100\ N$

42. According to Bohr's theory, the moment of momentum of an electron revolving in 4^{th} orbit of hydrogen atom is -

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

Sol. 3

moment of momentum $L = \frac{nh}{2\pi}$

put n = 4

$$L = \frac{4h}{2\pi} = \frac{2h}{\pi}$$

43. Arrange the following in the ascending order of wavelength :

A. Gamma rays (λ_1)

B. x – rays (λ_2)

C. Infrared waves (λ_3)

D. Microwaves (λ_4)

Choose the most appropriate answer from the options given below

(1) $\lambda_4 < \lambda_3 < \lambda_1 < \lambda_2$ (2) $\lambda_2 < \lambda_1 < \lambda_4 < \lambda_3$ (3) $\lambda_4 < \lambda_3 < \lambda_2 < \lambda_1$ (4) $\lambda_1 < \lambda_2 < \lambda_3 < \lambda_4$

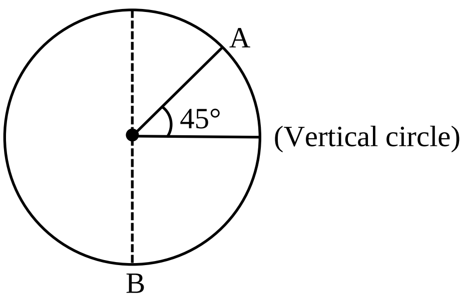
Sol. 4

order of wavelength

gamma rays < x – rays < infrared < microwaves

$\Rightarrow \lambda_1 < \lambda_2 < \lambda_3 < \lambda_4$

44. A body of m kg slides from rest along the curve of vertical circle from point A to B in friction less path. The velocity of the body at B is –



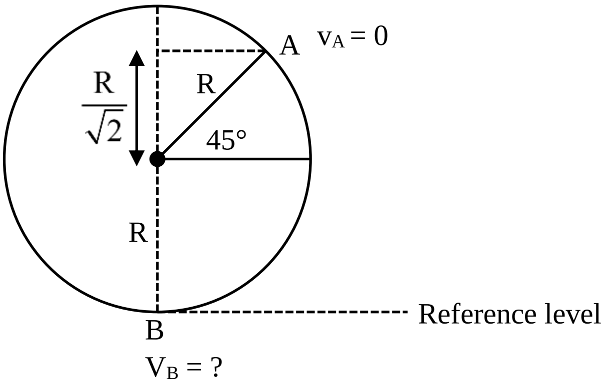
(given, R = 14m, g = 10 m/s^2 and $\sqrt{2}$ = 1.4)

(1) 21.9 m/s (2) 10.6 m/s (3) 19.8 m/s (4) 16.7 m/s

Sol. **1**

by conservation of mechanical energy

decrease in P.E. = increase in K.E.



$$\Rightarrow mg\left(R+\frac{R}{\sqrt{2}}\right)=\frac{1}{2}mv_B^2-0$$

$$\Rightarrow \quad 2gR\left(1+\frac{1}{\sqrt{2}}\right)=v_B^2$$

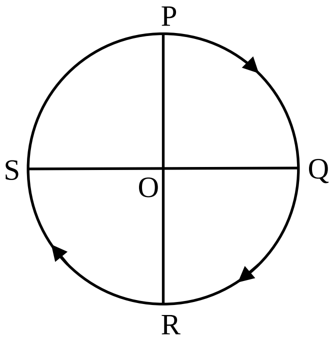
$$\Rightarrow \quad v_B^2=2\times10\times14\times\left(1+\frac{1}{1.4}\right)$$

$$v_B=\sqrt{20\times24}$$

$$= 4\sqrt{30}$$

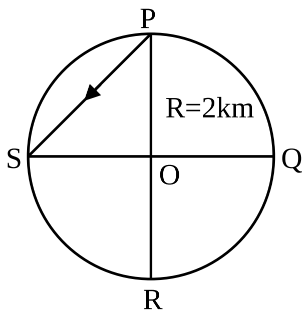
$$\approx\ 21.9 \text{ m/s}$$

45. A cyclist starts from the point P of a circular ground of radius 2 km and travels along its circumference to the point S. The displacement of a cyclist is –



(1) 4 km (2) 6 km (3) $\sqrt{8}$ km (4) 8 km

Sol. **3**



displacement

$$PS = \sqrt{(OS)^2+(OP)^2}$$

$$=\sqrt{2^2+2^2}$$

$$=\sqrt{8}\,\text{km}$$

46. The translational degrees of freedom (f_t) and rotational degrees of freedom (f_r) of CH_4 molecule are -

(1) $f_t = 3$ and $f_r = 3$ (2) $f_t = 2$ and $f_r = 3$ (3) $f_t = 2$ and $f_r = 2$ (4) $f_t = 3$ and $f_r = 2$

Sol. **1**

CH_4 is non-linear and polyatomic

47. Applying the principle of homogeneity of dimensions, determine which one is correct, where T is time period, G is gravitational constant, M is mass, r is radius of orbit.

(1) $T^2 = \frac{4\pi^2 r^3}{GM}$ (2) $T^2 = \frac{4\pi^2 r^2}{GM}$ (3) $T^2 = 4\pi^2 r^3$ (4) $T^2 = \frac{4\pi^2 r}{GM^2}$

Sol. **1**

$[T^2] = T^2$

Now,

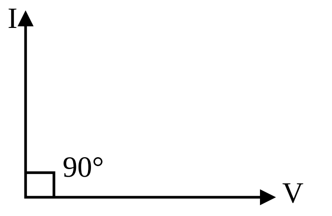
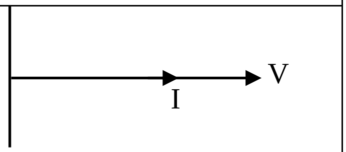
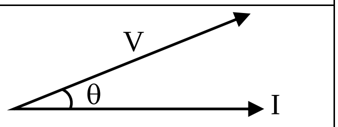
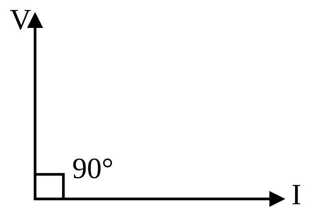
(1) $\left[\frac{4\pi^2 r^3}{GM}\right] = \frac{L^3}{M^{-1}L^3T^{-2}M^1} = T^2$

(2) $\left[\frac{4\pi r^2}{GM}\right] = \frac{L^2}{M^{-1}L^3T^{-2}M^1} = LT^2$

(3) $[4\pi^2 r^3] = L^3$

(4) $\left[\frac{4\pi^2 r}{GM^2}\right] = \frac{L}{M^{-1}L^3T^{-2}M^2} = M^{-1}L^{-2}T^2$

48. Match List-I with List-II

List-I		List-II	
A.	Purely capacitive circuit	I.	
B.	Purely inductive circuit	II.	
C.	LCR series at resonance	III.	
D.	LCR series circuit	IV.	

Choose the correct answer from the options given below -

(1) A-IV, B-I, C-II, D-III (2) A-I, B-IV, C-III, D-II
(3) A-I, B-IV, C-II, D-III (4) A-IV, B-I, C-III, D-II

Sol. **3**

In purely capacitive, current leads voltage by 90°

In purely inductive, current lags voltage by 90°

At resonance, $X_C = X_L$

i.e., Z = R

49. A 2kg brick begins to slide over a surface which is inclined at an angle of 45° with respect to horizontal axis. The co-efficient of static friction between their surfaces is -

(1) 1 (2) 0.5 (3) 1.7 (4) $\frac{1}{\sqrt{3}}$

Sol. **1**

Slipping starts when

$\tan\theta = \mu_s$

$\Rightarrow \mu_s = \tan 45°$

$\mu_s = 1$

50. The magnetic moment of a bar magnet is 0.5 Am^2. It is suspended in a uniform magnetic field of 8×10^{-2} T. The work done in rotating it from its most stable to most unstable position is -

(1) 16×10^{-2} J (2) zero (3) 8×10^{-2} J (4) 4×10^{-2} J

Sol. **3**

$U = -\vec{M}\cdot\vec{B}$

$\Delta U = 2MB = 2\times 0.5\times 8\times 10^{-2}$

$= 8 \times 10^{-2}$ J

SECTION – B

51. Two wires A and B are made up of the same material and have the same mass. Wire A has radius of 2.0 mm and wire B has radius of 4.0 mm. The resistance of wire B is 2Ω. The resistance of wire A is ________ Ω.

Sol. **32**

$r_A = 2 \times 10^{-3}$ m, $r_B = 4 \times 10^{-3}$ m, $\rho_A = \rho_B$

$R_B = 2\Omega$

we know $R = \frac{\rho\ell}{A}$

$\frac{R_A}{R_B} = \frac{\rho_A \ell_A}{A_A} \times \frac{A_B}{\rho_B \ell_B} = \frac{\ell_A}{\ell_B}\frac{A_B}{A_A}$ ...(1)

We have $m_A = m_B$

$\rho_A \ell_A A_A = \rho_B \ell_B A_B$

$\Rightarrow \frac{\ell_A}{\ell_B} = \frac{A_B}{A_A}$ ...(2)

from equation (1) & equation (2)

$$R_A = R_B\left(\frac{A_B}{A_A}\right)^2 = 2\left(\frac{\pi\times\left(4\times10^{-3}\right)^2}{\pi\times\left(2\times10^{-3}\right)^2}\right)^2$$

$= 2 \times 16 = 32\ \Omega$

52. Mercury is filled in a tube of radius 2 cm up to a height of 30 cm. The force exerted by mercury on the bottom of the tube is ______ N.

(Given, atmospheric pressure = 10^5 Nm^{-2}, density of mercury = 1.36×10^4 kgm^{-3}, g = 10 ms^{-2}, $\pi = \frac{22}{7}$)

Sol. **177**

$P = P_0 + \rho gh$

$F = P_0A + \rho ghA = \frac{22}{7} \times 4 \times 10^{-4} \left(10^5 + 1.36 \times 10^4 \times 10 \times \frac{30}{100}\right)$

$\Rightarrow F = \frac{88}{7} \times 10^{-4}\left(10^5 + 0.408 \times 10^5\right)$

$= \frac{88}{7} \times 10 \times 1.408 = 177$

53. The displacement of a particle executing SHM is given by x = 10 sin $\left(\omega t + \frac{\pi}{3}\right)$ m. The time period of motion is 3.14 s. The velocity of the particle at t = 0 is ________ m/s.

Sol. **10**

$x = 10\sin\left(\omega t + \frac{\pi}{3}\right)$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{3.14} = 2\,\text{rad/s}$

at t = 0, x = 10 sin $\frac{\pi}{3} = 5\sqrt{3}$

now $v = \omega\sqrt{\left(A^2 - x^2\right)}$

$= 2\sqrt{10^2 - \left(5\sqrt{3}\right)^2}$

$= 2\sqrt{100 - 75} = 10\,\text{m/s}$

54. A parallel plate capacitor of capacitance 12.5 pF is charged by a battery connected between its plates to potential difference of 12.0 V. The battery is now disconnected and a dielectric slab $\left(\epsilon_r = 6\right)$ is inserted between the plates. The change in its potential energy after inserting the dielectric slab is _______ $\times 10^{-12}$ J.

Sol. **750**

$v_0 = \frac{1}{2} \times 12.5 \times 10^{-12} \times 144$

$= 900 \times 10^{-12}$J

$v = \frac{v_0}{K} = \frac{900}{6} \times 10^{-12} = 150 \times 10^{-12}\,J$

$\Delta v = (900 - 150) \times 10^{-12}\,J$

$= 750 \times 10^{-12}$J

55. In a system two particles of masses $m_1 = 3$ kg and $m_2 = 2$ kg are placed at certain distance from each other. The particle of mass m_1 is moved towards the center of mass of the system through a distance 2 cm. In order to keep the center of mass of the system at the original position. The particle of mass m_2 should move towards the center of mass by the distance ______ cm.

Sol. **3**

$m_1x_1 = m_2x_2$

$3 \times 2 = 2 \times x_2$

$x_2 = 3$ cm

56. A light ray is incident on a glass slab of thickness $4\sqrt{3}$ cm and refractive index $\sqrt{2}$. The angle of incidence is equal to the critical angle for the glass slab with air. The lateral displacement of ray after passing through glass slab is ______ cm. (Given sin 15° = 0.25)

Sol. **2**

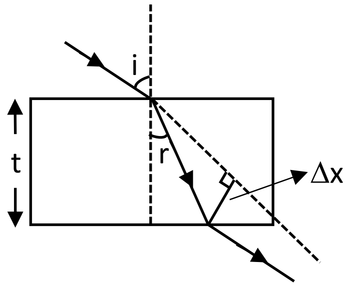
$\sin i = \sqrt{2} \sin r$

$\sin i = \sin c = \sqrt{2} \sin r$

$\Rightarrow \frac{1}{\sqrt{2}} = \sqrt{2} \sin r$

$\Rightarrow r = 30^o$

and $i = C = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^o$



Now, $\Delta x = t \sec 30^o \sin 15^o$

$= 4\sqrt{3} \times \frac{2}{\sqrt{3}} \times \frac{1}{4}$

= 2 cm

57. The disinteration energy Q for the nuclear fission of $^{235}U \rightarrow {}^{140}Ce + {}^{94}Zr + n$ is ______ MeV.
Given atomic masses of ^{235}U : 235.0439u; ^{140}Ce; 139.9054 u,
^{94}Zr : 93.9063u; n : 1.0086 u,
Value of $c^2 = 931$ MeV/u.

Sol. **208**

$\Delta m = \{235.0439 - (139.9054 + 93.9063 + 1.0086)\}u$

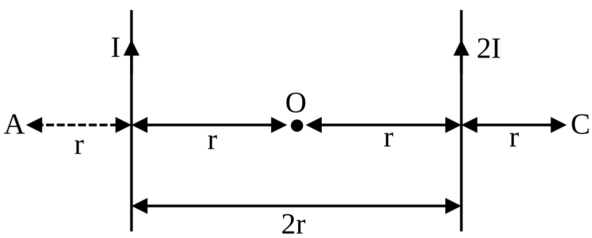
= 0.2236 u

$\theta = \Delta mc^2 = 0.2236 \times 931$ Mev

$\simeq$ 208.17 Mev

$\approx$ 208 Mev

58. Two parallel long current carrying wire separated by a distance 2r are shown in the figure. The ratio of magnetic field at A to the magnetic field produced at C is $\frac{x}{7}$. The value of x is ______ .



Sol. **5**

$$B_A = \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 .2I}{2\pi .3r}$$

$$= \frac{5}{3} \cdot \frac{\mu_0 I}{2\pi r} = \frac{5\mu_0 I}{6\pi r}$$

$$B_C = -\frac{\mu_0 I}{2\pi \times 3r} - \frac{\mu_0 .2I}{2\pi r}$$

$$\Rightarrow B_C = -\frac{\mu_0 I}{2\pi r} - \frac{7}{3}$$

$$\Rightarrow \frac{|B_A|}{|B_C|} = \frac{5}{7}$$

59. A bus moving along a straight highway with speed of 72 km/h is brought to halt within 4s after applying the brakes. The distance travelled by the bus during this time (Assume the retardation is uniform) is ______ m.

Sol. **40**

$$u = 72 \times \frac{5}{18} = 20\,m/s$$

v = 0

t = 4

v = u + at

$\Rightarrow$ 0 = 20 + a × 4

$\Rightarrow$ a = –5 m/s^2

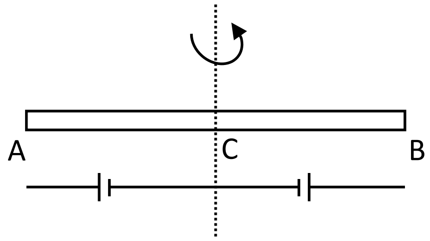
Now, $v^2 = u^2 + 2as$

$\Rightarrow$ 0 = 400 – 10 . x

x = 40 m

60. A rod of length 60 cm rotates with a uniform angular velocity 20 rads^{-1} about its perpendicular bisector, in a uniform magnetic field 0.5T. The direction of magnetic field is parallel to the axis of rotation. The potential difference between the two ends of the rod is ______ V.

Sol. **0**



$$V_B - V_C = \frac{B_0 \omega \ell^2}{8}$$

$$V_A - V_C = \frac{B_0 \omega \ell^2}{8}$$

$V_B - V_A = 0$

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5993/8497 = **70.53%**
(2022)
4818/6653 = **72.41%**

NITIN VIIJAY (NV Sir)
Founder & CEO

Motion