

PHYSICS

SECTION-1

[:Q.1] An amount of ice of mass 10^{-3} kg and temperature -10°C is transformed to vapour of temperature 110°C 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 = $2.25 \times 10^6 \text{ Jkg}^{-1}$)

[:A] 3024 J

[:B] 3003 J

[:C] 3022 J

[:D] 3043 J

[:ANS] D

[:SOLN] $Q = m_{\text{ice}}\Delta T_{\text{i}} + m_{\text{ice}}L_{\text{f}} + m_{\text{ice}}\Delta T_{\text{w}} + m_{\text{ice}}L_{\text{v}} + m_{\text{ice}}\Delta T_{\text{v}}$
 $= 10^{-3} [2100 \times 10 + 3.35 \times 10^5 + 4180 \times 100 + 2.25 \times 10^6]$
 $21 + 335 + 418 + 2250 \times 15.2$
 $= 3043.2 \text{ J}$

[:Q.2] An electron in the ground state of the hydrogen atom has the orbital radius of $5.3 \times 10^{-11} \text{ m}$ while that for the electron in third excited state is $8.48 \times 10^{-10} \text{ m}$. The ratio of the de Broglie wavelengths of electron in the ground state to that in the excited state is

[:A] 9

[:B] 16

[:C] 4

[:D] 3

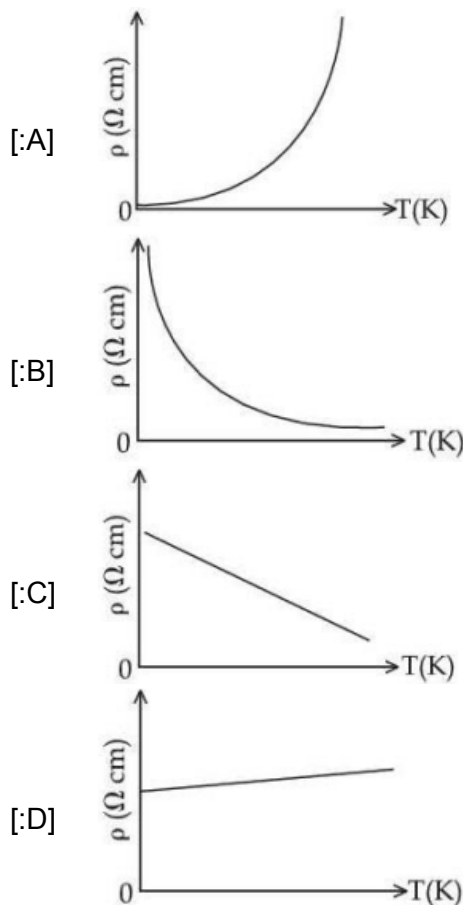
[:ANS] D

[:SOLN] $\lambda = \frac{h}{mv}$ but $V \propto Z/n$

$\therefore \lambda \propto n$

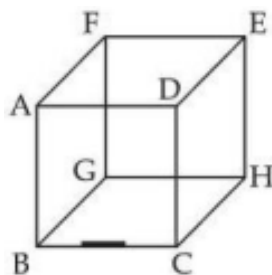
$$\frac{\lambda_1}{\lambda_2} = \frac{n_1}{n_2} = \frac{1}{4}$$

[:Q.3] Which of the following resistivity (ρ) v/s temperature (T) curves is most suitable to be used in wire bound standard resistors ?



[:ANS] A

[:Q.4] 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 charge is λ C 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)



[:A] $\frac{\lambda a}{16 \epsilon_0}$

$$[:B] \quad \frac{\lambda a}{2 \epsilon_0}$$

$$[:C] \quad \frac{\lambda a}{8 \epsilon_0}$$

$$[:D] \quad \frac{\lambda a}{4 \epsilon_0}$$

[ANS] C

$$[:SOLN] \quad \phi_{\text{cube}} = \frac{Q}{4 \epsilon_0} = \frac{\lambda a / 2}{4 \epsilon_0} = \frac{\lambda a}{8 \epsilon_0}$$

[Q.5] The work functions of cesium (Cs) and lithium (Li) metals are 1.9 eV and 2.5 eV, respectively. If we incident a light of wavelength 550 nm on these two metal surface, then photo-electric effect is possible for the case of

[:A] Li only

[:B] Neither Cs nor Li

[:C] Both Cs and Li

[:D] Cs only

[ANS] A

[SOLN] Energy of incident photon

$$= \frac{1240}{550} = 2.25$$

$E_{\text{photon}} > (\phi_o)_{\text{Cs}} \rightarrow \text{P.E.E takes place}$

but $E_{\text{photon}} < (\phi_o)_{\text{Li}}$

P.E.E does not

take place

[Q.6] 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 electric field region with a horizontal component of velocity 10^6 m/s. If the magnitude of the electric field between the plates (mass of electron = 9.1×10^{-31} kg and charge of electron = 1.6×10^{-19} C)

[:A] 16×10^6 m/s

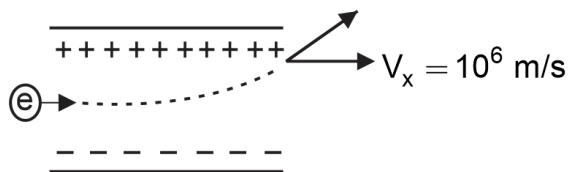
[:B] 16×10^4 m/s

[:C] 1×10^6 m/s

[:D] 0

[:ANS] A

[:SOLN]



$$t = \frac{L}{V_n} = \frac{0.1}{10^6} = 10^{-7} \text{ sec}$$

$$V_y = \frac{eE}{m_e} t$$

$$= \frac{1.6 \times 10^{-19} \times 910}{9.1 \times 10^{-31}} \times 10^{-7}$$

$$= 1.6 \times 10^7 = 16 \times 10^6 \text{ m/s}$$

[:Q.7] If B is magnetic field and μ_0 is permeability of free space, then the dimensions of (B/μ_0) is

[:A] $LT^{-2}A^{-1}$

[:B] $ML^2T^{-2}A^{-1}$

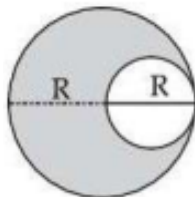
[:C] $L^{-1}A$

[:D] $MT^{-2}A^{-1}$

[:ANS] C

[:SOLN] $B = \mu_0 ni \quad \frac{B}{\mu_0} = ni = \frac{Ni}{\ell} = A/m$

[:Q.8] 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.



[:A] $\frac{9}{32}MR^2$

[:B] $\frac{13}{32}MR^2$

$$[:C] \quad \frac{17}{32}MR^2$$

$$[:D] \quad \frac{7}{32}MR^2$$

[ANS] B

[SOLN] $I = I_W - I_{cut}$

$$= \frac{mR^2}{2} - \left[\frac{3}{2} \times \frac{m}{4} \times \left(\frac{R}{2} \right)^2 \right]$$

$$= \frac{mR^2}{2} - \frac{3mR^2}{32}$$

$$= \frac{13mR^2}{32}$$

[Q.9] 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

[A] 2 mC and 0.2 J

[B] 8 mC and 2.0 J

[C] 2 mC and 0.4 J

[D] 4 mC and 0.2 J

[ANS] D

[SOLN] $C_0 = 40\mu\text{F} \rightarrow Q_i = C_0 V$

$$C = 80\mu\text{F} \rightarrow Q_f = CV$$

$$\therefore \Delta Q = Q_L - Q_i = (C - C_0) V$$

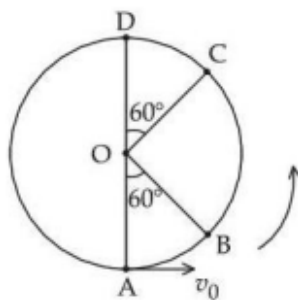
$$= 40 \times 100\mu\text{C} = 4\text{mC}$$

$$\Delta\mu = \frac{1}{2}(C - C_0) V^2$$

$$\frac{1}{2} \times 40 \times 10^4 \mu\text{J}$$

$$= 0.2 \text{ J}$$

[Q.10] 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 _____.



[:A] 1

[:B] 4

[:C] 2

[:D] 3

[:ANS] C

[:SOLN] Here $V_0 = \sqrt{5gR}$

$$V_B = \sqrt{V_0^2 - 2g \times R/2}$$

$$= \sqrt{5gR - gR} = \sqrt{4gR}$$

$$V_C = \sqrt{V_0^2 - 2g \times \frac{3R}{2}}$$

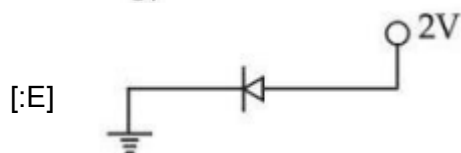
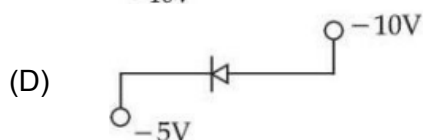
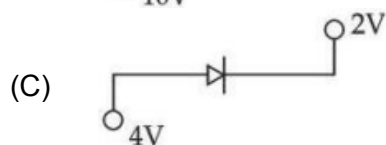
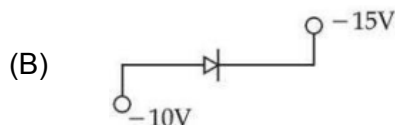
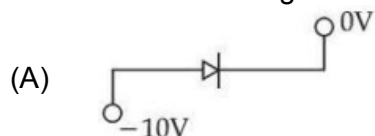
$$= \sqrt{5gR - 3gR} = \sqrt{2gR}$$

$$\frac{K_B}{K_C} = \frac{V_B^2}{V_C^2}$$

$$= \frac{4gR}{2gR}$$

$$= 2 \text{ Ans}$$

[:Q.11] Which of the following circuits represents a forward biased diode ?



Choose the correct answer from the options given below :

[A] (B), (D) and (E) only

[B] (C) and (E) only

[C] (B), (C) and (E) only

[D] (A) and (D) only

[ANS] C

[SOLN] Low - high \rightarrow R.B

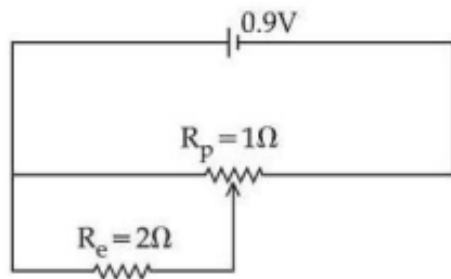
High - low \rightarrow F.B

High - low \rightarrow F.B

High - low \rightarrow R.B

low - High \rightarrow F.B

[Q.12] 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. The electric current in the circuit is :



[A] 1.0 A

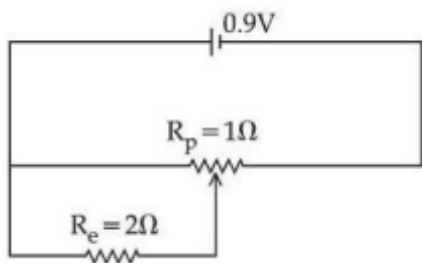
[B] 1.35 A

[C] 0.3 A

[D] 0.9 A

[ANS] B

[SOLN]



$$R_{eq} = \frac{2 \times 0.5}{2.5} + 0.5$$

$$R_{eq} = 0.4 + 0.5 = 0.9 \, \Omega$$

$$I = \frac{V}{R_{eq}} = \frac{0.9}{0.9} = 1 \text{ Amp}$$

[:Q.13] 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 the bigger body is 400 K. If the energy radiated from the smaller body is E, the energy radiated from the bigger body is (assume, effect of the surrounding temperature to be negligible).

[:A] 256 E

[:B] 16 E

[:C] 64 E

[:D] E

[:ANS] D

[:SOLN] $E \propto AT^4$

$$E \propto R^2 T^4$$

$$\frac{E'}{E} = \left(\frac{R'}{R} \right)^2 \times \left(\frac{T'}{T} \right)^4$$

$$\frac{E'}{E} = \left(\frac{0.8}{0.2} \right)^2 \left(\frac{400}{800} \right)^4$$

$$= 4^2 \times \frac{1}{2^4} = 1$$

$$E' = E$$

[:Q.14] 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 divisions.

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

[:A] Statement-I is false but Statement-II is true

[:B] Both Statement-I and Statement-II are false

[:C] Both Statement-I and Statement-II are true

[:D] Statement-I is true but Statement-II is false

[:ANS] D

[:Q.15] 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.

[:A] Statement-I is false but Statement-II is true

[:B] Both Statement-I and Statement-II are false

[:C] Both Statement-I and Statement-II are true

[:D] Statement-I is true but Statement-II is false

[:ANS] A

[:SOLN] $\frac{\varepsilon_p - \varepsilon_1}{\varepsilon_2 - \varepsilon_p} = \frac{r_2}{r_1} = +ve$

$$\therefore \varepsilon_1 < \varepsilon_p < \varepsilon_2$$

Or

$$\varepsilon_2 < \varepsilon_p < \varepsilon_1 \rightarrow \text{Statement I is false}$$

$$R_p = \frac{r_1 r_2}{r_1 + r_2}$$

$$\therefore r_p < r_1$$

$$r_p < r_2 \rightarrow \text{Statement II is true.}$$

[:Q.16] 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 ?

[:A] $R / (2\mu - 1)$

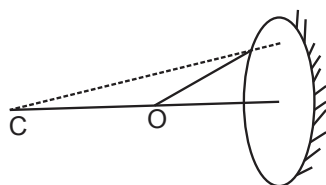
[:B] μR

[:C] R / μ

[:D] $R / (2\mu - 3)$

[:ANS] A

[:SOLN]



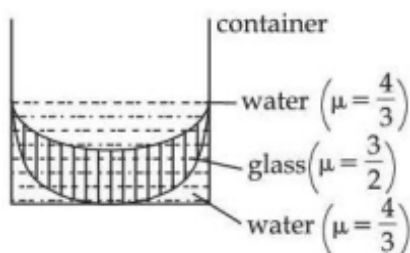
$$\frac{\mu_2}{V} - \frac{\mu_2}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{\mu}{-R} + \frac{1}{x} = \frac{\mu - 1}{+R}$$

$$\frac{1}{x} = \frac{\mu - 1}{R} + \frac{\mu}{R}$$

$$x = R / 2\mu - 1$$

[Q.17] In the diagram given below, there are three lenses formed. Considering negligible thickness of each of them as compared to $|R_1|$ and $|R_2|$, i.e., the radii of curvature for upper and lower surfaces of the glass lens, the power of the combination is



[A] $\frac{1}{6} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$

[B] $-\frac{1}{6} \left(\frac{1}{|R_1|} + \frac{1}{|R_2|} \right)$

[C] $-\frac{1}{6} \left(\frac{1}{|R_1|} - \frac{1}{|R_2|} \right)$

[D] $\frac{1}{6} \left(\frac{1}{|R_1|} + \frac{1}{|R_2|} \right)$

[ANS] C

[SOLN] $\frac{1}{f_w} = \left(\frac{4}{3} - 1 \right) \left\{ \frac{1}{R_1} \right\}$

$$\frac{1}{f_g} = \left(\frac{3}{2} - 1 \right) \left\{ \frac{1}{-R_1} + \frac{1}{R_2} \right\}$$

$$\frac{1}{f_w} = \left(\frac{4}{3} - 1 \right) \left\{ \frac{-1}{R_2} \right\}$$

$$P_{\text{combination}} = \frac{1}{f_w} + \frac{2}{f_g} + \frac{1}{f_w}$$

$$P = \frac{1}{3R_1} + \frac{1}{2} \left(\frac{1}{R_2} - \frac{1}{R_1} \right) - \frac{1}{3R_2}$$

$$P = \left(\frac{1}{3} - \frac{1}{2} \right) \frac{1}{R_1} + \left(\frac{1}{2} - \frac{1}{3} \right) \frac{1}{R_2}$$

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

[:Q.18] 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 :

[:A] Both (A) and (R) are true but (R) is not the correct explanation of (A)

[:B] (A) is false but (R) is true

[:C] (A) is true but (R) is false

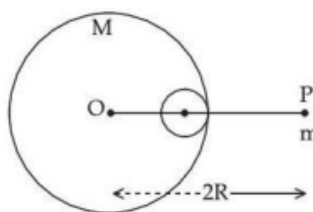
[:D] Both (A) and (R) are true and (R) is the correct explanation of (A)

[:ANS] D

[:SOLN] $\beta_m = \frac{\beta_{\text{air}}}{\mu}$ = fringe width decreases

$$\mu = \frac{c}{u}$$

[:Q.19] 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



[:A] 11 : 10

[:B] 12 : 9

[:C] 16 : 9

[:D] 12 : 11

[:ANS] D

$$[:\text{SOLN}] F_1 = mE_w = \frac{GMm}{4R^2}$$

$$E_{\text{remaining}} = E_{\text{whole}} - E_{\text{cut}}$$

$$E_{\text{remaining}} = \frac{GM}{4R^2} - \frac{GM/27}{(4R/3)^2}$$

$$\frac{GM}{4R^2} - \frac{GM}{48R^2}$$

$$\therefore F_2 = \frac{3GMm}{16R^2} = \frac{11GM}{48R^2}$$

$$\frac{F_1}{F_2} = \frac{\frac{1}{4}}{\frac{11}{48}} = \frac{12}{11}$$

[:Q.20] A closed organ and an open organ tube are 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 :

[:A] $\frac{15}{9}$ cm[:B] $\frac{20}{9}$ cm[:C] $\frac{20}{7}$ cm[:D] $\frac{15}{7}$ cm

[:ANS] B

$$[:\text{SOLN}] (v_{9\text{th}})_{\text{closed}} = (\mu_{4\text{th}})_{\text{open}}$$

$$\frac{9\sqrt{\frac{B}{\rho_1}}}{4\ell_1} = \frac{4\sqrt{B/\rho_2}}{2\ell_2}$$

$$\frac{\ell_2}{\ell_1} = \frac{8}{9} \sqrt{\frac{\rho_1}{\rho_2}}$$

$$\frac{\ell_2}{\ell_1} = \frac{8}{9} \sqrt{\frac{1}{16}}$$

$$\ell_2 = 2/9 \times 10 \text{ cm}$$

$$= 20/9 \text{ cm}$$

SECTION-2

[:Q.21] 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 _____

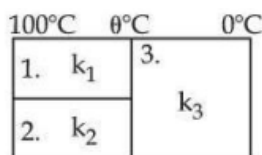
[:ANS] 4

[:SOLN] $\frac{1}{r} = \frac{1}{2} - \frac{1}{4}$

$$\frac{1}{r} = \frac{1}{4}$$

$$r = 4 \text{ cm}$$

[:Q.22] 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

[:SOLN] $R_1 = \frac{\ell}{60A}$ $R_2 = \frac{\ell}{120A}$ $R_3 = \frac{\ell}{135 \times 2A}$

$$i_1 + i_2 = i_3 \Rightarrow \frac{\ell}{270} \frac{100 - \theta}{\ell} \times 60A + \frac{100 - \theta}{\ell} \times 120A = \frac{\theta}{\ell} \times 270A$$

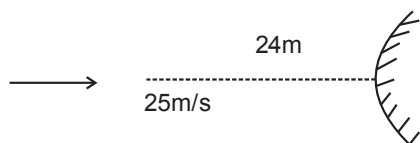
$$600 - 6\theta + 1200 - 2\theta = 27\theta$$

$$45\theta = 1800 \Rightarrow \theta = 40^\circ$$

[:Q.23] 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 car in the side view mirror is 'a'. The value of $100a$ is _____ m/s^2 .

[:ANS] 8

[:SOLN] $f = 1 \text{ m}$



$$V_i = m^2 V_0$$

$$V_i = \left(\frac{1}{x+1} \right)^2 V_0$$

$$Q_i = \frac{-2}{(24+1)^3} \times 25^2$$

$$\frac{dV_i}{dt} = \frac{-2}{(x+1)^3} V_0^2$$

$$a_i = \frac{-2}{25}$$

$$100a_i = 8 \text{ m/s}^2$$

[:Q.24] The position vectors of two 1 kg particles, (A) and (B), are given by

$$\vec{r}_A = (\alpha_1 t^2 \hat{i} + \alpha_2 t \hat{j} + \alpha_3 t \hat{k}) \text{ m and } \vec{r}_B = (\beta_1 t \hat{i} + \beta_2 t^2 \hat{j} + \beta_3 t \hat{k}) \text{ m, respectively;}$$

$\alpha_1 = 1 \text{ m/s}^2, \alpha_2 = 3 \text{ nm/s}, \alpha_3 = 2 \text{ m/s}, \beta_1 = 2 \text{ m/s}, \beta_2 = -1 \text{ m/s}^2, \beta_3 = 4 \text{ pm/s}$, where t is time, n and p are constants. At $t = 1 \text{ s}$, $|\vec{V}_A| = |\vec{V}_B|$ and velocities \vec{V}_A and \vec{V}_B of the particles are orthogonal to each other. At $t = 1 \text{ s}$, 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

[:SOLN] $\vec{V}_A = (2t\hat{i} + 3n\hat{j} + 2\hat{k})$

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

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

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

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

$$3n = 2 + 4p$$

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

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

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

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

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

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

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

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

[:Q.25] 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

[:SOLN] $V_y = 60 \sin 30^\circ = 30 \text{ m/s}$

$$h_0 = 30 \times 1 - \frac{1}{2} \times 10 \times 1^2 = 25 \text{ m}$$

$$h_1 = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 1^2 = 5 \text{ m}$$

$$\therefore \frac{h_0}{h_1} = \frac{25}{5} = 5$$