JEE Main 2025 Physics Paper Solution

By Mr. Sunil Sethi

11th AND 12th STANDARD PCM FOR CBSE BOARD, JEE MAIN, NEET (UG), CUET AND OTHER ENTRANCE EXAMS

JEE MAIN -2025: PHYSICS PAPER

DETAILED SOLUTION

(22.1.2025→SHIFT-1)

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Q.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.

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CONCEPT APPLICABLE AND SOLUTION:

Statement I is correct

Vernier constant $= \dfrac{\text{Smallest Main Division}}{\text{No of Vernier scale division}}$

option (2) is correct.

Vernier const or least count:

$VC = LC = 1\,MSD - 1\,VSD = \frac{1}{n}\,MSD$

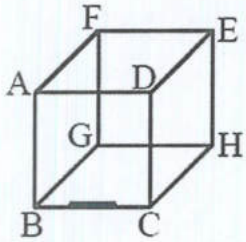
$= \dfrac{\text{Smallest division on main scale}}{\text{No of Divisions on Vernier scale}}$

zero error: Algebraically subtracted

zero correct: Algebraically added.

Q.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, $\in_0$ as the free space pennittivity)



(1) $\frac{\lambda a}{8 \in_0}$ **(2)** $\frac{\lambda a}{16 \in_0}$

(3) $\frac{\lambda a}{2 \in_0}$ **(4)** $\frac{\lambda a}{4 \in_0}$

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CONCEPT APPLICABLE AND SOLUTION:

Gauss's Theorem:

$\oint \vec{E} \cdot d\vec{s} = \frac{1}{\epsilon_0}$ (charge enclosed by G.S)

Total charge on the line = Line of charge length × Charge density

$= \left(\frac{a}{2}\right) \lambda = \frac{\lambda a}{2}$

∴ charge enclosed $= \frac{\lambda a}{2}$

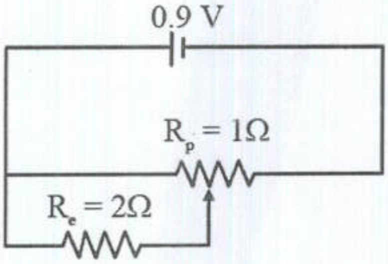
As the line charge is along the centre of BC of cube. So only 1/4 of the total charge contributes to the flux through the cube

So $q_{enclosed} = \left(\frac{1}{4} \cdot \lambda \frac{a}{2}\right) = \frac{\lambda a}{8}$

∴ flux $= \left(\frac{1}{\epsilon_0} \cdot \frac{\lambda a}{8}\right)$

Option (1) is correct.

Q.28



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

(1) 0.3 A **(2) 1.35**

(3) 1.0 A **(4) 0.9 A**

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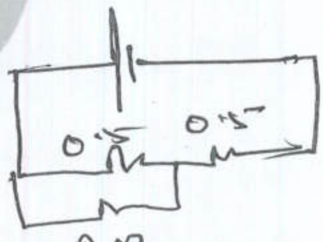
CONCEPT APPLICABLE AND SOLUTION:

ATQ circuit can be redrawn



As. $R = \rho \frac{l}{a}$

$R \propto l$ → ρ & a same

for mid point : mean half of length.

$Req = (0.5 \| 2) + 0.5 = \frac{0.5 \times 2}{0.5+2} + 0.5$

$= \frac{1}{2.5} + \frac{1}{2} = \frac{2+2.5}{5} = \frac{4.5}{5} = 0.9\Omega$.

∴ Current drawn from the battery $= \frac{\text{applied emf}}{Req} = \frac{0.9}{0.9} = \boxed{1.0\ A}$

option (3) is correct.

Q.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 time but (R) is false.

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CONCEPT APPLICABLE AND SOLUTION:

fringe width $\beta = \frac{D\lambda}{d}$

D → Dist between slits & screen

d → Distance between two slits

λ → wave length of monochromatic light.

If system of Young's Double slit experiment is dipped in a medium of R.I = μ

$$\beta_{medium} = \frac{\beta_{air}}{\mu}$$

→ R.I of I w.r.t 2

Snell's law: $_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

colour spectrum: VIBGYOR → increasing order of λ.

$\beta_{medium} < \beta_{air}$ → A is correct

R is also correct

Correct ans is (3)

Q.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

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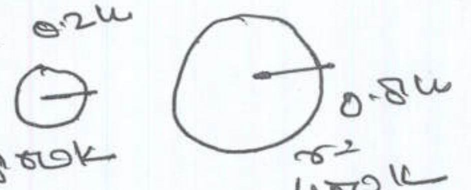
CONCEPT APPLICABLE AND SOLUTION:

Stefan's law: Radiant energy emitted by a perfectly body per unit area per unit time is directly proportional to the fourth power of its absolute temp.

$E \propto T^4 \Rightarrow E = \sigma T^4$

Stefan's const → value $= 5.67 \times 10^{-8}\ W/m^2K^4$

→ dimension $= MT^{-3}\theta^{-4}$



$E_{smaller} = E$ (energy radiated)

$E_{bigger} = ?$

$$\frac{E_1}{E_2} = \frac{\sigma A_{smaller} \times T^4_{smaller}}{\sigma A_{bigger} \times T^4_{bigger}}$$

$A = 4\pi r^2$

$$\frac{E}{E_{bigger}} = \frac{(0.2)^2}{(0.8)^2} \times \frac{(800)^4}{(400)^4}$$

$$\frac{E}{E_{bigger}} = \frac{1}{16} \times \frac{16}{1} = 1$$

$\therefore E_{bigger} = \boxed{E}$

option (2) is correct.

Q.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 $Jkg^{-1}K^{-1}$, specific heat of water = 4180 $Jkg^{-1}K^{-1}$, specific heat of steam = 1920 $Jkg^{-1}K^{-1}$, Latent heat of ice = 3.35×10^5 Jkg^{-1} and Latent heat of steam = 2.25×10^6 Jkg^{-1})

(1) 3022 J
(2) 3043 J
(3) 3003 J
(4) 3024 J

work = sub

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CONCEPT APPLICABLE AND SOLUTION:

For change of temp $Q = m.c.\Delta\theta$ (c → specific heat; → change temp)

For change of state $Q = m.L$ (L → latent heat)

Conversions involved are

- −10°C ice to 0°C ice = $m.s.\Delta\theta$
- 0°C ice to 0°C water = mL
- 0°C water to 100°C water = $m.s.\Delta\theta$
- 100°C water to 100°C steam = mL
- 100°C steam to 115°C vapour = $m.s.\Delta\theta$

Add all Ans

Sub values

$$Q = 10^{-3} \times 2100 \times (0-(-10^\circ C)) + 10^{-3} \times 3.35 \times 10^{5} + 10^{-3} \times 4180 \times (100) + 10^{-3} \times 2.25 \times 10^{6} + 10^{-3} \times 1920 \times (115-100)$$

On simplification, we get 3043.2 Joule.

∴ Amount of work = option (2) is correct

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Q.32 An electron in the ground state of the hydrogen atom has the orbital radius of 5.3×10^{-11} m while that for the electron in third excited state is 8.48×10^{-10} m. The ratio of the de Broglie wavelengths of electron in the ground state to that in excited state is

(1) 4 (2) 9

(3) 3 (4) 16

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CONCEPT APPLICABLE AND SOLUTION:

- n^{th} excited means $(n+1)$ state

As angular momentum $= \frac{nh}{2\pi}$

$mvr = \frac{nh}{2\pi}$

$\lambda = \frac{h}{p} \Rightarrow$

$pr = \frac{nh}{2\pi} \Rightarrow \frac{h}{p} = \frac{2\pi r}{n}$

$\therefore \lambda = \frac{h}{p} \propto \frac{r}{n}$

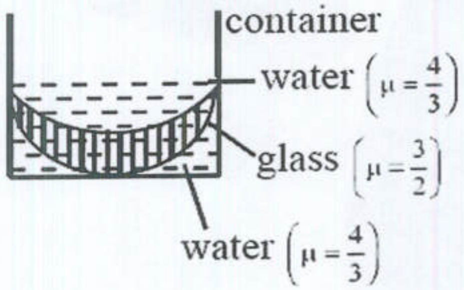
$\therefore \frac{\lambda_1}{\lambda_4} = \left(\frac{r_1}{r_4}\right)\left(\frac{4}{1}\right) = \left(\frac{5.31 \times 10^{-11}}{8.48 \times 10^{-10}}\right) \times 4$

← Third excited state

$\therefore \frac{\lambda_1}{\lambda_4} = \frac{2.14}{8.48} = \frac{1}{0.25} = 4$

option (1) is correct

Q.33 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



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

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

(3) $\frac{1}{6}\left(\frac{1}{|R_1|} + \frac{1}{|R_2|}\right)$

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

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CONCEPT APPLICABLE AND SOLUTION:

Here: it is combination of three lens.
water lens + glass lens + water lens
Plane concave (1) convexo-concave (2) convex-plane (3).

lens's Maker's formula

$P = \frac{1}{f(\text{in meter})} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

↳ R.I of material of lens w.r.t medium in which it is placed

Power of combination

$= P_1 + P_2 + P_3 =$

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FPP Q.33.

For P_1 : $R_1 = \infty$, $R_2 = -R_2$

$\therefore P_1 = \left(\frac{4}{3}-1\right)\left(\frac{1}{\infty} - \left(-\frac{1}{R_1}\right)\right) = \frac{1}{3R_1}$

$P_2 = \left(\frac{3}{2}-1\right)\left(\frac{1}{-R_1} - \left(-\frac{1}{R_2}\right)\right) =$

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

$P_3 = \left(\frac{4}{3}-1\right)\left(-\frac{1}{R_2} - \frac{1}{\infty}\right) = -\frac{1}{3R_2}$

$\therefore$ Power of combination

$P = P_1 + P_2 + P_3$

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

$= -\frac{1}{6}\left[\frac{1}{|R_1|} - \frac{1}{|R_2|}\right]$

option 'b' is correct.

Q.34 An electron is made to enters 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 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**

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CONCEPT APPLICABLE AND SOLUTION:

→ Electric force $F = ma = qE$

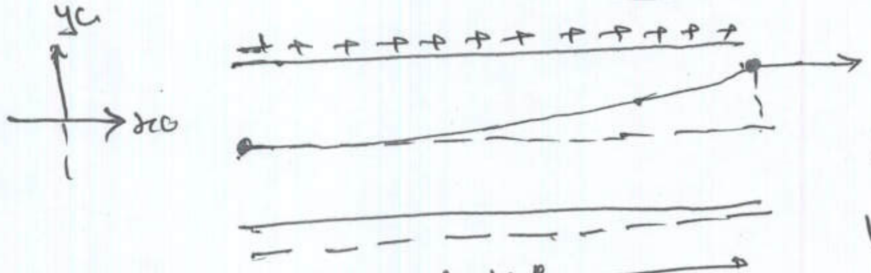
so $a = \frac{qE}{m}$

time taken by electron to exit the electric field region

$= \frac{\text{Dist.}}{\text{speed}} = \frac{\text{length of plate}}{\text{Horizontal component}} = \frac{10 \times 10^{-2}}{10^6}$

$= \boxed{10^{-7}\ \text{sec}}$

$l = 10\ \text{cm} = 10 \times 10^{-2}\ \text{m}$



$l = 10\ \text{cm} = 10 \times 10^{-2}\ \text{m}$

As to vertical component:

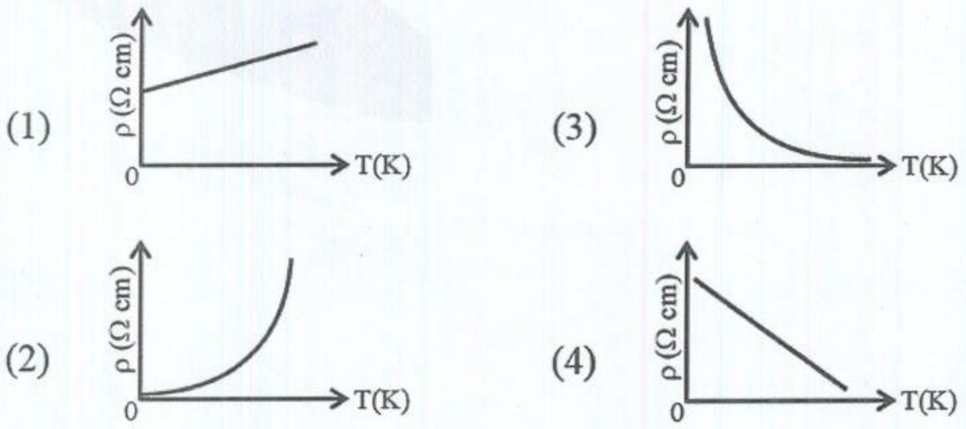
$v_y = u_y + a_y t$

$v_y = 0 + \left(\frac{qE}{m}\right) \times t$

$\therefore v_y = \frac{1.6 \times 10^{-19} \times 9.1 \times 10^{+2}}{9.1 \times 10^{-31}} \times 10^{-7} = \boxed{16 \times 10^6\ \text{m/sec}}$

option (4) is correct

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



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CONCEPT APPLICABLE AND SOLUTION:

- For resistivity: Over a small temp range (up to 100°C), the resistivity of metal (or conductors) can be represented approx by equation

$\rho = \rho_0(1+\alpha\Delta T)$ → This shows linear variation

α → temp coefficient of resistivity

ρ_0 → Resistivity at reference temp (often taken as 0°C or 20°C)

option (1) is correct.

Q.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

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CONCEPT APPLICABLE AND SOLUTION:

- In. Organ pipes: standing waves are the result of interference between longitudinal sound waves travelling in opposite direction.
- Velocity of sound is also given by $\sqrt{\frac{B}{\rho}}$
- $f_{n_o} = \frac{n \cdot v_o}{2L_o}$ $n = 1, 2, 3 \ldots$
- $f_{n_c} = \frac{n v_c}{4L_c}$ $n = 1, 3, 5, 7, 9 \ldots$

for 9th harmonic in closed pipe: $n = 9$
for 4th Harmonic in open pipe: $n = 4$

ATQ

$$f_{4_o} = f_{9_c}$$

$$\Rightarrow 4 \cdot \frac{v_o}{2l_o} = \frac{9 v_c}{4 l_c}$$

$$\Rightarrow \frac{2 \cdot \sqrt{\frac{B_o}{\rho_o}}}{l_o} = \frac{9}{4} \frac{\sqrt{\frac{B_c}{\rho_c}}}{l_c}$$

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$$2 \cdot \frac{1}{\sqrt{\rho_0}} \cdot \frac{1}{l_0} = \frac{9}{4} \cdot \frac{1}{\sqrt{\rho_c}} \cdot \frac{1}{l_c}$$

$$l_0 = \left(\sqrt{\frac{\rho_c}{\rho_0}}\right) 2 \times \frac{4}{9} \times 10$$

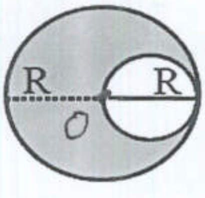
ATQ $\frac{\rho_c}{\rho_0} = \frac{1}{16}$

$$= \frac{1}{4} \cdot 2 \cdot \frac{4}{9} \cdot 10$$

$$\boxed{l_0 = \frac{20}{9} \text{ cm}}$$ Ans.

option (3) is correct

Q.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) $\frac{7}{32}MR^2$

(2) $\frac{9}{32}MR^2$

(3) $\frac{17}{32}MR^2$

(4) $\frac{13}{32}MR^2$

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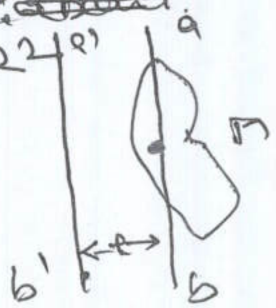
CONCEPT APPLICABLE AND SOLUTION:

- M.I of uniform circular disc ~~about~~ ⊥ to the disc about centre $= \frac{1}{2}MR^2$



- Parallel axis Theorem:
  I_C = M.I of the body about centroid axis $aa' = MK^2$, $a'b'$
  & M.I about an axis ∥ to ab is $I = MK^2 + Mh^2$ → h is distance between two parallel axis

- Theorem of ∥ axis is applicable to any type of rigid body whether it is two dimension or 3-D, while ⊥ axis theorem is applicable to laminar type or two dimensional body only.

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FPP QN037

As M is mass of πR^2.

$\therefore$ mass of removed part

$$m = \frac{M}{\pi R^2} \cdot \pi \left(\frac{R}{2}\right)^2 = \frac{M}{4}$$

Moment of Inertia of disc about centre

$$I_{Dis} = \frac{1}{2} MR^2 \quad \text{---(1)}$$

I_c = M.I of cut portion about centre of disc

$$= \frac{1}{2}\left(\frac{M}{4}\right)\left(\frac{R}{2}\right)^2 + \frac{M}{4}\cdot\left(\frac{R}{2}\right)^2$$

By Parallel axis Theorem.

$$= \frac{MR^2}{32} + \frac{MR^2}{16} = \frac{3MR^2}{32} \quad \text{---(2)}$$

$\therefore I_R$ = M.I of remaining part

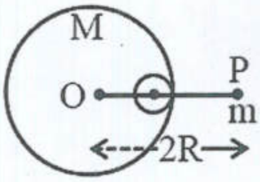
$$= I_{Disc} - I_c \quad ((1)-(2))$$

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

$$\frac{16MR^2 - 3MR^2}{32} = \boxed{\frac{13}{32}MR^2}$$

Option (4) is correct

Q.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**

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CONCEPT APPLICABLE AND SOLUTION:

Universal Law of Gravitation: Every body in this Universe attracts each other with a force whose magnitude is directly to the product of their masses & inversely proportional to the square of the distances between their centres. This force acts along the line joining the centres of two bodies

$F = G\frac{m_1 m_2}{r^2}$ G: Universal gravitation constant $= 6.67 \times 10^{-8}$ C.G.S unit $= 6.67 \times 10^{-11}$ S.I unit

ATQ: $F_1 = G\frac{Mm}{(2R)^2} = G\frac{Mm}{4R^2}$ —(1)

Mass of the removed part.

$M' = \frac{M}{\frac{4}{3}\pi R^3} \cdot \frac{4}{3}\pi\left(\frac{R}{3}\right)^3 = \frac{M}{27}$

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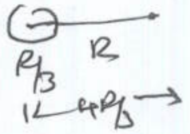
FPP for Q.NO38



$$\therefore F_2 = F_1 - \frac{G\left(\frac{M}{27}\right)m}{\left(R+\frac{R}{3}\right)^2}$$

$$= \frac{GMm}{4R^2} - \frac{GMm}{R^2}\left(\frac{\frac{1}{27}}{\frac{16}{9}}\right)$$

$$= \frac{GMm}{4R^2} - \frac{GMm}{R^2}\left(\frac{9 \times 1}{27 \times 16}\right)$$

$$= \frac{GMm}{R^2}\left(\frac{1}{4} - \frac{1}{48}\right)$$

$$= \frac{GMm}{R^2}\left(\frac{12-1}{48}\right)$$

$$= \frac{GMm}{R^2}\left(\frac{11}{48}\right) \quad \text{---(2)}$$

(1) ÷ (2) i.e.

$$\frac{F_1}{F_2} = \frac{\frac{GMm}{4R^2}}{\frac{11\,GMm}{48R^2}} = \frac{48}{4 \times 11} = \boxed{12:11}$$

Ans

option (3) is correct.

Q.39 **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 mm on these two-metal surface, then photo-electric effect is possible for the case of**

(1) Li only **(2) Cs only**

(3) Neither Cs nor Li **(4) Both Cs and Li**

(JEE-Main 2025)

CONCEPT APPLICABLE AND SOLUTION:

Law's of photoelectric emission:

1. The photo electric emission is an instaneous process. (time lag is less than 10^{-9} s)

2. $f > f_0$ or $\lambda < \lambda_0$. for a given material, there exists a certain freq. of incident radiation below which no emission of photoelectrons takes place.

f_0: Threshold freq.

(3) $i \propto I$

No of photoelectrons emitted ie photo electric current is prop. to Intensity of light

(4) for a given material & freq, saturation current is $\propto$ to I & V_0 is independent of its Intensity.

V_0 stopping potential.

Einstein's photo electric eqn.

$$W = W_0 + \frac{1}{2} m v_{max}^2 \; (= eV_0)$$

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PPP Q.NO 38

Given

W_0 to Cs = 1.9 eV

W_0 to Li = 2.5

λ incident = 550 nm.

find $E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{550\times10^{-9}\times1.6\times10^{-19}}$ eV

= 2.25 eV

As. W_0 Cs < 2.25 eV

& W_0 Li > 2.25 eV

→ ~~for~~ this photoelectric effect is possible only

option (2) is correct.

Q.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) $ML^2T^2A^{-1}$

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CONCEPT APPLICABLE AND SOLUTION:

As we know that

$B = \mu_0 n I$ } $\vec{B}$ due to infinite solenoid

n = No. of turns per unit length

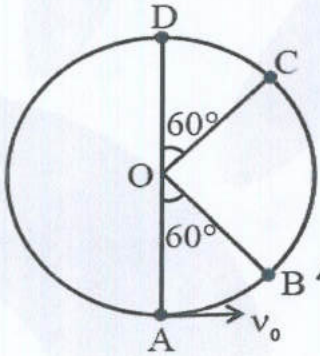
∴ Dimension of $\frac{B}{\mu_0} = nI$

$= [L^{-1}A]$

Ans

Option (2) is correct

Q.41 A bob of mass m is suspended at a point O by a light string of length l and left to perform veltical motion (circular) as shown in figure. Initially, by applying horizontal velocity v_o 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

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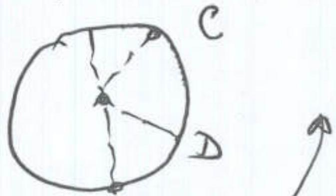
CONCEPT APPLICABLE AND SOLUTION:

vertical circle



Regarding vertical circle

Tension at the lowest pt. = 6mg

Velocity at the lowest pt ≥ $\sqrt{5gR}$.

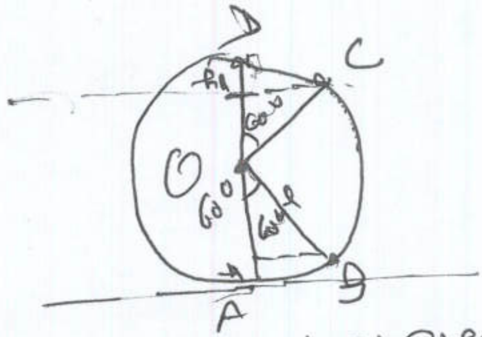
Velocity at the top = $\sqrt{gR}$

→ velocity at the top

At highest pt. $v_{top} \geq \sqrt{gR}$.

if $\sqrt{gR}$: string becomes slack

FPP Q 41



Applying conservation of Mech energy at B is

At B: $\frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mgh$

To find h: $l - l\cos 60° = l - l \times \frac{1}{2} = l/2$

$\frac{1}{2}m\,5gl = \frac{1}{2}mv_B^2 + mg\frac{l}{2}$

$\therefore \frac{1}{2}mv_B^2 = KE_B = \frac{5}{2}mgl - \frac{mgl}{2} = \boxed{2mgl}$

11ly Applying law of conservation of energy at C

$\frac{1}{2}mv_C^2 = \frac{1}{2}mv_D^2 + mg(l - l\cos 60°)$

$= \frac{1}{2}mv_D^2 + mg\,l/2$

$= \frac{1}{2}mgl + \frac{mgl}{2} = mgl$

$\boxed{\text{so KE at C} = mgl}$

so $\frac{K_B}{K_C} = \frac{2mgl}{mgl} = 2:1$

option is correct.

Q.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 ~~time~~ true but Statement-II is false

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

(3) Both Statement-I and Statement-II are ~~time~~ true

(4) Statement-I is false but Statement-II is ~~time~~ true

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CONCEPT APPLICABLE AND SOLUTION:

As in || combination of battery

$$E_q = \frac{\Sigma \frac{E}{r}}{\Sigma \frac{1}{r}}$$

E is emf of individual cell
r is internal resistance of the individual cell

Option (4) is correct
Hence R_{eq} e

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In 11 Grouping of cells

→ +ve terminals connected to one pt.
& -ve terminals connected to the other pt.

$$E_{eq} = \frac{\Sigma \frac{E}{r}}{\Sigma \frac{1}{r}} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2} + \cdots + \frac{E_n}{r_n}}{\frac{1}{r_1} + \frac{1}{r_2} + \cdots \frac{1}{r_n}}$$

Let $E_1 = 5$ volt, $r_1 = 1\Omega$
$E_2 = 10$ volt, $r_2 = 2\Omega$
$E_3 = 15$ volt, $r_3 = 3\Omega$

$$E_p = \frac{\frac{5}{1} + \frac{10}{2} + \frac{15}{3}}{\frac{1}{1} + \frac{1}{2} + \frac{1}{3}} = \frac{5+5+5}{\left(\frac{6+3+1}{6}\right)}$$

$$= \frac{15 \times 6}{10} = \frac{90}{10} = \boxed{9 \text{ volt}}$$

For two batteries:

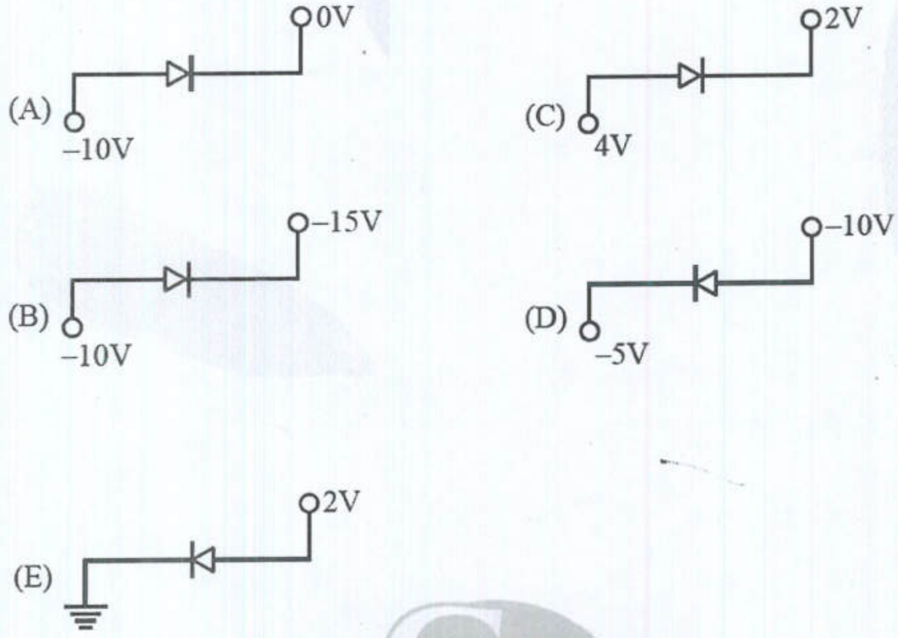
$$E_p = \frac{\frac{5}{1} + \frac{10}{2}}{\frac{1}{1} + \frac{1}{2}} = \frac{5+5}{3/2} = \frac{10 \times 2}{3}$$

$$= \frac{20}{3} = \boxed{6.67 \text{ volt}}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

In 11 resistance final result is less than the least value.

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



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

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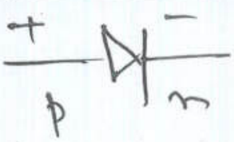
CONCEPT APPLICABLE AND SOLUTION:



For Forward Biasing p is at higher potential & n is at lower potential

& For reverse Bias: p is at lower potential & n is at higher potential

∴ option 'C' is correct

Q.44 A parallel-plate capacitor of capacitance $40\mu F$ 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

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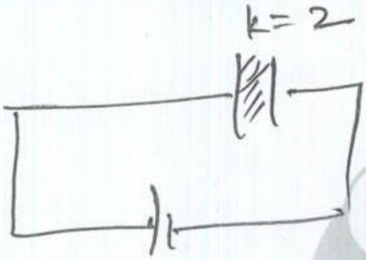
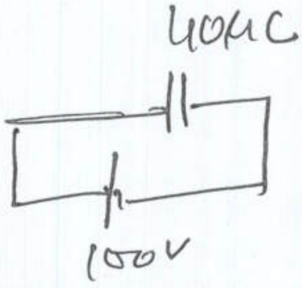
CONCEPT APPLICABLE AND SOLUTION:





$C_o = 40\mu C$

$C_m = K C_o$
$= 2 \times 40\mu F$

As Battery remains connected

$\therefore$ for extra charge

As $C = Q/V \Rightarrow Q = CV$

$\Rightarrow Q_m - Q_o = \frac{C_m - C_o}{V} = \frac{KC_o - C_o}{V} = \frac{C_o}{V}(K-1)$

$= \frac{40\times10^{-6}}{100}(2-1) = \boxed{4 mC}$

$\Delta U = \frac{1}{2}C_m V^2 - \frac{1}{2}C_o V^2 = \frac{1}{2}KC_o V^2 - \frac{1}{2}C_o V^2$

$= \frac{1}{2}C_o V(K-1) = \frac{1}{2}(40\times10^{-6})\times(100)^2(2-1)$

$= 0.2$ joule.

Option (3) is correct

Q.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)** $R/(2\mu-1)$

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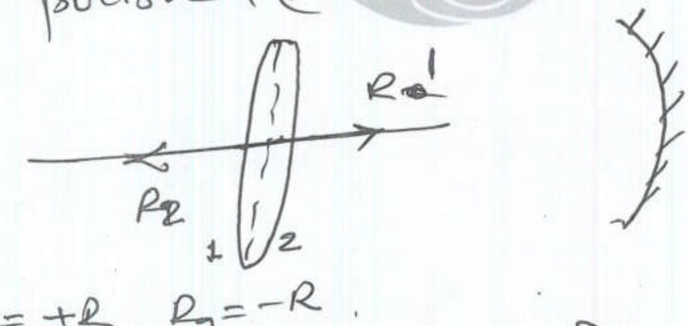
CONCEPT APPLICABLE AND SOLUTION:

Given polished (lens+mirror) can be shown as below



$R_1 = +R \quad R_2 = -R$

$\therefore \frac{1}{f_L} = (\mu-1)\left(\frac{1}{R} - \left(-\frac{1}{R}\right)\right)$

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

$$f_L = \frac{R}{2\mu-1} \quad \text{—(1)}$$

$\therefore P_{eq} = 2P_L + P_{mirror}$

$\frac{1}{f_{eq}} = \frac{2}{f_L} + \frac{1}{f_m}$

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

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

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FPP Q.No. 45

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

As object and image coincide

$\therefore |v| = |u|$ (As it behave as mirror)

$\frac{1}{f_{eq}} = \frac{1}{v} + \frac{1}{u}$

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

$\therefore \boxed{u = \frac{R}{2\mu-1}}$

Option (4) is correct

Q.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 ______________.**

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CONCEPT APPLICABLE AND SOLUTION:

Radius of curvature of common interface

$$\Rightarrow \frac{1}{r} = \frac{1}{r_2} - \frac{1}{r_1} = \frac{1}{2} - \frac{1}{4}$$

$$\frac{1}{r} = \frac{2-1}{4} = \frac{1}{4}$$

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

~~option~~ — This is fill in the blank.

Q.47 **The driver sitting inside a parked car is watching vehicles approaching from behind with the help of his side view ~~minor~~ mirror, which is a convex ~~m11T~~ mirror with radius of curvature R = 2 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 minor is 'a'. The value of 100a is __________ m/s².**

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CONCEPT APPLICABLE AND SOLUTION:

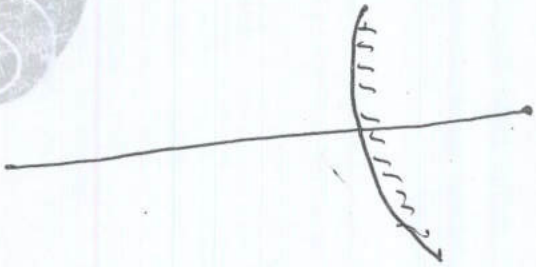
Concept:

Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$f = R/2$. $\quad m = -v/u$

To find velocity: Differentiate mirror formula w.r.t "t"

To find acc: Differentiate mirror formula two times w.r.t t



ATQ $f = R/2$

$= 2/2$

$= 1\,m$

at $u = -24$, $f = 1$, $v = ?$

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

$\frac{1}{v} - \frac{1}{24} = \frac{1}{1} \Rightarrow \frac{1}{v} = 1 + \frac{1}{24} = \frac{25}{24}$

$\therefore v = \frac{24}{25}\,m$

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

$m = 1/25$

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Continued for previous page 33

Mirror formula:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad \text{—— (1)}$$

Diff w.r.t 't'

$$-\frac{1}{v^2}\frac{dv}{dt} - \frac{1}{u^2}\frac{du}{dt} = 0$$

$$-\frac{1}{v^2} V_I - \frac{1}{u^2} V_O = 0 \quad \text{—— (2)}$$

where V_I & V_O are velocity of image and object resp.

$$\frac{V_I}{V_O} = -\frac{v^2}{u^2} = -m^2$$

$$\boxed{V_I = -m^2 V_O}$$

∴ Speed of image $= -\left(\frac{1}{25}\right)^2 \times 90 \times \frac{5}{18}$ m/sec $= -\frac{1}{25}$ m/sec

(2) ⇒ $$\frac{1}{v^2} V_I + \frac{1}{u^2} V_O = 0$$

Diff. eqn. w.r.t 't' (To find acc)

$$\left(-\frac{2}{v^3}\frac{dv}{dt}\right)V_I + \left(\frac{d}{dt}V_I\right)\frac{1}{v^2} + \left(-\frac{2}{u^3}\frac{du}{dt}\right)V_O + \frac{1}{u^2}\frac{dV_O}{dt} = 0$$

$\frac{dV_I}{dt}$ = acc of Image $= a_I$

$\frac{dV_O}{dt}$ = acc of Object $= a_O$

$$-\frac{2}{v^3} V_I \cdot V_I + \frac{1}{v^2} a_I - \frac{2}{u^3} V_O \cdot V_O + \frac{1}{u^2} a_O = 0$$

$$\boxed{-\frac{2}{v^3} V_I^2 + \frac{1}{v^2} a_I - \frac{2}{u^3} V_O^2 + \frac{1}{u^2} a_O = 0}$$

for acceleration.

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As acceleration of object i.e $a_0 = 0$

$\therefore$ sub $a_0 = 0$ in above equation

Given equation reduces to

$$\therefore \frac{1}{v^2} a_I = \frac{2}{v^3} v_I^2 + \frac{2}{u^3} v_0^2$$

$\therefore$ acceleration of the image

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

$$= 2\left(-\frac{1}{25}\right)^2 \left(\frac{1}{24/25}\right) + 2\left(\frac{v^2}{u}\right)\frac{1}{u}\left(\frac{-90 \times 5}{18}\right)^2$$

$$= 2 \times \frac{1}{25^2} \times \frac{25}{24} + 2 \cdot \left(-\frac{1}{25}\right)^2 \frac{1}{(-24)} (25)^2$$

$$= 2\left[\frac{1}{25 \times 24} + \left(-\frac{1}{24}\right)\right]$$

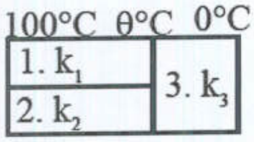
$$= 2\left[\frac{1 - 25}{25 \times 24}\right]$$

$$= 2\left[\frac{-24}{25 \times 24}\right] = -\frac{2}{25}$$

$$\therefore |100 a| = 100 \times \frac{2}{25} = \boxed{8}$$

Ans

Q.48 **Three conductions of same length having thermal conductivity k_1, k_2 and k_3 and Is 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 $Js^{-1}\,m^{-1}K^{-1}, k_2 = 120\,Js^{-1}\,m^{-1}K^{-1}, k_3 = 135\,Js^{-1}m^{-1}K^{-1}$)

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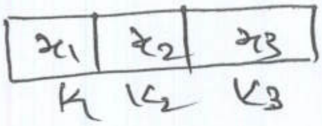
<u>CONCEPT APPLICABLE AND SOLUTION:</u>

↳

Rate of transfer of heat $= H = \frac{dQ}{dt} = \frac{KA(\theta_1-\theta_2)}{l}$

<u>Conducting slabs in series</u>



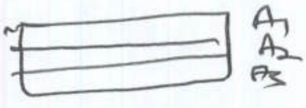
$$K_{eq} = \frac{\Sigma x_i}{\Sigma \frac{x_i}{K_i}}$$

and if $x_1 = x_2 = x_3 = \ldots$ i.e. of equal thickness i.e. equally divided along the length keeping area same.

K_{eq} = Harmonic Mean

$$\frac{n}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2} + \ldots \frac{1}{K_n}$$

<u>Conducting slabs in Parallel</u>



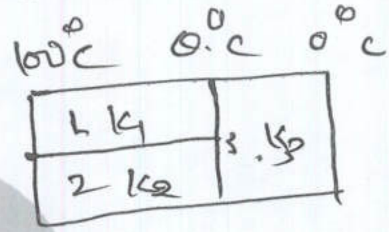
i.e. Area is divided & length is same, i.e. equal area

$K_{eq} = \frac{\Sigma A_i K_i}{\Sigma A_i}$ if $A_1 = A_2 = \ldots$ then K_{eq} = Arithmetic Mean.

Thermal conduction	Electrical conduction
1. $H = \frac{dQ}{dt}$	$I = \frac{dq}{dt}$
2. Resistance: Thermal resistance $= \frac{l}{KA}$	Electric Resistance: $R = \frac{\rho l}{a}$

In series Heat flow rate is same.
in Parallel temp difference is same.

Now ATQ :-

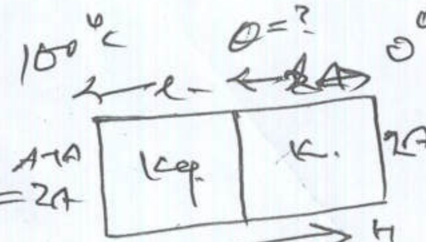


for K_1 & K_2 → lengths are same & area is divided → Parallel combination of K_1 & K_2

so K_{eq} => A.M of K_1 & K_2 (As value of $l_1 = l_2 = l$ & $A_1 = A_2 = A$)

for K_1 & K_2: $K_p = \frac{K_1 + K_2}{2}$

$= \frac{120 + 60}{2} = 90$ s.



In series combination rate of flow of heat is same

$^{2}\cancel{90}^{6}(100 - \theta) = \cancel{135}^{9\ 3}(\theta - 0)$

$\therefore \frac{100° - \theta}{\frac{l}{90 \cdot 2A}} = \frac{\theta - 0}{\frac{l}{135 \cdot (2A)}} \Rightarrow$

$200 - 2\theta = 3\theta$

$5\theta = 200$

$\boxed{\theta = 40°C}$ Ans

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

$\vec{r}_B = (a_2 t^2 \hat{\imath} + a_2 t\hat{\jmath} + a_3 t\hat{k})\, m$

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

$(\alpha_1 = 1\, m/s^2, \alpha_2 = 3n\, m/s, \alpha_3 = 2m/s, \beta_1 = 2m/s,\ \beta_2 = -1\, m/s^2,\ \beta_3 = 4p\, m/s)$ where t is time, n and p are constant, At t = 1s, $|\vec{V}_A| = |\vec{V}_B|$ and velocities $\vec{V}_A$ and $\vec{V}_B$ of the particle are orthogonal to each other. At $t = 1s$, magnitude of angular momentum of particle (A) with respect to the position of particle (B) is $\sqrt{L}$ kg$m^2 s^{-1}$. The value of L is ________.

(JEE-Main 2025)

CONCEPT APPLICABLE AND SOLUTION:

$V_A = \frac{dr_A}{dt}$ & $V_B = \frac{dr_B}{dt}$

Diff & sub values :-

$V_A = 2\alpha_1 t\hat{i} + \alpha_2 \hat{j} + a_3 \hat{k} = (2t\hat{i} + 3n\hat{j} + 2\hat{k})$

$V_B = \beta_1 \hat{i} + 2\beta_2 t\hat{j} + \beta_3 \hat{k} = (2\hat{i} + (-2t)\hat{j} + 4p\hat{k})$

As $\vec{V_A}$ & $\vec{V_B}$ are orthogonal to each other at t = 1 sec

$\therefore \vec{V_A} \cdot \vec{V_B} = 0$

$a_1 b_1 + a_2 b_2 + a_3 b_3 = 0$

$2 \cdot 2 + 3n \times (-2) + 2 \times 4p = 0$ —— (1)

$4 - 6n + 8p = 0$

$|V_A| = |V_B|$ at t = 1s

$\sqrt{4 + 9n^2 + 4} = \sqrt{4 + 4 + 16p^2}$

$8 + 9n^2 = 8 + 16p^2$

Next page

$\therefore 9n^2 = 16p^2$

$\Rightarrow \frac{n}{p} = \pm\frac{4}{3}$ —(2)

Angular Momentum of Particle A w.r.t B

$L = m(r_{AB} \times v_A)$

$\vec{r}_{AB} = \vec{r}_B - \vec{r}_A$ on simplification

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

$\therefore \vec{L} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & 2 & 3 \\ 2 & 1 & 2 \end{vmatrix}$

$= \hat{i}(4-3) - \hat{j}(-2-6) + \hat{k}(-1-4)$

$\hat{i} + 8\hat{j} - 5\hat{k}$

$|\vec{L}| = \sqrt{1+64+25} = \sqrt{90} = \sqrt{L}$.

$\therefore \boxed{L = 90}$ Ans.

Q.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, $g = 10\ m/s^2$]

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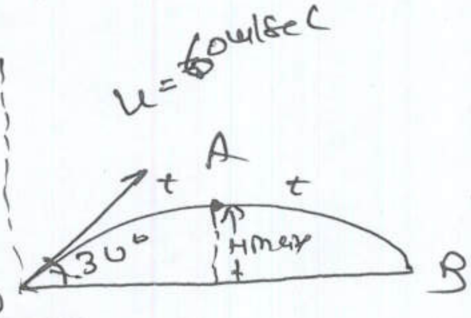
<u>CONCEPT APPLICABLE AND SOLUTION:</u>

Time of flight = $t + t = 2T$ (OA + AB)



$T = \frac{2u\sin\theta}{g}$

$= \frac{2 \times 60 \times \sin 30^\circ}{10} = \boxed{6\ sec}$

∴ Particle reaches Max^m ht in $t = 3$ sec.

ATQ ∴ $S_y = u_y t + \frac{1}{2} a_y t^2 \Rightarrow h_0 = u\sin\theta - \frac{1}{2} g t^2$

sub values

$= 60 \times \frac{1}{2} - \frac{1}{2} \times 10 \times 1$

$= 30 - 5 = \boxed{25\ m}$

$\boxed{h_0 = 25\ m}$

$h_1 = H_{max} - h_{(at\ 2\ sec)}$ [As max^m ht reaches at $t = 3$ sec.]

$= \left(\frac{u^2\sin^2\theta}{2g}\right) - \left[u\sin\theta t - \frac{1}{2} g t^2\right]$

$= \left(\frac{60 \times 60 \times \frac{1}{4}}{2 \times 10}\right) - \left(60 \times \frac{1}{2} \times 2 - \frac{1}{2} \times 10 \times 4\right)$

$= 45 - 40 = \boxed{5\ m}$

∴ Ratio: $\frac{h_0}{h_1} = \frac{25}{5} = \boxed{5}$ Ans → To be filled in the blank

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Quick Revision of Formulae

- Time of flight $= T = \frac{2u\sin\theta}{g}$
- Height $= H = \frac{u^2\sin^2\theta}{2g}$
- Range $= R =$ Horizontal component of velocity $\times$ time of flight

$$= \frac{u^2\sin 2\theta}{g}$$

- $v_{inst} = \sqrt{(u\cos\theta)^2 + (u\sin\theta - gt)^2} = \sqrt{v_x^2 + v_y^2}$

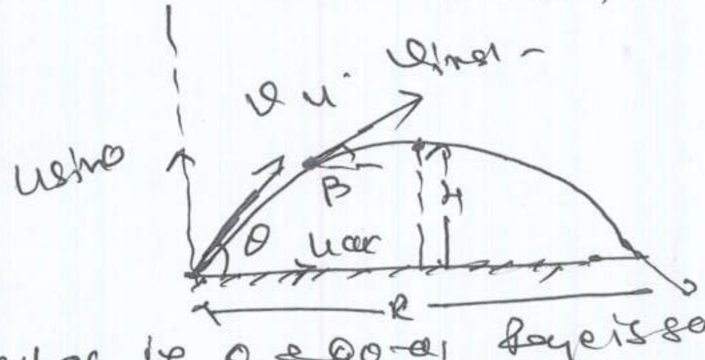
$$= \sqrt{u^2\cos^2\theta + u^2\sin^2\theta + g^2t^2 - 2u\sin\theta\, gt}$$

$$= \sqrt{u^2 + g^2t^2 - 2ugt\sin\theta}$$

$$\tan\beta = \frac{v_y}{v_x} = \frac{u\sin\theta - gt}{u\cos\theta}$$

Eqn. of Trajectory: $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$$= x\tan\theta\left(1 - \frac{x}{R}\right)$$



for

- Complementary angles i.e. θ & $(90-\theta)$ range is same
- for complementary angles ratio of hts $\frac{H_1}{H_2} = \tan^2\theta$