Topics To Be Covered

1 - Kinematics

2 - NLM + friction

3 - Circular

4 - WPE

5 - COM

6 - Rotation

7 - SHM

8 - Gravitation

9 Elasticity

10 { Thermal Exp.
Calorimetry
Heat transfer (Conduction + Radiation)

11 KTG & thermodynamics

12 Wave

13 Fluid mechanics

(Unit & Dim. & error)

QUESTION

$$x_2 = 5\sqrt{2}\times\sqrt{2}\left(\frac{1}{\sqrt{2}}\sin 2\pi t + \frac{1}{\sqrt{2}}\cos 2\pi t\right)$$

Two simple harmonic motions are represented by the equations $x_1 = 5\sin\left(2\pi t + \frac{\pi}{4}\right)$ and $x_2 = 5\sqrt{2}(\sin 2\pi t + \cos 2\pi t)$. The amplitude of second motion is _____ times the amplitude in first motion.

[JEE Mains 2021]

$$x_2 = 10\sin(2\pi t + 45^\circ)$$

10

Ans. (2)

QUESTION

$T = 4\pi = 2\pi\sqrt{\frac{4}{g}}$ $g = 1$

A mass of 5 kg is connected to a spring. The potential energy curve of the simple harmonic motion executed by the system is shown in the figure. A simple pendulum of length 4 m has the same period of oscillation as the spring system. What is the value of acceleration due to gravity on the planet where these experiments are performed?

[JEE Mains 2021]

(1) $10\ \mathrm{m/s^2}$ $\omega^2 = \frac{20}{80} = \frac{1}{4}$

(2) $5\ \mathrm{m/s^2}$ $\omega = \frac{1}{2} = \frac{2\pi}{T}$

(3) $4\ \mathrm{m/s^2}$ $T = 4\pi$

(4) $9.8\ \mathrm{m/s^2}$

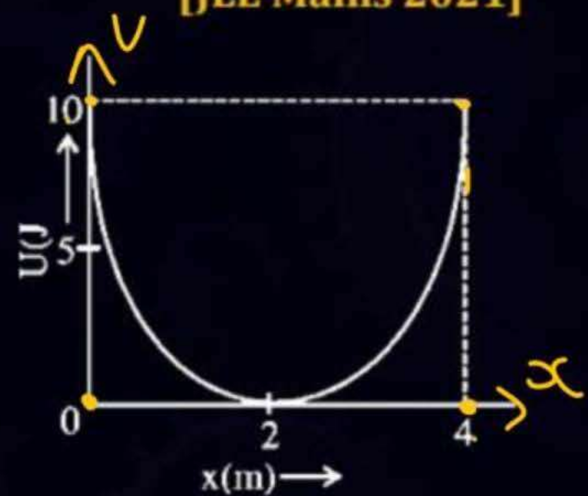
$A = 4$

$U_{max} = \frac{1}{2}KA^2 = 10$

$\frac{1}{2} \times m\omega^2 A^2 = 10$

$\frac{1}{2} \times m \times \omega^2 4^2 = 10$

$5\,\omega^2 = \frac{20}{16}$



Ans. (3)

QUESTION

$x_2 = 5\sqrt{2}\times\sqrt{2}\left(\frac{1}{\sqrt{2}}\sin 2\pi t + \frac{1}{\sqrt{2}}\cos 2\pi t\right)$

Two simple harmonic motions are represented by the equations $x_1 = 5\sin\left(2\pi t + \frac{\pi}{4}\right)$ and $x_2 = 5\sqrt{2}(\sin 2\pi t + \cos 2\pi t)$. The amplitude of second motion is _____ times the amplitude in first motion.

[JEE Mains 2021]

$x_2 = 10\sin(2\pi t + 45^\circ)$

10

Ans. (2)

QUESTION

A mass of 5 kg is connected to a spring. The potential energy curve of the simple harmonic motion executed by the system is shown in the figure. A simple pendulum of length 4 m has the same period of oscillation as the spring system. What is the value of acceleration due to gravity on the planet where these experiments are performed?

[JEE Mains 2021]

$A = 2$

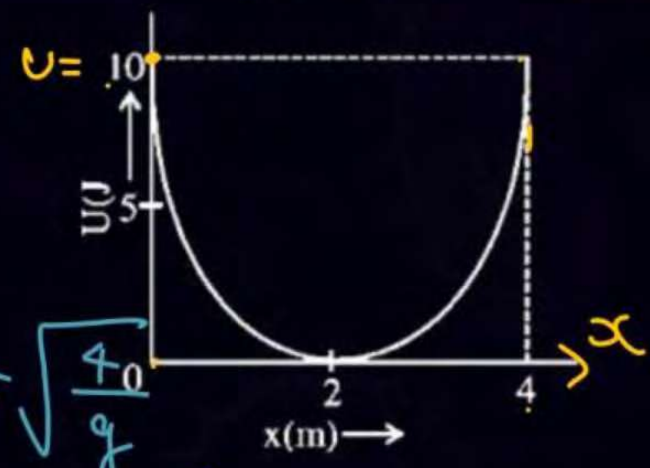
$U_{max} = 10 = \frac{1}{2} K A^2$

$10 = \frac{1}{2} \times K \times 2^2$

$K = 5$

$T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{5}{5}} = 2\pi\sqrt{\frac{4}{g}}$

$g = 4$



(1) $10\ m/s^2$

(2) $5\ m/s^2$

(3) $4\ m/s^2$

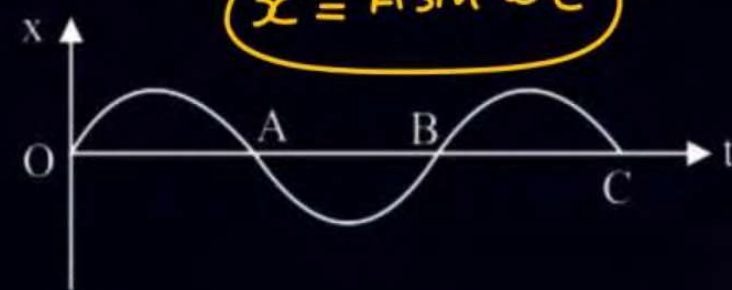
(4) $9.8\ m/s^2$

Ans. (3)

QUESTION

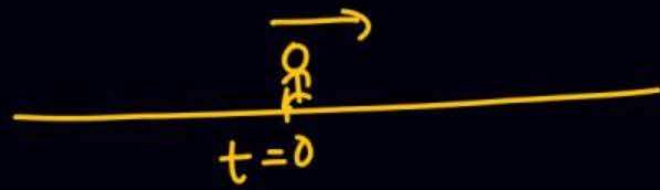
The variation of displacement with time of a particle executing free simple harmonic motion is shown in the figure.

$x = A\sin\omega t$



The potential energy U(x) versus time (t) plot of the particle is correctly shown in figure:

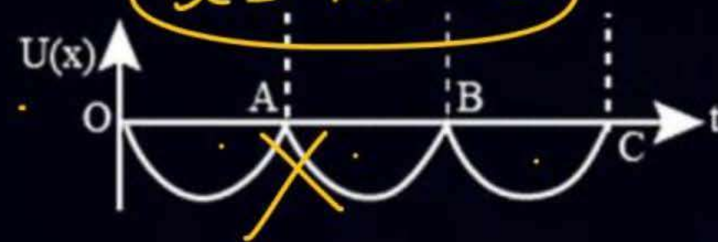
[JEE Mains 2021]



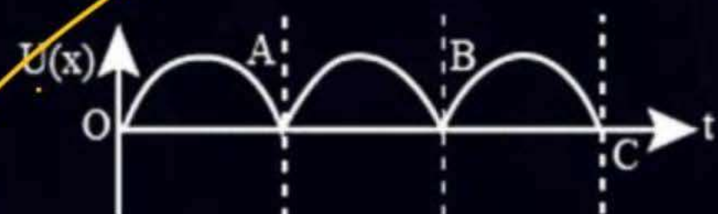
$U = \frac{1}{2} k x^2$

$x = A \sin \omega t$

1


2


3


4


Ans. (4)

QUESTION

Two simple harmonic motions are represented by the equations $y_1 = 10 \sin\left(3\pi t + \frac{\pi}{3}\right)$, $y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$. Ratio of amplitude of y_1 to $y_2 = x : 1$. The value of x is ______.

[JEE Mains 2021]

$$y_2 = 5\times 2\left(\frac{1}{2}\sin 3\pi t + \frac{\sqrt{3}}{2}\cos 3\pi t\right)$$

$$y_2 = 10 \sin(3\pi t + 60)$$

Ans. (1)

QUESTION

When a particle executes simple Harmonic motion, the nature of graph of velocity as function of displacement will be: **[JEE Mains 2022]**

1. Circular
2. Elliptical
3. Sinusoidal
4. Straight line

Ans. (2)

QUESTION

A mass m is suspended from a spring of negligible mass and the system oscillates with a frequency f_1. The frequency of oscillations if a mass 9 m is suspended from the same spring is f_2. The value of $\frac{f_1}{f_2}$ is ______.

[01 Feb. 2024 - Shift 2]

$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$

Ans. (3)

QUESTION

A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is $\sqrt{\alpha}$ cm, where α = ______.

[27 Jan. 2024 - Shift 1]

$$v = A\omega$$

$$10 = 4 \times \omega$$

$$\omega = 5/2$$

$$\frac{A\sqrt{3}}{2}$$

$$2\sqrt{3} = \sqrt{12}$$

Ans. (12)

QUESTION

WET $\theta = 2\tan^{-1}\left(\frac{1}{2}\right)$ $\sin\theta = \frac{2}{\cancel{R}}\cancel{R}(1-\cos\theta) = 2\left(2\sin^2\theta/2\right)$

A ball suspended by a thread swings in a vertical plane so that its magnitude of acceleration in the extreme position and lowest position are equal. The angle (θ) of thread deflection in the extreme position will be:

$2\sin\theta/2\cos\theta/2 = 4\sin^2\theta/2$

$\tan\frac{\theta}{2} = \frac{1}{2}$

[27 Jan. 2024 - Shift 2]

$v = \sqrt{2gh}$

$\cancel{g}\sin\theta = \frac{2\cancel{g}h}{R}$

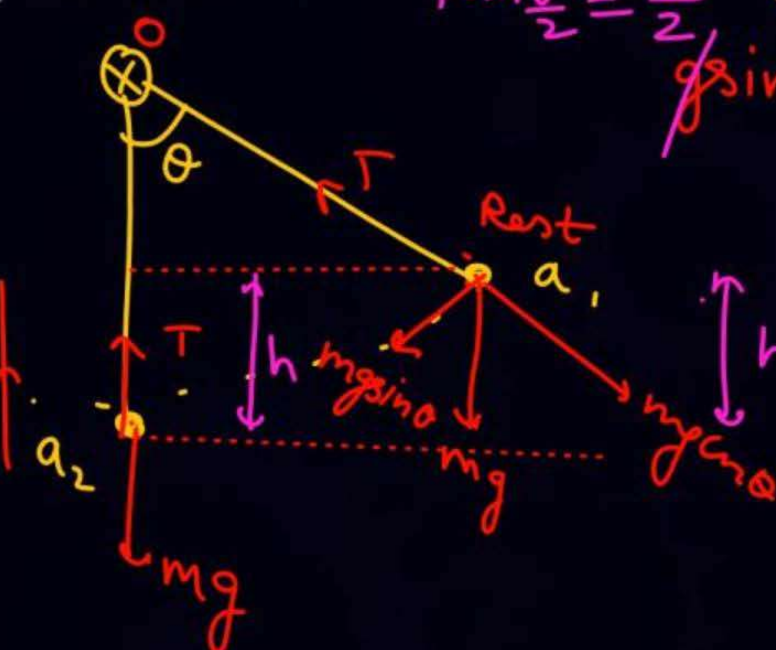
(1) $\tan^{-1}(\sqrt{2})$

(2) $2\tan^{-1}\left(\frac{1}{2}\right)$

(3) $\tan^{-1}\left(\frac{1}{2}\right)$

(4) $2\tan^{-1}\left(\frac{1}{\sqrt{5}}\right)$

$\frac{v^2}{R} = a_2$



$h = R - R\cos\theta$

Ans. (2)

QUESTION

When the displacement of a simple harmonic oscillator is one third of its amplitude, the ratio of total energy to the kinetic energy is $\frac{x}{8}$, where x = ______ .

[29 Jan. 2024 - Shift 1]

$$\frac{\frac{1}{2}KA^2}{\frac{1}{2}K\left[A^2-(A/3)^2\right]}$$

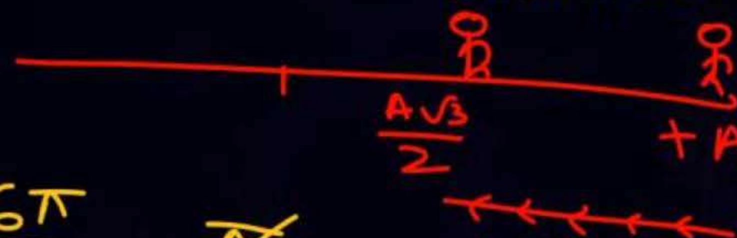
Ans. (9)

QUESTION

A simple harmonic oscillator has an amplitude A and time period 6π second. Assuming the oscillation starts from its mean position, the time required by it to travel from $x = A$ to $x = \frac{\sqrt{3}}{2}A$ will be $\frac{\pi}{x}$ s, where x = ______.

[29 Jan. 2024 - Shift 2]

$$60^\circ \equiv \pi/3$$



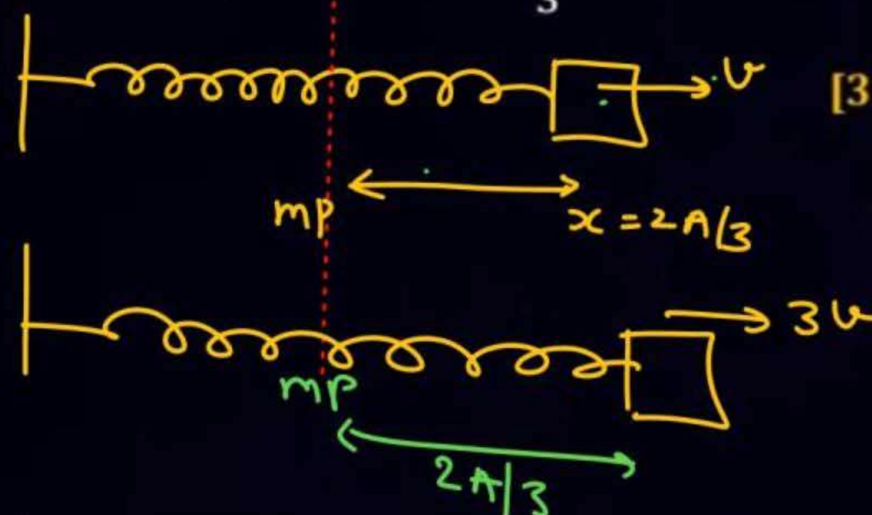
$$\frac{T}{12} = \frac{6\pi}{12} = \frac{\cancel{\pi}}{2} = \frac{\cancel{\pi}}{x}$$

Ans. (2)

QUESTION

A particle performs simple harmonic motion with amplitude A. Its speed is increased to three times at an instant when its displacement is $\frac{2A}{3}$. The new amplitude of motion is $\frac{nA}{3}$. The value of n is ______. [31 Jan. 2024 - Shift 1]

$$v = \omega\sqrt{A^2 - (2A/3)^2}$$



$$3v = \omega\sqrt{A_{\text{नया}}^2 - \left(\frac{2A}{3}\right)^2}$$

Ans. (7)

QUESTION

A particle is doing simple harmonic motion of amplitude 0.06 m and time period 3.14 s. The maximum velocity of the particle is ______ cm/s. [06 Apr. 2024 - Shift 1]

$A\omega$

Ans. (12)

QUESTION

$k = m\omega^2$

An object of mass 0.2 kg executes simple harmonic motion along x axis with frequency of $\left(\frac{25}{\pi}\right)$ Hz. At the position x = 0.4 m the object has kinetic energy 0.5 J and potential energy 0.4 J. The amplitude of oscillation is ______ cm. **[08 Apr. 2024 - Shift 2]**

$\cdot 9 = \frac{1}{2} K A^2$

Ans. (6)

QUESTION

The position, velocity and acceleration of a particle executing simple harmonic motion are found to have magnitudes of 4 m, 2 ms^{-1} and 16 ms^{-2} at a certain instant. The amplitude of the motion is $\sqrt{x}$, m where x is ______. [09 Apr. 2024 - Shift 1]

17

$x = 4$

$v = 2$

$a = 16$

$v = \omega\sqrt{A^2 - x^2}$

$2 = 2\sqrt{A^2 - 4}$

$a = \omega^2 x$

$16 = \omega^2 \times 4$

$\omega = 2$

Ans. (17)

QUESTION

A particle of mass executes simple harmonic motion under force F = −50 (Nm^{-1})x. The time period of oscillation is $\frac{x}{35}$ s. The value of x is ______.

(Given $\pi = \frac{22}{7}$)

[09 Apr. 2024 - Shift 2]

$$T = 2\pi\sqrt{\frac{m}{50}}$$

Ans. (22)

* $\frac{F}{A} = Y \frac{\Delta l}{l}$

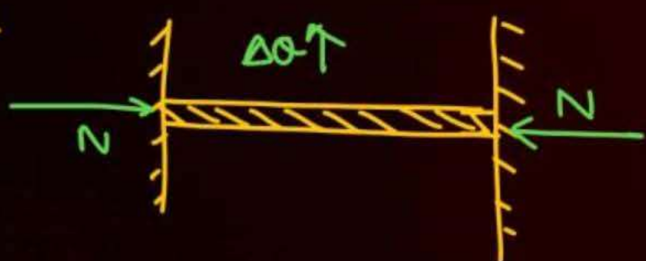
Stress $= Y(\text{strain})$

* $(E.P.E)/\text{Vol} = \frac{1}{2} \times \text{stress} \times \text{strain}$.

$$B = -\frac{\Delta P}{(\Delta V/V)}$$

excess pressure.

*



$$\Delta l = l \alpha \Delta \theta$$

$$\frac{N}{A} = Y \frac{\Delta l}{l} = Y \alpha \Delta \theta$$

$$\boxed{\frac{N}{A} = Y \alpha \Delta \theta}$$

$$\Delta l = l\,\alpha\,\Delta T \longrightarrow l_f = l_i(1+\alpha\Delta T)$$

$$\Delta A = A\,\beta\,\Delta T \longrightarrow A_f = A_i(1+\beta\Delta T)$$

$$\beta = \alpha_x + \alpha_y$$

isotrop $\alpha_x = \alpha_y = \alpha$

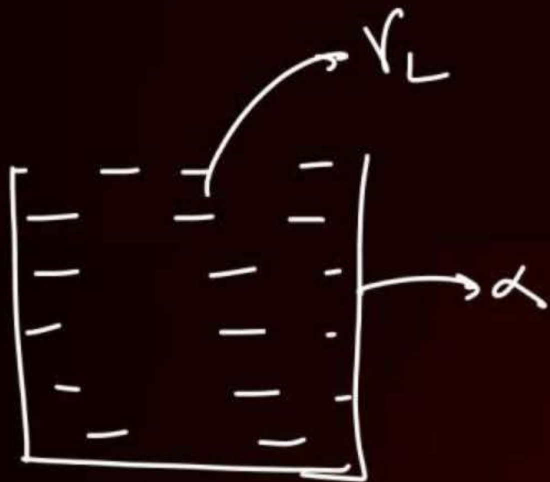
$$\beta = 2\alpha$$

isotropic $\gamma = 3\alpha$

$$\beta = 2\alpha$$

$$\Delta V = V\,\gamma\,\Delta T \longrightarrow V_f = V_0(1+\gamma\Delta T)$$

$$\gamma = \alpha_x + \alpha_y + \alpha_z$$



$$\xrightarrow[\gamma_L > 3\alpha]{T\uparrow}$$

overflow $= V_0(\gamma_L - 3\alpha)\Delta T$

γ_{app}

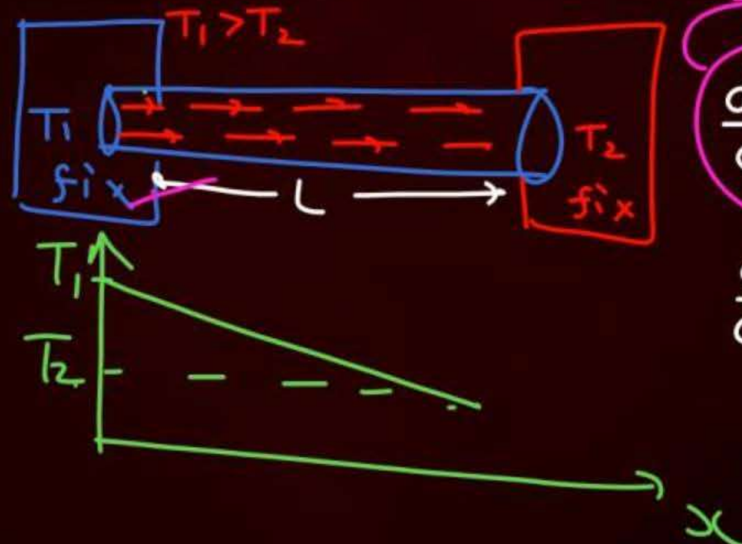
* $\boxed{\begin{aligned}\Delta\theta &= m s \Delta T \\ \Delta\theta &= m L\end{aligned}}$

$$R \equiv \frac{L}{KA}$$

Volt. diff $\Delta V \equiv \Delta T$

* Heat transfer → Conduction

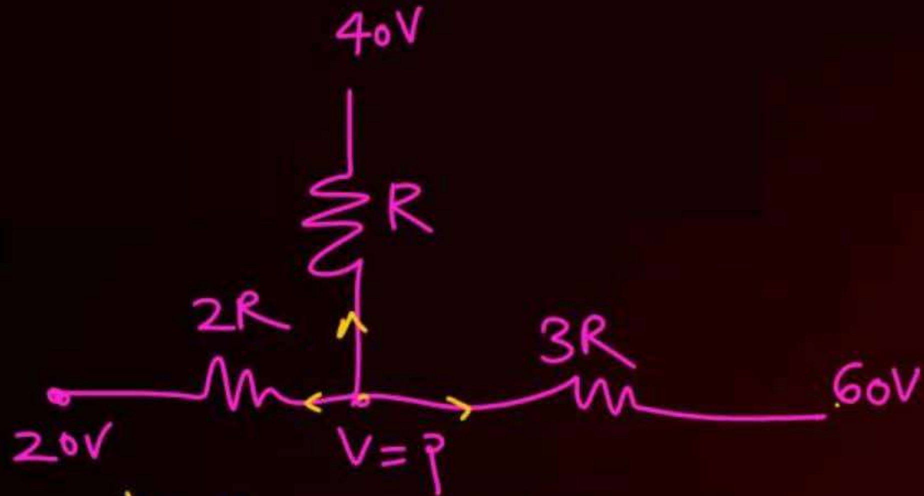
Heat transfer → Radiation



$$i = \frac{\Delta V}{R} \quad \text{(magnitude)}$$

$$\frac{dQ}{dt} = \frac{KA\Delta T}{L} = \frac{\Delta T}{L/KA}$$

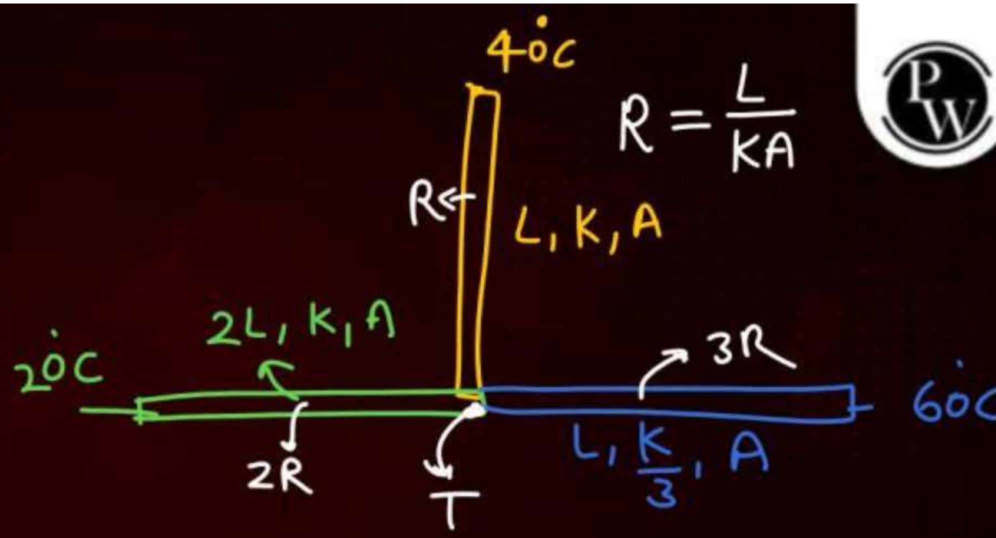
$$\frac{dQ}{dt} = -KA\frac{dT}{dx}$$



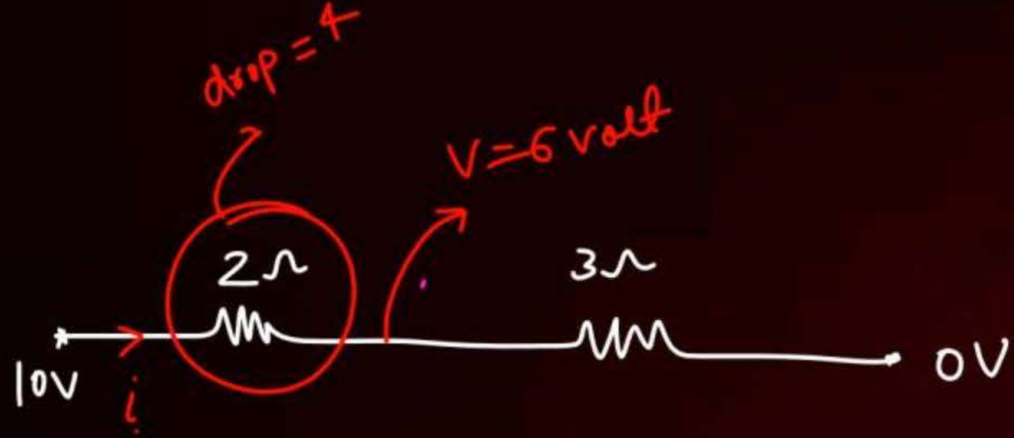
$$\frac{V-40}{R}+\frac{V-20}{2R}+\frac{V-60}{3R}=0$$

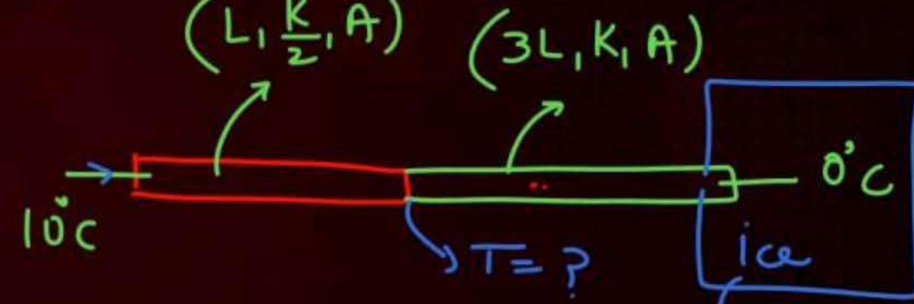
$V=$ ✓

$$R=\frac{L}{KA}$$



$$\frac{L}{KA} = R = 1 \text{ (unit)}$$

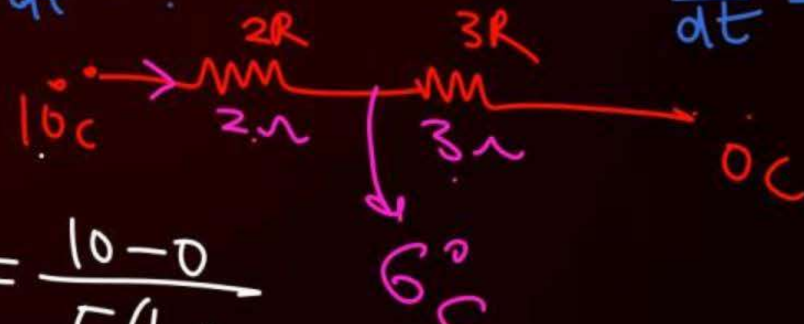




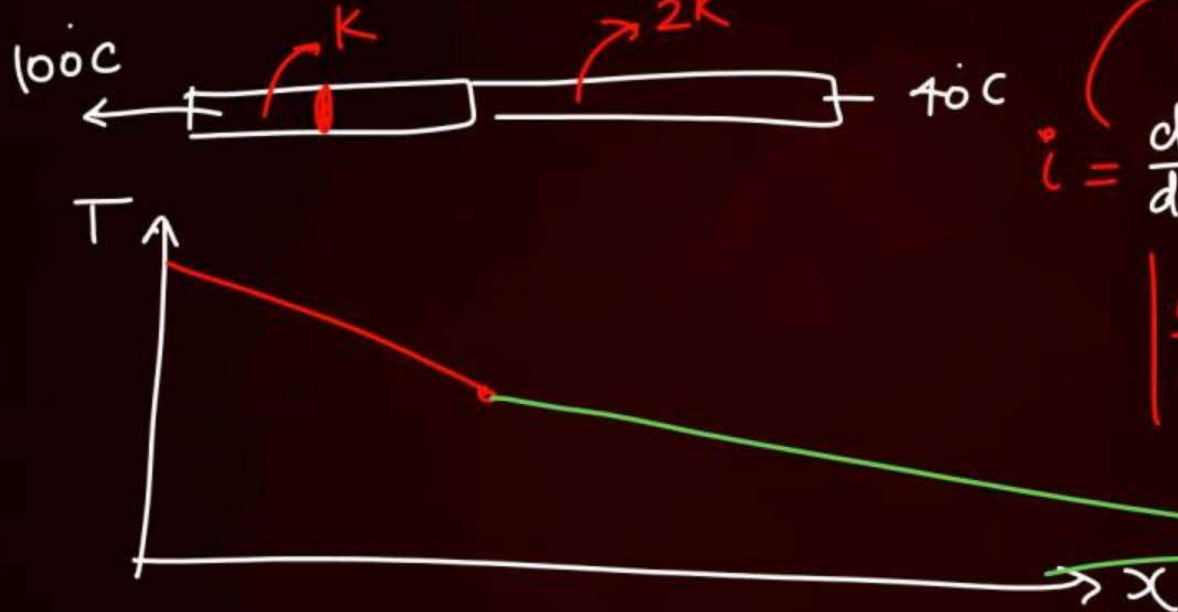
$$i = \frac{10-0}{5} = 2A$$

$$i \equiv \frac{dQ}{dt} = ?$$

$$\frac{dm}{dt} = ?$$



$$L\frac{dm}{dt} = \frac{dQ}{dt} = \frac{\Delta T}{R_{eq}} = \frac{10-0}{5\left(\frac{L}{KA}\right)}$$



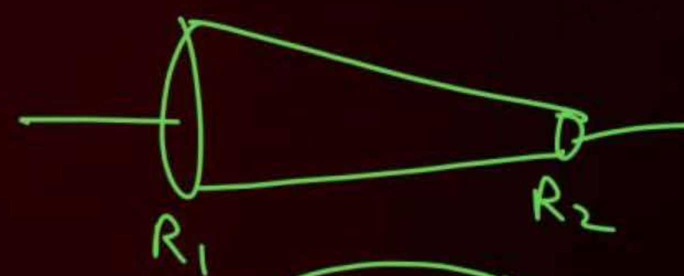
Same

$$i = \frac{dQ}{dt} = KA\frac{dT}{dt}$$

$$\left|\frac{dT}{dt}\right| = \frac{i}{KA}$$

$K \uparrow \quad |\text{slope}| \downarrow$

$$R = \frac{L}{KA} \implies R = \rho \frac{l}{A} = \frac{1}{\sigma}\frac{l}{A}$$



$$\rho = \frac{1}{\sigma}$$

$$R = \frac{1}{K}\frac{l}{\pi R_1 R_2}$$

T_b

$\left(\frac{dQ}{dt}\right)_{\text{जान}}$

$$\lambda_m T = \text{Const} = b$$

$$\lambda_m \propto \frac{1}{T}$$

T_s

T_b

$T_b > T_s$

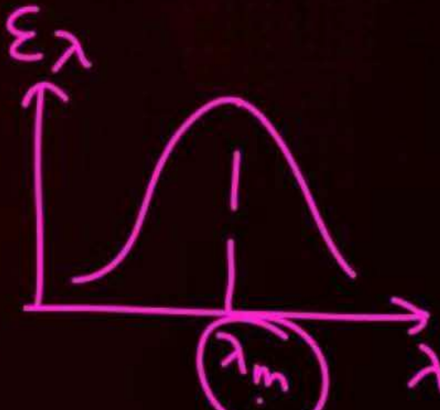
$$\left(\frac{dQ}{dt}\right)_{\text{जाने वाली}} = eA\sigma T_b^4$$

$$\left(\frac{dQ}{dt}\right)_{\text{आने}} = eA\sigma T_s^4$$

$$\frac{1}{A}\left(\frac{dQ}{dt}\right) = E = e\sigma T^4$$

$$\left(\frac{dQ}{dt}\right)_{net} = eA\sigma\left(T_b^4 - T_s^4\right)$$

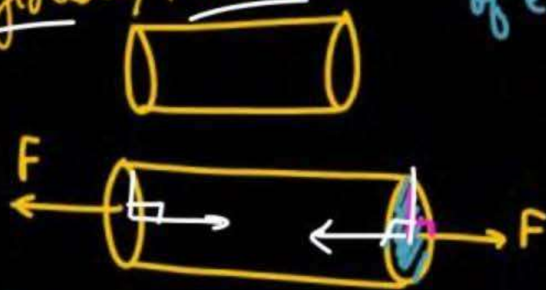
$$\left(\frac{dT}{dt}\right) = \frac{eA\sigma\left(T_b^4 - T_s^4\right)}{ms}$$



$\text{stress} = E\,(\text{strain})$

E → modulus of elasticity

Longitude / Normal



Longit. $\text{stress} = F/A$

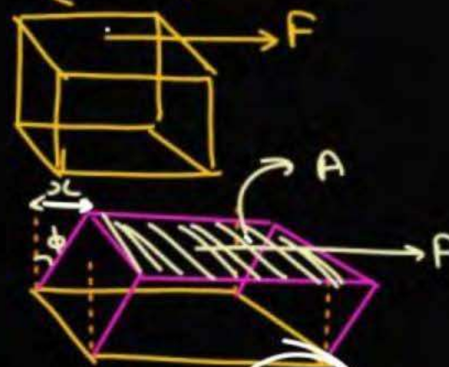
Longitud. $\text{strain} = \Delta l / l$

$$E = Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\Delta l / l}$$

80%

$$E = \frac{\text{stress}}{\text{strain}}$$

(Shear / tangential)



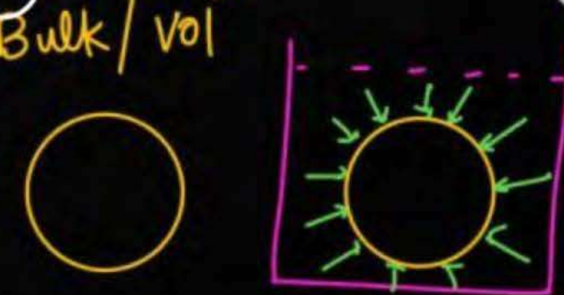
$\text{Shear stress} = F/A$

" $\text{strain} = \frac{x}{L} = \tan\phi$

$$E = \frac{F/A}{\tan\phi} = \eta$$

η → modulus of rigidity

Bulk / Vol^n



$\text{Bulk stress} \equiv \text{Vol}^n\ \text{stress} = P$

$\text{Vol}^n\ \text{strain} = \frac{\Delta V}{V}$

$$B = \frac{\text{Bulk stress}}{\text{Bulk strain}} = \frac{-P}{\frac{\Delta V}{V}}$$

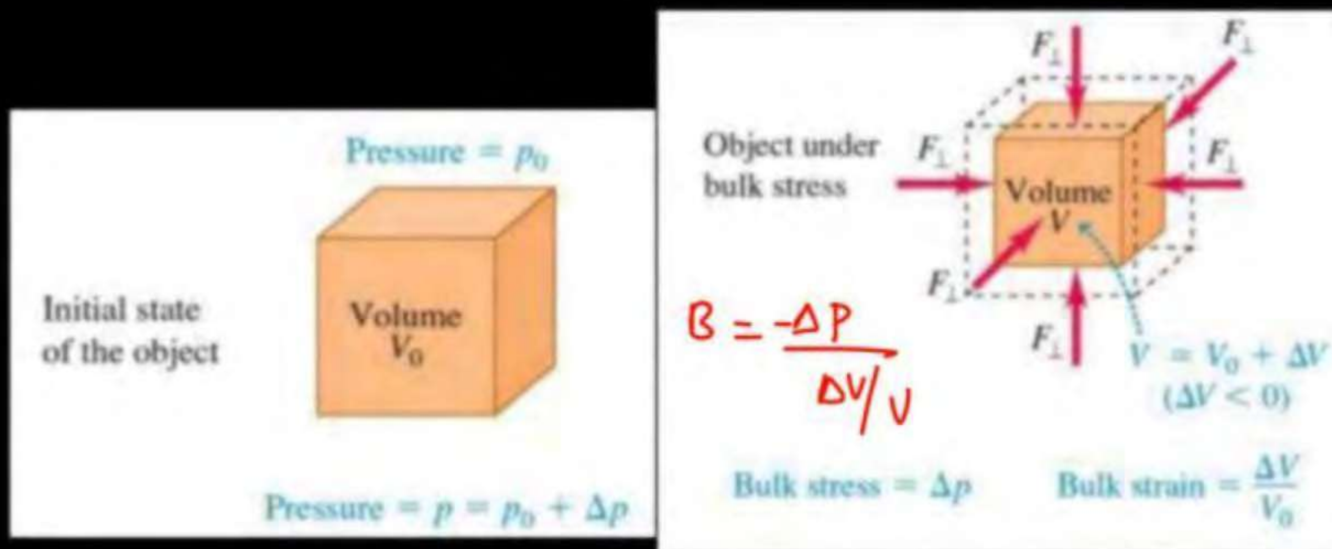
B → Bulk modulus of elasticity

$$\text{compressibility} = \frac{1}{B}$$

ELASTICITY

Bulk /volume strain:

$$\text{bulk strain} = \frac{\textit{change in volume}}{\textit{original volume}} = \frac{\Delta V}{V}$$



$$B = \frac{-\Delta P}{\Delta V / V}$$

Question 7

Bulk modulus

B

The normal density of a material is ρ and its bulk modulus of elasticity is K. The magnitude of increase in density of material, when a pressure P is applied uniformly on all sides, will be : [JEE Mains 2021]

(A) $\frac{\rho K}{P}$

(B) $\frac{\rho P}{K}$

(C) $\frac{K}{\rho P}$

(D) $\frac{PK}{\rho}$

$$B = \frac{-P}{\frac{\Delta V}{V}}$$

$$m = V\rho$$

$$\cancel{\frac{\Delta m}{m}} = \frac{\Delta V}{V} + \frac{\Delta \rho}{\rho}$$

0

$$\frac{\Delta V}{V} = \frac{-P}{B} = \frac{-\Delta \rho}{\rho}$$

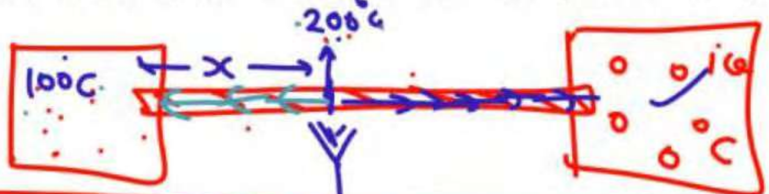
$$\frac{\Delta V}{V} = -\frac{\Delta \rho}{\rho}$$

$$\boxed{\Delta \rho = \frac{P\rho}{B}}$$

Ans. (B)

22. One end of copper rod of uniform cross-section and of length 1.5 meters is in contact with melting ice and the other end with boiling water. At what point along its length should a temperature of 200°C be maintained, so that in steady state, the mass of ice melting is equal to that of steam produced in the same interval of time? Assume that the whole system is insulated from the surroundings.

समरूप अनुप्रस्थ काट तथा 1.5 m लम्बी तांबे की छड़ का एक सिरा पिघली हुई बर्फ के तथा दूसरा सिरा गर्म पानी के सम्पर्क में हैं। इसकी लम्बाई के अनुदिश किस बिन्दु पर ताप 200°C रखा जाना चाहिये ताकि स्थायी अवस्था में पिघलने वाली बर्फ का द्रव्यमान उसी समयान्तराल में उत्पन्न भाप के द्रव्यमान के समान हो? मान लीजिये कि सम्पूर्ण निकाय परिवेश से विलगित है।



$$\frac{dQ}{dt} = \boxed{\frac{KA\,200}{(1.5-x)} = 80\,\frac{dm}{dt}}$$

Ans. 10.34 cm

$$\frac{dQ}{dt} = \boxed{\frac{KA\times 100}{x} = 540\left(\frac{dm}{dt}\right)}$$

7. A rod of length 2m at 0°C and having expansion coefficient $\alpha = (3x + 2) \times 10^{-6}\,°C^{-1}$ where x is the distance (in cm) from one end of rod. The length of rod at 20°C is :

एक छड़ की 0°C ताप पर लम्बाई 2m है तथा इसका रेखीय प्रसरण गुणांक $\alpha = (3x + 2) \times 10^{-6}\,°C^{-1}$ है, यहां x छड़ के एक सिरे से दूरी (सेमी में) है। 20°C ताप पर छड़ की लम्बाई होगी

(A) 2.124 m (B) 3.24 m (C) 2.0120 m (D) 3.124 m

Ans. (C)

$$\alpha = (3x+2) \times 10^{-6}$$

$$\int dz = \int (dx) \cdot \alpha \cdot (\Delta T)$$

$$\Delta l = \int dz = \int_0^2 dx\,(3x+2) \times 10^{-6} \times 20$$

16. Two rectangular blocks, having identical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :- **[JEE-Advance-2013]**

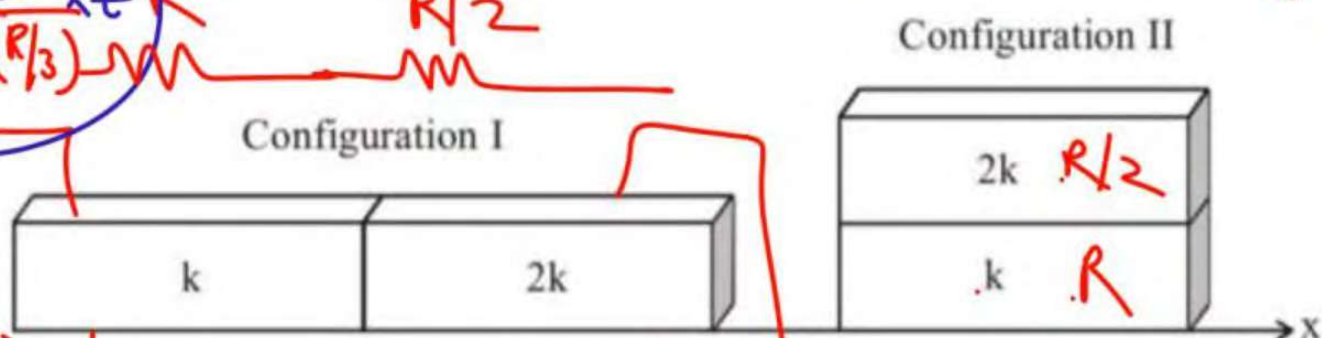
$t = 2\,sec$

दो समरूपी आयताकार गुटकों को दर्शाये चित्रानुसार दो विन्यासों I और II में व्यवस्थित किया गया है। गुटकों की ऊष्मा चालकता k व 2k है। दोनों विन्यासों में x-अक्ष के दोनों छोरों पर तापमान का अन्तर समान है। विन्यास I में, ऊष्मा की एक निश्चित मात्रा गरम छोर से ठंडे छोर तक अभिगमन में 9s लेती है। विन्यास II में, समान मात्रा की ऊष्मा के अभिगमन के लिए समय है :-

$R_{eq} = 3R/2$ $\quad R = \frac{L}{KA}$ $\quad R_{eq} = \frac{.5R}{1.5} = R/3$ $\quad \left(\frac{dQ}{dt}\right)_{net} = \frac{\Delta T}{R_{eq}}$

$\frac{\cancel{\Delta T}}{\frac{3R}{2}} \times 9 = \frac{\cancel{\Delta T}}{(R/3)} \times t$

R $\quad$ R/2



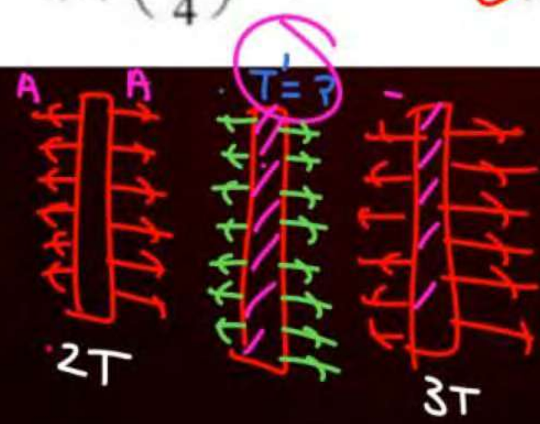
(A*) 2.0 s (B) 3.0 s (C) 4.5 s (D) 6.0 s

$$\frac{dQ}{dt} = \frac{KA\,\Delta T}{L} = \frac{\Delta T}{\frac{L}{KA}} = \frac{\Delta T}{R_{eq}}$$

15. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures 2T and 3T respectively. The temperature of the middle (i.e. second) plate under steady state condition is **[JEE 2012]**

तीन बहुत बड़ी प्लेटें, जिनका क्षेत्रफल बराबर है, समांतर व एक दूसरे के पास रखी गयी हैं। उनको आदर्श-कृष्ण सतह माने और उनकी ऊष्मा चालकता बहुत अधिक है। पहली और तीसरी प्लेटों को क्रमश: 2T व 3T तापमान पर रखा जाता है। स्थाई अवस्था में बीच की (अर्थात् दूसरी) प्लेट का तापमान है

(A) $\left(\frac{65}{2}\right)^{1/4} T$ (B) $\left(\frac{97}{4}\right)^{1/4} T$ (C*) $\left(\frac{97}{2}\right)^{1/4} T$ (D) $(97)^{1/4} T$



$$eA\sigma(2T)^4 + eA\sigma(3T)^4 = e(2A)\sigma T_B^4$$

3. Two spherical stars A and B emit blackbody radiation. The radius of A is 400 times that of B and A emits 10^4 times the power emitted from B. The ratio $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is ______.

$$\frac{dQ}{dt} = eA\sigma T^4$$

(JEE Advanced 2015)

A	B
$400r$	r
$10^4 P$	$\frac{dQ}{dt} = P$
T_A	T_B

$$\frac{\left(\frac{dQ}{dt}\right)_A}{\left(\frac{dQ}{dt}\right)_B} = \left(\frac{r_A}{r_B}\right)^2 \left(\frac{T_A}{T_B}\right)^4$$

$$\frac{P}{10^4 P} = \left(\frac{400r}{r}\right)^2 \left(\frac{\lambda_B}{\lambda_A}\right)^4$$

2. Two spherical bodies A (radius 6 cm) and B (radius 18 cm) are at temperature T_1 and T_2 respectively. The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B? **(IIT-JEE 2010)**

R 3R

$eA\sigma T^4$ $e=1$ $a=1$

$$\frac{\left(\frac{dQ}{dt}\right)_A}{\left(\frac{dQ}{dt}\right)_B} = \frac{r_A^2}{r_B^2}\times\left(\frac{T_A}{T_B}\right)^4 = \left(\frac{R}{3R}\right)^2 \times \left(\frac{1500}{500}\right)^4$$

$$= \frac{1}{9}\times 9\times 9 = 9$$

3. A piece of ice (heat capacity = 2100 J kg^{-1} °C^{-1} and latent heat = 3.36×10^5 J kg^{-1}) of mass m grams is at –5°C at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice–water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m is **[JEE 2010]**

m ग्राम द्रव्यमान का बर्फ का टुकड़ा (विशिष्ट ऊष्मा= 2100 J kg^{-1} °C^{-1} तथा गुप्त ऊष्मा = 3.36×10^5 J kg^{-1}) वायुमण्डलीय दाब पर –5°C पर रखा है। इसे 420 J ऊष्मा दी जाती है जिससे यह पिघलना शुरू हो जाती है। अन्त में जब बर्फ-पानी का मिश्रण साम्यावस्था में है, तब यह पाया जाता है कि 1 ग्राम बर्फ पिघल चुकी है। यह मानते हुए कि इस प्रक्रिया में किसी अन्य ऊष्मा का आदान प्रदान नहीं हुआ है, m का मान (ग्राम में) होगा :- **[JEE 2010]**

Ans. 8

$$S = \frac{\Delta Q}{m\Delta T} = \frac{J}{kg\,°C}$$

m gram ice $-5°C$ $\xrightarrow{\Delta Q}$ 1gm water, (m-1)gm ice $0°C$

$$\Delta Q = m\,s\,\Delta T + \frac{1}{1000} \times L_f$$

$$420 = m \times 2100 \times \Delta T + \frac{1}{1000} \times 336 \times 10^3$$

6. Steel wire of length 'L' at 40°C is suspended from the ceiling and then a mass 'm' is hung from its free end. The wire is cooled down from 40° to 30° C to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is 10^{-5}/°C, Young's modulus of steel is 10^{11} N/m^2 and radius of the wire is 1 mm. Assume that L>> diameter of the wire. Then the value of 'm' in kg is nearly

'L' लम्बाई की स्टील-तार, जो 40°C तापमान पर है, को छत से लटका कर उसके मुक्त सिरे पर द्रव्यमान 'm' संलग्न किया जाता है। अब तार को ठंडा करके उसका तापमान 40° से 30° C लाने पर उसकी लम्बाई फिर से 'L' हो जाती है। स्टील का तापीय-प्रसार गुणांक 10^{-5}/°C है, यंग्स-माडलस 10^{11} N/m^2 है तथा तार की त्रिज्या 1 mm है। मानें कि L>> तार का व्यास 'm' का kg में मान लगभग है **[JEE 2011]**

$\Delta l = l \alpha \times 10 =$

Ans. 3

$$\frac{mg}{A} = Y\frac{\Delta l}{l} = Y(\alpha \Delta\theta)$$

$$\frac{mg}{\pi r^2} = Y\,\alpha\,(\Delta\theta)$$

$\Delta\theta = 10$

QUESTION

When the temperature of a metal wire is increased from 0°C to 10°C, its length increased by 0.02%. The percentage change in its mass density will be closest to:

[Main 2020]

(1) 0.06

(2) 2.3

(3) 0.008

(4) 0.8

$$\rho = \frac{m}{\pi r^2 h}$$

$$\frac{\Delta \rho}{\rho} = \cancel{\frac{\Delta m}{m}} - 2\frac{\Delta r}{r} - \frac{\Delta h}{h}$$

$$\frac{\Delta \rho}{\rho} = 2 \times .02 + .02$$

Ans : (1)

QUESTION

At 40°C, a brass wire of 1 mm radius is hung from the ceiling. A small mass, M is hung from the free end of the wire. When the wire is cooled down from 40°C to 20°C it regains its original length of 0.2 m. The value of M is close to:

(Coefficient of linear expansion and Young's modulus of brass are $10^{-5}/°C$ and $10^{11}\ N/m^2$, respectively; $g = 10\ ms^{-2}$).

[Main 2019]

$$\frac{mg}{\pi r^2} = Y(\alpha \Delta\theta)$$

1. 9 kg
2. 6.3 kg
3. 1.5 kg
4. 0.9 kg

Ans : (2)

QUESTION RM

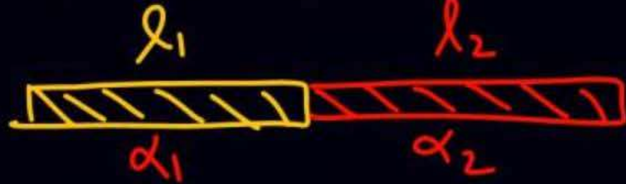
Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion α_1 and α_2 are joined end-to-end. Then the effective temperature coefficient of linear expansion is: **[Main 2020]**

(1) $\dfrac{\alpha_1 L_1 + \alpha_2 L_2}{L_1 + L_2}$

(2) $2\sqrt{\alpha_1 \alpha_2}$

(3) $\dfrac{\alpha_1 + \alpha_2}{2}$

(4) $4\dfrac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2}\dfrac{L_2 L_1}{(L_2 + L_1)^2}$



$\alpha_{eq} = ?$

$(l_1)_f = l_1(1+\alpha_1 \Delta T)$

$(l_2)_f = l_2(1+\alpha_2 \Delta T)$

$(l_1+l_2)_f = (l_1+l_2)(1+\alpha_{eq}\Delta T)$

Ans : (1)

QUESTION

Two rods A and B of identical dimensions are at temperature 30°C. If A is heated up-to 180°C and B up-to T°C, then the new lengths are the same. If the ratio of the coefficients of linear expansion of A and B is 4 : 3, then the value of T is:

[Main 2019]

$$l_f = \cancel{l_0}(\cancel{1} + 4\cancel{\alpha} \times 150) = \cancel{l_0}(\cancel{1} + 3\cancel{\alpha}(T-30))$$

$$600 = 3(T-30)$$

(1) 230° C

(2) 270° C

(3) 200° C

(4) 250° C

Ans : (1)

QUESTION

A rod, of length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion $\alpha/^{\circ}C$. It is observed that an external compressive force F, is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by ΔT K. Young's modulus, Y, for this metal is:

[Main 2019]

$$\frac{F}{A} = Y \alpha \Delta\theta$$

$$Y = \frac{F}{A\alpha\Delta\theta}$$

(1) $\dfrac{F}{A\alpha\Delta T}$

(2) $\dfrac{F}{A\alpha(\Delta T - 273)}$

(3) $\dfrac{F}{2\,A\alpha\Delta T}$

(4) $\dfrac{2\,F}{A\alpha\Delta T}$

Ans : (1)

QUESTION

RM → 3 बार Repeated

$V = l^3$

An external pressure P is applied on a cube at 0°C so that it is equally compressed from all sides. K is the bulk modulus of the material of the cube and α is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by: [Main 2017]

Sphere

$V = \frac{4}{3}\pi R^3$

(1) $\frac{3\alpha}{PK}$

(2) $3PK\alpha$

(3) $\frac{P}{3\alpha K}$

(4) $\frac{P}{\alpha K}$

$$B = \frac{-\Delta P}{\left(\frac{\Delta V}{V}\right)} = \frac{-\Delta P}{3\left(\Delta R/R\right)}$$

$$B = \frac{-\Delta P}{3\alpha\Delta\theta}$$

$$\Delta\theta = \frac{\Delta P}{3\alpha B}$$

Ans : (3)

QUESTION

A compressive force, F is applied at the two ends of a long thin steel rod. It is heated, simultaneously, such that its temperature increases by ΔT. The net change in its length is zero. Let l be the length of the rod, A its area of cross-section, Y its Young's modulus, and α its coefficient of linear expansion. Then, F is equal to:

[Main 2017]

$$\frac{F}{A} = Y\alpha\Delta T$$

(1) $l^2 Y\alpha\Delta T$

(2) $lAY\alpha\Delta T$

(3) $AY\alpha\Delta T$

(4) $AY/\alpha\Delta T$

Ans : (3)

QUESTION

A non-isotropic solid metal cube has coefficients of linear expansion as: $5 \times 10^{-5}/°C$ along the x-axis and $5 \times 10^{-6}/°C$ along the y and the z-axis. If the coefficient of volume expansion of the solid is $C \times 10^{-6}/°C$ then the value of C is: [Main 2020]

$$\gamma = \alpha_x + \alpha_y + \alpha_z$$

Ans : (60.11)

QUESTION

A water heater of power 2000 W is used to heat water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. The efficiency of heater is 70%. Time required to heat 2 kg of water from 10° C to 60°C is ________ s.

(Assume that the specific heat capacity of water remains constant over the temperature range of the water).

[31 January 2023 - Shift 2]

$$\cancel{2000} \times \frac{\cancel{70}}{\cancel{100}} \times t = m s \Delta T = 2 \times \cancel{4200} \times 5\cancel{0}$$

6

5

$t =$

Ans. (300)

QUESTION

A steel rod of length 1 m and cross-sectional area 10^{-4} m^2 is heated from 0° C to 200° C without being allowed to extend or bend. The compressive tension produced in the rod is _____ $\times 10^4$ N.

(Given Young's modulus of steel $= 2 \times 10^{11}$ N m^{-2}, coefficient of linear expansion $=10^{-5}$ K^{-1})

[08 April 2023 - Shift 2]

$$\frac{T}{A} = Y \alpha \Delta\theta$$

Ans. (4)

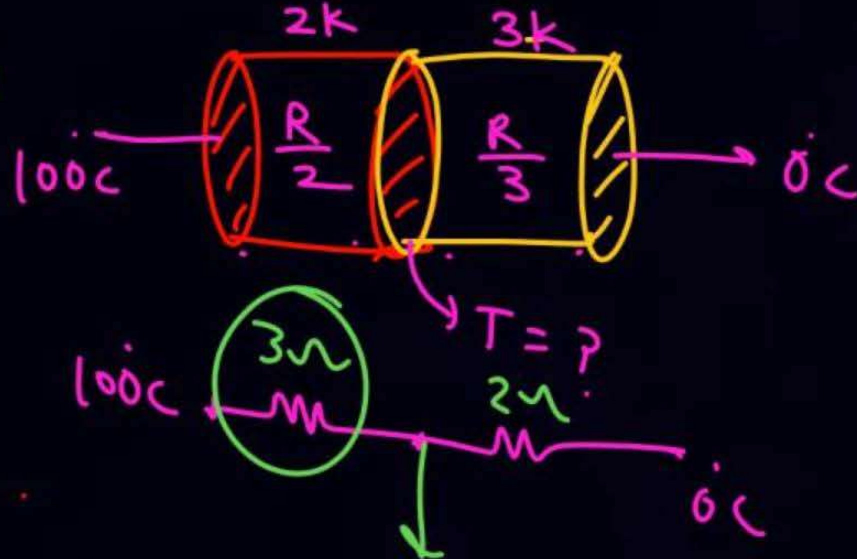
QUESTION

2K   3K

Two plates A and B have thermal conductivities 84 W m^{-1} K^{-1} and 126 W m^{-1} K^{-1} respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at 100° C and 0° C respectively, then the temperature of the surface of contact in steady state is °C.

[13 April 2023 - Shift 2]

$R = 6$



Ans. (40)

QUESTION

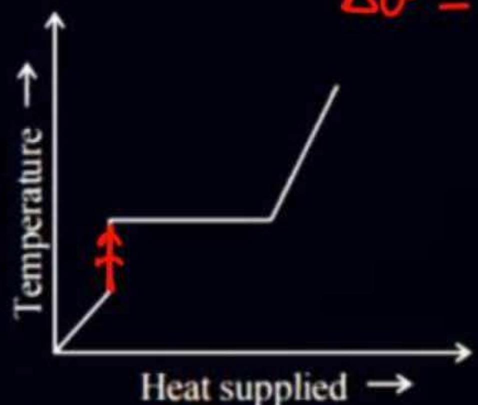
$0^\circ C$ (ice)

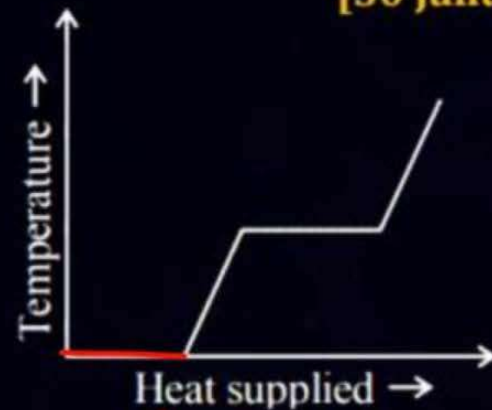
$-10^\circ C \longrightarrow \underset{\text{ice}}{0^\circ C} \longrightarrow \underset{\text{water}}{0^\circ} \longrightarrow 100^\circ$ water $\longrightarrow$ 100 steam

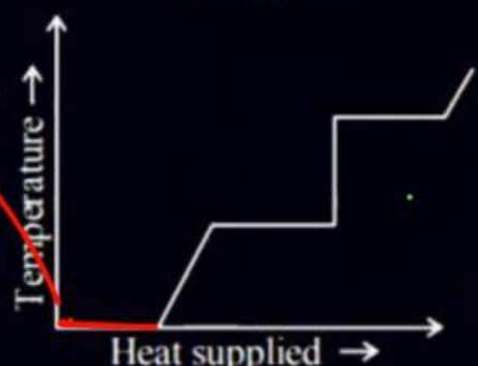
A block of ice at -10° C is slowly heated and converted to steam at 100° C. Which of the following curves represent the phenomenon qualitatively:

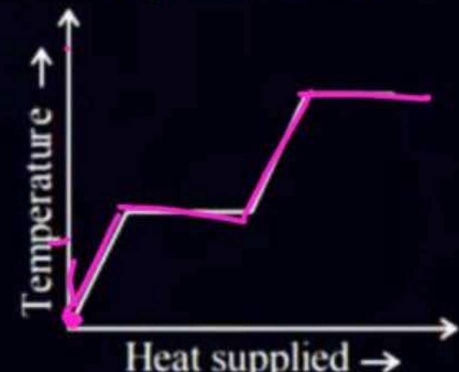
$\Delta Q = m S \Delta T$

[30 January 2024 - Shift 2]

(1) 

(2) 

(3) 

(4) 

Ans. (4)

QUESTION

RM

Two conductors have the same resistances at 0° C but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients for their series and parallel combinations are: **[31 January 2024 - Shift 1]**

(1) $\alpha_1 + \alpha_2, \frac{\alpha_1+\alpha_2}{2}$

(2) $\boxed{\frac{\alpha_1+\alpha_2}{2}, \frac{\alpha_1+\alpha_2}{2}}$

(3) $\alpha_1 + \alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$

(4) $\frac{\alpha_1+\alpha_2}{2}, \alpha_1 + \alpha_2$

Ans. (2)

QUESTION

The specific heat of water = 4200 J kg^{-1} K^{-1} and the latent heat of ice = 3.4×10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams):

[Main 2020]

1. 61.7
2. 63.8
3. 69.3
4. 64.6

Ans : (1)

water equiv. = 10 gm = ms

① steam

50gm water
$60^\circ C$ + m gm steam $100^\circ C$ $\longrightarrow$ $80^\circ C = T_f$

$$10 \times 20 + 500 \times 1 \times 20 = m \times 540 + m \times 1 \times 20$$

② $-10^\circ C$ ice 10gm + 80gm water $50^\circ C$ $\longrightarrow$ $T_f = ?$

(2) 20 gm $-10^\circ C$ ice + 80 gm water $50^\circ C$ $\longrightarrow$ $T_f = ?$

10 gm

$0^\circ C$ water

$$\Delta Q_1 = 20 \times \frac{1}{2} \times 10 + 20 \times 80 = 1700 \Rightarrow -1700$$

$$\Delta Q_2 = 80 \times 1 \times 50 = 4000$$

$$\Delta Q = 2300 \text{ cal}$$

100 gm water $0^\circ C$ $\longrightarrow$ $T = 23$

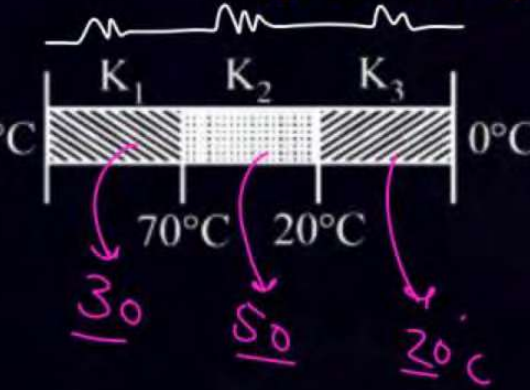
$$2300 = 100 \times 1 \times T - 0$$

QUESTION

$V = iR$ → sam

Three rods of identical cross-section and lengths are made of three different materials of thermal conductivity K_1, K_2 and K_3, respectively. They are joined together at their ends to make a long rod (see figure). One end of the long rod is maintained at 100°C and the other at 0°C (see figure). If the joints of the rod are at 70°C and 20°C in steady state and there is no loss of energy from the surface of the rod, the correct relationship between K_1, K_2 and K_3 is: **[Main 2020]**

$i \rightarrow$ same



(1) $K_1 : K_3 = 2 : 3, K_1 < K_3 = 2 : 5$

(2) $K_1 < K_2 < K_3$

$3 : 5 : 2$

$\frac{1}{3} : \frac{1}{5} : \frac{1}{2}$

(3) $K_1 : K_2 = 5 : 2, K_1 : K_3 = 3 : 5$

(4) $K_1 > K_2 > K_3$

Ans : (1)

QUESTION

A calorimeter of water equivalent 20 g contains 180 g of water at 25°C. 'm' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to (Latent heat of water = 540 cal g^{-1}, specific heat of water = 1 cal g^{-1} °C^{-1}). [Main 2020]

$m_b s_b \Delta T + m s \Delta T = m' \times 540 + m' \times 1 \times 69$

1. 2
2. 4
3. 3.2
4. 2.6

Ans : (1)

QUESTION

$\rightarrow 0^\circ C$

M grams of steam at 100° C is mixed with 200 g of ice at its melting point in a thermally insulated container. If it produces liquid water at 40°C [heat of vaporization of water is 540 cal/g and heat of fusion of ice is 80 cal/g], the value of M is _____. [Main 2020]

$$m \times 540 + m \times 1 \times 60 = 200 \times 80 + 200 \times 1 \times 40$$

$$600m = 16000 + 8000 = 24000$$

$$m = 40 \text{ gm}$$

Ans : (40)

QUESTION

$$\frac{S_A}{S_B} = \frac{15\times\cancel{50}}{\cancel{100}\times 10} = \frac{15}{20} = \frac{3}{4}$$

When 100 g of a liquid A at 100°C is added to 50g of a liquid B at temperature 75°C, the temperature of the mixture becomes 90°C. The temperature of the mixture, if 100 g of liquid A at 100°C is added to 50g of liquid B at 50°C, will be: **[Main 2019]**

(1) 85°C

(2) 60°C

(3) 80°C

(4) 70°C

100gm A 100°C + 50gm 75°C B $\longrightarrow$ 90

$$100\times S_A\times 10 = 50\times S_B\times 15$$

100gm A 100°C + 50gm B 50°C $\longrightarrow T_f$

$$\cancel{100}^{\,2}\times S_A\times(100-T) = \cancel{50}\times S_B\times(T-50)$$

$$2\frac{S_A}{S_B}(100-T) = T-50$$

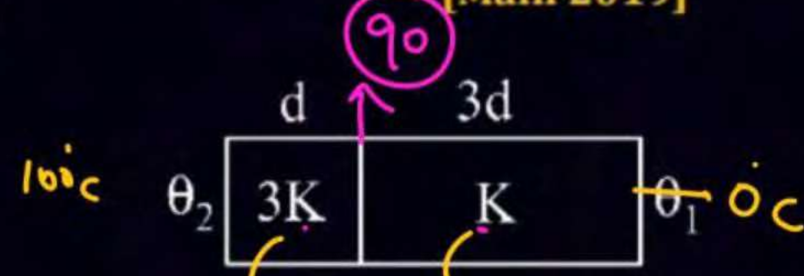
Ans : (3)

QUESTION

Two materials having coefficients of thermal conductivity '3K' and 'K' and thickness 'd' and '3d', respectively, are joined to form a slab as shown in the figure. The temperatures of the outer surfaces are 'θ_2' and 'θ_1' respectively, ($\theta_2 > \theta_1$). The temperature at the interface is:

$i = 10$

[Main 2019]



$R_1 = \frac{d}{3K \cdot A} = R$

$R_2 = \frac{3d}{KA} = 9R$

(1) $\frac{\theta_1}{10} + \frac{9\theta_2}{10}$

(2) $\frac{\theta_2 + \theta_1}{2}$

(3) $\frac{\theta_1}{6} + \frac{5\theta_2}{6}$

(4) $\frac{\theta_1}{3} + \frac{2\theta_2}{3}$

Ans : (1)

QUESTION

RM

Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion α_1 and α_2, are joined end-to-end. Then the effective temperature coefficient of linear expansion is: **[5 Sep, 2020 (Shift-II)]**

(1) $\sqrt[2]{\alpha_1\alpha_2}$

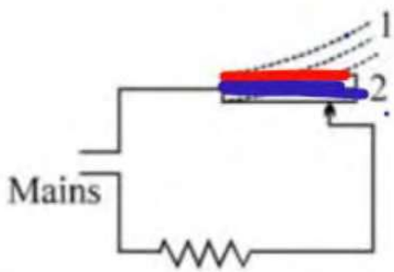
(2) $\frac{4\alpha_1\alpha_2}{\alpha_1+\alpha_2}\frac{L_2L_1}{(L_2+L_1)^2}$

(3) $\frac{\alpha_1+\alpha_2}{2}$

(4) $\frac{\alpha_1L_1+\alpha_2L_2}{L_1+L_2}$

Ans : (4)

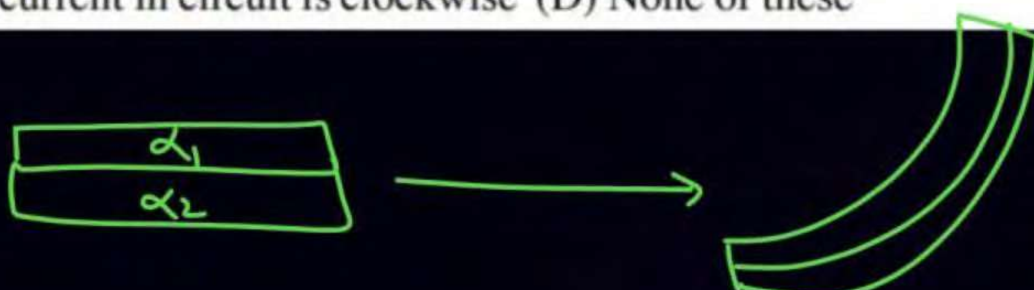
Figure shows the action of a switch by a bimetallic strip. If α_1 and α_2 are coefficients of thermal expansion of metal 1 and metal 2 respectively.



$T\uparrow, \ l\uparrow, \ \alpha\uparrow$

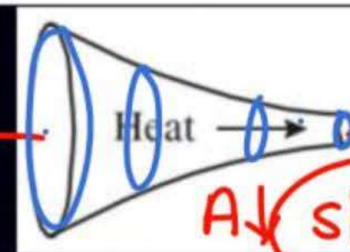
(A*) $\alpha_1 < \alpha_2$ (B) $\alpha_1 > \alpha_2$

(C) $\alpha_1 > \alpha_2$ if the current in circuit is clockwise (D) None of these



Ans. (A)

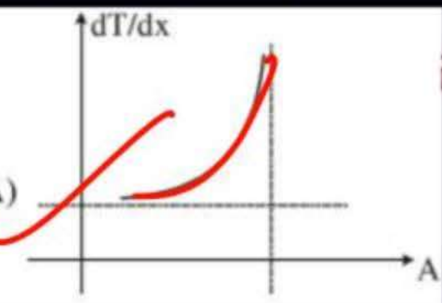
An irregular rod of same uniform material as shown in figure is conducting heat at a steady rate. The temperature gradient at various sections versus area of cross section graph will be



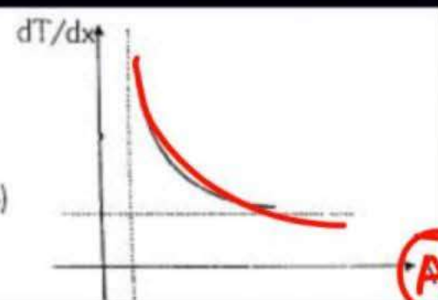
T_1 → T_2

A↓ slope↑

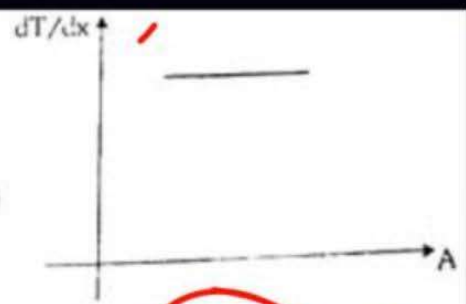
(A)



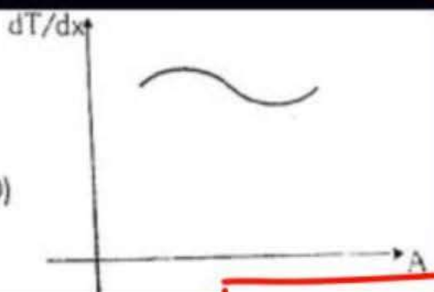
(B)



(C)



(D)



$$\frac{dT}{dx} = \frac{i}{kA}$$

$$\frac{d\theta}{dt} = \boxed{i = kA\frac{dT}{dx}}$$

Ans. (B)

A black body has maximum wavelength λ_m at temperature 2000 K. Its corresponding wavelength at temperature 3000 K will be

(a) $\frac{3}{2}\lambda_m$ (b) $\frac{2}{3}\lambda_m$ (c) $\frac{4}{9}\lambda_m$ (d) $\frac{9}{4}\lambda_m$

$$\frac{\lambda_1}{\lambda_2} = \frac{T_2}{T_1}$$

$$\frac{\lambda_m}{\lambda_2} = \frac{3000}{2000}$$

Ans. (b)

A block of ice with mass m falls into a lake. After impact, a mass of ice $\left(\frac{m}{5}\right)$ melts. Both the block of ice and the lake have a temperature of 0°C. If L represents the heat of fusion, the minimum distance the ice fell before striking the surface is

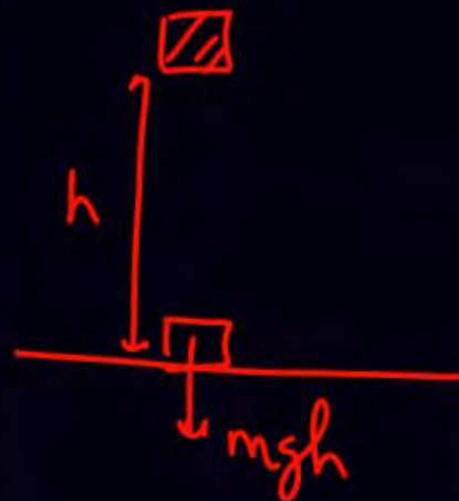
(a) $\frac{L}{5g}$

(b) $\frac{5L}{g}$

(c) $\frac{gL}{5m}$

(d) $\frac{mL}{5g}$

$\cancel{m}gh = \frac{\cancel{m}}{5} L$



Ans. (a)

$$\text{mean free path} = \frac{1}{\sqrt{2}\,\pi d^2 \frac{N}{V_{Gas}}} = \frac{RT}{\sqrt{2}\,\pi d^2 N_A P} = \frac{KT}{\sqrt{2}\,\pi d^2 P}$$

KTG & thermodynamics

*

DIFFERENT SPEEDS OF GAS MOLECULES

$V_{rms} = \sqrt{\frac{3RT}{m}}$

- **Average velocity**

Because molecules are in random motion in all possible direction in all possible velocity. Therefore, the average velocity of the gas in molecules in container is zero.

$$\langle \vec{v} \rangle = \frac{\vec{v}_1 + \vec{v}_2 + \cdots \ldots\ldots \vec{v}_N}{N} = 0$$

rms speed of molecules $v_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M_w}} = \sqrt{\frac{3kT}{m}} = 1.73\sqrt{\frac{kT}{m}}$

Mean speed of molecules : By maxwell's velocity distribution law v_M or

$$\langle |\vec{v}| \rangle = v_{mean}$$

DIFFERENT SPEEDS OF GAS MOLECULES

$\sqrt{\frac{8}{\pi}\frac{RT}{m}}$

$$\langle|\vec{v}|\rangle = v_{mean} = \frac{|\vec{v}_1| + |\vec{v}_2| + \cdots \ldots \ldots .|\vec{v}_n|}{N} = \sqrt{\frac{8}{\pi}\frac{P}{\rho}} = \sqrt{\frac{8RT}{\pi M_w}} = \sqrt{\frac{8kT}{\pi m}} = 1.59\sqrt{\frac{kT}{m}}$$

Most probable speed of molecules (v_{mp})

At a given temperature, the speed to which maximum number of molecules belongs is called as most probable speed (v_{mp}) $v_{mp} = \sqrt{\frac{2P}{\rho}} = \sqrt{\frac{2RT}{M_w}} = \sqrt{\frac{2kT}{m}} = 1.41\sqrt{\frac{kT}{m}}$

$$V_{rms} = \sqrt{\frac{3RT}{m}}$$

$$V_{avg} = \sqrt{\frac{8RT}{\pi m}}$$

$$v_{m.p} = \sqrt{\frac{2RT}{m}}$$

$$V_R > V_A > V_m$$

$$U = \frac{nfRT}{2}$$

$$T\uparrow \Rightarrow U\uparrow \Rightarrow \Delta U > 0$$

$$\Delta U = \frac{nfR\Delta T}{2}$$

$$U = \frac{nfRT}{2}$$

$$\Delta U = \frac{nfR\Delta T}{2}$$

$T\uparrow,\ U\uparrow,\ \Delta U > 0$

$$(WD)_{\text{by gas}} = \int P.dV$$

$V\uparrow \Rightarrow W_g > 0 \equiv$ Expansion

$V\downarrow \Rightarrow W_g < 0 \equiv$ Compression

polytropic $\longrightarrow PV^{x} = \text{const} \Rightarrow W_g = \dfrac{nR\Delta T}{1-x}$

isobaric, $P \rightarrow \text{const}$ $\longrightarrow P\Delta V = nR\Delta T = W_g$

$T \rightarrow \text{const}$, isothermal, $P_1V_1 = P_2V_2$ $\longrightarrow W_g = nRT\ln\dfrac{V_2}{V_1} = nRT\ln\dfrac{P_1}{P_2}$

isochoric, $V \rightarrow \text{const}$ $\longrightarrow W_g = 0$

Adiabatic, $\Delta Q = 0$, $PV^{\gamma} = \text{const}$ $\longrightarrow \dfrac{nR\Delta T}{1-\gamma} = W_g$

* $\Delta Q = \Delta U + \Delta W$

$\Delta W = W_{gas} = \int P\,dV$

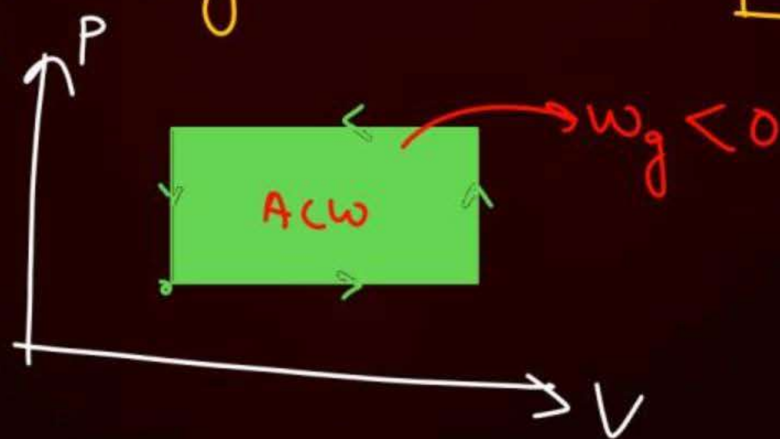
* $\Delta Q > 0 \equiv$ heat आ रही है
  heat is given to the system

$\Delta Q < 0 \Rightarrow$ heat rejected by

cyclic process

$\Delta U = 0$

$\Delta Q = W_g$



$\Delta\theta = \Delta U + \Delta W$

mono $\longrightarrow$ $f = 3$

$C = \frac{\Delta\theta}{n\Delta T}$

Adiab. $\longrightarrow C = 0$

isothermal $\longrightarrow C \longrightarrow \infty$

isochoric $\longrightarrow C = \frac{\Delta\theta}{n\Delta T} = \frac{\frac{nfR\Delta T}{2} + 0}{n\Delta T} = \frac{fR}{2} = C_V$

isobaric $\longrightarrow C = C_p = \frac{\Delta\theta}{n\Delta T} = \frac{\Delta U + \Delta W}{n\Delta T} = \frac{\frac{nfR\Delta T}{2} + nR\Delta T}{n\Delta T}$

$\boxed{C_p = C_V + R}$

$\boxed{C_p - C_V = R}$

$C_p - C_V = R$

$c_p - c_v = R/m$

Polytropic $\longrightarrow PV^x = \text{const}$

$\boxed{C = C_V + \frac{R}{1-x}}$

Q

2 mole, monoatomic

$PV^{3} = \text{const}$

$T_i = 100\,K$

$V \longrightarrow \text{double}$

$V \longrightarrow 2V$

$P \longrightarrow \frac{P}{8}$

$T \longrightarrow T/4$

$T = 100K \longrightarrow T_f = 25$

(1) $\Delta U = \frac{nfR\Delta T}{2} = \frac{\cancel{2} \times 3 \times R \times (-75)}{\cancel{2}}$

(2) $C = C_v + \frac{R}{1-x} = \frac{3R}{2} + \frac{R}{1-3} =$ ✓

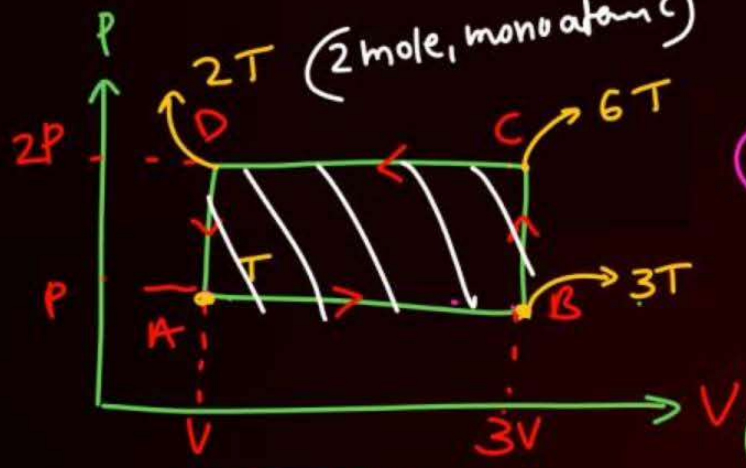
(3) $W_g = \frac{nR\Delta T}{1-x} = \frac{2 \times R \times (-75)}{1-3} = 75R$

$\Delta Q = \Delta U + \Delta W$

$= -225R + 75R$

$\Delta Q = -150R$

$\Delta Q < 0$



$PV = 2 \times R \times T$

$(A \rightarrow B) \Rightarrow W_g = +P \times 2V = 4RT$

$\Delta U_{AB} = \frac{nfR\Delta T}{2} = \frac{2 \times 3 \times R \times (2T)}{2}$

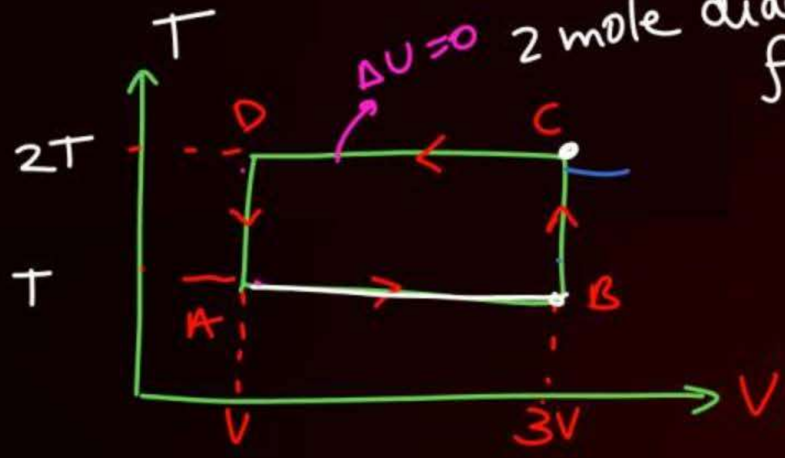
$T_A = T = 100K$

$(B \rightarrow C) \Rightarrow W_g = 0, \; \Delta U = \frac{2 \times 3 \times R \times (3T)}{2}$

$= \Delta Q$

$(WD)_{net} =$

$PV = nRT$



2 mole diatomic
$f = 5$

$(C \to D)$ $W_{CD} = nR(2T)\ln\left(\frac{V}{3V}\right)$

$\Delta U_{CD} = 0$

$(D \to A)$ $W_g = 0$, $\Delta U = \frac{nfR(-T)}{2}$

$(A \to B)$ $W_{AB} = nRT \ln \frac{3V}{V} = \Delta Q$

$\Delta U_{AB} = 0$

$(B \to C)$ $V \to$ const, $W_g = 0$, $\Delta U = \frac{2 \times 5 \times R\,T}{2}$

$\Delta Q = \Delta U + 0$

$$\gamma = \frac{C_p}{C_v} = \frac{C_v + R}{C_v} = 1 + \frac{R}{fR/2} = 1 + \frac{2}{f}$$

Adiabatic $\Delta Q = 0$,

$$\left.\begin{aligned} PV^{\gamma} &= \text{const} \\ TV^{\gamma-1} &= \text{const} \end{aligned}\right\}$$

** $$(C_v)_{mix} = \frac{n_1 C_{v_1} + n_2 C_{v_2} + \ldots}{n_1 + n_2 + \ldots}$$

$$(C_p)_{mix} = \frac{n_1 C_{p_1} + n_2 C_{p_2} + \ldots}{n_1 + n_2 + \ldots}$$

$$\gamma_{mix} = \frac{(C_p)_{mix}}{(C_v)_{mix}}$$

4-5

Q

2 mole He + 4 mole O_2 $\Rightarrow$ $(C_V)_{mix} = \dfrac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2}$

$$= \frac{2 \times \frac{3R}{2} + 4 \times 5R/2}{2+4}$$

$C_V = fR/2$

$C_p = C_V + R$

$$(C_p)_{mix} = \frac{2 \times 5R/2 + 4 \times 7R/2}{2+4}$$

$$\gamma = \frac{(C_p)_m}{(C_V)_m}$$

QUESTION

n mole a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes.

$A \rightarrow B$: Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2.

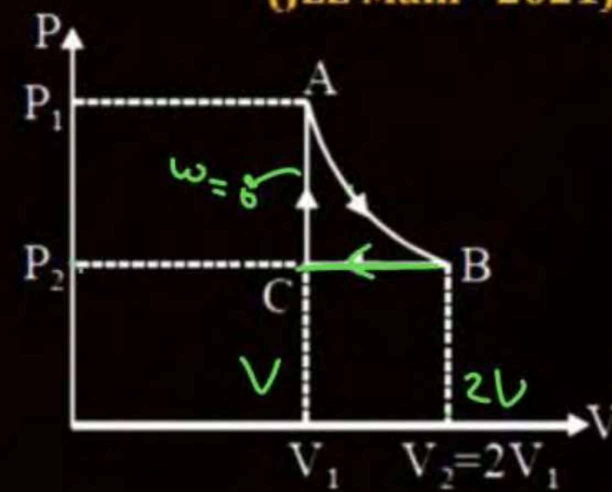
$B \rightarrow C$: Isobaric compression at pressure P_2 to initial volume V_1.

$C \rightarrow A$: Isochoric change leading to change of pressure from P_2 to P_1.

Total work-done in the complete cycle ABCA is :

(JEE Main - 2021)

$nRT \ln 2 - P_2 V$



(1) 0

(2) $nRT\left(\ln 2 + \frac{1}{2}\right)$

(3) $nRT \ln 2$

(4) $nRT\left(\ln 2 - \frac{1}{2}\right)$

Ans : (4)

QUESTION

For an adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to (where γ is the ratio of specific heats): **(JEE Main - 2021)**

(1) $-\gamma \frac{dV}{V}$

(2) $-\gamma \frac{V}{dV}$

(3) $-\frac{1}{\gamma} \frac{dV}{V}$

(4) $\frac{dV}{V}$

$PV^{\gamma} = \text{Const}$

$$\boxed{\begin{aligned} B &= P \text{ (isoth.)} \\ B &= \gamma P \text{ (Adiab.)} \end{aligned}}$$

$$\frac{\Delta P}{\frac{\Delta V}{V}} = \gamma P$$

$$\frac{\Delta P}{P} = \gamma \frac{\Delta V}{V}$$

Ans : (1)

QUESTION

What will be the average value of energy for a monoatomic gas in thermal equilibrium at temperature T?

(JEE Main - 2021)

(1) $\frac{2}{3}k_B T$

(2) $k_B T$

(3) $\frac{3}{2}k_B T$

(4) $\frac{1}{2}k_B T$

Ans : (3)

QUESTION

At a certain temperature, the degrees of freedom per molecule for a gas is 8. The gas performs 150 J of work when it expands under constant pressure. The amount of heat absorbs by the gas will be ___750___ J.

(JEE Main - 2022)

$$\Delta Q = \Delta U + \Delta W$$

$$(WD) = nR\Delta T = 150$$

$$\Delta Q = \frac{nfR\Delta T}{2} + 150$$

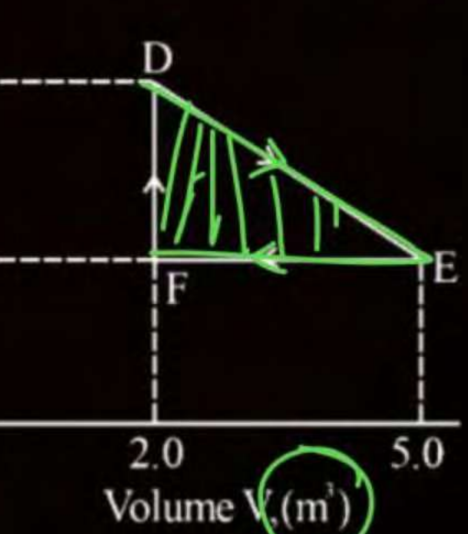
$$= \frac{150 \times 8}{2} + 150$$

Ans : (750)

QUESTION

A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in the figure. Its volume is then reduced to the original volume from E to F by an isobaric process. The total work done by the gas from D to E to F will be

(JEE Main - 2022)



1. −450 J
2. 450 J
3. 900 J
4. 1350 J

Ans : (2)

QUESTION

Match List I with List II:

Choose the correct answer from the options given below :

(25 January 2023 - Shift 2)

	List I		List II
A.	Isothermal Process $\Delta U = 0$,	I.	Work done by the gas decreases internal energy
B.	Adiabatic Process	II.	No change in internal energy
C.	Isochoric Process $W_g = 0$	III.	The heat absorbed goes partly to increase internal energy and partly to do work
D.	Isobaric Process	IV.	No work is done in or by the gas

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

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

(3) A-~~I~~, B-II, C-IV, D-III

(4) A-~~I~~, B-II, C-III, D-IV

Ans : (2)

QUESTION

According to law of equipartition of energy the molar specific heat of a diatomic gas at constant volume where the molecule has one additional vibrational mode is:-

(25 January 2023 - Shift 2)

$$C_v = \frac{fR}{2} = \frac{(5+2)R}{2}$$

1. $\frac{9}{2}R$
2. $\frac{5}{2}R$
3. $\frac{3}{2}R$
4. $\frac{7}{2}R$ ✓

Ans : (4)

QUESTION

V≡P

A hypothetical gas expands adiabatically such that its volume changes from 08 litres to 27 litres. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then the ratio of $\frac{C_P}{C_V}$ will be.

(31 January 2023 - Shift 2)

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

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

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

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

$PV^{\gamma} = \text{const}$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma}$

$\frac{16}{81} = \left(\frac{8}{27}\right)^{\gamma}$

$\left(\frac{2}{3}\right)^{4} = \left(\frac{2}{3}\right)^{3\gamma}$

Ans : (1)

QUESTION

Adiab.

The initial pressure and volume of an ideal gas are P_0 and V_0. The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_0}{4}$ will be: (Given γ = ratio of specific heats at constant pressure and at constant volume.)

(13 April 2023 - Shift 2)

$$P_0 V_0^{\gamma} = P_f \left(\frac{V_0}{4}\right)^{\gamma}$$

(1) $P_0(4)^{\gamma}$

(2) $4P_0$

(3) P_0

(4) $P_0(4)^{\frac{1}{\gamma}}$

Ans : (1)

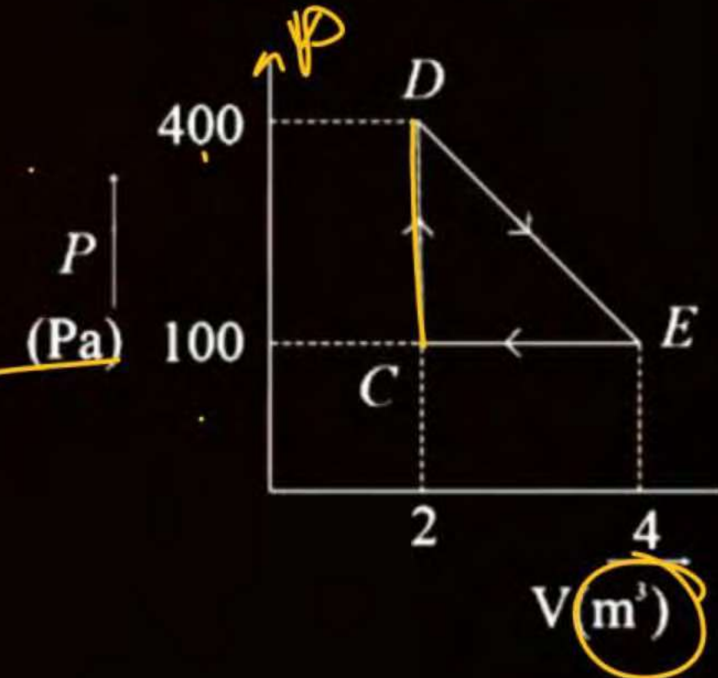
QUESTION

A thermodynamic system is taken through cyclic process. The total work done in the process is :

(15 April 2023 - Shift 1)

1. 200 J
2. 300 J
3. 100 J
4. Zero

$\frac{1}{2} \times 2 \times 300$



Ans : (2)

QUESTION

$W_D = nR\Delta T = 200$

A diatomic gas (γ = 1.4) does 200 J of work when it is expanded isobarically. The heat given to the gas in the process is: [01 Feb. 2024 - Shift 2]

1. 850 J
2. 800 J
3. 600 J
4. 700 J

$\Delta Q = nC_p\Delta T$

$\gamma = 7/5 = 1 + \frac{2}{f}$

$f = 5$

$\Delta Q = \Delta U + \Delta W$

$= \frac{nfR\Delta T}{2} + 200\ J$

$= \frac{200 \times 5}{2} + 200 = 700$

Ans. (4)

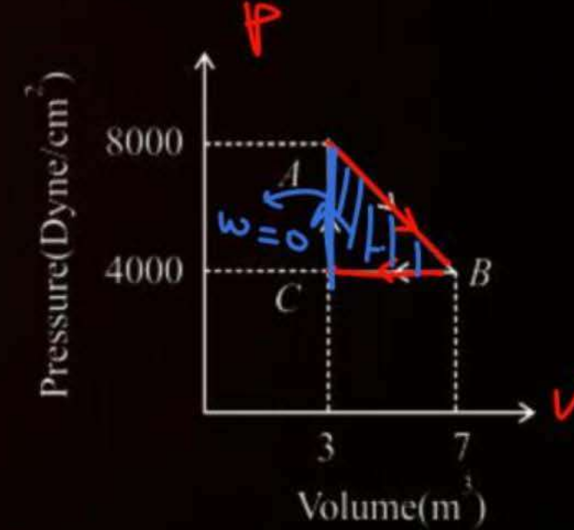
QUESTION

A thermodynamic system is taken from an original state A to an intermediate state B by a linear process as shown in the figure. It's volume is then reduced to the original value from B to C by an isobaric process. The total work done by the gas from A to B and B to C would be: **[29 Jan. 2024 - Shift 1]**

$$W_{net} = \cancel{W_{CA}} + W_{AB} + W_{BC}$$

0

Area



(1) 33800 J

(2) 2200 J

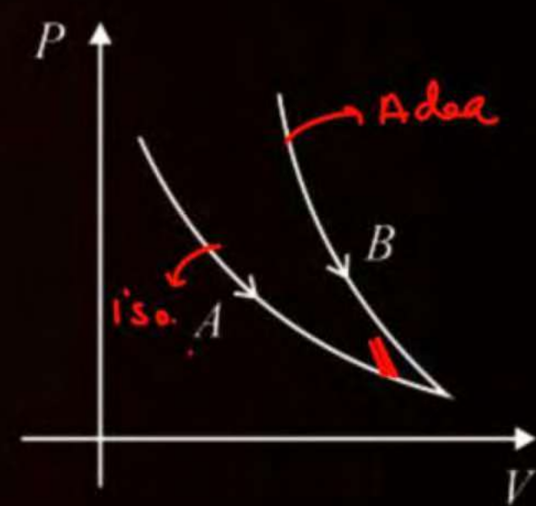
(3) 600 J

(4) 800 J

Ans. (4)

QUESTION

Choose the correct statement for processes A & B shown in figure. **[30 Jan. 2024 - Shift 2]**



1. $PV^{\gamma} = k$ for process B and $PV = k$ for process A.
2. $PV = k$ for process B and A.
3. $\frac{T^{\gamma}}{P^{\gamma-1}} = k$ for process A and $PV = k$ for process B.
4. None of these

Ans. (1)

QUESTION

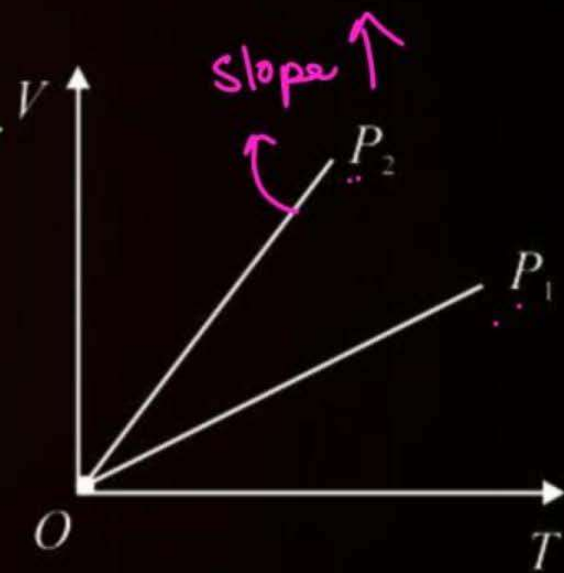
The given figure represents two isobaric processes for the same mass of an ideal gas, then

[31 Jan. 2024 - Shift 2]

$$PV = nRT$$

$$V = \left(\frac{nR}{P}\right)T$$

slope ↑ P ↓



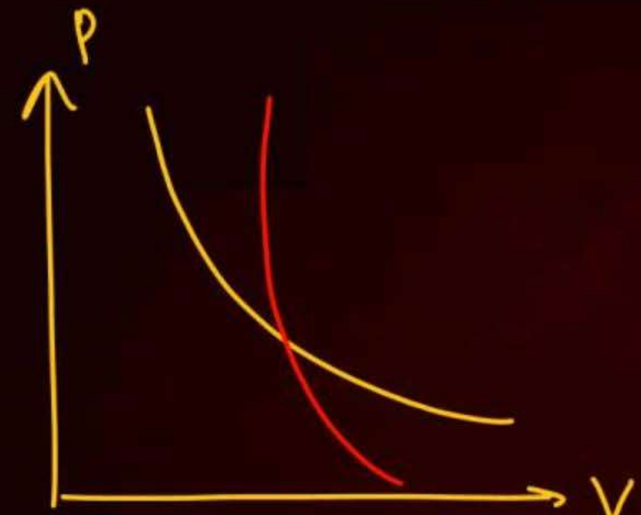
(1) $P_2 \geq P_1$

(2) $P_2 > P_1$

(3) $P_1 = P_2$

(4) $P_1 > P_2$

Ans. (4)


P
V

QUESTION

Two moles a monoatomic gas is mixed with six moles of a diatomic gas. The molar specific heat of the mixture at constant volume is: [01 Feb. 2024 - Shift 1]

C_v

(1) $\frac{9}{4}R$

(2) $\frac{7}{4}R$

(3) $\frac{3}{2}R$

(4) $\frac{5}{2}R$

Ans. (1)

QUESTION

The average kinetic energy of a monatomic molecule is 0.414 eV at temperature:
(Use $K_B = 1.38 \times 10^{-23}$ J/mol–K).

[27 Jan. 2024 - Shift 1]

1. 3000 K
2. 3200 K
3. 1600 K
4. 1500 K

Ans. (2)

QUESTION

The total kinetic energy of 1 mole of oxygen at 27°C is:
[Use universal gas constant (R) = 8.31 J/mole K]

[27 Jan. 2024 - Shift 2]

1. 6845.5 J $\frac{3}{2}KT$
2. 5942.0 J
3. 6232.5 J
4. 5670.5 J

Ans. (3)

QUESTION

$C_V = fR/2$

N moles of a polyatomic gas ($f = 6$) must be mixed with two moles of a monoatomic gas so that the mixture behaves as a diatomic gas. The value of N is: **[29 Jan. 2024 - Shift 2]**

$$(C_V)_{mix} = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2}$$

$$\frac{5\cancel{R}}{2} = \frac{n\frac{6\cancel{R}}{2} + 2 \times \frac{3\cancel{R}}{2}}{n+2}$$

$$\frac{5}{2} = \frac{3n+3}{n+2}$$

$5n + 10 = 6n + 6$

$n = 4$

(1) 6

(2) 3

(3) 4

(4) 2

Ans. (3)

QUESTION

At which temperature the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47°C?

[30 Jan. 2024 - Shift 1]

$$v = \sqrt{\frac{3RT}{m}}$$

(1) 80 K

(2) –73 K

(3) 4 K

(4) 20 K

Ans. (4)

QUESTION

If three moles of monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with two moles of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of adiabatic exponent γ for the mixture is: **[30 Jan. 2024 - Shift 2]**

$\gamma =$ ✓

(1) 1.75

(2) 1.40

(3) 1.52

(4) 1.35

Ans. (3)

Question

The root mean square velocity of molecules of gas is (25 January 2023 - Shift 1)

$\sqrt{\frac{3RT}{m}}$

1. Proportional to square of temperature (T^2).
2. Inversely proportional to square root of temperature $\sqrt{\frac{1}{T}}$.
3. Proportional to square root of temperature $\sqrt{T}$.
4. Proportional to temperature (T).

Ans : (3)

Question

The average kinetic energy of a molecule of the gas is. (01 February 2023 - Shift 1)

1. proportional to absolute temperature
2. proportional to volume
3. proportional to pressure
4. dependent on the nature of the gas

Ans : (1)

Question

Match List I with List II .

(10 April 2023 - Shift 1)

List I		List II	
A.	3 Translational degrees of freedom	I.	Monoatomic gases
B.	3 Translational, 2 rotational degrees of freedoms	II.	Polyatomic gases
C.	3 Translational, 2 rotational and 1 vibrational degrees of freedom	III.	Rigid diatomic gases
D.	3 Translational, 3 rotational and more than one vibrational degrees of freedom	IV.	Nonrigid diatomic gases

Choose the correct answer from the options given below:

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

Ans : (1)

Question

A gas mixture consists of 2 moles of oxygen and 4 moles of neon at temperature T. Neglecting all vibrational modes, the total internal energy of the system will be:

(10 April 2023 - Shift 2)

1. 11RT
2. 8RT
3. 4RT
4. 16RT

$$\frac{2 \times 5 \times R \times T}{2} + \frac{4 \times 3 \times R \times T}{2}$$

Ans : (1)

Question

Three vessels of equal volume contain gases at the same temperature and pressure. The first vessel contains neon (monoatomic), the second contains chlorine (diatomic) and third contains uranium hexafluoride (polyatomic). Arrange these on the basis of their root mean square speed (v_{rms}) and choose the correct answer from the options given below: (11 April 2023 - Shift 1)

$$V = \sqrt{\frac{3RT}{m}}$$

$m \uparrow \; V_{rms} \downarrow$

(1) $v_{rms}(\text{mono}) > v_{rms}(\text{dia}) > v_{rms}(\text{poly})$

(2) $v_{rms}(\text{mono}) = v_{rms}(\text{dia}) = v_{rms}(\text{poly})$

(3) $v_{rms}(\text{mono}) < v_{rms}(\text{dia}) < v_{rms}(\text{poly})$

(4) $v_{rms}(\text{dia}) < v_{rms}(\text{poly}) < v_{rms}(\text{mono})$

Ans : (1)

Question

The rms speed of oxygen molecule in a vessel at particular temperature is $\left(1+\frac{5}{x}\right)^{\frac{1}{2}}$ v, when v is the average speed of the molecule. The value of x will be: (take $\pi = \frac{22}{7}$)

(13 April 2023 - Shift 1)

$$V_{rms} = \sqrt{\frac{3RT}{m}}$$

$$V = \sqrt{\frac{8}{\pi}\frac{RT}{m}}$$

$$\left(1+\frac{5}{x}\right)^{\frac{1}{2}} \cdot \sqrt{\left(\frac{8}{\pi}\frac{RT}{m}\right)} = \sqrt{\frac{3RT}{m}}$$

$$\left(1+\frac{5}{x}\right)\frac{8}{\pi} = 3$$

(1) 27

(2) 8

(3) 28

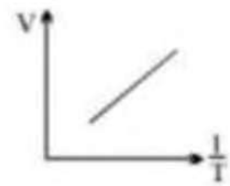
(4) 4

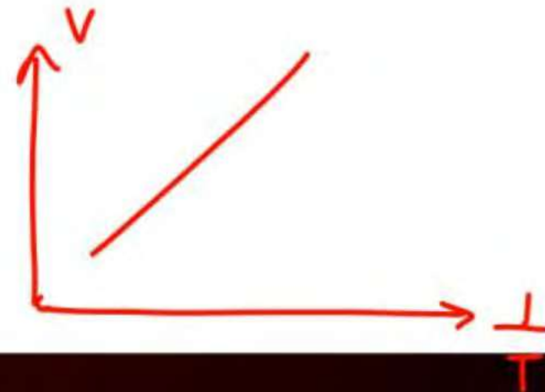
Ans : (3)

14. One mole of an ideal monoatomic gas undergoes a process as shown in the figure. Find the molar specific heat of the gas in the process.

एकपरमाण्विक आदर्श गैस के एक मोल को चित्र में प्रदर्शित प्रक्रम से गुजारा जाता है। इस प्रक्रम में गैस की मोलर विशिष्ट ऊष्मा की गणना कीजिए।

$PV^x = \text{Const}$





Ans. R/2

$$PV^2 = \text{const}$$

$$PV^x = \text{Con}$$

$$C = C_v + \frac{R}{1-x}$$

$$= \frac{3R}{2} + \frac{R}{1-2}$$

$$= R/2$$

$$y = mx$$

$$V = m\frac{1}{T}$$

$$TV = \text{const}$$

$$\frac{PV}{nR}\cdot V = \text{const}$$

13. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state A to B via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the latter case ? (Take 1 cal = 4.19 J)

किसी गैस की अवस्था को रूद्धोष्म रूप से साम्यावस्था स्थिति A से अन्य साम्यावस्था स्थिति B तक परिवर्तित करने के लिये निकाय पर 22.3 J कार्य करना पड़ता है। यदि गैस को अवस्था A से B तक एक ऐसे प्रक्रम द्वारा ले जाया जाये जिसमें निकाय द्वारा कुल अवशोषित ऊष्मा 9.35 cal हो तो इस स्थिति में निकाय द्वारा किया गया कुल कार्य होगा? (1 cal = 4.19 J)

Ans. 16.9 J

$\Delta Q = \Delta U + \Delta W$

$0 = \Delta U - 22.3$

$\Delta Q = 0$

$\Delta W = -22.3\ J$

$\Delta U = 22.3\ J$

$A \longrightarrow B$

$A \longrightarrow B$

$\Delta Q = +9.35\ cal$

$\Delta Q = \Delta U + \Delta W$

$4.2 \times 9.35 = 22.3 + \Delta W$

22. C_p and C_v are specific heats at constant pressure and constant volume respectively. It is observed that

$C_p - C_v = a$ for hydrogen gas $a = R/2$

$C_p - C_v = b$ for nitrogen gas $b = R/28$

$C_p - C_v = R$

$C_p - C_v = R/m$

The correct relation between a and b is :

स्थिर दाब तथा स्थिर आयतन पर विशिष्ट ऊष्मायें क्रमशः C_p तथा C_v है। पाया जाता है कि

हाइड्रोजन गैस के लिये $C_p - C_v = a$

नाइट्रोजन गैस के लिये $C_p - C_v = b$

a और b के बीच का सही सम्बन्ध होगा : [JEE-Main 2017]

(1) $a = 14\ b$ (2) $a = 28\ b$ (3) $a = \frac{1}{14} b$ (4) $a = b$

Ans. (1)

10. One mole of a monatomic ideal gas undergoes a cyclic process as shown in the figure (whre V is the volume and T is the temperature). Which of the statements below is (are) true ?

एकपरमाण्विक आदर्श गैस (monatomic ideal gas) का एक मोल चित्र में दर्शाये गये चक्रीय प्रक्रम (cyclic process) से गुजरता है (जहाँ V आयतन है तथा T तापमान है)। निम्नलिखित कथनों में से कौन सा (से) सही है (हैं) ?

[JEE-Advance 2018]

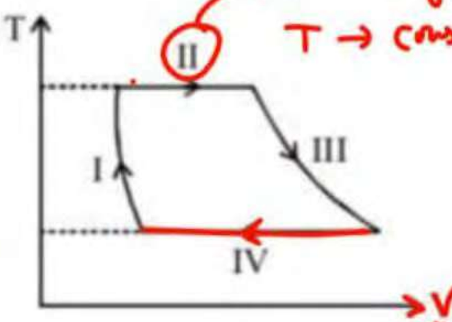
T

V↑ $w_g > 0$

T → const $\Delta U = 0$

$\Delta U = 0$

V↓ $w_g < 0$



(A) Process I is an isochoric process

(B) In process II, gas absorbs heat

(C) In process IV, gas releases heat

(D) Processes I and II are not isobaric

(A) प्रक्रम I एक समाआयतनिक (isochoric) प्रक्रम है

(B) प्रक्रम II में गैस ऊष्मा को अवशोषित (absorb) करती है

(C) प्रक्रम IV में गैस ऊष्मा को निष्कासित (release) करती है

(D) प्रक्रम I और प्रक्रम III समदाबीय (isobaric) नहीं हैं

Ans. **(B,C,D)**

11. One mole of a monatomic ideal gas undergoes an adiabatic expansion in which its volume becomes eight times its initial value. If the initial temperature of the gas is 100 K and the universal gas constant $R = 8.0\ J\ mol^{-1}\ K^{-1}$, the decrease in its internal energy, in Joule, is............ .

एकपरमाण्विक आदर्श गैस (monatomic ideal gas) के एक मोल का आयतन (volume), रूद्धोष्म प्रसार (adiabatic expansion) से, अपने आरम्भिक मान का आठ गुना बढ़ जाता है। सार्वत्रिक गैस नियतांक (universal gas constant) R का मान $8.0\ J\ mol^{-1}\ K^{-1}$ लें। यदि गैस का आरम्भिक तापमान 100 K हो, तो इस प्रक्रिया में गैस की आन्तरिक ऊर्जा (internal energy) .... जूल (Joule) से कम हो जाती है। **[JEE-Advance 2018]**

Ans. 900 [899.95, 900.05]

$V \longrightarrow 8V$

$T_i = 100\,K \longrightarrow T_f$

$\Delta U = \dfrac{nfR(T_f - 100)}{2}$

$TV^{\gamma-1} = \text{Const}$

$\gamma = 1 + \frac{2}{f}$

$100\, V^{5/3-1} = T_f (8V)^{5/3-1}$

$\gamma = 1 + \frac{2}{3}$

$\gamma = 5/3$

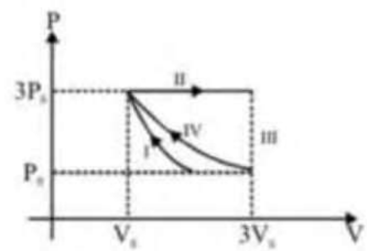
$100\, V^{2/3} = T_f (2^3)^{2/3}$

$T_f = 25$

12. One mole of a monatomic ideal gas undergoes four thermodynamic processes as shown schematically in the PV-diagram below. Among these four processes, one is isobaric, one is isochoric, one is isothermal and one is adiabatic. Match the processes mentioned in List-I with the corresponding statements in List–II.

एकपरमाण्विक आदर्श गैस (monatomic ideal gas) का एक मोल (one mole), चार ऊष्मागतीय प्रक्रमों (thermodynamics processes) से गुजरता है, जैसा कि नीचे PV-व्यवस्था चित्र (schematic diagram) में दर्शाया गया है। यहाँ दिए गये प्रक्रमों में एक समदाबीय (isobaric), एक समआयतनिक (isochoric), एक समतापीय (isothermal) और एक रूद्धोष्म (adiabatic) हैं। सूची-I में दिए गए प्रक्रमों का सूची–II में दिए गए संगत कथनों से सुमेल करें।

[JEE-Advance 2018]



List–I		List–II	
P.	In process I	1.	Work done by the gas is zero
Q.	In process II	2.	Temperature of the gas remains unchanged
R.	In process III	3.	No heat is exchanged between the gas and its surroundings
S.	In process IV	4.	Work done by the gas is $6\,P_0V_0$

सूची–I		सूची–II	
P.	प्रक्रम I में	1.	गैस द्वारा किया गया कार्य शून्य है
Q.	प्रक्रम II में	2.	गैस का तापमान नहीं बदलता है
R.	प्रक्रम III में	3.	गैस और परिवेश के बीच ऊष्मा प्रवाह नहीं होता है
S.	प्रक्रम IV में	4.	गैस द्वारा किया गया कार्य $6\,P_0V_0$ है

(A) $P \to 4$; $Q \to 3$; $R \to 1$; $S \to 2$

(B) $P \to 1$; $Q \to 3$; $R \to 2$; $S \to 4$

(C) $P \to 3$; $Q \to 4$; $R \to 1$; $S \to 2$

(D) $P \to 3$; $Q \to 4$; $R \to 2$; $S \to 1$

Ans. (C)

1. *A sample of an ideal gas is taken through the cyclic process abca (figure 26-W1). It absorbs* 50 J *of heat during the part ab, no heat during bc and rejects* 70 J *of heat during ca.* 40 J *of work is done on the gas during the part bc. (a) Find the internal energy of the gas at b and c if it is* 1500 J *at a. (b) Calculate the work done by the gas during the part ca.*

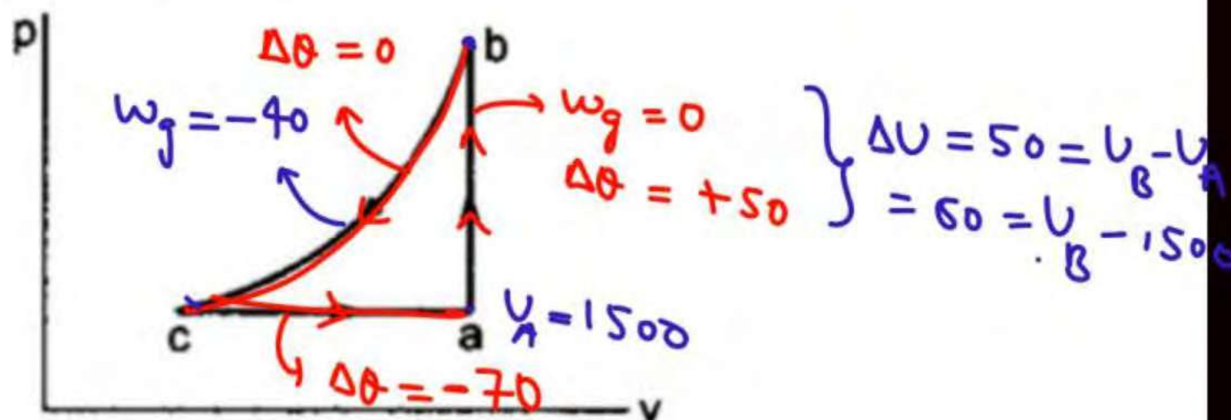


Figure 26-W1

P 17. Consider the cyclic process *ABCA*, shown in figure (26-E9), performed on a sample of 2·0 mol of an ideal gas. A total of 1200 J of heat is withdrawn from the sample in the process. Find the work done by the gas during the part *BC*.

$\Delta Q_{net} = \Delta U_{net} + \Delta W_{net}$

$-1200 = 0 + W_{AB} + W_{BC} + W_{CA}$

$-1200 = 2R\,200 + W_{BC} + 0$

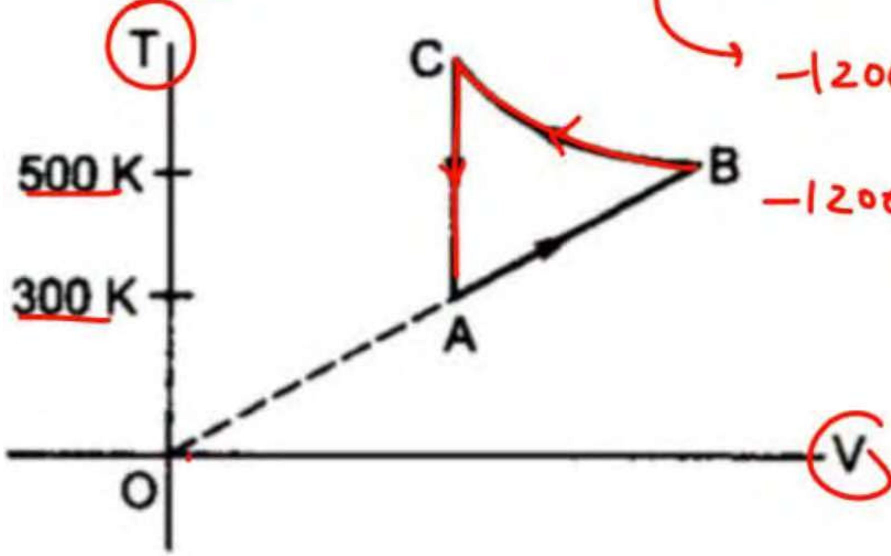


Figure 26-E9

$$\eta = \frac{(WD)_{net}}{Q_{+}}$$

QUESTION

Calculate the value of mean free path (λ) for oxygen molecules at temperature 27°C and pressure 1.01×10^5 Pa. Assume the molecular diameter 0.3 nm and the gas is ideal. ($k = 1.38 \times 10^{-23}$ JK^{-1}) **(JEE Main - 2021)**

(1) 58 nm

(2) 32 nm

(3) 86 nm

(4) 102 nm

P = ✓
K = ✓
d = ✓
T = ✓

$$\frac{KT}{\sqrt{2}\pi d^2 P}$$

Ans : (4)

Fluid

* Imp Ques & formula

Dynamics

* 

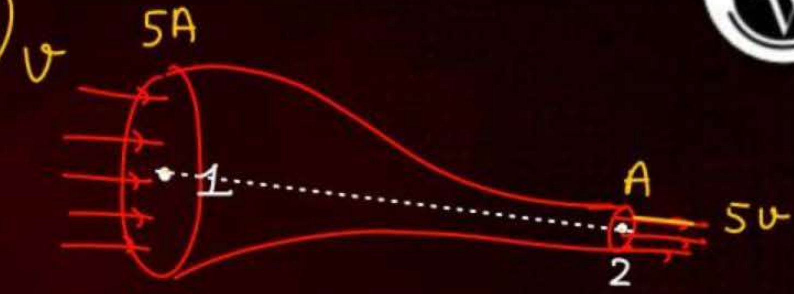
* $A_1 V_1 = A_2 V_2$

* $P + \frac{1}{2}\rho v^2 + \rho g h = \text{const}$

* $\frac{dm}{dt}$ = Rate of flow of mass $= \rho A v$

* $\frac{d(\text{Vol}^n)}{dt} = A v$

1



$P_1 - P_2 = ?$

$P_1 + 0 + \frac{1}{2}\rho v_1^2 = P_2 + 0 + \frac{1}{2}\rho v_2^2$

$P_1 - P_2 = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right)$

(2) पानी की धार

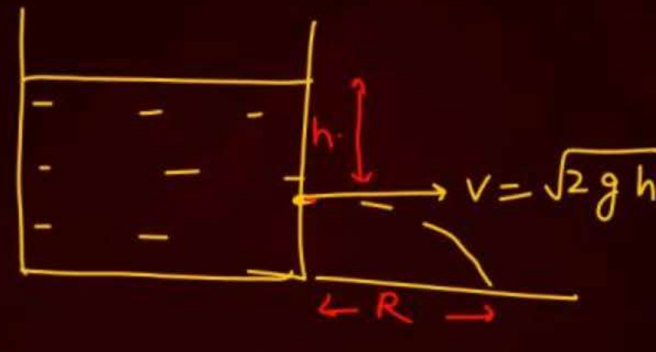
$A_1V_1 = A_2V_2$

$\frac{dVol^n}{dt} = A_1V_1$

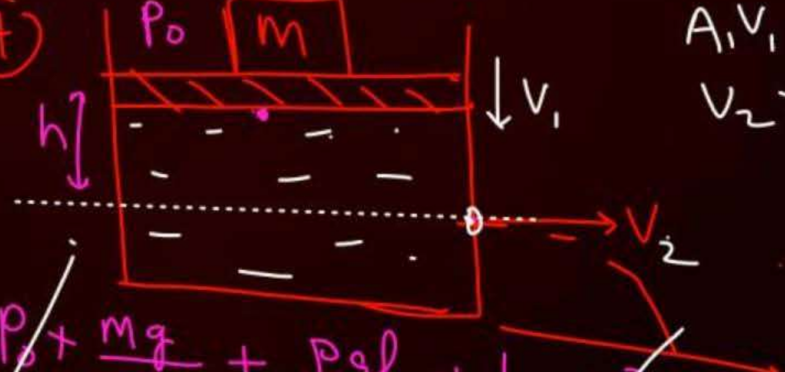
$= A_2V_2$

$$\boxed{V_2^2 = V_1^2 + 2gh}$$

(3)



(4)



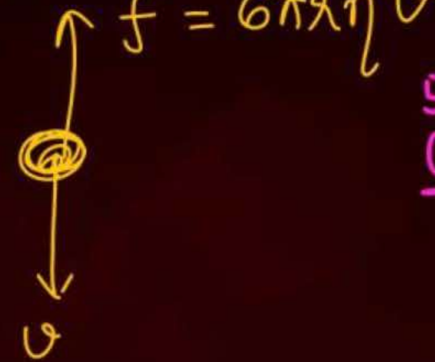
$A_1V_1 = A_2V_2$ — (1)

$V_2 >> V_1$

$$\cancel{P_0} + \frac{mg}{A_{\text{सतह}}} + \rho gh + \frac{1}{2}\rho \cancel{V_1^2} = \cancel{P_0} + 0 + \frac{1}{2}\rho V_2^2$$

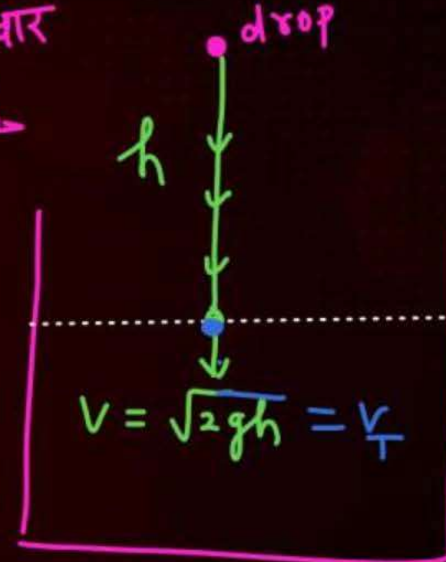
0

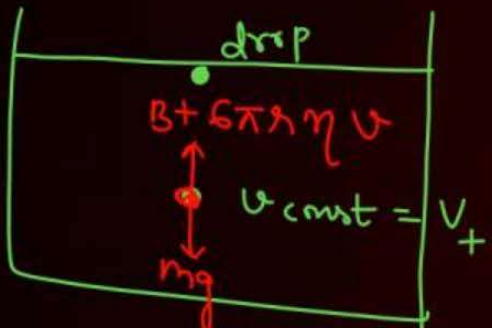
(4) $F = 6\pi r \eta v$



5 बार

Q

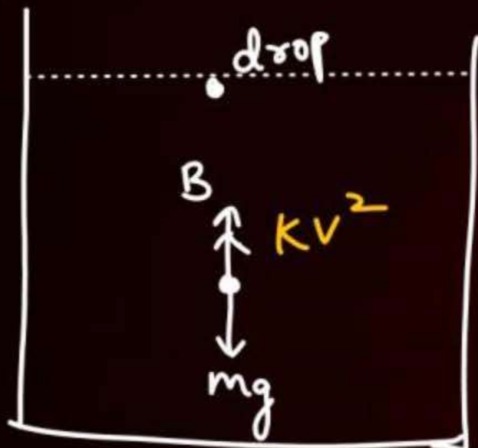




$$mg = B + 6\pi r \eta v$$

$$v = \frac{mg - B}{6\pi r \eta} = \frac{2}{9}\frac{r^2(\rho_s - \rho_L)g}{\eta}$$

(6)

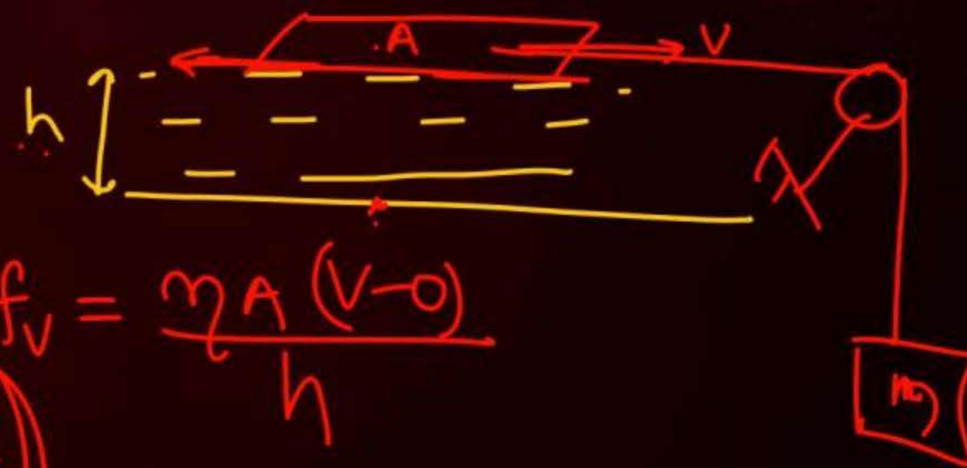


$$f_v = KV^2$$

$$mg = B + Kv^2$$

$$V = \sqrt{\frac{mg - B}{K}}$$

(7) $$f_v = \eta A \frac{\Delta V}{h}$$



$$f_v = \frac{\eta A (V-0)}{h}$$

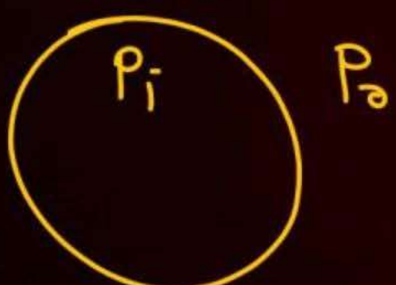
$$\frac{f}{A} = \frac{\eta V}{h} \equiv \text{shear stress}$$

8 Surface ten

$$F = S \cdot l$$

$$S.E = S \cdot A$$

soap bubble

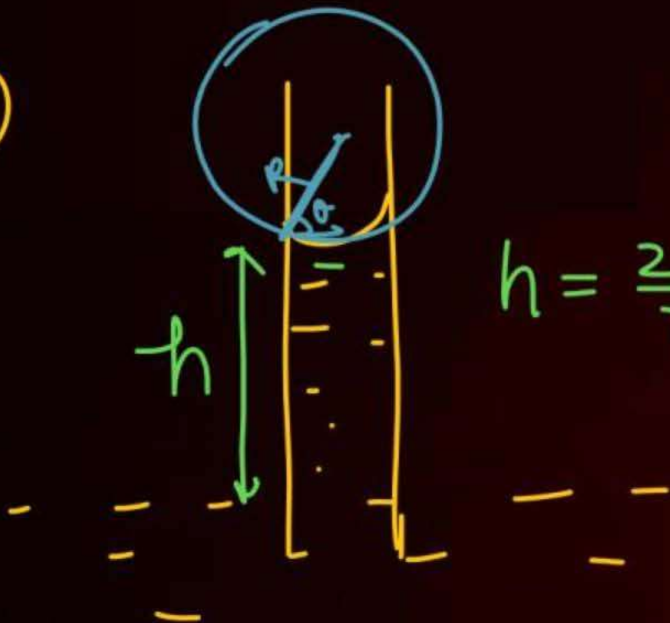


$$\Delta P = \frac{4S}{R}$$

liq droop

$$P_i - P_o = \frac{2S}{R}$$

(9)

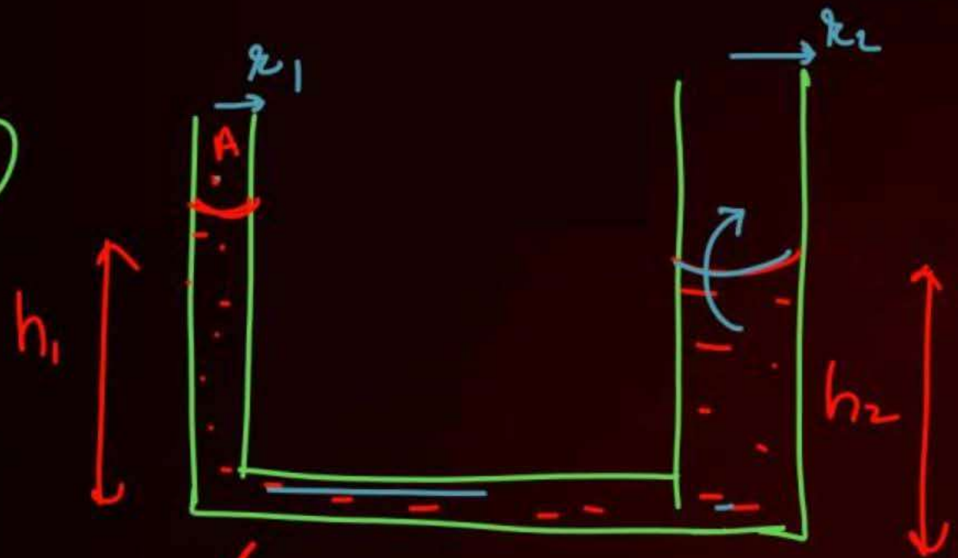


$$h = \frac{2S\cos\theta}{r\rho g} = \frac{2S}{R\rho g}$$

$$R = \frac{r}{\cos\theta}$$

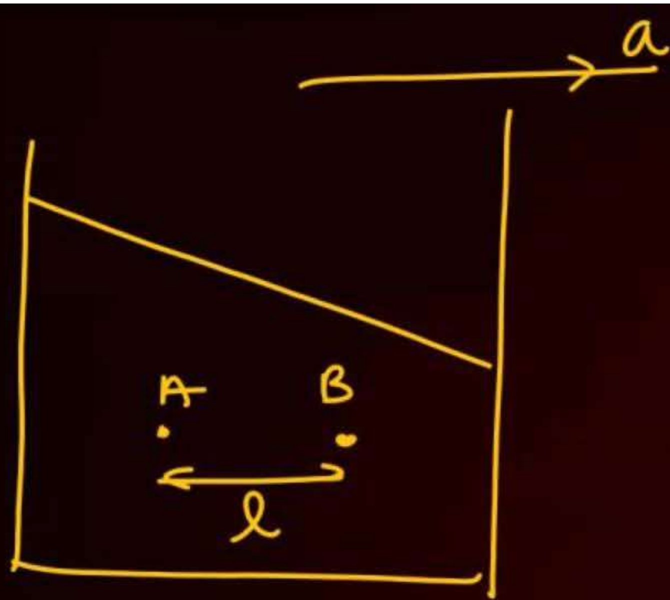
$$r = R\cos\theta$$

10

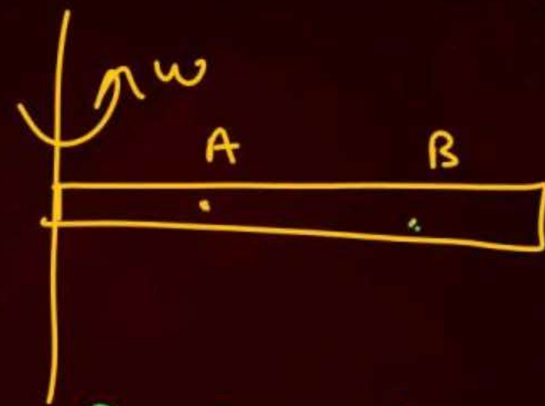


$$\cancel{P_0} + \frac{2S\cos\theta}{r_1} + \rho g h_1 + 0 - \rho g h_2 + \frac{2S\cos\theta}{r_2} = \cancel{P_0}$$

11

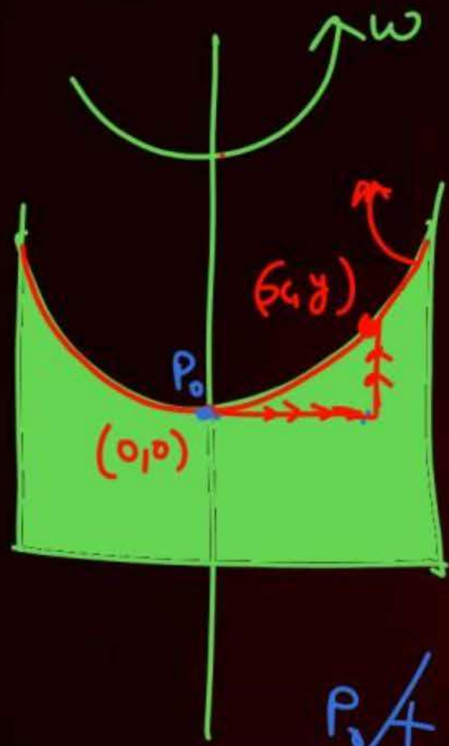


$$P_A - P_B = \rho a l$$



$$P_B - P_A = \frac{1}{2}\rho\omega^2\left(r_2^2 - r_1^2\right)$$

(12)

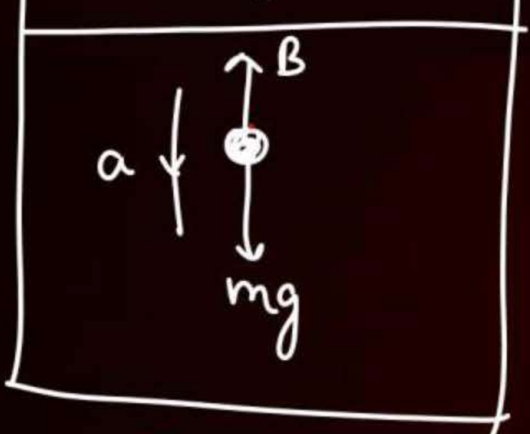


(B)

(13) $B = \rho_L V_d g$

$$\cancel{P_0} + \frac{1}{2}\rho\omega^2(x^2 - 0) - \rho g y = \cancel{P_0}$$

(13) $\rho_{body} > \rho_l$

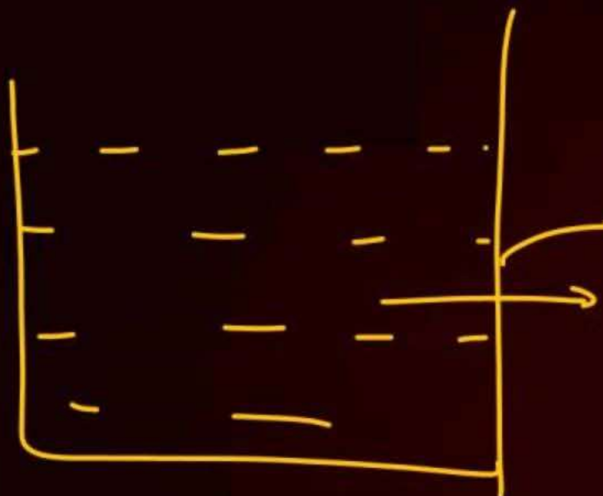


simple $T = 2\pi\sqrt{\frac{l}{g}}$

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$g_{eff} = \frac{mg - B}{m}$$

$$a = \frac{mg - B}{m} = \frac{\rho_b V g - \rho_L V g}{\rho_b V} = \left(1 - \frac{\rho_L}{\rho_b}\right) g$$



$$F = \left(\rho g \frac{h}{2} + P_0\right) \text{Area of wall.}$$

QUESTION

An ideal fluid flows (laminar flow) through a pipe of non-uniform diameter. The maximum and minimum diameters of the pipes are 6.4 cm and 4.8 cm, respectively. The ratio of the minimum and the maximum velocities of fluid in this pipe is:

(JEE Mains 2020)

1. $\frac{\sqrt{3}}{2}$
2. $\frac{3}{4}$
3. $\frac{81}{256}$
4. $\frac{9}{16}$

$A_1 V_1 = A_2 V_2$

$\frac{r_1^2}{r_2^2} = \frac{A_1}{A_2} = \frac{V_2}{V_1}$

Ans. (4)

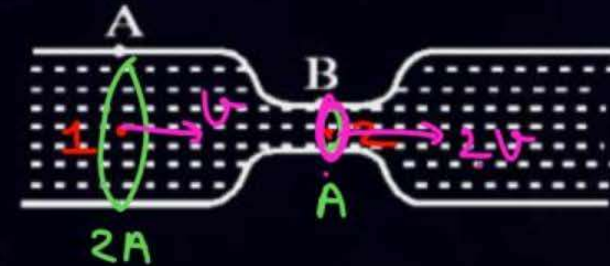
QUESTION

Water flows in a horizontal tube (see figure). The pressure of water changes by $700 \mathrm{Nm}^{-2}$ between A and B where the area of cross section are $40\ \mathrm{cm}^2$ and $20\ \mathrm{cm}^2$, respectively. Find the rate of flow of water through the tube. $= \dfrac{d\,\mathrm{Vol}^n}{dt} = A \times 2v = \checkmark$ (density of water $= 1000 \mathrm{kgm}^{-3}$). **(JEE Mains 2020)**

$$P_1 - P_2 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

$$700 = 500\left((2v)^2 - v^2\right)$$

$$\boxed{v = \checkmark}$$



1. $1810\ \mathrm{cm}^3/\mathrm{s}$
2. $3020\ \mathrm{cm}^3/\mathrm{s}$
3. $2720\ \mathrm{cm}^3/\mathrm{s}$
4. $2420\ \mathrm{cm}^3/\mathrm{s}$

Ans. (3)

QUESTION

A small spherical droplet of density d is floating exactly half immersed in a liquid of density ρ and surface tension T. The radius of the droplet is: (take note that the surface tension applies an upward force on the droplet).

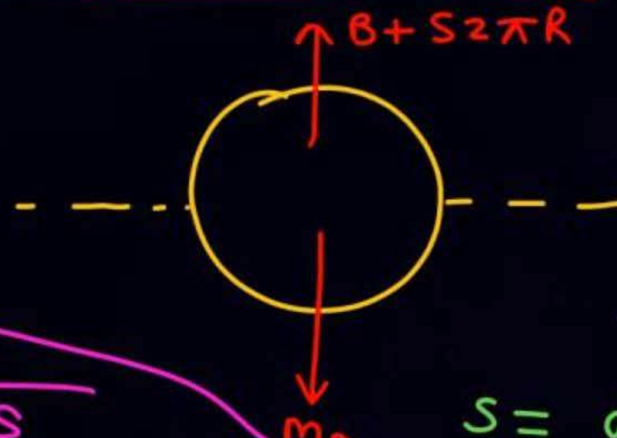
(JEE Mains 2020)

(1) $r = \sqrt{\dfrac{2T}{3(d+\rho)g}}$ ✗

(2) $r = \sqrt{\dfrac{3T}{(2d-\rho)g}}$ ✓

(3) $r = \sqrt{\dfrac{T}{(d-\rho)g}}$

(4) $r = \sqrt{\dfrac{T}{(d+\rho)g}}$



$$B + S2\pi R = mg$$

$$\rho \frac{2}{3}\pi R^3 g + S2\pi R = d\,\frac{4}{3}\pi R^3 g$$

$$\frac{\rho R^2 g}{3} + S = d\,\frac{2}{3}R^2 g$$

$$S = d\,\frac{2}{3}R^2 g - \rho\frac{R^2}{3}g$$

$$3S = R^2(2d-\rho)g$$

$$\sqrt{\frac{3S}{g(2d-\rho)}} = R$$

Ans. (2)

QUESTION

A cylindrical vessel containing a liquid is rotated about its axis so that the liquid rises at its sides as shown in the figure. The radius of vessel is 5 cm and the angular speed of rotation is ω rad s^{-1}. The difference in the height, h(in cm) of liquid at the centre of vessel and at the side will be:

(JEE Mains 2020)

(1) $\frac{25\omega^2}{2g}$

(2) $\frac{2\omega^2}{5g}$

(3) $\frac{5\omega^2}{2g}$

(4) $\frac{2\omega^2}{25g}$

Ans. (1)

QUESTION

Pressure inside two soap bubbles are 1.01 and 1.02 atmosphere, respectively. The ratio of their volumes is:

(JEE Mains 2020)

(1) 8 : 1

(2) 0.8 : 1

(3) 2 : 1

(4) 4 : 1

$$P_i = P_0 + \frac{4S}{R}$$

$$1.01 = 1 + \frac{4S}{R_1}$$

$$\frac{4S}{R_1} = .01$$

$$\frac{4S}{R_2} = .02$$

$$\frac{R_1}{R_2} = 2$$

$$V = \frac{4}{3}\pi R^3$$

Ans. (1)

QUESTION

When a long glass capillary tube of radius 0.015 cm is dipped in a liquid, the liquid rises to a height of 15 cm within it. If the contact angle between the liquid and glass to close to 0°, the surface tension of the liquid, in milli Newton m^{-1}, is [$\rho_{(liquid)} = 900 \text{ kg m}^{-3}$, $g = 10 \text{ ms}^{-2}$] (Give answer in closest integer) ______.

(JEE Mains 2020)

$$h = \frac{2S\cos\theta}{r\rho g}$$

Ans. 101

QUESTION

A hollow spherical shell at outer radius R floats just submerged under the water surface. The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t. water, the value of r is: (JEE Mains 2020)

$$B = mg$$

$$\frac{4}{3}\pi R^3 \rho_L g = \rho_m \frac{4}{3}\pi (R^3 - r^3) g$$

(1) $\frac{4}{9}R$

(2) $\frac{8}{9}R$

(3) $\frac{1}{3}R$

(4) $\frac{2}{3}R$

Ans. (2)

QUESTION

In an experiment to verify Stokes law, a small spherical ball of radius r and density ρ falls under gravity through a distance h in air before entering a tank of water. If the terminal velocity of the ball inside water is same as its velocity just before entering the water surface, then the value of h is proportional to: (ignore viscosity of air).

(JEE Mains 2020)

$$v = \sqrt{2gh} = \frac{2}{9}\frac{r^2 g(\rho_1 - \rho_2)}{\eta}$$

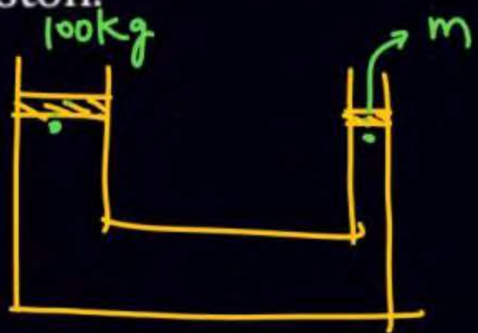
1. r
2. r^4
3. r^3
4. r^2

Ans. (2)

QUESTION

A hydraulic press can lift 100 kg when a mass 'm' is placed on the smaller piston. It can lift ______ kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.

(JEE Mains 2021)



$$\frac{100}{A_1} = \frac{m}{A_2}$$

$$\frac{m_1 g}{A_1} = \frac{m_2 g}{A_2}$$

$$\frac{m'}{16A_1} = \frac{m}{A_2/16}$$

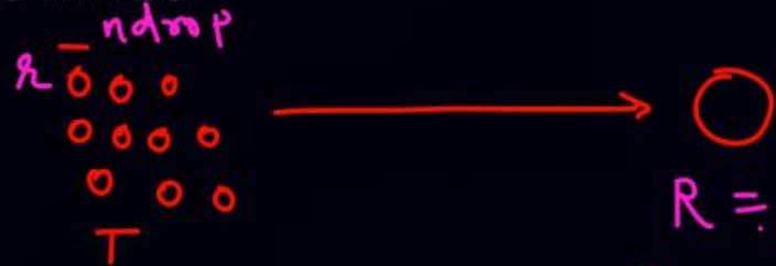
Ans. 25600

QUESTION

$W = JQ$

A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be:

(JEE Mains 2021)



(1) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

(2) $\frac{2T}{rJ}$

(3) $\frac{3T}{rJ}$

(4) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

$R = n^{\frac{1}{3}} r$

$(S.E)_i = S n 4\pi r^2$

$(SE)_f = S \times 4\pi R^2$

$\Delta(SE) = S \cdot 4\pi n^{2/3} r^2 - n 4\pi r^2 \cdot S = ms\Delta T$

$Q = \frac{W}{J} =$

Ans. (4)

QUESTION

When two soap bubbles of radii a and b (b > a) coalesce, the radius of curvature of common surface is:

(JEE Mains 2021)

(1) $\frac{ab}{b-a}$

(2) $\frac{a+b}{ab}$

(3) $\frac{b-a}{ab}$

(4) $\frac{ab}{a+b}$

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

$$r_{eq} = \frac{r_1 r_2}{r_1 - r_2}$$

Ans. (1)

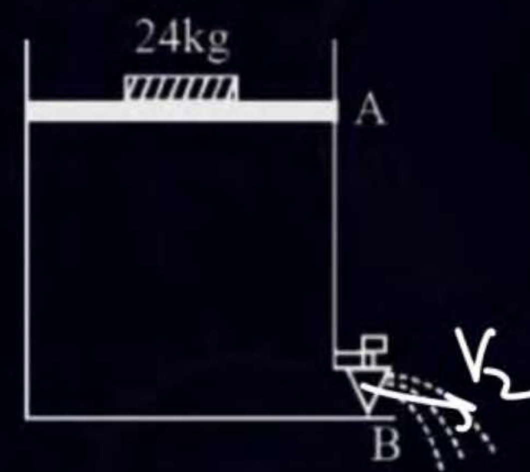
QUESTION

Consider a water tank as shown in the figure. It's cross-sectional area is $0.4\,m^2$. The tank has an opening B near the bottom whose cross-section area is $1\,cm^2$. A load of 24 kg is applied on the water at the top when the height of the water level is 40 cm above the bottom, the velocity of water coming out the opening B is $v\,ms^{-1}$. The value of v, to the nearest integer, is.

[Take value of g to be $10\,ms^{-2}$].

(JEE Mains 2021)

$$\frac{240}{A} + \rho g h = \frac{1}{2}\rho v_2^2$$



Ans. 3

QUESTION

Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is: **(JEE Mains 2021)**

(1) $2^{\frac{1}{2}} : 1$

(2) $1 : 2^{\frac{1}{3}}$

(3) $2 : 1$

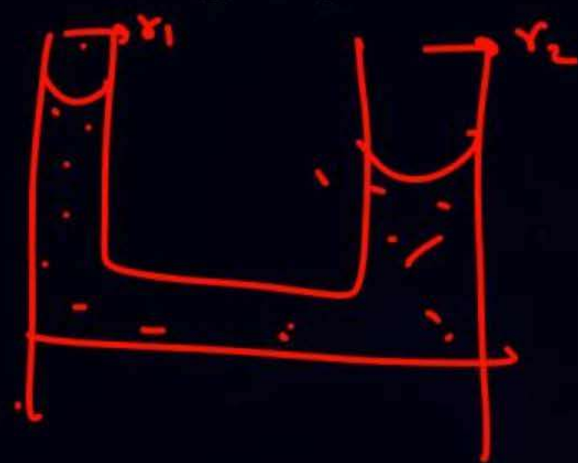
(4) $1 : 2$

Ans. (1)

QUESTION

Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.

[Take surface tension of water $T = 7.3 \times 10^{-2}\ \mathrm{Nm^{-1}}$, angle of contact = 0, $g = 10\ \mathrm{ms^{-2}}$ and density of water $= 1.0 \times 10^{3}\ \mathrm{kg\ m^{-3}}$]. **(JEE Mains 2021)**



(1) 3.62 mm

(2) 2.19 mm

(3) 5.34 mm

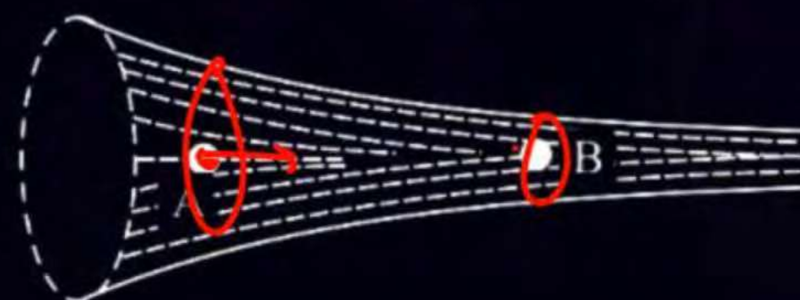
(4) 4.97 mm

Ans. (2)

QUESTION

The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross-section. Cross-sectional areas at A is 1.5 cm^2, and B is 25 mm^2, if the speed of liquid at B is 60 cm s^{-1} then $(P_A - P_B)$ is ______.
(Given P_A and P_B are liquid pressures at A and B points. Density $\rho = 1000$ kg m^{-3} A and B are on the axis of tube).

(13 April 2023 - Shift 1)



(1) 135 Pa

(2) 27 Pa

(3) 175 Pa

(4) 36 Pa

Ans. (3)

QUESTION

In a test experiment on a model aeroplane in wind tunnel, the flow speeds on the upper and lower surfaces of the wings are 70 ms^{-1} and 65 ms^{-1} respectively. If the wing area is 2 m^2 the lift of the wing is _____ N.
(Given density of air = 1.2 kg m^{-3})

(29 Jan. 2024 - Shift 1)

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$A(P_1 - P_2) = \frac{1}{2}\rho(v_2^2 - v_1^2) \times A = mg$$

$$\cancel{\frac{1}{2}} \times 1.2 \times \cancel{2} \times (70^2 - 65^2) = \checkmark$$

Ans. (810)

QUESTION

Rm

Given below are two statements:

Statement (I) : Viscosity of gases is greater than that of liquids.

Statement (II) : Surface tension of a liquid decreases due to the presence of insoluble impurities.

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

(27 Jan. 2024 - Shift 1)

1. Statement I is correct but statement II is incorrect
2. Statement I is incorrect but Statement II is correct
3. Both Statement I and Statement II are incorrect
4. Both Statement I and Statement II are correct

Ans. (2)

QUESTION

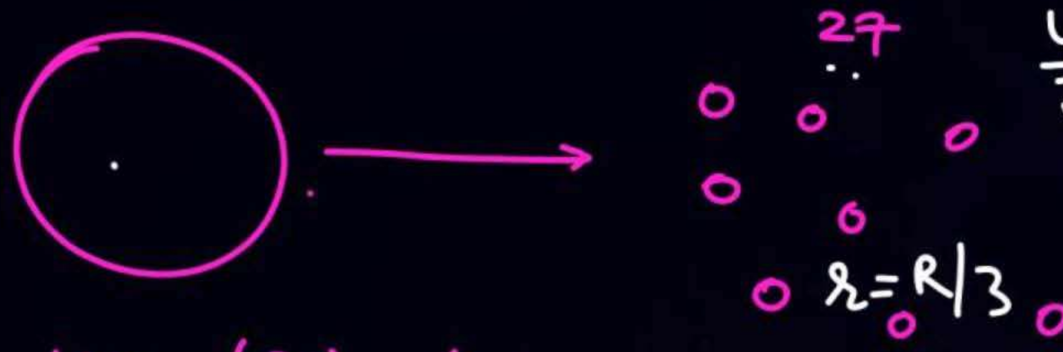
A small liquid drop of radius is divided into 27 identical liquid drops. If the surface tension is T, then the work done in the process will be: **(29 Jan. 2024 - Shift 2)**

(1) $8\pi R^2T$

(2) $3\pi R^2T$

(3) $\frac{1}{8}\pi R^2T$

(4) $4\pi R^2T$



$$\frac{4}{3}\pi R^3 = 27 \times \frac{4}{3}\pi r^3$$

$$R = 3r$$

$$WD = (S.E)_f - (S.E)_i$$

$$= S \times 4\pi r^2 \times n - S \times 4\pi R^2$$

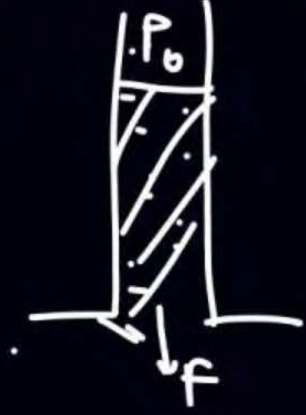
$$= S\,4\pi \frac{R^2}{9} \times 27 - S \times 4\pi R^2$$

Ans. (1)

QUESTION

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 $= 10^5 \mathrm{Nm}^{-2}$,

density of mercury $= 1.36 \times 10^4 \mathrm{~kg~m}^{-3}, \mathrm{g} = 10 \mathrm{~m~s}^{-2}, \pi = \frac{22}{7}$)



$mg + P_0 A$

(04 Apr. 2024 - Shift 2)

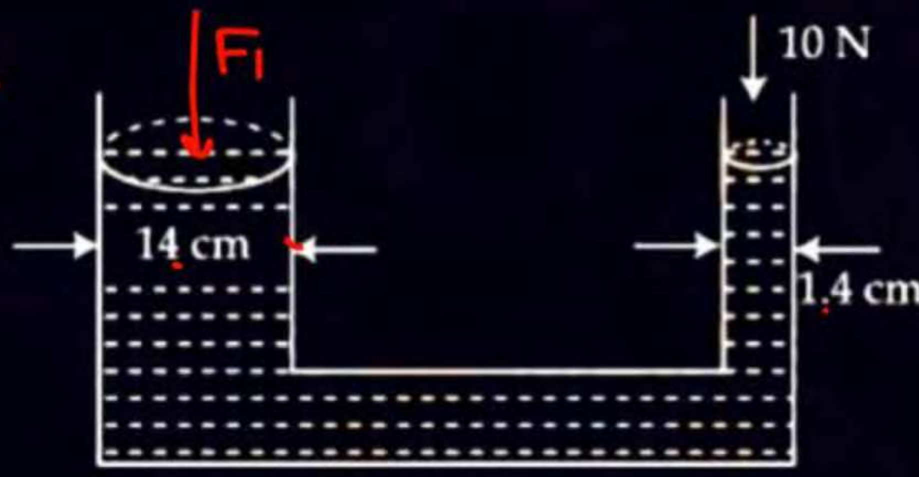
Ans. (177)

QUESTION

A hydraulic press containing water has two arms with diameters as mentioned in the figure. A force of 10 N is applied on the surface of water in the thinner arm. The force required to be applied on the surface of water in the thicker arm to maintain equilibrium of water is ______ N.

(05 Apr. 2024 - Shift 2)

$$\frac{F_1}{\pi r_1^2} = \frac{10}{\pi r_2^2}$$



Ans. (1000)

QUESTION

A big drop is formed by coalescing 1000 small droplets of water. The ratio of surface energy of 1000 droplets to that of energy of big drop is $10/x$. The value of x is ______

(06 Apr. 2024 - Shift 1)

Ans. (1)

QUESTION

Correct Bernoulli's equation is (symbols have their usual meaning):

(08 Apr. 2024 - Shift 1)

(1) $P + mgh + \frac{1}{2}mv^2 = \text{constant}$

(2) $\boxed{P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}}$

(3) $P + \rho gh + \rho v^2 = \text{constant}$

(4) $P + \frac{1}{2}\rho gh + \frac{1}{2}\rho v^2 = \text{constant}$

Ans. (2)

QUESTION

r $2R$

Small water droplets of radius 0.01 mm are formed in the upper atmosphere and falling with a terminal velocity of 10 cm/s. Due to condensation, if 8 such droplets are coalesced and formed a larger drop, the new terminal velocity will be _____ cm/s.

(08 Apr. 2024 - Shift 2)

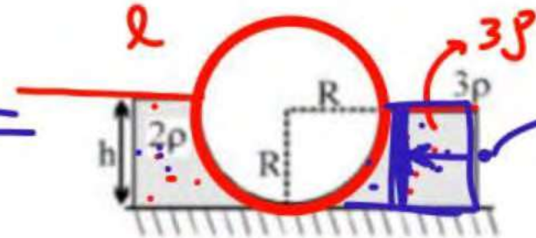
$$V_T = \frac{2}{9\eta} r^2 g (\rho_1 - \rho_2)$$

$$V_T \propto r^2$$

Ans. (40)

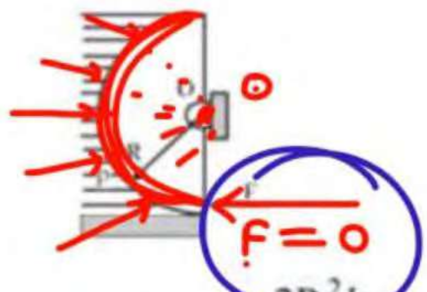
3. In the figure shown, the heavy cylinder (radius R) resting on a smooth surface separates two liquids of densities 2ρ and 3ρ. Find the height 'h' for the equilibrium of cylinder.

प्रदर्शित चित्र में R त्रिज्या का एक भारी बेलन, चिकनी सतह पर 2ρ व 3ρ घनत्व वाले दो द्रवों को पृथक-पृथक करता है। बेलन की साम्यावस्था के लिये ऊंचाई h ज्ञात कीजिये।

$2\rho g \frac{h}{2} h \ell =$  $3\rho g \frac{R}{2} \times R \times \ell$

Ans. $R\sqrt{\frac{3}{2}}$

2. A light semi cylindrical gate of radius R is pivoted at its mid point O, of the diameter as shown in the figure holding liquid of density ρ. The force F required to prevent the rotation of the gate is equal to
त्रिज्या R वाले एक हल्के अर्द्धबेलनाकार द्वार को इसके व्यास के मध्य बिन्दु O पर कीलकीत किया गया है। यह ρ घनत्व वाले द्रव को रोककर रखता है। द्वार को घूर्णन करने से रोकने के लिये आवश्यक बल F का मान होगा :-



(A) $2\pi R^3 \rho g$ (B) $2\rho g R^3 l$ (C) $\frac{2R^2 l \rho g}{3}$ (D) none of these

Ans. (D)

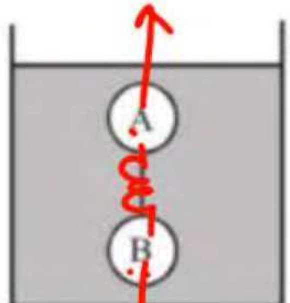
11. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into an equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if **[IIT-JEE-2011]**

समान आयतन परन्तु असमान घनत्वों d_A तथा d_B वाले दो ठोस गोले A व B एक धागे से जोड़े गये हैं। वे दोनों d_F घनत्व के एक द्रव में पूर्णतया डूबे हुए हैं। साम्यावस्था में वे दोनों चित्र में दिखाये अनुसार है और धागे में तनाव है। गेंदों को इस अवस्था में रहने के लिए जरूरी है कि

$\rho_L V.g$

$V\rho_A g$

T



$B + T = \rho_L V g + T$

$V\rho_B g$

$T = Kx$

(A) $d_A < d_F$ (B) $d_B > d_F$ (C) $d_A > d_F$ (D) $d_A + d_B = 2d_F$

Ans. (A,B,D)

13. A solid sphere of radius R and density ρ is attached to one end of a mass-less spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statement(s) is (are)
[IIT-JEE-2013]

(A) the net elongation of the spring is $\frac{4\pi R^3 \rho g}{3k}$

(B) the net elongation of the spring is $\frac{8\pi R^3 \rho g}{3k}$

(C) the light sphere is partially submerged.

(D) the light sphere is completely submerged.

एक त्रिज्या R व घनत्व ρ वाले ठोस गोलक को एक द्रव्यमान रहित स्प्रिंग के एक सिरे से जोड़ा गया हे। इस स्प्रिंग का बल नियतांक k है। स्प्रिंग के दूसरे सिरे को दूसरे ठोस गोलक से जोड़ा गया है जिसकी त्रिज्या R व घनतव 3ρ है। पूर्ण विन्यास को 2ρ घनतव के द्रव में रखा जाता है और इसको साम्यावस्था में पहुँचने दिया जाता है। सही प्रकथन है/हैं

[JEE-Advance-2013]

(A) स्प्रिंग की नेट दैर्ध्यवृद्धि $\frac{4\pi R^3 \rho g}{3k}$ है।

(B) स्प्रिंग की नेट दैर्ध्यवृद्धि $\frac{8\pi R^3 \rho g}{3k}$ है।

(C) हल्का गोलक आंशिक रूप से डूबा हुआ है।

(D) हल्का गोलक पूर्ण रूप से डूबा हुआ है।

Ans. (A, D)

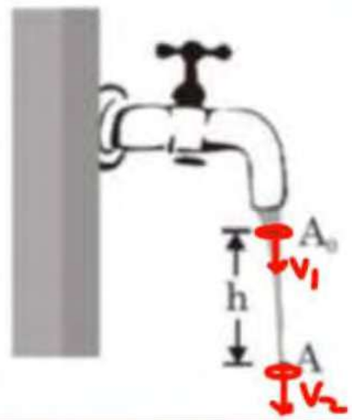
Figure shows how the stream of water emerging from a faucet "necks down" as it falls. The indicated cross-sectional areas are $A_0 = 1.2$ cm2 and $A = 0.35\ cm^2$. The two levels are separated by a vertical distance h = 45 mm. What is the volume flow rate from the tap?
The volume flow rate through the higher cross section must be the same as that through the lower cross section.

$$\frac{d\,vol^n}{dt} = A_2 v_2$$

$$V_2^2 = V_1^2 + 2gh$$

$$A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{A_2 V_2}{A_1}.$$



22. Consider a thin square plate floating on a viscous liquid in a large tank. The height h of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true ?**[JEE Advanced-2018]**

(A) The resistive force of liquid on the plate is inversely proportional to h

(B) The resistive force of liquid on the plate is independent of the area of the plate

(C) The tangential (shear) stress on the floor of the tank increases with u_0.

(D) The tangential (shear) stress on the plate varies linearly with the viscosity η of the liquid.

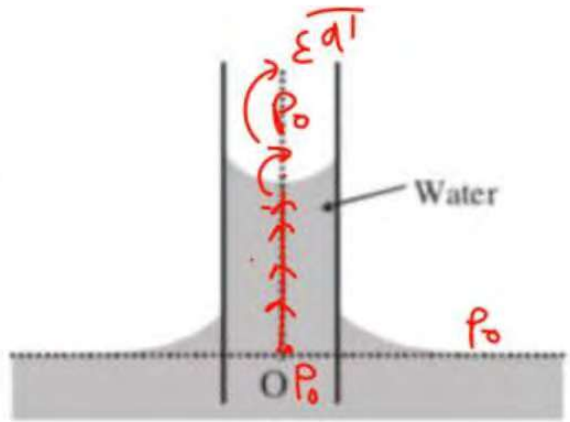
$$f_v = \eta A\left(\frac{v-0}{h}\right)$$

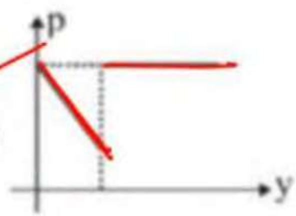
$$\frac{f}{A} = \frac{\eta v}{h}$$

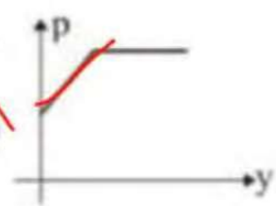
36. Water rises in a capillary as shown. The correct graph of pressure (p) vs height (y) above point O along the axis of capillary is :-

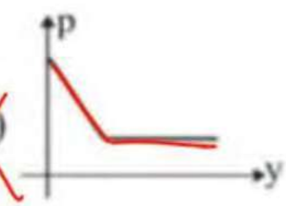
चित्र में प्रदर्शित केशनली में पानी ऊपर चढ़ रहा है। केशनली की अक्ष के अनुदिश बिन्दु O के ऊपर दाब (p) तथा ऊंचाई (y) के मध्य सही ग्राफ होगा :-

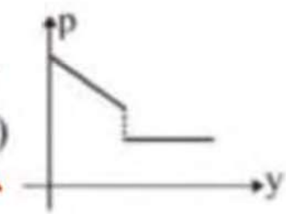
$P = P_0 - \rho g h$



(A) 

(B) 

(C) 

(D) 

Ans. (A)

21. A uniform capillary tube of inner radius r is dipped vertically into a beaker filled with water. The water rises to a height h in the capillary tube above the water surface in the beaker. The surface tension of water is σ. The angle of contact between water and the wall of the capillary tube is θ. Ignore the mass of water in the meniscus. Which of the following statements is (are) true? **[JEE Advanced-2018]**

(A) For a given material of the capillary tube h decreases with increase in r.

(B) For a given material of the capillary tube, h is independent of σ.

(C) If this experiment is performed in a lift going up with a constant acceleration, then h decreases.

(D) h is proportional to contact angle θ. $\cos\theta$

$$h = \frac{2S\cos\theta}{r\rho g_{eff}}$$

Reyonald's number

$$R_n = \frac{\rho v d}{\eta}$$

ρ → density

v → speed of fluid

d → daimeter of pipe

η → coff of viscocity

Laminar flow

Turbulent flow

$R_n < 2300$ ≡ Laminar flow

$R_n > 2900$ ≡ Turbulent flow

> 3000

wave

wave on string

$$y = A\sin(\omega t + kx + \phi) \equiv -x$$

(1) $$y = A\sin(\omega t \pm kx + \phi)$$

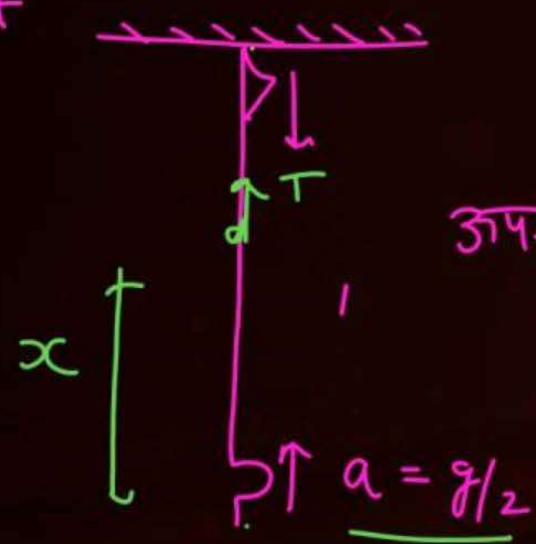
$$V_w = \frac{\omega}{k} = \frac{\text{Coff of } t}{\text{Coff of } x}$$

$$y = A\sin(\omega t - kx + \phi) \Rightarrow +ve$$

$$V_p = \frac{\partial y}{\partial t}$$

$$\boxed{V_w = \frac{\omega}{k} = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\rho A}}}$$

#



$$v = f\lambda$$

$$v_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\frac{\cancel{m}}{L} x g}{\cancel{m}/L}}$$

ऊपर जाएगी $\Rightarrow v\uparrow, \lambda\uparrow$

$$L = 0 + \frac{1}{2} \times (g/2)\, t^2$$

$$v = \sqrt{xg}$$

$$v^2 = xg$$

$$2v\frac{dv}{dx} = g$$

$$a = g/2$$

Length of string = 2m

$$y = 20\sin 2\pi x \cos \omega t$$

Amplitude $= 20\sin 2\pi x$

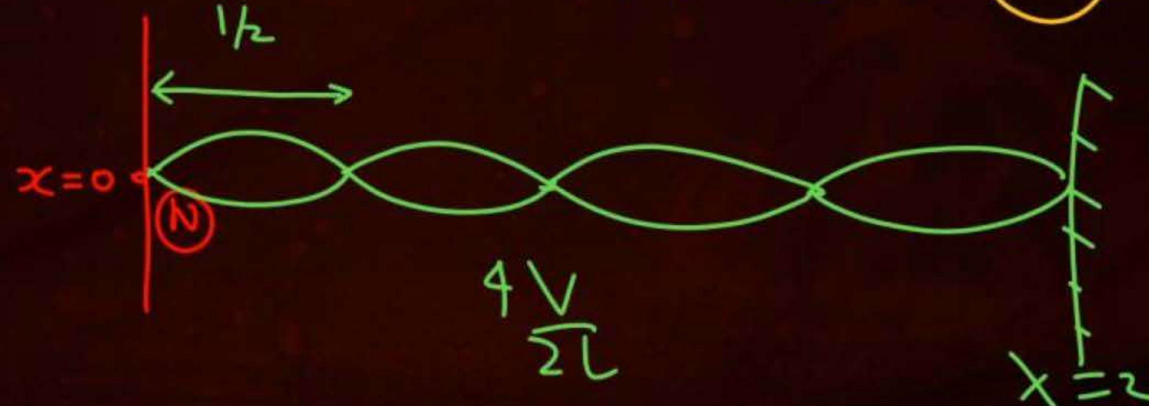
$x = 0,\ A_{mp} = 0 \Rightarrow$ N

$$k = \frac{2\pi}{\lambda} = 2\pi$$

$$\lambda = 1\,\text{m}$$

$A(x) = 0$ N

$A(x) = \pm 20$ AN

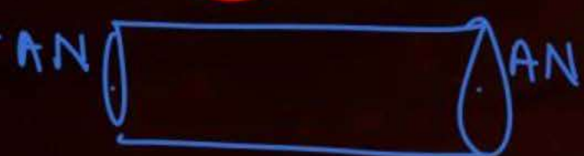


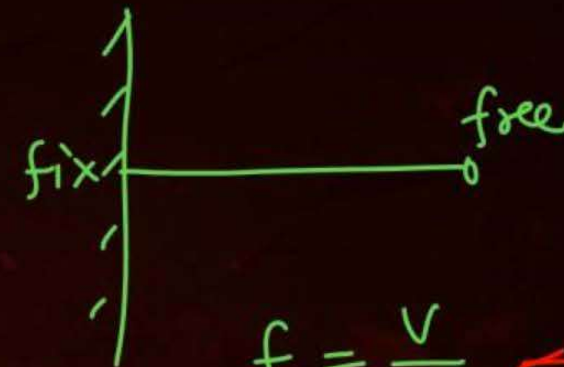
$$f_0 = \frac{V}{2L}$$

$$f_n = \frac{nV}{2L}$$

$$v = \sqrt{T/\mu}$$

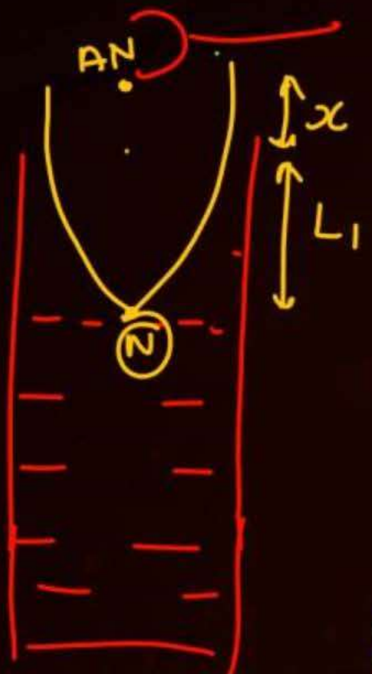
$$\boxed{V_{sound} = \sqrt{\frac{\gamma RT}{M}}}$$





$$f_0 = \frac{V}{4L}$$

$$f = (\text{odd})\frac{V}{4L}$$



$$L_1 + x = \frac{\lambda}{4}$$

$$L_2 + x = \frac{3\lambda}{4}$$

$$L_2 - L_1 = \frac{\lambda}{2}$$

$$x =$$

$$\boxed{x = .6r}$$

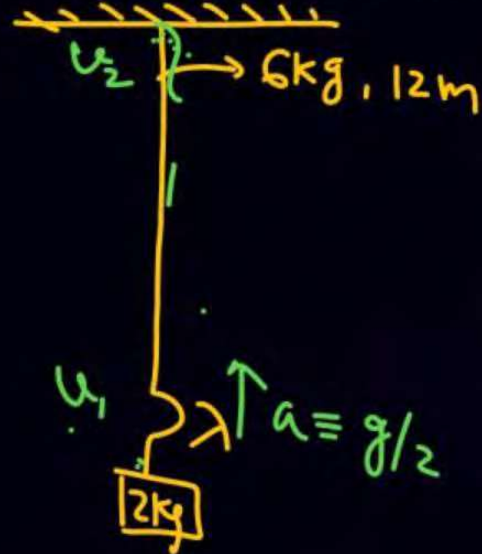
$$v = f\lambda$$

QUESTION

$$v = \overset{\text{Same}}{f}\,\lambda$$

A uniform thin rope of length 12 m and mass 6 kg hangs vertically from a rigid support and a block of mass 2 kg is attached to its free end. A transverse short wavetrain of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wavetrain (in cm) when it reaches the top of the rope?

[JEE Mains 2020]



$$\frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2}$$

(1) 9

(2) 12

(3) 6

(4) 3

Ans : (2)

QUESTION

Two light beams of intensities 4 I and 9 I interfere on a screen. The phase difference between these beams on the screen at point A is zero and at point B is π. The difference of resultant intensities, at the point A and B, will ______ I.

[JEE Mains 2022]

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\Delta\phi$$

$$I_A = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

$$I_B = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$$

Ans : 24

QUESTION

The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is 20 cm. The length of the open organ pipe is _______ cm. **[JEE Mains 2022]**

Ans : 80

QUESTION

If a wave gets refracted into a denser medium, then which of the following is true?

[JEE Mains 2022]

c/μ, λ/μ, $f \rightarrow$ sam

1. wavelength speed and frequency decreases.
2. wavelength increases, speed decreases and frequency remains constant.
3. wavelength and speed decreases but frequency remains constant.
4. wavelength, speed and frequency increases.

Ans : (3)

$$I \propto A^2$$

$$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

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

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

QUESTION

$v = f\lambda$

The velocity of sound in a gas. in which two wavelengths 4.08 m and 4.16 m produce 40 beats in 12 s, will be:

[JEE Mains 2022]

(1) 2.82 ms^{-1}

(2) 175.5 ms^{-1}

(3) 353.6 ms^{-1}

(4) 707.2 ms^{-1}

$$\frac{40}{12} = f_1 - f_2 = \frac{v}{\lambda_1} - \frac{v}{\lambda_2}$$

$$\frac{40}{12} = \frac{v}{4.08} - \frac{v}{4.16}$$

Ans : (4)

QUESTION

A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to:

[JEE Mains 2022]

$$A\omega = 4\frac{\omega}{k}$$

$$10 = \frac{4}{2\pi}\times\lambda$$

(1) 2π

(2) 5π

(3) π

(4) $\frac{5\pi}{2}$

Ans : (2)

QUESTION

$v = f\lambda$

In an experiment to determine the velocity of sound in air at room temperature using a resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of ______ cm.

[JEE Mains 2022]

$$L_1 + x = \frac{\lambda}{4}$$

$$20 + x = \frac{\lambda}{4}$$

$$L_3 + x = \frac{5\lambda}{4}$$

$$L_3 - 20 = \frac{5\lambda}{4} - \frac{\lambda}{4} = \lambda$$

$$L_3 = 20 + \lambda = \frac{20}{100} + \frac{336}{400} = \frac{80}{400} + \frac{336}{400} =$$

$$\frac{416}{400}\,m = 104\ c.m$$

Ans : 104

QUESTION

The displacement equations of two interfering waves are given by $y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$ cm, $y_2 = 5[\sin(\omega t) + \sqrt{3}\cos\omega t]$ cm respectively. The amplitude of the resultant wave is ______ cm. **[31 January 2023 - Shift 2]**

$y_2 = 10\sin(\omega t + 60^\circ)$

$y_1 = 10\sin(\omega t + 60^\circ)$

$y_{net} = 20\sin(\omega t + 60)$

Ans : (20)

QUESTION

An organ pipe 40 cm long is open at both ends. The speed of sound in air is $360\ ms^{-1}$. The frequency of the second harmonic is ______ Hz.

[08 April 2023 - Shift 1]

$$\frac{2v}{2L}$$

Ans : (900)

QUESTION

For a certain organ pipe, the first three resonance frequencies are in the ratio of 1 : 3 : 5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is 324 ms^{-1} the length of the organ pipe is ______ m.

[12 April 2023 - Shift 1]

$\to COP = (odd)\frac{V}{4L}$

$f_0 = \cancel{81} = \frac{V}{4\ell} = \frac{\cancel{324}}{\cancel{4}\ell}$

$\ell = 1$

$f_3 = 243$

$f_5 =$

Ans : (1)

QUESTION

A closed organ pipe 150 cm long gives 7 beats per second with an open organ pipe of length 350 cm, both vibrating in fundamental mode. The velocity of sound is ______ m/s.

[27 Jan. 2024 - Shift 2]

l_1 l_2

$$\frac{V}{4l_1} - \frac{V}{2l_2} = 7$$

$$\frac{V}{4\times 1.5} - \frac{V}{2\times 3.5} = 7$$

$$\frac{V}{6} - \frac{V}{7} = 7$$

$$\frac{V}{42} = 7$$

$$V = 42\times 7$$
$$= 294$$

Ans : (294)

QUESTION

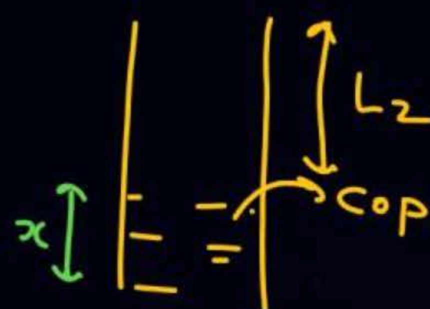
$$Vol^n = x \times A = 2 \times 2 \times 10^{-4} = 4 \times 10^{-4}$$

In a closed organ pipe, the frequency of fundamental note is 30 Hz. A certain amount of water is now poured in the organ pipe so that the fundamental frequency is increased to 110 Hz. If the organ pipe has a cross-sectional area of 2 cm^2, the amount of water poured in the organ tube is 400 g. (Take speed of sound in air is 330 m/s).

[30 Jan. 2024 - Shift 1]

$$\frac{V}{4L_1} = 30$$

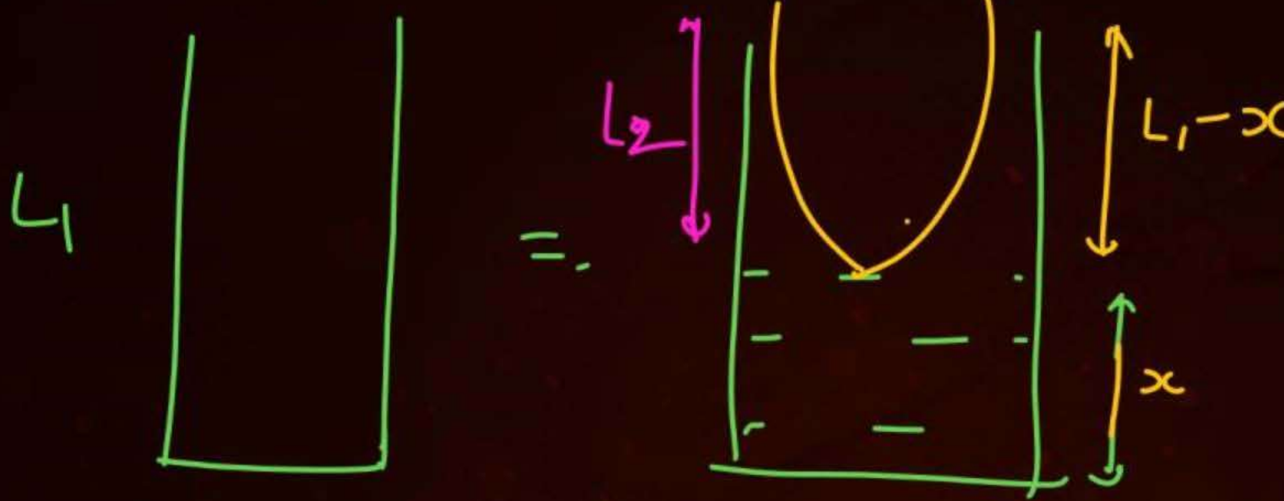
$$\frac{V}{4L_2} = 110$$



$$L_1 - L_2 = Am$$

$$m = \rho \, Vol^n$$
$$= 4 \times 10^{-4} \times 1000$$
$$= \frac{4}{10} kg = 400 gm$$

Ans : (400)



$$x = \frac{11}{4} - \frac{3}{4} = 2$$

$$f = 30 = \frac{V}{4L_1}$$

$$30 = \frac{330}{4L_1}$$

$$\boxed{L_1 = \frac{330}{30 \times 4} = \frac{11}{4}}$$

$$f_0 = 110 = \frac{V}{4L_2}$$

$$110 = \frac{330}{4L_2}$$

$$L_2 = \frac{3}{4}$$

QUESTION

The fundamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If length of the open pipe is 60 cm, the length of the closed pipe will be: [31 Jan. 2024 - Shift 1]

$$\frac{\cancel{v}}{4L_1} = \frac{\cancel{2}\cancel{v}}{\cancel{2}\times 60}$$

1. 60 cm
2. 45 cm
3. 30 cm
4. 15 cm

Ans : (4)

QUESTION

Two open organ pipes of lengths 60 cm and 90 cm resonate at 6th and 5th harmonics respectively. The difference of frequencies for the given modes is _____ Hz. (Velocity of sound in air = 333 m/s).

[06 Apr. 2024 - Shift 2]

$$\frac{6v}{2l_1} - \frac{5v}{2l_2}$$

Ans : (740)

QUESTION

COP $\equiv 15\frac{V}{4L}$ OOP $\equiv \frac{8V}{2L}$

A closed and an open organ pipe have same lengths. If the ratio of frequencies of their seventh overtones is $\left(\frac{a-1}{a}\right)$ then the value of a is ______. **[08 Apr. 2024 - Shift 1]**

$$\frac{15}{4\times 4}=\frac{a-1}{a}$$

$$\frac{15}{16}=\frac{a-1}{a}$$

$$a=16$$

Ans : (16)

QUESTION

A plane progressive wave is given by $y = 2\cos 2\pi(330t - x)$m. The frequency of the wave is:

[08 Apr. 2024 - Shift 2]

(1) 330 Hz

(2) 660 Hz

(3) 340 Hz

(4) 165 Hz

$330\cancel{2\pi} = \cancel{2\pi} f$

Ans : (1)

Ans. (D)

Ex.3 $Y(x,t) = 0.05 / [(4x + 2t)^2 + 5]$ represents a moving wave pulse, where x and y are in meters and t is in seconds. Then which statement(s) are **CORRECT**:

(A) Pulse is moving in – x direction (B) Wave speed is 0.5 m/s

(C) Maximum particle displacement is 1 cm (D) It is a symmetric pulse

समीकरण $Y(x,t) = 0.05 / [(4x + 2t)^2 + 5]$ एक गतिशील तरंग स्पन्द को व्यक्त करती है। यहां x तथा y मीटर में तथा t सेकण्ड में है। सही कथन(कथनों) को चुनिये।

(A) स्पन्द – x दिशा में गतिशील है। (B) तरंग चाल 0.5 m/s है।

(C) अधिकतम कणीय विस्थापन 1 cm है। (D) यह एक सममित स्पन्द है।

Ans. (A,B,C,D)

$v_w = \frac{2}{4} = \frac{1}{2}$ (–x Axis)

6. The extension in a string, obeying Hooke's law is x. The speed of wave in the stretched string is v. If the extension in the string is increased to 1.5 x find the new speed of wave.

हुक के नियम का पालन कर रही एक रस्सी में विस्तार x है। खिंची हुई रस्सी में तरंग की चाल v है। यदि रस्सी में विस्तार को 1.5 x तक बढ़ा देते हैं तो तरंग की नई चाल ज्ञात कीजिए।

Ans. 1.22 v

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{Kx}{\mu}}$$

$$v_{\text{नयी}} = \sqrt{\frac{K\,1.5\,x}{\mu}}$$

$$\frac{V}{V_{new}} = \sqrt{\frac{1}{1.5}} \qquad V_{new} = V\sqrt{1.5} = 1.22V$$

8. A copper wire is held at the two ends by rigid supports. At 30°C, the wire is just taut, with negligible
Find the speed of transverse waves in this wire at 10°C.
Given : Young modulus of copper = 1.3×10^{11} ~~N/m²~~.
Coefficient of linear expansion of copper = 1.7×10^{-5} °C⁻¹.
Density of copper = 9×10^{3} kg/m³.

Ans 70 m/s

$$V_w = \sqrt{\frac{T}{\rho A}} \qquad \frac{T}{A} = Y \alpha \Delta\theta$$

$$V_w = \sqrt{\frac{Y\alpha\Delta\theta . \cancel{A}}{\rho \cancel{A}}} = \sqrt{\frac{1.3 \times 10^{11} \times 1.7 \times 10^{-5} \times 20}{9 \times 10^{3}}}$$

[4t – 3x = 0].

2. At $x = 0$ particle oscillate by law $y = \frac{3}{2t^2+1}$. If wave is propagating along –ve x axis with velocity 2m/s. Find equation of wave

$$y = \frac{3}{2\left(t+\frac{x}{2}\right)^2+1}$$

$x = 0$ पर एक कण $y = \frac{3}{2t^2+1}$ नियम द्वारा दोलन करता है। यदि तरंग ऋणात्मक x–अक्ष की दिशा में 2 m/s के वेग से संचरित हो तो तरंग का समीकरण ज्ञात कीजिए।

(A) $y = \frac{3}{2\left(t-\frac{x}{2}\right)^2+1}$ (B) $y = \frac{3}{2\left(t+\frac{x}{2}\right)^2+1}$ (C) $y = \frac{3}{2\left(t-\frac{z}{2}\right)^2+1}$ (D) $y = \frac{3}{2\left(t+\frac{z}{2}\right)^2+1}$

Ans. (B)

① $y = f(x)$ given t (missin)

$x \xrightarrow{\bar{+x}} x - vt$

$x \longrightarrow x + vt$

② $y = f(t)$ x (missin)

$t \xrightarrow{\bar{+x}} t - x/v$

$t \xrightarrow{-x} t + x/v$

At $t=0$

Q $y = \dfrac{1}{2+x^2}$

$\vec{v_w} = +3\ m/s\ \hat{i}$

$$y = \frac{1}{2+(x-3t)^2}$$

for $x=0$

$y = \dfrac{1}{2+t^2}$

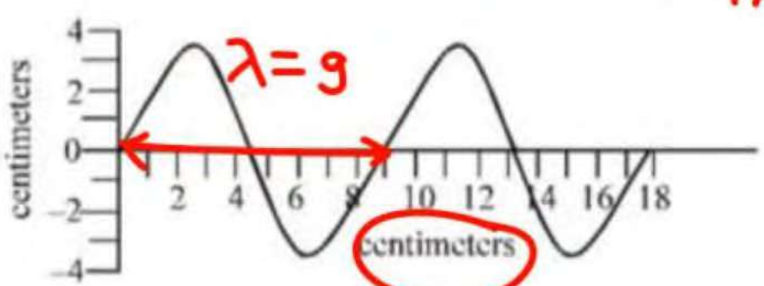
$\vec{v_w} = +3\ m/s\ \hat{i}$

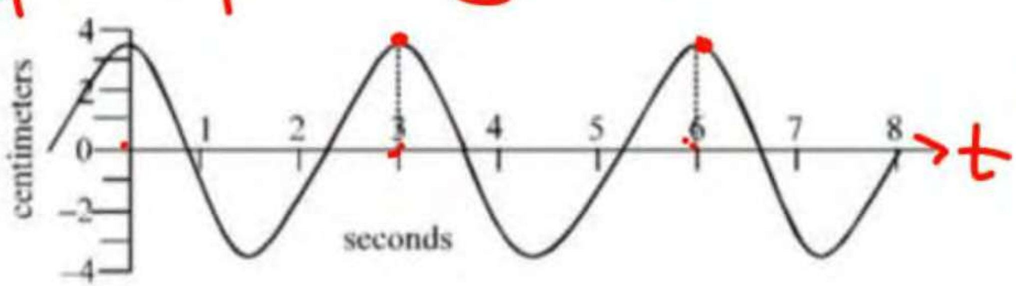
$$y = \frac{1}{2+\left(t-\frac{x}{3}\right)^2}$$

A transverse wave is travelling along a horizontal string. The first picture shows the shape of the string at an instant of time. This picture is superimposed on a coordinate system to help you make any necessary measurements. The second picture is a graph of the vertical displacement of *one* point along the string as a function of time. How far does this wave travel along the string in one second?

एक अनुप्रस्थ तरंग क्षैतिज रस्सी में गतिशील है। प्रथम चित्र किसी क्षण रस्सी की आकृति को दर्शाता है। किसी भी प्रकार के आवश्यक प्रेक्षण के लिए इस चित्र को एक निर्देशांक निकाय पर उकेरा जाता है। द्वितीय चित्र रस्सी पर एक बिन्दु के ऊर्ध्वाधर विस्थापन को समय के फलन के रूप में दर्शाता है। यह तरंग इस रस्सी पर एक सेकण्ड में कितनी दूरी तय करेगी?

$$V_\omega = \frac{\omega}{K} = \frac{2\pi/T}{2\pi/\lambda} = \lambda/T = \frac{9}{3} = 3$$





(A) 0.3 cm (B) 3.0 cm (C) 9.0 cm (D) 27 cm

18. A wave travels on a light string .The equation of the wave is Y= Asin(kx−wt+30°) .It is reflected from a heavy string tied to an end of the light string at x = 0.If 64% of the incident energy is reflected the equation of the reflected wave is

एक तरंग जिसका समीकरण Y = Asin(kx−wt+30°) है, एक हल्की रस्सी पर गतिशील है। यह इस हल्की रस्सी पर x = 0 पर बंधी एक अन्य भारी रस्सी द्वारा परावर्तित होती है। यदि आपतित ऊर्जा का 64% भाग परावर्तित हो तो परावर्तित तरंग की समीकरण होगी :-

(A) $Y = 0.8A\sin(kx - wt + 30^0 + 180^0)$ (B) $Y = 0.8A\sin(kx + wt + 30^0 + 180^0)$

(C) $Y = 0.8A\sin(kx + wt - 30^0)$ (D) $Y = 0.8A\sin(kx + wt + 30^0)$

Ans. (C)

$$y_r = .8A\sin(-kx - \omega t + 30 + 180)$$

2. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right]$. The tension in the string is : **[AIEEE - 2010]**

रैखिक द्रव्यमान घनत्व 0.04 kg m^{-1} वाली एक डोरी पर एक तरंग का समीकरण

$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right]$ से दिया जाता है, डोरी में तनाव है :

(1) 6.25 N (2) 4.0 N (3) 12.5 N (4) 0.5 N

Ans. (1)

$$V_w = \sqrt{\frac{T}{.04}} = \frac{\omega}{K}$$

3. The transverse displacement y(x, t) of a wave on a string is given by $y(x,t)=e^{-\left(ax^2+bt^2+2\sqrt{ab}xt\right)}$. This represents a :- [AIEEE - 2011]

(1) standing wave of frequency $\sqrt{b}$

(2) standing wave of frequency $\frac{1}{\sqrt{b}}$

(3) wave moving in +x directionwith speed $\sqrt{\frac{a}{b}}$

(4) wave moving in –x direction with speed $\sqrt{\frac{b}{a}}$

$$y = e^{-\left(ax^2+bt^2+2\sqrt{ab}\,xt\right)}$$

$$y = e^{-\left(\sqrt{a}\,x+\sqrt{b}\,t\right)^2}$$

$$\boxed{v_w = \sqrt{\frac{b}{a}}}$$

1. A wave travelling along the x-axis is described by the equation $y(x, t) = 0.005 \cos(\alpha x - \beta t)$. If the wavelength and the time period of the wave in 0.08m and 2.0 s respectively then α and β in appropriate units are **[AIEEE - 2008]**

x-अक्ष के अनुदिश गति कर रही एक तरंग का समीकरण $y(x, t) = 0.005 \cos(\alpha x - \beta t)$ द्वारा प्रदर्शित किया गया है। यदि तरंग की तरंगदैर्ध्य तथा आवर्तकाल क्रमश: 0.08m तथा 2.0 s हो तो α तथा β के मान होगें

(1) $\alpha = 25.00\pi, \beta = \pi$

(2) $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

$K = \alpha = \frac{2\pi}{\lambda}$

(3) $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$

(4) $\alpha = 12.50\pi, \beta = \frac{\pi}{2.0}$

$\beta = \omega = \frac{2\pi}{T}$

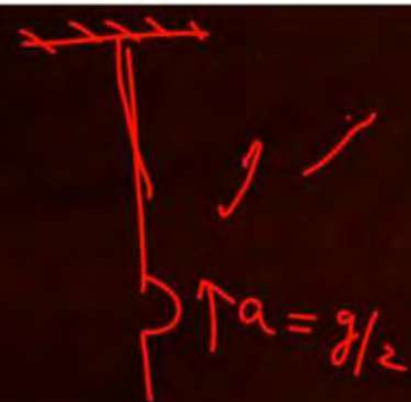
Ans. (1)

7. A uniform string of length 20m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is :-
(take $g = 10\ ms^{-2}$)
20m लम्बाई की एकसमान डोरी को एक दृढ़ आधार से लटकाया गया है। इसके निचले सिरे से एक सूक्ष्म तरंग-स्पंद चालित होता है। ऊपर आधार तक पहुँचने में लगने वाला समय है :- **[JEE-Main-2016]**
($g = 10\ ms^{-2}$ लें)

$$20 = 0 + \frac{1}{2} \times \frac{g}{2} \times t^2$$

(1) $\sqrt{2}$ s (2) $2\pi\sqrt{2}$ s (3) 2s (4) $2\sqrt{2}$ s

Ans. (4)



14. A transverse periodic wave on a string with a linear mass density of 0.200 kg/m is described by the following equation

$$y = 0.05 \sin(420t - 21.0\,x)$$

where x and y are in metres and t is in seconds.

$$V_\omega = \frac{420}{21} = \sqrt{\frac{T}{.2}}$$

The tension in the string is equal to :

एक आवर्ती अनुप्रस्थ तरंग एक डोरी जिसका रेखीय द्रव्यमान घनत्व 0.200 kg/m है, पर निम्न समीकरण द्वारा व्यक्त की जाती है :

$$y = 0.05 \sin(420t - 21.0\,x)$$

जहाँ x व y मीटर में है एवं t सैकण्ड में है। डोरी में तनाव है :

(A) 32 N (B) 42 N (C) 66 N (D) 80 N

Ans. **(D)**

12. A transverse wave is represented by y = 2sin (ωt – kx) cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity, will be:

एक अनुप्रस्थ तरंग समीकरण y = 2sin (ωt – kx) cm द्वारा प्रदर्शित है। उस तरंगदैर्ध्य का मान (cm में) ज्ञात कीजिए, जिस पर तरंग वेग, कण के अधिकतम वेग के बराबर होगा। **[JEE-Main-2022_July]**

(A) 4π (B) 2π (C) π (D) 2

$v_\omega = \frac{\cancel{\omega}}{k} = A\cancel{\omega}$

Ans. (A)

$\frac{\lambda}{2\pi} = 2$

14. The speed of a transverse wave passing through a string of length 50 cm and mass 10 g is 60 ms^{-1}. The area of cross-section of the wire is 2.0 mm^2 and its Young's modulus is 1.2×10^{11} Nm^{-2}. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}$ m. The value of x is_______.

$$\mu = \frac{50 \times 1000}{10 \times 100} = 50$$

एक 50 cm लम्बी एवं 10 g द्रव्यमान की रस्सी पर चलने वाली अनुप्रस्थ तरंग की चाल 60 ms^{-1} है। तार का अनुप्रस्थ क्षेत्राफल 2.0 mm^2 और इसका यंग गुणांक 1.2×10^{11} Nm^{-2} है। तन्यता के कारण इसकी वास्तविक लम्बाई में हुई वृद्धि $x \times 10^{-5}$ m है। x का मान है _______.

$$V_w = \sqrt{\frac{T}{\mu}}$$

[JEE-Main-2022 July]

$$60 = \sqrt{\frac{T}{50}} \Rightarrow T = \checkmark = 3600 \times 50$$

Ans. (15)

$$\frac{T}{A} = Y \frac{\Delta l}{l} \qquad V_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\rho A}}$$

$$\frac{3600 \times 50}{2 \times 10^{-6}} = \frac{1.2 \times 10^{11} \times \Delta l}{.50}$$

1. 1D
   2D
2. NLM + friction
3. Circular
4. WPE
5. COM
6. Rotation
7. SHM
8. Gravitation

9. Elasticity →
10. Thermal Exp. →
    Calorimetry →
    Heat transfer (Conduction + Radiation) →
11. KTG & thermodynamics
12. Wave
13. Fluid mechanics

Unit & Dim. (& error)

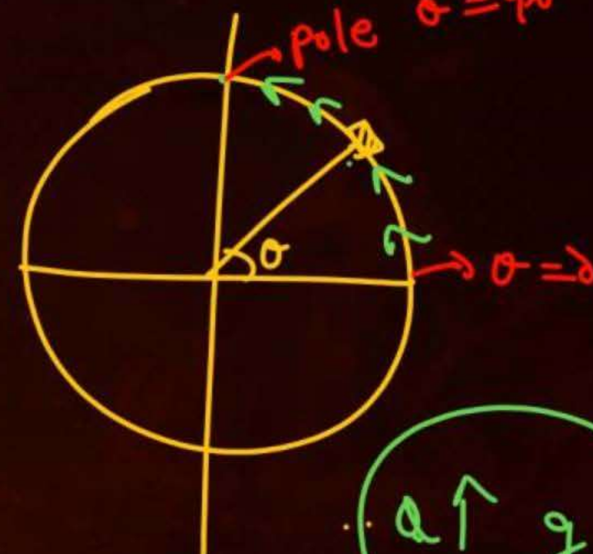
$g_0 = \frac{GM}{R^2}$

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

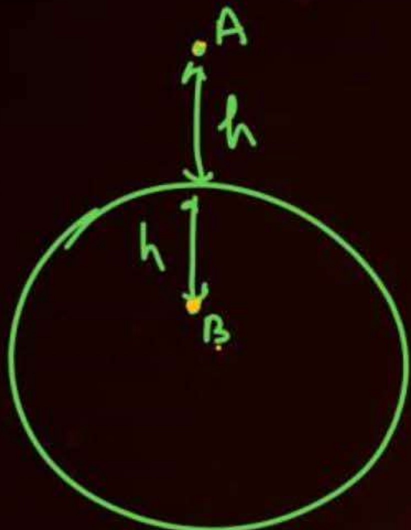
If $h \ll R$ $\quad \boxed{g = g_0\left(1 - \frac{2h}{R}\right)}$

$g = g_0\left(1 - \frac{d}{R}\right)$

$g = g_0 - R\omega^2\cos^2\theta$



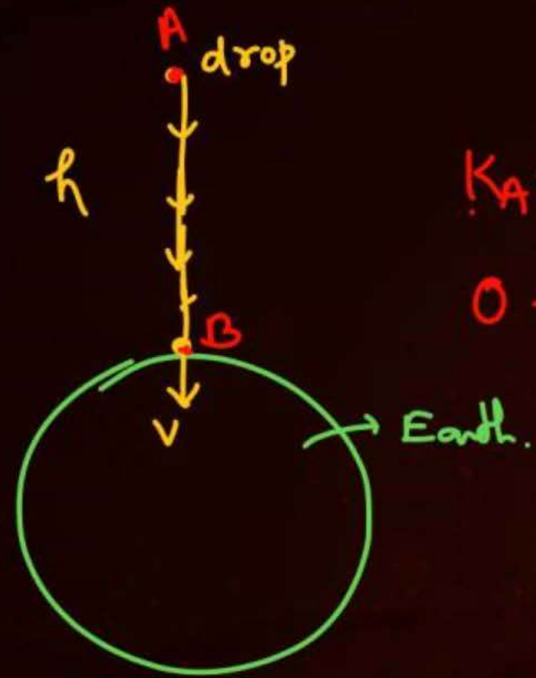
$\theta \uparrow \quad g \downarrow$



$$g_0 = \frac{GM}{R^2}$$

$$g_A = g_B$$

$$\frac{\cancel{GM}}{(R+h)^2} = \frac{\cancel{GM}}{R^2}\left(1-\frac{h}{R}\right)$$



$$K_A + U_A = K_B + U_B$$

$$0 +$$

$$\frac{KQx}{(R^2+x^2)^{3/2}} \Rrightarrow \frac{GMx}{(R^2+x^2)^{3/2}}$$

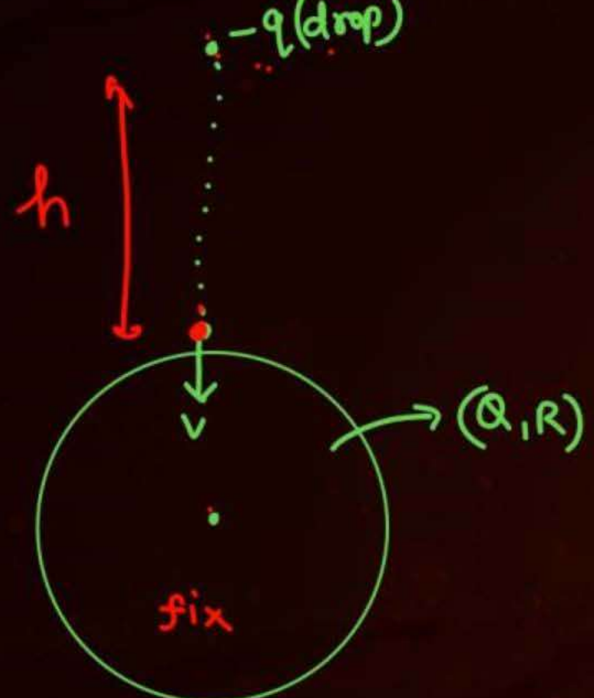
$$\frac{2K\lambda}{r} \qquad \frac{2G\lambda}{r}$$

$$K \longrightarrow G$$

$$\frac{1}{4\pi\epsilon_0} \longrightarrow G$$

$$\epsilon_0 \longrightarrow \frac{1}{4\pi G}$$

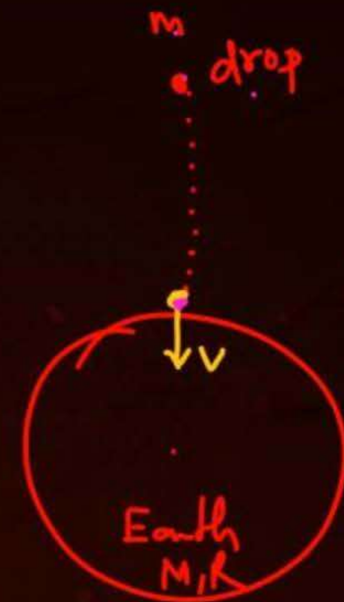
Q



$$K_i + U_i = K_f + U_f$$

$$0 + -q\left(\frac{kQ}{h+R}\right) = \frac{1}{2}mv^2 - q\frac{kQ}{R}$$

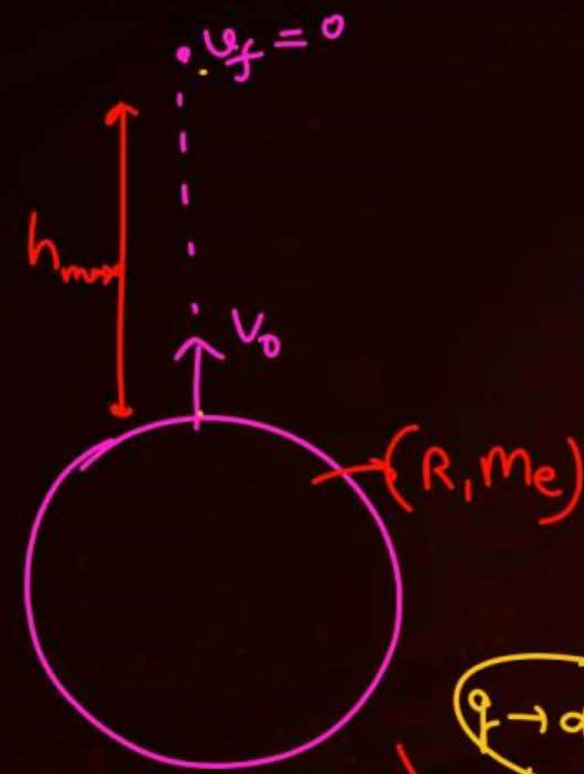
Q



$$K_i + U_i = K_f + U_f$$

$$0 + \left(-\frac{GMm}{(R+h)}\right) = \frac{1}{2}mv_f^2 + \left(-\frac{GMm}{R}\right)$$

Q

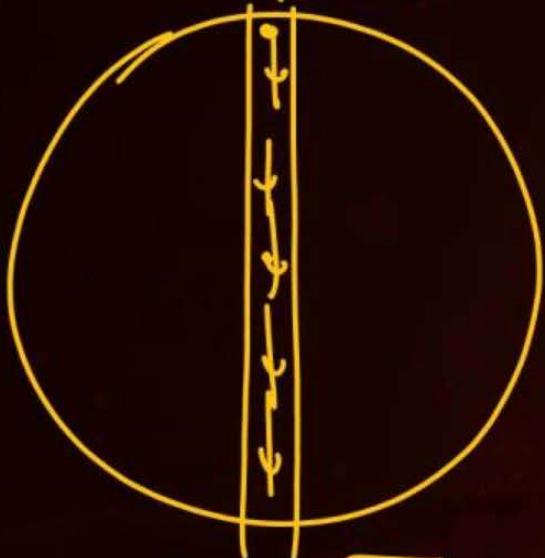


$$\frac{1}{2}mv_0^2 + \left(-\frac{GM_e}{R}\cdot m\right) = 0 - \left(\frac{GM_e}{R+h}\cdot m\right)$$

g → बदला

$h_{max} = \cancel{\dfrac{v_0^2}{2g}}$

Q2

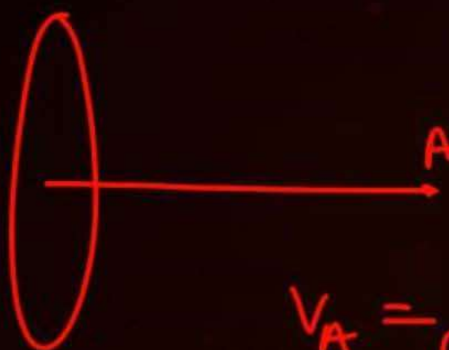


$$T = 2\pi\sqrt{\frac{R}{g}}$$

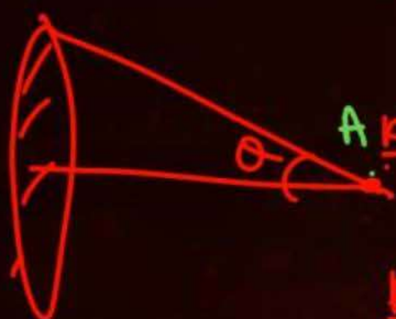
$$E = \frac{2k\lambda}{r} \longrightarrow \frac{2G\lambda}{r}$$

∞ sheet $\;E = \frac{\sigma}{2\epsilon_0} \longrightarrow E = \frac{\sigma}{2}4\pi G$

$$\Delta V = 2k\lambda \ln\left(\frac{r_2}{r_1}\right) \longrightarrow \checkmark$$



$$V_A = \frac{KQ}{\sqrt{R^2+x^2}} \longrightarrow V_A = -\frac{GM}{\sqrt{R^2+x^2}}$$

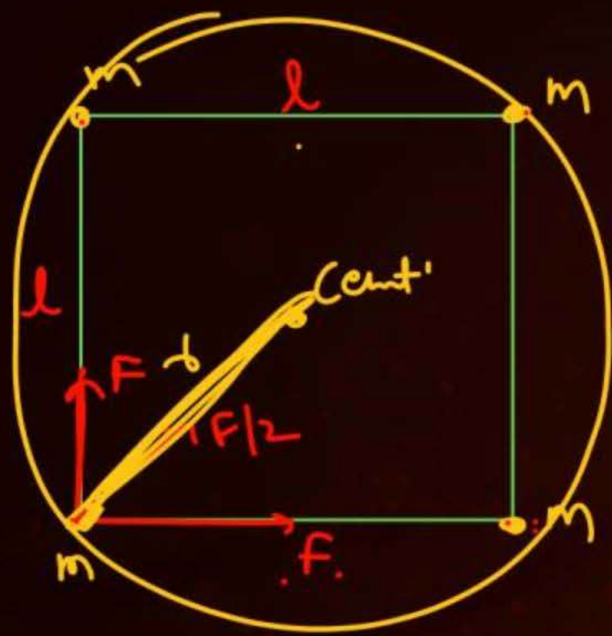


A $E = \frac{\sigma}{2\epsilon_0}(1-\cos\theta)$

$$V_A = \frac{\sigma}{2\epsilon_0}(1-\cos\theta)\left(\sqrt{R^2+x^2}\right)$$

$$E = \frac{\sigma}{2}4\pi G(1-\cos\theta)$$

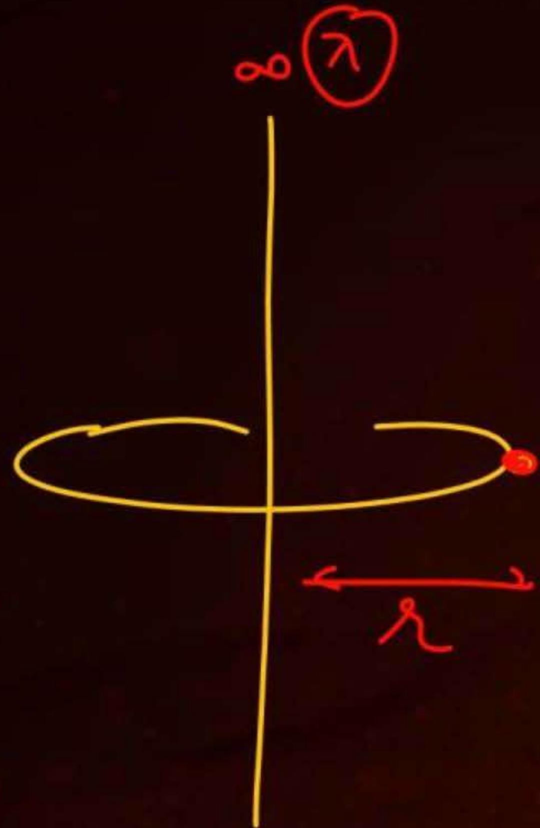
$$V_A = -\frac{\sigma}{2\frac{1}{4\pi G}}(1-\cos\theta)\left(\sqrt{R^2+x^2}\right)$$



$$F = \frac{Gmm}{l^2}$$

$$F\sqrt{2} + \frac{F}{2} = \frac{mv^2}{(l/\sqrt{2})} = m\left(\frac{l}{\sqrt{2}}\right)\omega^2$$

Q



$$\frac{2G\lambda}{r}\cdot m = \frac{mv^2}{r}$$

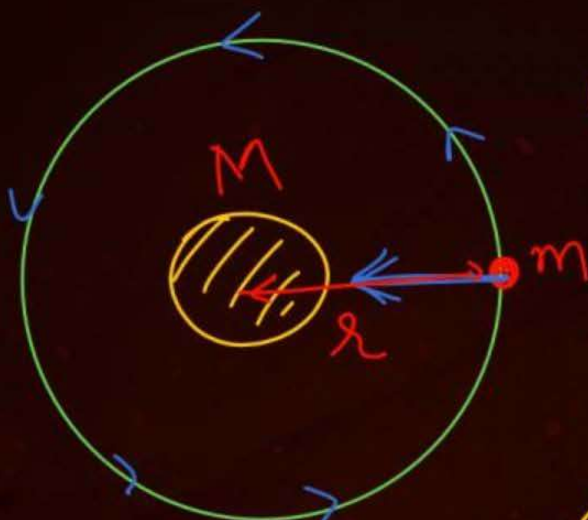
$$v \propto r^0$$

$$\frac{\rho\,\overrightarrow{O_1O_2}}{3\epsilon_0} \equiv \frac{\rho\,\overrightarrow{O_2O_1}}{3\,\frac{1}{4\pi G}}$$

*

$$\frac{GM\cancel{m}}{r^2} = \frac{\cancel{m}v^2}{r}$$

$$\boxed{v_0 = \sqrt{\frac{GM}{r}}}$$



$$v_0 = \frac{2\pi r}{T}$$

$$\sqrt{\frac{GM}{r}} = \frac{2\pi r}{T}$$

$$T^2 \propto r^3$$

Sattelite motion.

- $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$

- $v = \sqrt{\dfrac{Gm}{r}} = \dfrac{2\pi r}{T}$

- $P.E = -\dfrac{GMm}{r}$

$KE = \dfrac{1}{2}mV^2 = \dfrac{GMm}{2r}$

$T.E = -\dfrac{GMm}{2r}$.

$$T.E. = -\frac{GMm}{2r}$$

$r_1 \longrightarrow r_2$

$Ext(WD) \equiv (T.E)_f - (T.E)_i$

$=$

(1). $r_1 \longrightarrow r_2$ (orbit change)

$$(\Delta W.D)_{ext} = (T.E)_f - (T.E)_i = \frac{GMm}{2}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

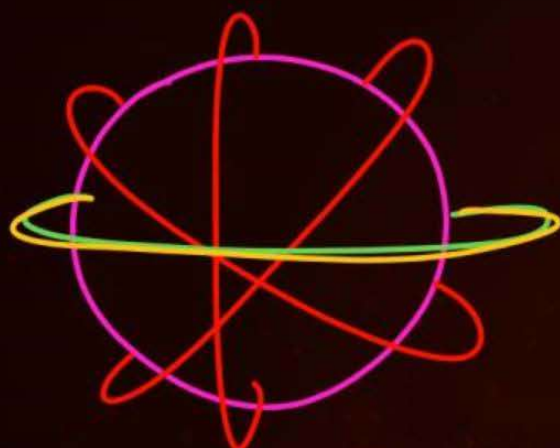
(2) If sattelite is very close to earth & revolving

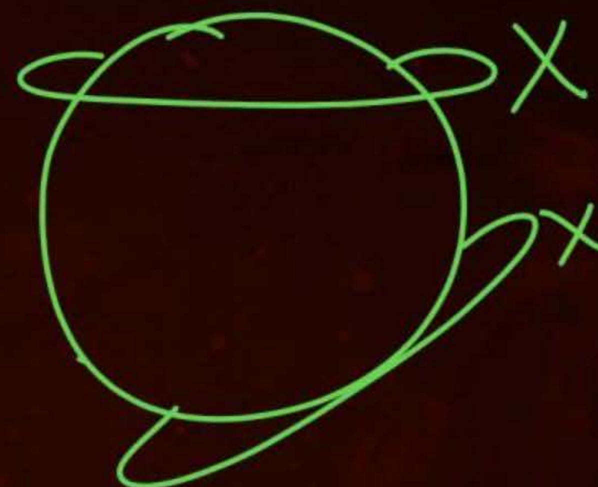
$$(T.E) = -\frac{GMm}{2R}$$

*

(3) Sattellite Rest पर At ground $\equiv (W.D)_{ext} \equiv r_1$ (orbit)

$$(W.D)_{ext} = \left(-\frac{GMm}{2r_1}\right) - \left(0 - \frac{GMm}{R}\right)$$





$T = 24$ hour

$h \approx 36000$

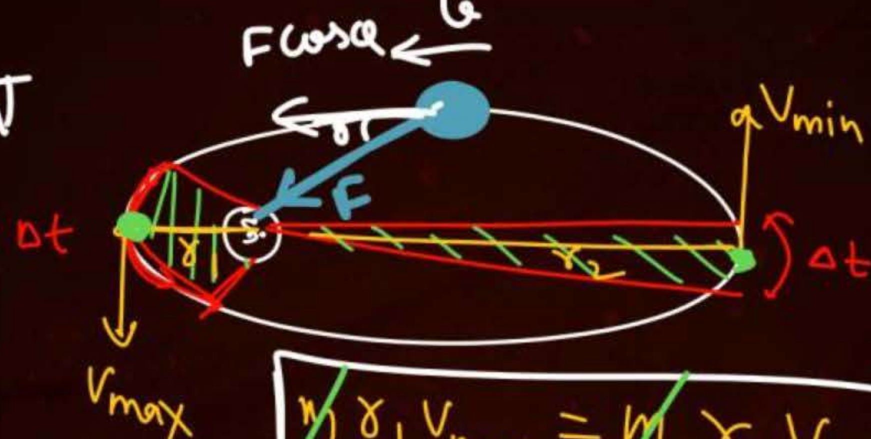
Kepler law

$mv r_\perp$

ज्यादा

कम

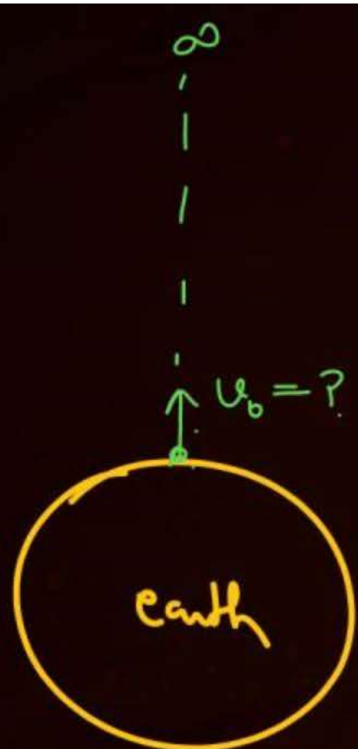
①



② $L_{sun} \longrightarrow$ Const

$$\boxed{\cancel{m}\, r_1 V_{max} = \cancel{m}\, r_2 V_{min}}$$

$$r_1 V_1 = r_2 V_2$$

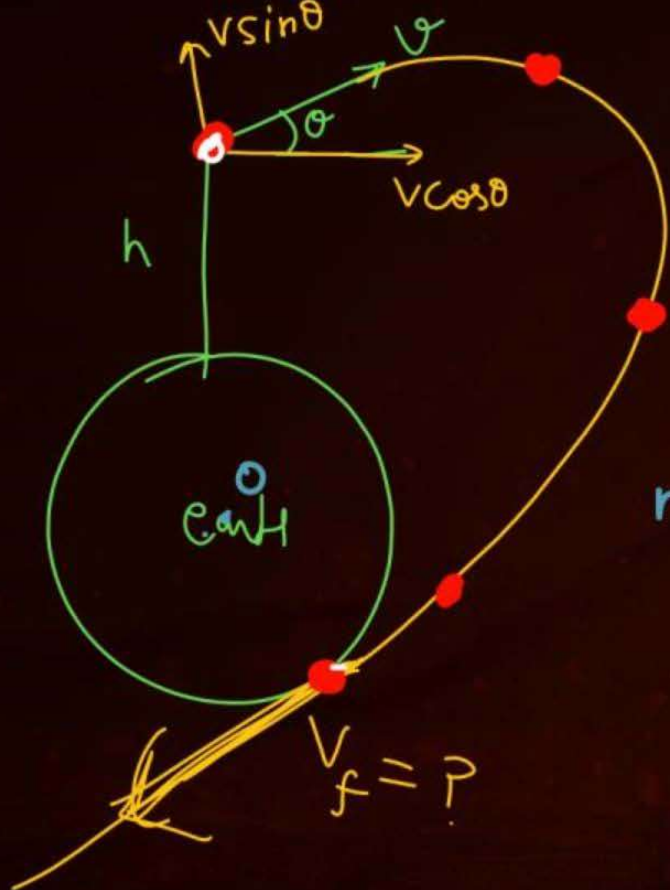


$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2} m v_e^2 + \left(-\frac{GMm}{R}\right) = 0 - 0$$

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

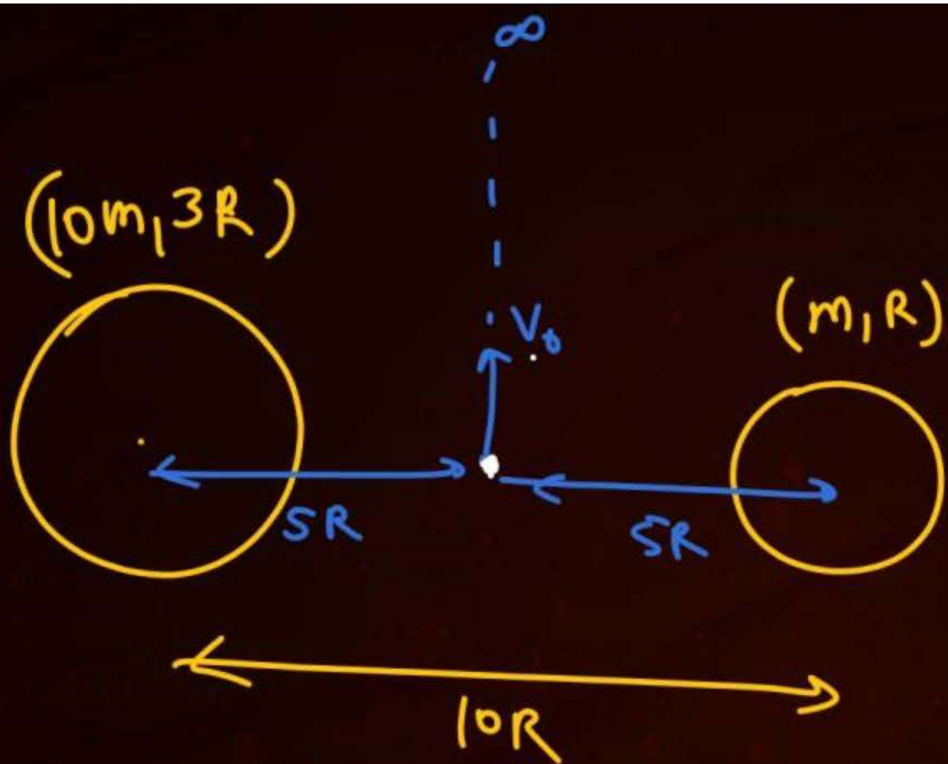
Q2



$L_O \longrightarrow$ Conserve.

$$m(v\cos\theta)(R+h) = m V_f \cdot R$$

$$\frac{1}{2}mv^2 + \left(-\frac{GMm}{R+h}\right) = \frac{1}{2}mV_f^2 - \frac{GMm}{R}$$



$$\frac{1}{2}mv_0^2 + \left(-\frac{G(10m)}{5R} - \frac{Gm}{5R}\right)m = 0 + 0$$

$g = \frac{GM}{R^2}$

$$\rho = \frac{m}{\frac{4}{3}\pi R^3}$$

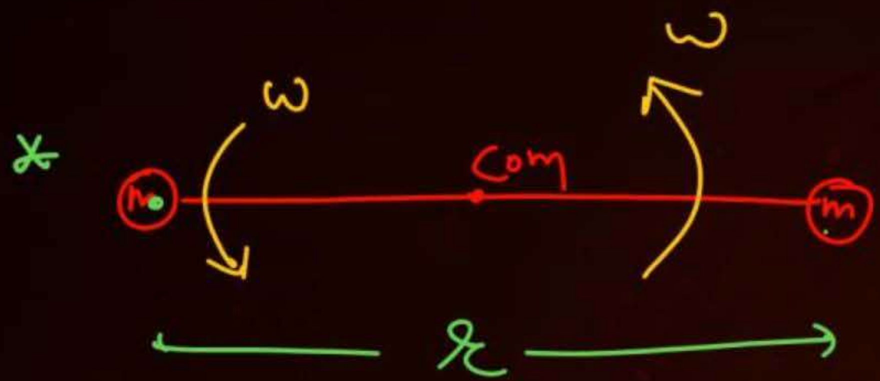
$$g = \frac{G\rho \frac{4}{3}\pi R^3}{R^2}$$

$$\boxed{g = \frac{G4\pi}{3}\rho R}$$

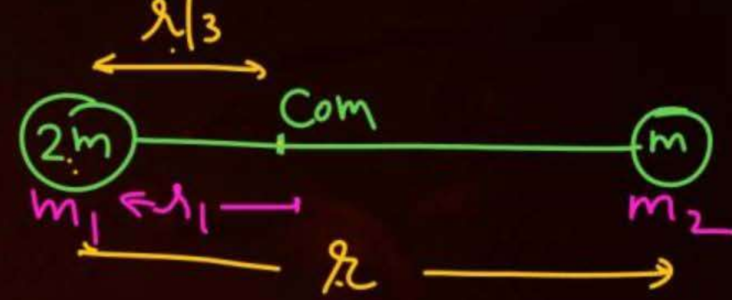
Ⓐ	Ⓑ
m	$8m$
$2R$	R

$$g_A = \quad g_B$$

$$\frac{g_A}{g_B} = \frac{m}{(2R)^2} \times \frac{R^2}{8m}$$



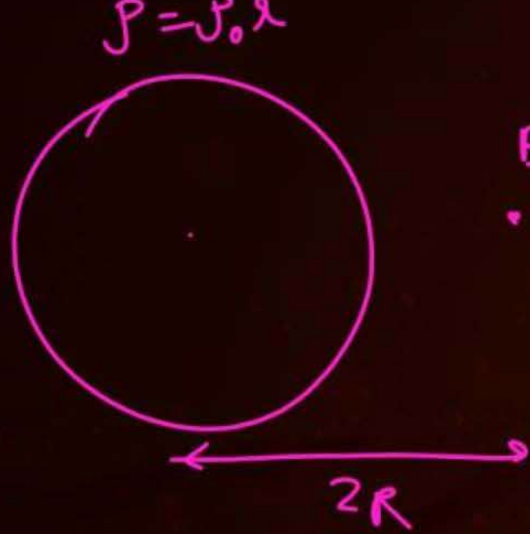
$$\frac{Gmm}{r^2} = m\left(\frac{r}{2}\right)\omega^2$$



$$\frac{G(2m)(m)}{r^2} = (2m)\left(\frac{r}{3}\right)\omega^2$$

$$\frac{Gm_1m_2}{r^2} = m_1 r_1 \omega^2$$

Q



$E_g = ?$

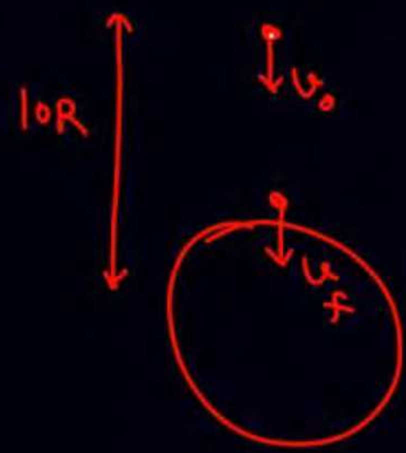
$$E \cdot 4\pi r^2 = \frac{q_{in}}{\epsilon_0}$$

$$= \frac{\int_0^R \rho_0 r \, 4\pi r^2 \, dr}{\epsilon_0}$$

QUESTION

An asteroid is moving directly towards the centre of the earth. When at a distance of $10R$ (R is the radius of the earth) from the earths centre, it has a speed of 12 km/s. Neglecting the effect of earths atmosphere, what will be the speed of the asteroid when it hits the surface of the earth (escape velocity from the earth is 11.2 km/s)? Give your answer to the nearest integer in kilometre/s ______.

(JEE Main-2020)



$$\frac{1}{2}mv_0^2 - \frac{GMm}{10R} = \frac{1}{2}mv_f^2 - \frac{GMm}{R}$$

Ans : (16)

QUESTION

The value of the acceleration due to gravity is g_1 at a height $h = \frac{R}{2}$ (R = radius of the earth) from the surface of the earth. It is again equal to g_1 at a depth d below the surface of the earth. The ratio $\left(\frac{d}{R}\right)$ equals: **(JEE Main-2020)**

(1) $\frac{7}{9}$

(2) $\frac{4}{9}$

(3) $\frac{1}{3}$

(4) $\frac{5}{9}$

$$g_1 = \frac{GM}{\left(R + \frac{R}{2}\right)^2} = \frac{GM}{R^2}\left(1 - \frac{d}{R}\right)$$

$$\frac{4}{9}\frac{G\cancel{M}}{\cancel{R^2}} = \frac{G\cancel{M}}{\cancel{R^2}}\left(1 - \frac{d}{R}\right)$$

$$\frac{d}{R} = 5/9$$

Ans : (4)

QUESTION

A satellite is in an elliptical orbit around a planet P. It is observed that the velocity of the satellite when it is farthest from the planet is 6 times less than that when it is closest to the planet. The ratio of distances between the satellite and the planet at closest and farthest points is: (JEE Main-2020)

r_1 कम (v_1 max)

$\cancel{m} v_1 r_1 = \cancel{m} v_2 r_2$

$\frac{v}{6} r_1 = v r_2$

(1) 1 : 6

(2) 3 : 4

(3) 1 : 3

(4) 1 : 2

Ans : (1)

QUESTION

Consider two solid spheres of radii $R_1 = 1\text{m}$, $R_2 = 2\text{m}$ and masses M_1 and M_2, respectively. The gravitational field due to sphere (1) and (2) are shown. The value of $\frac{M_1}{M_2}$ is:

(JEE Main-2020)

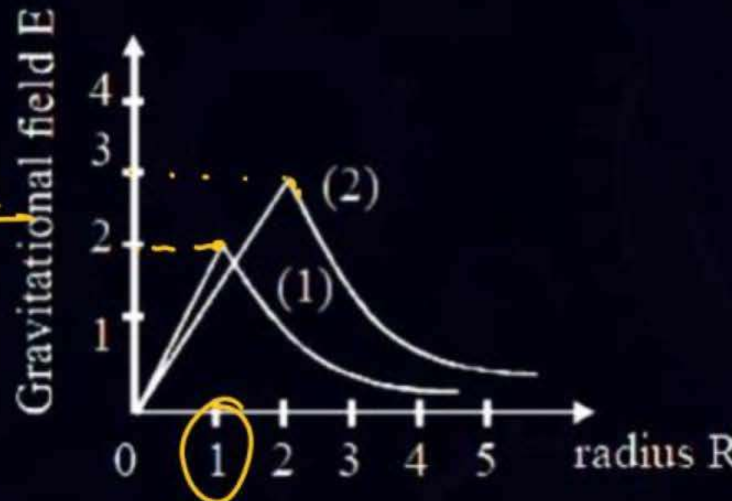
$g = \frac{Gm}{R^2}$

$g_1 = 2$
$g_2 = 3$

$\frac{g_1}{g_2} = \frac{2}{3} = \frac{\cancel{G}m_1}{1 \times \cancel{G}m_2 / 4}$

$\frac{2}{3} = 4\frac{m_1}{m_2}$

$\frac{m_1}{m_2} = \frac{1}{6}$



(1) $\frac{1}{2}$

(2) $\frac{2}{3}$

(3) $\frac{1}{3}$

(4) $\frac{1}{6}$

Ans : (4)

QUESTION

Planet A has mass M and radius R. Planet B has half the mass and half the radius of Planet A. If the escape velocities from the Planets A and B are v_A and v_B, respectively, then $\frac{v_A}{v_B} = \frac{n}{4}$. The value of n is: **(JEE Main-2020)**

$$v = \sqrt{\frac{2Gm}{R}}$$

(1) 4

$$v = \sqrt{2gR}$$

(2) 1

$$\frac{v_A}{v_B} = \sqrt{\frac{g_A R_A}{g_B R_B}}$$

(3) 2

(4) 3

Ans : (1)

QUESTION

$\rho = \frac{k}{r}$

The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance 'r' from its centre. In that region a small star is in circular orbit of radius R. Then the period of revolution T depends on R as: (JEE Main-2020)

(1) $T \propto R$

(2) $T^2 \propto \frac{1}{R^3}$

(3) $T^2 \propto R$

(4) $T^2 \propto R^3$

$E_g 4\pi r^2 = \frac{\int_0^r \frac{k}{r} 4\pi r^2 dr}{\epsilon_0}$

$E_g r^2 = \frac{\int_0^r k r dr}{\epsilon_0}$

$E_g \cancel{r^2} = \frac{k \cancel{r^2}}{2\epsilon_0}$

$\boxed{E_g = \frac{k}{2\epsilon_0}}$

E_g

Const

$m E_g = m r \omega^2$

$\omega^2 \propto \frac{1}{r}$

$T^2 \propto r$ → correct

Ans : (3)

QUESTION

$h^2 + hR - R^2 = 0$

$hR + 2R^2 - R^2 - h^2 - 2hR = 0$

The height 'h' at which the weight of a body will be the same as that at the same depth 'h' from the surface of the earth is (Radius of the earth is R and effect of the rotation of the earth is neglected):

$h = \frac{-R + \sqrt{5}R}{2}$

(JEE Main-2020)

Rm

1. $\frac{\sqrt{5}R - R}{2}$
2. $\frac{\sqrt{5}}{2}R - R$
3. $\frac{R}{2}$
4. $\frac{\sqrt{3}R - R}{2}$

$g_1 = g_2$

$\frac{\cancel{Gm}}{(R+h)^2} = \frac{\cancel{Gm}}{R^2}\left(1 - \frac{h}{R}\right)$

$\frac{1}{R^2 + h^2 + 2hR} = \frac{1}{R^2} - \frac{h}{R^3} = \frac{R-h}{R^3}$

$R^3 = (R-h)(R^2 + h^2 + 2hR)$

$\cancel{R^3} = \cancel{R^3} + h^2R + 2hR^2 - R^2h - h^3 - 2h^2R$

Ans : (1)

QUESTION

On the x-axis and a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{(x^2+a^2)^{3/2}}$ in the x-direction. The magnitude of gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity, is:

$K\theta \equiv A$ $\quad$ $V = \frac{K\theta}{\sqrt{R^2+x^2}} \equiv$

(JEE Main-2020)

(1) $\frac{-A}{(x^2+a^2)^{1/2}}$

(2) $\frac{A}{(x^2+a^2)^{3/2}}$

(3) $(x^2+a^2)^{3/2}$

(4) $(x^2+a^2)^{1/2}$

Ans : (1)

QUESTION

The acceleration due to gravity on the earth's surface at the poles is g and angular velocity of the earth about the axis passing through the pole is ω. An object is weighed at the equator and at a height h above the poles by using a spring balance. If the weights are found to be same, then h is: (h<<R, where R is the radius of the earth)

(JEE Main-2020)

1. $\frac{R^2\omega^2}{8g}$
2. $\frac{R^2\omega^2}{4g}$
3. $\frac{R^2\omega^2}{g}$
4. $\frac{R^2\omega^2}{2g}$

$g' = g_0 - R\omega^2\cos^2\theta$

pole $\theta = 90$

$g = g_0$

$m(g_0 - R\omega^2) = m g_0\left(1 - \frac{2h}{R}\right)$

$\cancel{g_0} - R\omega^2 = \cancel{g_0} - \frac{2h}{R} g_0$

$$\boxed{h = \frac{R^2\omega^2}{2g_0}}$$

Ans : (4)

QUESTION

Two planets have masses M and 16 M and their radii are a and 2 a, respectively. The separation between the centres of the planets is 10 a. A body of mass m is fired from the surface of the larger planet towards the smaller planet along the line joining their centres. For the body to be able to reach at the surface of smaller planet, the minimum firing speed needed is: **(JEE Main-2020)**

(1) $\sqrt{\frac{GM^2}{ma}}$

(2) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$

(3) $4\sqrt{\frac{GM}{a}}$

(4) $2\sqrt{\frac{GM}{a}}$

Ans : (2)

QUESTION

Two stars of masses m and 2 m at a distance d rotate about their common centre of mass in free space. The period of revolution is: (JEE Main-2021)

(1) $\frac{1}{2\pi}\sqrt{\frac{d^3}{3Gm}}$

(2) $2\pi\sqrt{\frac{d^3}{3Gm}}$

(3) $\frac{1}{2\pi}\sqrt{\frac{3Gm}{d^3}}$

(4) $2\pi\sqrt{\frac{3Gm}{d^3}}$

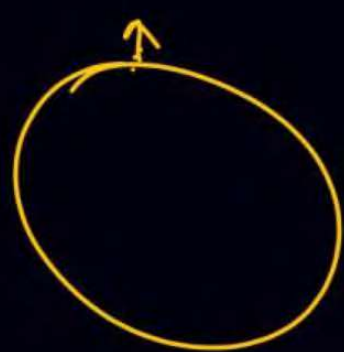
Ans : (2)

QUESTION

The initial velocity *vi* required to project a body vertically upward from the surface of the earth to reach a height of 10 *R*, where *R* is the radius of the earth, may be described in terms of escape velocity v_e such that $v_i = \sqrt{\frac{x}{y}} \times v_e$. The value of *x* will be ______.

$\cdot\ v_f = 0$

(JEE Main-2021)



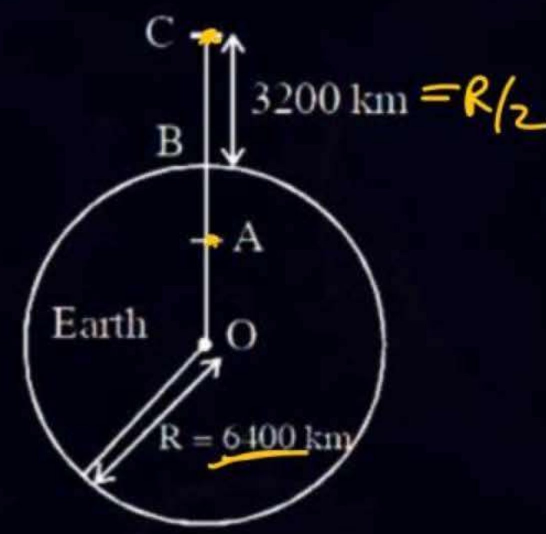
Ans : (10)

QUESTION

$$\frac{\rho r}{3\epsilon_0}, \frac{KQr}{R^3} \Rightarrow \frac{\rho r}{3\frac{1}{4\pi G}} = \frac{GMr}{R^3}$$

In the reported figure of earth, the value of acceleration due to gravity is same at point A and C but it is smaller than that of its value at point B (surface of the earth). The value of OA : AB will be x : y. The value of x is _____. **(JEE Main-2021)**

$$\frac{\dfrac{GM}{(R+R/2)^2}}{\dfrac{GM(R/2)}{R^3}}$$

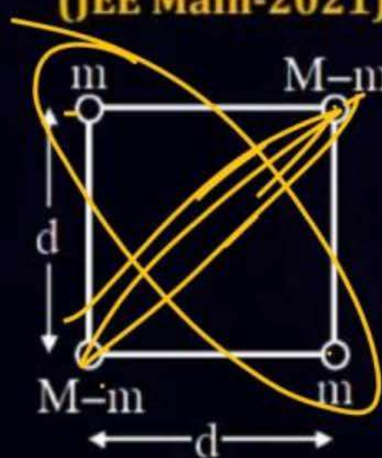


Ans : (4)

QUESTION

A body of mass (2 M) splits into four masses {m, M − m, m, M − m}, which are rearranged to form a square as shown in the figure. The ratio of $\frac{M}{m}$ for which, the gravitational potential energy of the system becomes maximum is x : 1. The value of x is ______.

(JEE Main-2021)



$$GPE \equiv -\left[\frac{Gm(M-m)}{\ell} \times 4 + \frac{G(M-m)^2}{\ell\sqrt{2}} x + \frac{Gm^2}{\ell\sqrt{2}}\right)$$

$$G.P.E =$$

Ans : (2)

QUESTION

Four particles each of mass M, move along a circle of radius R under the action of their mutual gravitational attraction as shown in figure. The speed of each particle is:

(JEE Main-2021)

(1) $\frac{1}{2}\sqrt{\frac{GM}{R(2\sqrt{2}+1)}}$

(2) $\frac{1}{2}\sqrt{\frac{GM}{R}(2\sqrt{2}+1)}$

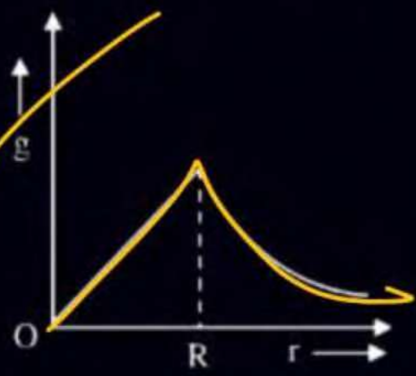
(3) $\frac{1}{2}\sqrt{\frac{GM}{R}(2\sqrt{2}-1)}$

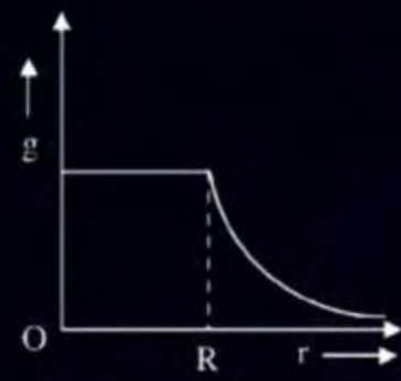
(4) $\sqrt{\frac{GM}{R}}$

Ans : (2)

QUESTION

The variation of acceleration due to gravity (g) with distance (r) from the center of the earth is correctly represented by: (given R = radius of earth). **(JEE Main-2022)**

(1)


(2)


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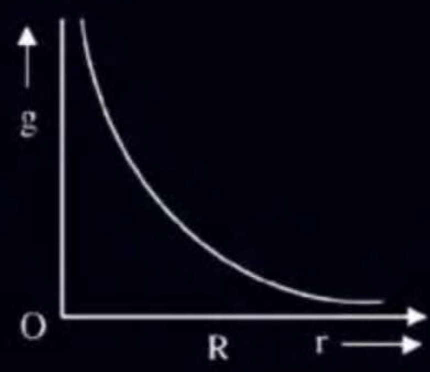
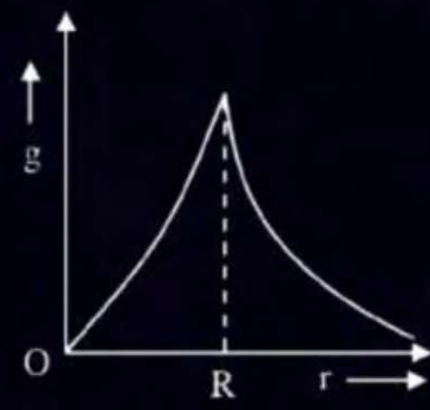


(4)


Ans : (1)

QUESTION

Two particles of equal mass 'm' move in a circle of radius 'r' under the action of their mutual gravitational attraction. The speed of each particle will be:

(29 January 2023 - Shift 1)

(1) $\sqrt{\frac{GM}{2r}}$

(2) $\sqrt{\frac{4GM}{r}}$

(3) $\sqrt{\frac{GM}{r}}$

(4) $\sqrt{\frac{GM}{4r}}$

Ans : (4)

QUESTION

Two satellites of masses m and 3 m revolve around the earth in circular orbits of radii r & 3r respectively. The ratio of orbital speeds of the satellites respectively is.

(10 April 2023 - Shift 1)

1. $\sqrt{3}:1$
2. $3:1$
3. $9:1$
4. $1:1$

$V_0 = \sqrt{\frac{GM_e}{r}}$

$\frac{GM_e \cancel{m}}{r^2} = \frac{\cancel{m} v^2}{r}$

$\frac{V_1}{V_2} = \sqrt{\frac{r_2}{r_1}}$

Ans : (1

QUESTION

$g = \frac{Gm}{(R+h)^2}$

If R is the radius of the earth and the acceleration due to gravity on the surface of earth is $g = \pi^2\ m/s^2$, then the length of the second's pendulum at a height $h = 2R$ from the surface of earth will be:

(01 Feb 2024 - Shift 1)

(1) $\frac{2}{9}$ m

(2) $\frac{1}{9}$ m

(3) $\frac{4}{9}$ m

(4) $\frac{8}{9}$ m

$T = 2\pi\sqrt{\frac{l}{g}}$

$\cancel{2} = \cancel{2}\pi\sqrt{\frac{l}{g/9}}$

$1 = \pi^2 \frac{l}{g/9}$

$gl = 1$

$l = \frac{1}{g}$

Ans : (2)

QUESTION

A light planet is revolving around a massive star in a circular orbit of radius R with a period of revolution T. If the force of attraction between planet and star is proportional to $R^{-3/2}$ then choose the correct option: (01 Feb 2024 - Shift 2)

(1) $T^2 \propto R^{5/2}$

(2) $T^2 \propto R^{7/2}$

(3) $T^2 \propto R^{3/2}$

(4) $T^2 \propto R^3$

$$F = KR^{-3/2} = mR\omega^2$$

$$\omega^2 \propto R^{-5/2}$$

$$T^2 \propto R^{5/2}$$

Ans : (1)

QUESTION

The acceleration due to gravity on the surface of earth is g. If the diameter of earth reduces to half of its original value and mass remains constant, then acceleration due to gravity on the surface of earth would be: (27 Jan 2024 - Shift 1)

$$g = \frac{GM}{R^2}$$

1. g/4
2. 2 g
3. g/2
4. 4 g

Ans : (4)

QUESTION

At what distance above and below the surface of the earth a body will have same weight, (take radius of earth as R). **(29 Jan 2024 - Shift 1)**

(1) $\sqrt{5}R - R$

(2) $\frac{\sqrt{3}R - R}{2}$

(3) $\frac{R}{2}$

(4) $\frac{\sqrt{5}R - R}{2}$

Ans : (4)

QUESTION

$$\frac{\cancel{200}^{50} \times \cancel{200}^{50}}{T_2^2} = \cancel{4} \times \cancel{4} \times 4 \qquad \frac{50 \times 50}{4} = T_2^2$$

A planet takes 200 days to complete one revolution around the Sun. If the distance of the planet from Sun is reduced to one fourth of the original distance, how many days will it take to complete one revolution?

(29 Jan 2024 - Shift 2)

1. 25
2. 50
3. 100
4. 20

$$T^2 \propto r^3$$

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3 \qquad T_2 = \frac{50}{2} = 25$$

$$\left(\frac{200}{T_2}\right)^2 = \left(\frac{r}{r/4}\right)^3$$

$T \quad R$

$y \quad T_2 =$

Ans : (1)

QUESTION

$$\frac{2G\lambda}{r} = \frac{2GM}{L\times L/\pi} = \frac{2GM\pi}{L^2}$$

A metal wire of uniform mass density having length L and mass M is bent to form a semicircular arc and a particle of mass m is placed at the centre of the arc. The gravitational force on the particle by the wire is:

(04 Apr. 2024 - Shift 1)

(1) $\frac{GmM\pi^2}{L^2}$

(2) $\frac{GMm\pi}{2L^2}$

(3) 0

(4) $\frac{2GmM\pi}{L^2}$

$\pi r = L$

$E = \frac{2k\lambda}{r}\sin\theta/2$

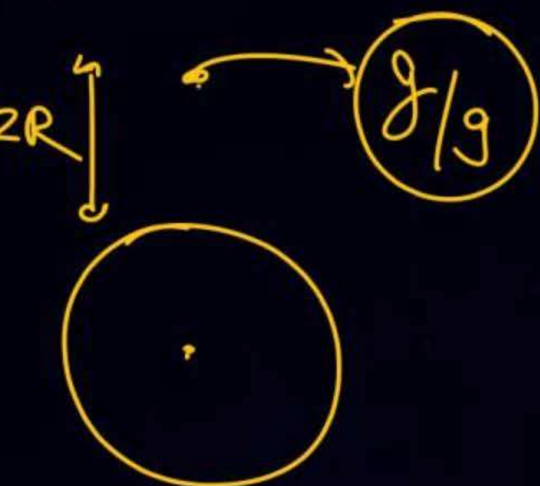
Ans : (4)

QUESTION

A 90 kg body placed at 2R distance from surface of earth experiences gravitational pull of:

(R = Radius of earth, g = 10 ms^{-2})

(04 Apr. 2024 - Shift 2)



(1) 100 N

(2) 300 N $90 \times \frac{10}{9}$

(3) 225 N

(4) 120 N

Ans : (1)

QUESTION

Two satellite A and B go round a planet in circular orbits having radii 4R and R respectively. If the speed of A is $3v$, the speed of B will be: (08 Apr. 2024 - Shift 2)

$$v = \sqrt{\frac{GM}{R}}$$

(1) $3v$

(2) $6v$

(3) $\frac{4}{3}v$

(4) $12v$

Ans : (2)

- ϵ_0
- μ_0
- K
- G

$$i = \frac{\Delta q}{\Delta t}$$

$$\Delta q = i \Delta t$$

$$F = \frac{G m_1 m_2}{r^2}$$

$$F = K \frac{q_1 q_2}{r^2}$$

$$K \equiv \frac{F r^2}{q_1 q_2}$$

$$G \equiv \frac{MLT^{-2} L^2}{MM} \equiv M^{-1} L^3 T^{-2}$$

$$\frac{1}{4\pi\epsilon_0} \equiv \frac{MLT^{-2} \cdot L^2}{A^2 T^2}$$

$$\Delta q = AT$$

$$v = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = c$$

$\epsilon_0 \equiv$ ✓

$\hat{i}$

$F = qvB$

$K \equiv ML^2T^{-2}\theta^{-1}$

$KT = ML^2T^{-2}$

$$B = \frac{\mu_0 \hat{i}}{2R}$$

$$\mu_0 \equiv \frac{2R \cdot B}{i} \quad \frac{F}{qv}$$

$$\frac{L\,MLT^{-2}}{A\;ATLT^{-1}}$$