

JEE-MAIN EXAMINATION – JANUARY 2025(HELD ON WEDNESDAY 22nd JANUARY 2025)

TIME : 9:00 AM TO 12:00 NOON

PHYSICS**TEST PAPER WITH SOLUTION****SECTION-A**

- 26.** Given below are two statements :

Statement I : In a vernier callipers, one vernier scale division is always smaller than one main scale division.

Statement II : The vernier constant is given by one main scale division multiplied by the number of vernier scale division.

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

- (1) Both **Statement I** and **Statement II** are false.
- (2) **Statement I** is true but **Statement II** is false.
- (3) Both **Statement I** and **Statement II** are true.
- (4) **Statement I** is false but **Statement II** is true.

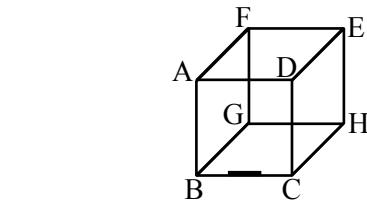
NTA Ans. (2)

Allen Ans. (1)

Sol. In general one vernier scale division is smaller than one main scale division but in some modified cases it may be not correct. Also least count is given by one main scale division / number of vernier scale division for normal vernier calliper.

Note: In JA, there are questions with modified V.C..

- 27.** A line charge of length $\frac{a}{2}$ is kept at the center of an edge BC of a cube ABCDEFGH having edge length 'a' as shown in the figure. If the density of line is λC per unit length, then the total electric flux through all the faces of the cube will be _____. (Take, ϵ_0 as the free space permittivity)



- (1) $\frac{\lambda a}{8\epsilon_0}$
- (2) $\frac{\lambda a}{16\epsilon_0}$
- (3) $\frac{\lambda a}{2\epsilon_0}$
- (4) $\frac{\lambda a}{4\epsilon_0}$

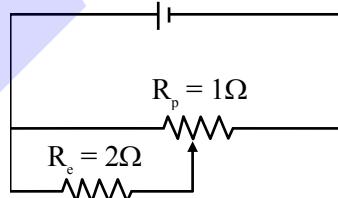
Ans. (1)

Sol. Total charge inside the cube

$$= \frac{\lambda a}{2} = \frac{\lambda a}{8}$$

$$\therefore \phi = \frac{q_{in}}{\epsilon_0} = \frac{\lambda a}{8\epsilon_0}$$

28.



Sliding contact of a potentiometer is in the middle of the potentiometer wire having resistance $R_p = 1\Omega$ as shown in the figure. An external resistance of $R_e = 2\Omega$ is connected via the sliding contact.

- (1) 0.3 A
- (2) 1.35 A
- (3) 1.0 A
- (4) 0.9 A

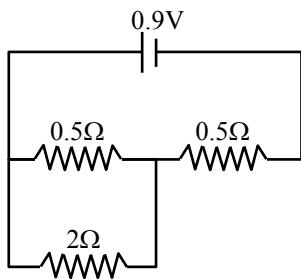
Ans. (3)



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Sol. The circuit can be considered as



$$\therefore R_{eq} = 0.5 + \frac{0.5 \times 2}{2 + 0.5} = \left(\frac{5}{10} + \frac{10}{25} \right) \Omega$$

$$= \frac{45}{50} = \frac{9}{10} = 0.9$$

$$\therefore i = \frac{0.9}{0.9} = 1A$$

- 29.** Given below are two statements : one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.

Assertion (A) : If Young's double slit experiment is performed in an optically denser medium than air, then the consecutive fringes come closer.

Reason (R) : The speed of light reduces in an optically denser medium than air while its frequency does not change.

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

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (2) (A) is false but (R) is true.
- (3) Both (A) and (R) are true but (R) is **not** the correct explanation of (A)
- (4) (A) is true but (R) is false.

Ans. (1)

Sol. $\beta(\text{fringe width}) = \frac{\lambda D}{d}$

In denser medium, $\lambda \downarrow \Rightarrow \beta \downarrow$

\Rightarrow fringe come closer

$$\text{Also, } \mu = \frac{c}{V} \Rightarrow V = \frac{c}{\mu}$$

Frequency remains same,

$$\Rightarrow \mu = \frac{\lambda_{vac.} f}{\lambda_{med} f} \Rightarrow \lambda_{med} = \frac{\lambda_{vac.}}{\mu}$$

- 30.** Two spherical bodies of same materials having radii 0.2 m and 0.8 m are placed in same atmosphere. The temperature of the smaller body is 800 K and temperature of bigger body is 400 K. If the energy radiate from the smaller body is E, the energy radiated from the bigger body is (assume, effect of the surrounding to be negligible)

(1) 256 E (2) E

(3) 64 E (4) 16 E

Ans. (2)

Sol. $\frac{d\theta}{dt} = \sigma e A T^4 \Rightarrow P \propto A T^4$

$$\frac{P_{smaller}}{P_{larger}} = \frac{(0.2)^2 \times 800^4}{(0.8)^2 \times 400^4}$$

$$\frac{1}{16} \times 16 = 1$$

$$\therefore P_{larger} = P_{smaller}$$

- 31.** An amount of ice of mass 10^{-3} kg and temperature -10°C is transformed to vapour of temperature 110° by applying heat. The total amount of work required for this conversion is,

(Take, specific heat of ice = $2100 \text{ Jkg}^{-1}\text{K}^{-1}$, specific heat of water = $4180 \text{ Jkg}^{-1}\text{K}^{-1}$, specific heat of steam = $1920 \text{ Jkg}^{-1}\text{K}^{-1}$, Latent heat of ice = $3.35 \times 10^5 \text{ Jkg}^{-1}$ and Latent heat of steam = $2.25 \times 10^6 \text{ Jkg}^{-1}$)

(1) 3022 J (2) 3043 J

(3) 3003 J (4) 3024 J

Ans. (2)



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$$\Rightarrow p_2 = \left(\frac{1}{2} \right) \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$$

$$\Rightarrow p_2 = \frac{1}{2} \left(\frac{1}{|R_2|} - \frac{1}{|R_1|} \right)$$

$$\Rightarrow p_3 = \left(\frac{1}{3} \right) \left(\frac{1}{|R_2|} - \frac{1}{\infty} \right) = -\frac{1}{3|R_2|}$$

$$\Rightarrow p_{eq} = \frac{1}{3} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right) - \frac{1}{2} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$$

$$= -\frac{1}{6} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$$

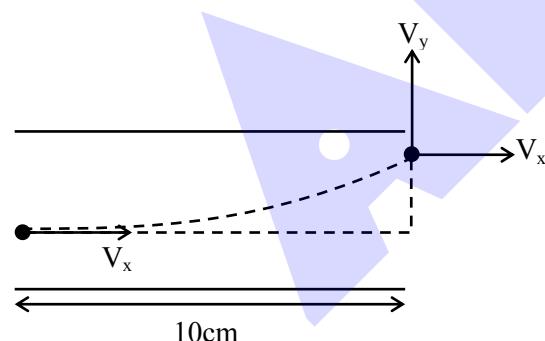
34. An electron is made to enter symmetrically between two parallel and equally but oppositely charged metal plates, each of 10 cm length. The electron emerges out of the field region with a horizontal component of velocity 10^6 m/s. If the magnitude of the electric field between the plates is 9.1 V/cm, then the vertical component of velocity of electron is

(mass of electron = 9.1×10^{-31} kg and charge of electron = 1.6×10^{-19} C)

- (1) 1×10^6 m/s (2) 0
 (3) 16×10^6 m/s (4) 16×10^4 m/s

Ans. (3)

Sol.



$$\Rightarrow t = \frac{\ell}{V_x} = \frac{10 \times 10^{-2}}{10^6} = 10^{-7}$$

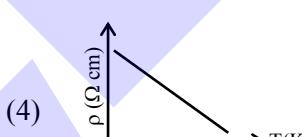
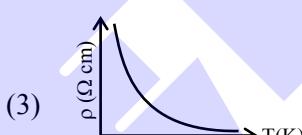
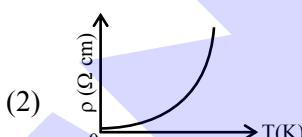
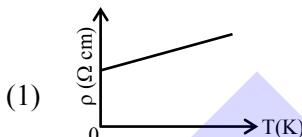
$$\Rightarrow V_y = u_y + a_y t$$

$$\Rightarrow V_y = 0 + \frac{eE}{m} \times 10^{-7}$$

$$\Rightarrow V_y = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31}} \times 9.1 \times 10^{-2} \times 10^{-7}$$

$$\Rightarrow V_y = 16 \times 10^6$$

35. Which of the following resistivity (ρ) v/s temperature (T) curves is most suitable to be used in wire bound standard resistors?



Ans. (1)

Sol. Resistivity is independent of temperature for wire bound resistors

36. A closed organ and an open organ tube filled by two different gases having same bulk modulus but different densities ρ_1 and ρ_2 respectively. The frequency of 9th harmonic of closed tube is identical with 4th harmonic of open tube. If the length of the closed tube is 10 cm and the density ratio of the gases is $\rho_1 : \rho_2 = 1 : 16$, then the length of the open tube is :

- (1) $\frac{20}{7}$ cm (2) $\frac{15}{7}$ cm
 (3) $\frac{20}{9}$ cm (4) $\frac{15}{9}$ cm

Ans. (3)



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Sol. 9th harmonic of closed pipe = $\frac{9V_1}{4\ell_1}$

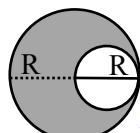
$$4^{\text{th}} \text{ harmonic of open pipe} = \frac{2V_2}{\ell_2}$$

$$\therefore \frac{9V_1}{4\ell_1} = \frac{2V_2}{\ell_2}$$

$$\therefore \frac{9}{4\ell_1} \sqrt{\frac{B}{\rho_1}} = \frac{2}{\ell_2} \sqrt{\frac{B}{\rho_2}} \Rightarrow \frac{\ell_2}{\ell_1} = \frac{8}{9} \sqrt{\frac{\rho_1}{\rho_2}}$$

$$\ell_2 = \ell_1 \times \frac{8}{9} \times \frac{1}{4} = \frac{20}{9} \text{ cm}$$

37. A uniform circular disc of radius 'R' and mass 'M' is rotating about an axis perpendicular to its plane and passing through its centre. A small circular part of radius $R/2$ is removed from the original disc as shown in the figure. Find the moment of inertia of the remaining part of the original disc about the axis as given above.



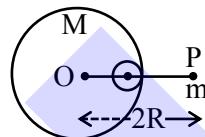
- (1) $\frac{7}{32} \text{MR}^2$ (2) $\frac{9}{32} \text{MR}^2$
(3) $\frac{17}{32} \text{MR}^2$ (4) $\frac{13}{32} \text{MR}^2$

Ans. (4)

$$\text{Sol. } I = \frac{MR^2}{2} - \left[\frac{\frac{M}{4} \left(\frac{R}{2} \right)^2}{2} + \frac{M}{4} \left(\frac{R}{2} \right)^2 \right]$$

$$I = \frac{13}{32} MR^2$$

38. A small point of mass m is placed at a distance $2R$ from the centre 'O' of a big uniform solid sphere of mass M and radius R . The gravitational force on 'm' due to M is F_1 . A spherical part of radius $R/3$ is removed from the big sphere as shown in the figure and the gravitational force on m due to remaining part of M is found to be F_2 . The value of ratio $F_1 : F_2$ is



- (1) 16 : 9 (2) 11 : 10
(3) 12 : 11 (4) 12 : 9

Ans. (3)

Sol. $F_1 = \frac{GMm}{(2R)^2}$... (1)

$$F_2 = \frac{GMm}{(2R)^2} - \left(G \left(\frac{M}{27} \right) m \left(\frac{4R}{3} \right)^2 \right)$$

$$F_2 = \frac{11}{48} \frac{GMm}{R^2} \quad \dots(2)$$

$$F_1 : F_2 = 12 : 11$$

Ans. (2)

$$\text{Sol. } E = \frac{1240}{\lambda} = \frac{1240}{550} \approx 2.25$$



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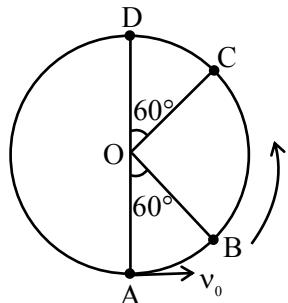
40. If B is magnetic field and μ_0 is permeability of free space, then the dimensions of (B/μ_0) is
 (1) $MT^{-2}A^{-1}$ (2) $L^{-1}A$
 (3) $LT^{-2}A^{-1}$ (4) $ML^2T^{-2}A^{-1}$

Ans. (2)

Sol. $B = \mu_0 ni$

$$\left[\frac{B}{\mu_0} \right] = [ni] = L^{-1}A^1$$

41. A bob of mass m is suspended at a point O by a light string of length l and left to perform vertical motion (circular) as shown in figure. Initially, by applying horizontal velocity v_0 at the point 'A'. the string becomes slack when, the bob reaches at the point 'D'. The ratio of the kinetic energy of the bob at the points B and C is _____.



- (1) 2 (2) 1
 (3) 4 (4) 3

Ans. (1)

Sol. $\frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mgh$
 $\Rightarrow \frac{1}{2}m(5gl) = \frac{1}{2}mv_B^2 + mg\frac{\ell}{2}$
 $\Rightarrow \frac{5mg\ell}{2} - \frac{mg\ell}{2} = KE_B$
 $\Rightarrow KE_B = 2mg\ell$
 $\frac{1}{2}mv_C^2 = \frac{1}{2}mv_D^2 + mg\frac{\ell}{2}$
 $\Rightarrow KE_C = \frac{1}{2}mg\ell + mg\frac{\ell}{2} = mg\ell \Rightarrow \frac{KE_B}{KE_C} = 2$

42. Given below are two statements :
Statement-I : The equivalent emf of two nonideal batteries connected in parallel is smaller than either of the two emfs.

Statement-II : The equivalent internal resistance of two nonideal batteries connected in parallel is smaller than the internal resistance of either of the two batteries.

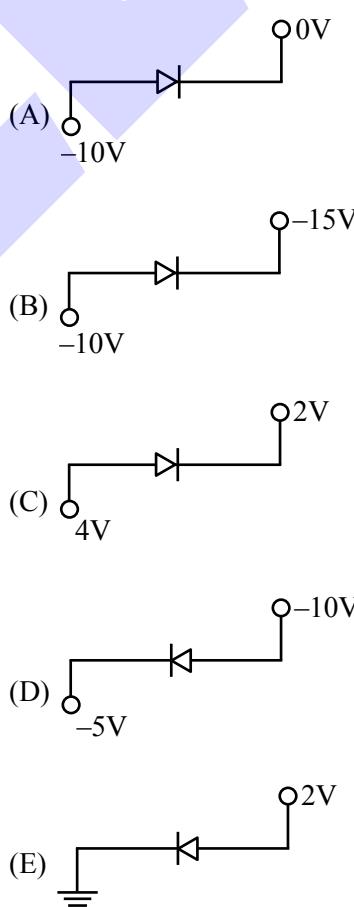
In the light of the above statements, choose the **correct** answer from the options given below.

- (1) **Statement-I** is true but **Statement-II** is false
 (2) Both **Statement-I** and **Statement-II** are false
 (3) Both **Statement-I** and **Statement-II** are true
 (4) **Statement-I** is false but **Statement-II** is true

Ans. (4)

Sol.
$$\frac{\frac{\epsilon_1}{r_1} + \frac{\epsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \epsilon$$

43. Which of the following circuits represents a forward biased diode ?



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Choose the **correct** answer from the options given below :

- (1) (B), (D) and (E) only
- (2) (A) and (D) only
- (3) (B), (C) and (E) only
- (4) (C) and (E) only

Ans. (3)

44. A parallel-plate capacitor of capacitance $40\mu\text{F}$ is connected to a 100 V power supply. Now the intermediate space between the plates is filled with a dielectric material of dielectric constant $K = 2$. Due to the introduction of dielectric material, the extra charge and the change in the electrostatic energy in the capacitor, respectively, are -
- (1) 2 mC and 0.2 J
 - (2) 8 mC and 2.0 J
 - (3) 4 mC and 0.2 J
 - (4) 2 mC and 0.4 J

Ans. (3)

$$\text{Sol. } \Delta q = (KC - C)V$$

$$= 40 \times 10^{-6} \times 100$$

$$= 4000 \times 10^{-3} = 4 \text{ mC}$$

$$\Delta U = \frac{1}{2}C'V^2 - \frac{1}{2}CV^2 = \frac{1}{2}(K-1)CV^2$$

$$= \frac{1}{2}CV^2(2-1)$$

$$= \frac{1}{2}CV^2 = \frac{1}{2} \times 40 \times 10^{-6} \times 10000$$

$$= 0.2 \text{ J}$$

45. Given is a thin convex lens of glass (refractive index μ) and each side having radius of curvature R . One side is polished for complete reflection. At what distance from the lens, an object be placed on the optic axis so that the image gets formed on the object itself.

- (1) R/μ
- (2) $R/(2\mu-3)$
- (3) μR
- (4) $R/(2\mu-1)$

Ans. (4)

$$\text{Sol. } P_{\text{eq}} = 2P_{\ell} + P_m$$

$$-\frac{1}{f_Q} = \frac{2}{f_{\ell}} - \frac{1}{f_m}$$

$$= \frac{4(\mu-1)}{R} - \frac{2}{-R} = \frac{1}{R}(4\mu-4+2)$$

$$-\frac{1}{f_{\text{eq}}} = \frac{1}{R}(4\mu-2)$$

$$\Rightarrow \frac{1}{f_{\text{eq}}} = \frac{-1}{R}(4\mu-2)$$

$$f_{\text{eq}} = \frac{R}{2}$$

$$R = 2f_{\text{eq}} = -2 \left(\frac{R}{4\mu-2} \right) = \frac{-R}{(2\mu-1)}$$

SECTION-B

46. Two soap bubbles of radius 2 cm and 4 cm, respectively, are in contact with each other. The radius of curvature of the common surface, in cm, is _____.

Ans. (4)

$$\text{Sol. } r = \frac{r_1 \cdot r_2}{r_1 - r_2} = \frac{2 \cdot 4}{4 - 2} = 4 \text{ cm}$$

47. The driver sitting inside a parked car is watching vehicles approaching from behind with the help of his side view mirror, which is a convex mirror with radius of curvature $R = 2 \text{ m}$. Another car approaches him from behind with a uniform speed of 90 km/hr. When the car is at a distance of 24 m from him, the magnitude of the acceleration of the image of the side view mirror is 'a'. The value of $100a$ is _____ m/s^2 .

Ans. (8)



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Sol. $v = \frac{uf}{u-f} = \frac{-24 \cdot 1}{-24-1} = \frac{24}{25}$

$$m = \frac{-v}{u} = -\frac{24}{25(-24)} = \frac{1}{25}$$

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

$$v_I = -m^2 \cdot v_0 = \frac{-1}{(25)^2} \cdot 25 = \frac{-1}{25}$$

Diff.

$$\frac{-1}{v^2} \left(\frac{dv}{dt} \right) + \frac{1}{u^2} \left(\frac{du}{dt} \right) = 0 \quad \left[\frac{dv}{dt} = v_I; \frac{du}{dt} = v_0 \right]$$

$$\frac{+2}{v^3} \cdot (v_I)^2 - \frac{1}{v^2} \cdot a_I - \frac{2}{u^3} \cdot (v_0)^2 + \frac{1}{u^2} \cdot a_0 = 0$$

$$\frac{a_I}{v^2} = \frac{2}{v^3} \cdot v_I^2 - \frac{2}{u^3} \cdot v_0^2$$

$$a_I = \frac{2}{v} \cdot v_I^2 - \frac{2v^2}{u^3} \cdot v_0^2$$

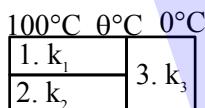
$$= \frac{2 \cdot 25}{24} \cdot \frac{1}{25} \cdot \frac{1}{25} - \frac{2}{(24)^3} \cdot \frac{24}{25} \cdot \frac{24}{25} \cdot 25 \cdot 25$$

$$a_I = \frac{2}{24 \cdot 25} - \frac{2}{24}$$

$$a_I = \frac{2}{24} \cdot \frac{-24}{25} = \frac{-2}{25}$$

$$100a_I = \frac{2}{25} \times 100 = 8$$

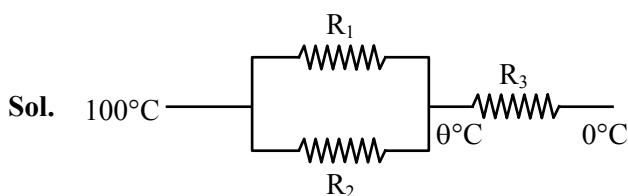
48. Three conductors of same length having thermal conductivity k_1 , k_2 and k_3 are connected as shown in figure.



Area of cross sections of 1st and 2nd conductor are same and for 3rd conductor it is double of the 1st conductor. The temperatures are given in the figure. In steady state condition, the value of θ is _____ °C.

(Given : $k_1 = 60 \text{ Js}^{-1} \text{m}^{-1} \text{K}^{-1}$, $k_2 = 120 \text{ Js}^{-1} \text{m}^{-1} \text{K}^{-1}$, $k_3 = 135 \text{ Js}^{-1} \text{m}^{-1} \text{K}^{-1}$)

Ans. (40)



$$R_1 = \frac{2L}{K_1 A}$$

$$R_2 = \frac{2L}{K_2 A}$$

$$R_3 = \frac{L}{K_3 A}$$

$$\frac{\theta - 100}{R_1 R_2} + \frac{\theta - 0}{R_3} = 0$$

$$\theta = 40$$

49. The position vectors of two 1 kg particles, (A) and (B), are given by

$$\vec{r}_A = (\alpha_1 t^2 \hat{i} + \alpha_2 t \hat{j} + \alpha_3 t \hat{k}) \text{ m}$$

$$\text{and } \vec{r}_B = (\beta_1 t \hat{i} + \beta_2 t^2 \hat{j} + \beta_3 t \hat{k}) \text{ m, respectively ;}$$

$$(\alpha_1 = 1 \text{ m/s}^2, \alpha_2 = 3n \text{ m/s}, \alpha_3 = 2 \text{ m/s}, \beta_1 = 2 \text{ m/s},$$

$\beta_2 = -1 \text{ m/s}^2, \beta_3 = 4p \text{ m/s})$, where t is time, n and p are constants, At t = 1s, $|\vec{V}_A| = |\vec{V}_B|$ and velocities

\vec{V}_A and \vec{V}_B of the particles are orthogonal to each other. At t = 1 s, the magnitude of angular momentum of particle (A) with respect to the position of particle (B) is $\sqrt{L} \text{ kgm}^2 \text{s}^{-1}$. The value of L is _____.

Ans. (90)



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Sol. $\vec{V}_A = (2\hat{i} + 3\hat{j} + 2\hat{k})$

$$\vec{V}_B = (2\hat{i} - 2\hat{j} + 4\hat{k})$$

$$\vec{V}_A \cdot \vec{V}_B = 0$$

$$4 - 6n + 8p = 0$$

$$2 - 3n + 4p = 0$$

$$3n = 2 + 4p$$

$$|\vec{V}_A| = |\vec{V}_B|$$

$$4 + 9n^2 + 4 = 4 + 4 + 16p^2$$

$$p = \frac{-1}{4} \Rightarrow n = \frac{1}{3}$$

$$\vec{L} = m_A (\vec{r}_{A/B} \times \vec{V}_A)$$

$$\vec{r}_{A/B} = (\alpha_1 - \beta_1)\hat{i} + (\alpha_2 - \beta_2)\hat{j} + (\alpha_3 - \beta_3)$$

$$= (1-2)\hat{i} + (1+1)\hat{j} + 3\hat{k}$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & 2 & 3 \\ 2 & 1 & 2 \end{vmatrix} = \hat{i} + 8\hat{j} - 5\hat{k}$$

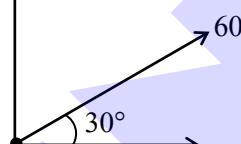
$$= \sqrt{1+64+25} = \sqrt{90}$$

50. A particle is projected at an angle of 30° from horizontal at a speed of 60 m/s. The height traversed by the particle in the first second is h_0 and height traversed in the last second, before it reaches the maximum height, is h_1 . The ratio $h_0 : h_1$ is _____.
[Take, $g = 10 \text{ m/s}^2$]

Ans. (5)

Sol.

$$60\sin 30 = 30$$



$$S_1 = 30 \times 1 - \frac{1}{2} \times 10 \times 1 = 25$$

$$S_3 = 30 + \left(\frac{-10}{2} \right) \times (2 \times 3 - 1) = 5$$

$$\frac{S_1}{S_3} = \frac{25}{5} = 5$$

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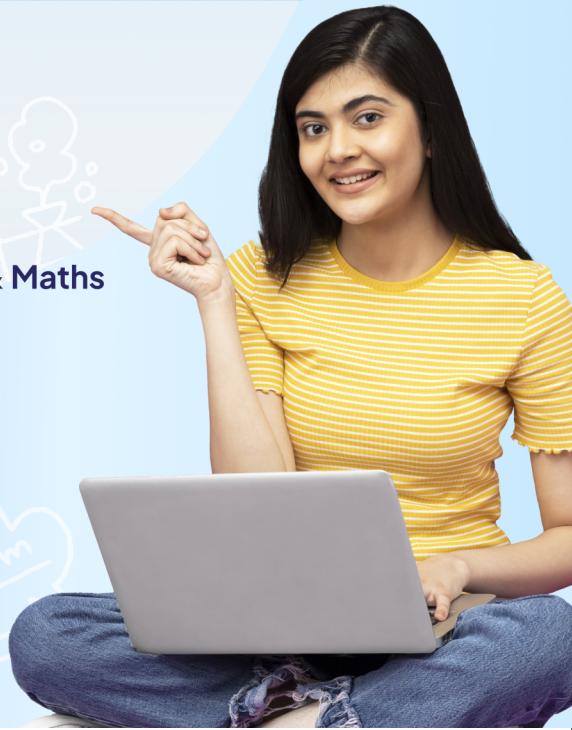


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