PHYSICS
JEE-MAIN (July-Attempt)
27 July (Shift-2) Paper Solution

SECTION - A

1. An expression of energy density is given by $u = \frac{\alpha}{\beta}\sin\left(\frac{\alpha x}{kt}\right)$, where α, β are constants x is displacement, k is Boltzmann constant and t is the temperature. The dimesnsions of β will be :

(A) $[ML^2T^{-2}\theta^{-1}]$ (B) $[M^0L^2T^0]$ (C) $[M^0L^0T^0]$ (D) $[M^0L^2T^0]$

Sol. **D**

Here $\frac{\alpha x}{Kt} = 1$ (is an angle)

$\alpha = \frac{KT}{x}$

$\alpha = \frac{PV}{x} = F$

Now $\frac{E}{v} = \frac{F}{\beta}$

So, $\beta = \frac{FV}{E} = \frac{L^3}{L} = L^2$

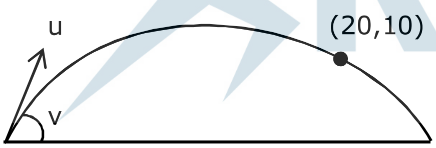
2. A body of mass 10 kg is projected at an angle of 45° with the horizontal. The trajectory of the body is observed to pass through a point (20,10). If T is the time of flight, then its momentum vector, at time $t = \frac{T}{\sqrt{2}}$, is _______.

[Take $g = 10\,m/s^2$]

(A) $100\hat{i} + (100\sqrt{2} - 200)\hat{j}$ (B) $100\sqrt{2}\hat{i} + (100 - 200\sqrt{2})\hat{j}$

(C) $100\sqrt{2}\hat{i} + (100 - 200\sqrt{2})\hat{j}$ (D) $100\sqrt{2}\hat{i} + (100\sqrt{2} - 200)\hat{j}$

Sol. **D**



By $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$10 = 20\tan 45° - \frac{1\times10\times20^2}{2\,u^2(\cos 45°)^2}$

Solving u = 20

Now time of flight $T = \frac{2\,u\sin\theta}{g} = \frac{2\times20\times\sin 45°}{10} = 2\sqrt{2}$

Momentume of $t = \frac{T}{\sqrt{2}} = 2sec$

P = $m\,u\cos\theta\ \hat{i} + m\,(u\sin\theta - gt)\hat{j}$

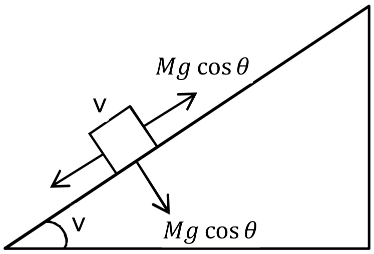
$= 10\,[20\cos 45°]\hat{i} + 10\,(20\sin 45° - 10\times 2)\hat{j}$

$= 100\sqrt{2}\,\hat{i} + \left(100\sqrt{2} - 200\right)\hat{j}$

3. A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be :

(A) Mg (B) Mg cosθ (C) $\sqrt{\text{Mg sin}\theta + \text{Mg cos}\theta}$ (D) $Mg \sin\theta \sqrt{1+\mu}$

Sol. **A**



Block sliding with constent v

So friction

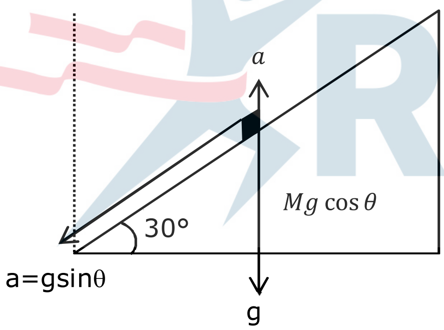
F = mg sin θ upward is a contact froce and another contact force is mg cos θ, both are ⊥hence

Net contact force = $\sqrt{(mg\sin\theta)^2 + (mg\cos\theta)^2} = mg$

4. A block 'A' takes 2 s to slide down a frictionless incline of 30° and length 'l' kept inside a lift going up with uniform velocity $'v'$. If the incline is changed to 45°, the time taken by the block, to slide down the incline, will be approximately :

(A) 2.66 s (B) 0.83 s (C) 1.68 s (D) 0.70 s

Sol. **C**



In case 30°

$t = \sqrt{\frac{2l}{g\sin 30^\circ}}$

Solving $l = 10$

In case of $\theta = 45^\circ$

$t_2 = \sqrt{\frac{2l}{g\sin 45^\circ}}$

$t_2 = \sqrt{\frac{2\times10}{10\times\frac{1}{\sqrt{2}}}}$

$t_2 = \sqrt{2\sqrt{2}} \Rightarrow 1.414\sqrt{1.414}$

⇒ 1.4 × 1.2

t = 1.68 sec

5. The velocity of the bullet becomes one third after it penetrates 4 cm in a wooden block. Assuming that bullet is facing a constant resistance during its motion in the block. The bullet stops completely after traveling at (4+x) cm inside the block. The value of x is :

(A) 2.0 (B) 1.0 (C) 0.5 (D) 1.5

Sol. **C**

Applying constant retardation equation

$\left(\frac{V}{3}\right)^2 = v^2 - 2a(4)$

$a = \frac{8v^2}{9\times 8}$ ...(i)

And now $0^2 = V^2 - 2a\ (4 + n)$

$= v^2 - 2a\ \left(\frac{v^2}{9}\right)(4 + n)$

8 + 2x = 9

2x = 1

$x = \frac{1}{2}$

6. A body of mass m is projected with velocity $\lambda\, v_e$ in vertically upward direction from the surface of the earth into space. It is given that v_e is escape velocity and $\lambda < 1$. If air resistance is considered to be negligible, then the maximum height from the centre of earth, to which the body can go, will be :

(A) $\frac{R}{1+\lambda^2}$ (B) $\frac{R}{1-\lambda^2}$ (C) $\frac{R}{1-\lambda}$ (D) $\frac{\lambda^2 R}{1-\lambda^2}$

Sol. **B**

Escape velocity $Ve = \sqrt{\frac{2GM}{R}}$

As V = $\lambda V_e = \lambda\sqrt{\frac{2GM}{R}}$

Initial total energy = $\frac{1}{2}mv^2 - \frac{GMm}{R}$ ...(1)

$= \frac{1}{2}m\lambda^2 . \frac{2GM}{R} - \frac{GMm}{R}$

Find total energy = $\frac{1}{2}m(0)^2 - \frac{GMm}{x}$ ...(2)

By energy conservation (1) = (2)

$\frac{1}{2}m\lambda^2\frac{2Gm}{R} - \frac{GMm}{R} = 0 - \frac{GMm}{x}$

$\frac{1}{x} = \frac{1}{R} - \frac{\lambda^2}{R}$ Hence

$x = \frac{R}{1-\lambda^2}$

7. A steel wire to length 3.2 m ($Y_s = 2.0 \times 10^{11}\ Nm^{-2}$) and a copper wire of length 4.4 m ($Y_c = 1.1 \times 10^{11}\ Nm^{-2}$) and a copper wire of length ($Y_c = 1.1 \times 10^{11}\ Nm^{-2}$), both of radius 1.4 mm Are connected end to end. When stretched by load, the net elongation is found to be 1.4 mm. The load applied, in Newton, will be : ($Given\ \pi = \frac{22}{7}$)

(A) 360 (B) 180 (C) 1080 (D) 154

Sol. **D**

Given $\Delta l_1 + \Delta l_2 = 1.4 \times 10^{-3} m$

Or

$\Delta l_5 + \Delta l_c = 1.4 \times 10^{-3}$

Or

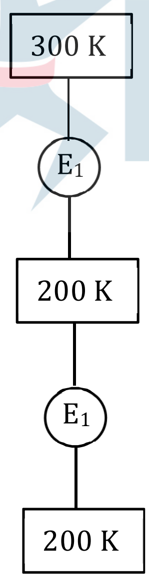
$\frac{F(3.2)}{\frac{22}{7}(1.4\times10^{-3})^2\times2\times10^{11}} + \frac{F(4.4)}{\frac{22}{7}(1.4\times10^{-3})^2\times1.1\times10^{11}} = 1.4 \times 10^{-3}$

or $F\left(\frac{3.2}{2}\right) + \frac{F(4.4)}{1.1} = 1.4 \times 1.4 \times 1.4 \times 10^2 \times \frac{22}{7}$

Or $F(5.6) = 8.6 \times 10^2$

Solving F = 154 N

8. In Ist case, Carnot engine operates between temperatures 300 K and 100 K. In 2 nd Case, as shown in the figure, a combination of two engines is used. The efficiency of this combination (in 2nd case) will be:



2nd Case

(A) same as the 1st case.

(B) always greater than the 1st case.

(C) always less than the 1st case.

(D) may increase or decrease with respect to the 1st case.

Sol. **C**

We know $n = \left(1 - \frac{T_2}{T_1}\right) \times 100$

So $n_1 = \left(1 - \frac{2}{3}\right) \times 100 \Rightarrow \frac{1}{3} \times 100 = 33\%$

$n_2 = \left(1 - \frac{1}{2}\right) \times 100 = \frac{1}{2} \times 100 = 50\%$

9. Which statements are correct about degrees of freedom ?

(A) A molecule with n degrees of freedom has n^2 different ways of storing energy.

(B) Each degree of freedom is associated with $\frac{1}{2}\ RT$ average energy per mole.

(C) A monatomic gas molecule has 1 rotational degree of freedom where as diatomic molecule has 2 rotational degrees of freedom.

(D) CH_4 has a total of 6 degress of freedom.

Choose the correct answer from the options given below :

(A) (B) and (C) only

(B) (B) only (D) Only

(C) (A)and (B) only

(D) (C) and (D) only

Sol. **B**

By theory

10. A charge $4\ \mu C$ is to be divided into two parts. The distance between the two divided charges so that the force between them is maximum, will be :

(A) $1\ \mu C\ and\ 3\ \mu C$ (B) $2\ \mu C\ and\ 2\ \mu C$ (C) $0\ \mu C\ and\ 4\ \mu C$ (D) $1.5\ \mu C\ and\ 2.5\ \mu C$

Sol. **B**

Let Q = 4

Now q is another part then

Force between them

$F = \frac{K(Q-q)q}{r^2}$

For $F_{max}\ \frac{dF}{dq} = 0$

Or Q – 2q = 0

$q = \frac{Q}{2}$

Hence q = $\frac{4}{2} = 2$

11. (A) The drift velocity of electrons decreases with the increase in the temperature of conductor.

(B) the drift velocity is inversely proportional to the area of cross-section of given conductor.....

(C) The drift velocity does not depend on the applied potential difference to the conductor.

(D) The drift velocity of electron is inversely proportional to the length of the conductor.

(E) The drift velocity increases with the temperature of conductor.

Choose the correct answer from the option given below :

(A) (A) and (B) only (B) (A) and (D) only (C) (B) and (E) only (D) (B) and (C) only

Sol. **B**

By Theory

12. A compass needle of oscillation magnetometer oscillates 20 times per minute at a place P of dip 30°. The number of oscillations per minute become 10 at another place Q of 60° dip. The ratio of the total magnetic field at the two places $\left(B_Q : B_p\right)$ is :

(A) $\sqrt{3}:4$ (B) $4:\sqrt{3}$ (C) $\sqrt{3}:2$ (D) $2:\sqrt{3}$

Sol. **B**

$$T_1 = 2\pi\sqrt{\frac{I}{MB_P\cos\alpha_1}}$$

$$T_2 = 2\pi\sqrt{\frac{I}{MB_Q\cos\alpha_2}}$$

Or $\frac{10}{20} = \frac{1}{2} = \sqrt{\frac{B_Q\cos\alpha_2}{B_P\cos\alpha}}$

$(B_H)_P = B_P\cos\alpha$

$$\frac{B_Q\cos 60°}{B_P\cos 30°} = \frac{1}{4}$$

$$\frac{B_Q}{B_P} = \frac{\cos 30}{4\cos 60} = \sqrt{3} : 4$$

13. A cyclotron is used to accelerate protons. If the operating magnetic field is 1.0 T and the radius of the cyclotron 'dees; is 60 cm, the kinetic energy of the accelerated protons in MeV will be: [use $m_p = 1.6 \times 10^{-27}$ kg, $e = 1.6 \times 10^{-19}$CJ]

(A) 12 (B) 18 (C) 16 (D) 32

Sol. **B**

$$r = \frac{mv}{Bq} \Rightarrow K = \frac{B^2q^2r^2}{2m} = \frac{\left(1.6\times10^{-19}\right)^2\times1^2\times\left(\frac{60}{100}\right)^2}{2\times1.6\times10^{-27}}$$

= 18 Mev

14. A series LCR circuit has $L = 0.01$ H, $R = 10\,\Omega$ and $C = 1\,\mu F$ and it is connected to ac voltage of amplitude (V_m)50 V. At frequency 60% lower than resonant frequency, the amplitude of current will be approximately :

(A) 466 mA (B) 312 mA (C) 238 mA (D) 196 mA

Sol. **B**

As

$\omega = \frac{.6}{\sqrt{LC}}$ given

$$\text{Current } I = \frac{V}{Z} = \frac{50}{\sqrt{(10)^2+\left(0.6\sqrt{\frac{L}{C}}-\frac{1}{0.6}\sqrt{\frac{C}{L}}\right)^2}}$$

$$\text{Or } I = \frac{50}{\sqrt{100+\left(0.6\times100-\frac{100}{0.6}\right)^2}} \cong 0.238 \text{ or } 238\text{mA}$$

15. Identify the correct statements from the following descriptions of various properties of electromagnetic waves.

(A) In a plane electromagnetic wave electric field and magnetic field must be perpendicular tO each other and direction of propagation of propagation of wave should be along electric field or magnetic field.

(B) The energy in electromagnetic wave is divided equally between electric and magnetic fields.

(C) Both electric field and magnetic field are parallel to each other and perpendicular to the direction of propagation of wave.

(D) The electric field, magnetic field and direction of propagation of wave must be perpendicular to each other.

(E) The ratio of amplitude of magnetic field to the amplitude of electric field is equal to speed of light.

Choose the most appropriate answer from the options given below :

(A) (D) only

(B) (B) and (D) only

(C) (C) and (E) only

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

Sol. **B**

By Theory

16. Two coherent sources of light interfere. The intensity ratio of two sources is 1 : 4. For this interference pattern if the value of $\frac{I_{max}+I_{min}}{I_{max}-I_{min}}$ is equal to $\frac{2\alpha+1}{\beta+3}$, then $\frac{\alpha}{\beta}$ wil be :

(A) 1.5 (B) 2 (C) 0.5 (D) 1

Sol. **B**

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (1+2)^2 = 9$

$I_{min}\left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (1-2)^2 = 1$

Now $\frac{10}{8} = \frac{2\alpha+1}{\beta+3}$

$5\beta + 15 = 8\alpha + 4$

$\frac{2(2)+1}{1+3} = \frac{2\alpha+1}{\beta+3}$

$\alpha = 2, \beta = 1$

Hence $\frac{\alpha}{\beta} = 2$

17. With reference to the observations in photo-electric effect, identify the correct statements from below :

(A) The square of maximum velocity of photoelectrons varies linearly with frequency of incident light.

(B) The value of saturation current increase on moving the source of light away from the metal surface.

(C) The maximum kinetic energy of photo-electrons decreases on decreasing the power of LED (light emitting diode) source of light.

(D) The immediate emission of photo-electrons out of metal surface can not be explained by particle nature of light/ electromagnetic waves.

(E) Existence of threshold wavelength can not be explained by wave nature of light/ electromagnetic waves.

Choose the correct answer from the options given below :

(A) (A) and (B) only

(B) (A) and (E) only

(C) (C) and (E) only

(D) (D) and (E) only

Sol. **B**

By Theory

18. The activity of a radioactive material is 6.4×10^{-4} curie. Its half life is 5 days. The activity will become 5×10^{-6} curie after :

(A) 7 days (B) 15 days (C) 25 days (D) 35 days

Sol. **D**

$A = \frac{A_0}{2^n}$

$2^n = \frac{A_0}{A} = \frac{64 \times 10^{-4}}{5 \times 10^{-4}} = 128 = 2^7$

N = 7 half lifes

So 7 × 5 = 35 days

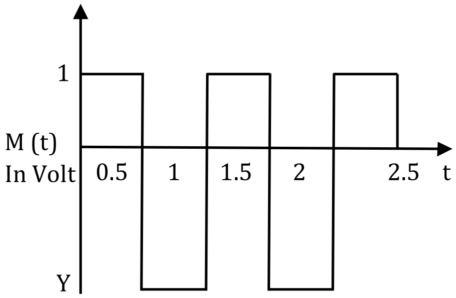
19. For a constant collector – emitter voltage of 8 V, the collector current of a a transistor reached to the value of 6 mA from 4 mA, whereas base current changed from $20\mu A\ to\ 25\ \mu A$ value. If transistor is in active state, small signal current gain (current amplication factor) will be :

(A) 240 (B) 400 (C) 0.0025 (D) 200

Sol. **B**

Curreng gain $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2mA}{5\mu A} = 400$

20. A square wave of the modulating signal is shown in the figure. The carrier wave is given by $C(t) = 5\sin(8\pi t)$ Volt. The modulation index is :



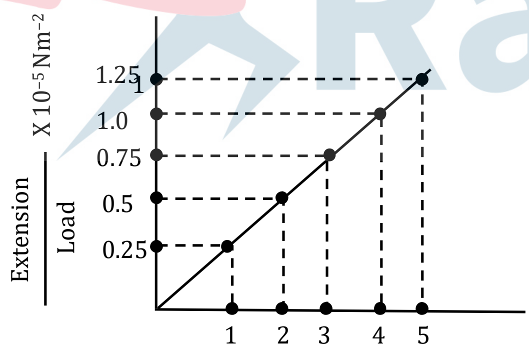
(A) 0.2 (B) 0.1 (C) 0.3 (D) 0.4

Sol. **A**

$\mu = \frac{A_m}{A_C} = \frac{1}{5} = 0.2$

Section - B

21. In an experiment to determine the Young's modulus steel wires of five different lengths (1,2,3,34 and 5m) but of same cross section ($2\ mm^2$) were taken and curves between extension and load were obtaibed. The slope (extension / load) of the curves were plotted with the wire length and the following graph is obtained. If the young's modules of given steel wires is x x 10^{11} NM^{-2} Then the value of x is ________.



Sol. **2**

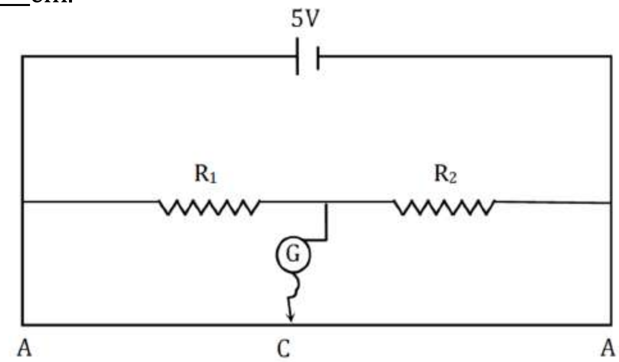
Let us take wire (2) and now

$Y = \frac{FL}{A\Delta x}$ $or = \frac{L}{A}\left(\frac{F}{\Delta x}\right)$

Putting values $Y = \frac{2\times 2}{.5\times 10^{-5}(2\times 10^{-3})^2}$

Solving $Y = 2\times 10^{11}$

22. In the given figure of meter bridge experiement, the balancing length AC corresponding to null deflection of the galvanometer is 40 cm. The balancing length, if the radius of the wire AB is doubled will be _____cm.



Sol. **40**

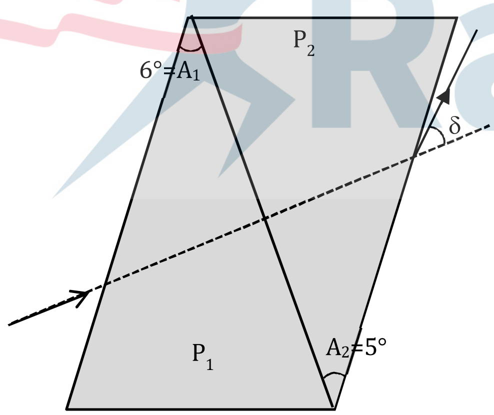
Potential gradient

x = $\frac{e}{l}$ does not depends on cross sectional area

Hence, balancing point will be same

x = 40 cm

23. A thin prism of angle 6° and refractive index for yellow light (n_y) 1.5 is combined with another prism of angle 5° and n_y = 1.55. The combination produces no dispersion. The net average deviation (δ) produced by the combination is $\left(\frac{1}{x}\right)^{\circ}$. The value of x is ______.



Sol. **4**

$\delta_{net} = \delta_1 - \delta_2$

$\delta_{net} = (1.5-1)6° - (1.55-1)5°$

= 3° - 2.75° = 0.25°

$\frac{1}{x} = \frac{1}{0.25} \Rightarrow x = 4$

24. A conducting circular loop is placed in $x - y$ plane in presence of magnetic field $\vec{B} = (3t^3\hat{j} + 3t^2\hat{k})$ in SI unit. If the radius of the loop is 1 m, the induced emf in the loop at time $t = 2\ s\ is\ n\pi\ V$. The value of n is ______.

Sol. 12

$e\ =\ A.\frac{dB}{dt}$

$e = \pi(1)^2 \times \frac{d}{dt}(3t^2)$

Or

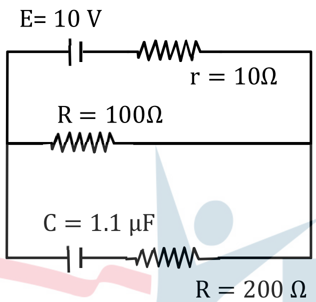
$e\ = 3\pi t^2$

At t = 2

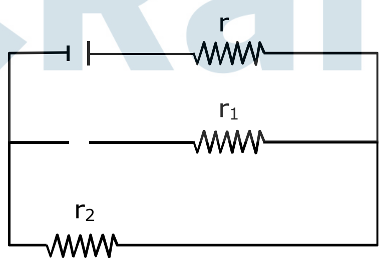
$e = 3\pi(2)^2$

$e = 12\pi$

25. As shown in the figure, in steady the charge stored in the capacitor is __________$\times\ 10^{-6} C$



Sol. **10**



In steady state

Current $I\ =\ \frac{E}{r+r_2}$

Potential disterence across AB = $Ir_2\ = \frac{Er_2}{r+r_2}$

Charge on capacitor Q = C (ΔV)AB

Q = $\frac{CEr_2}{r+r_2} = 10\mu C$

26. A parallel plate capacitor with width 4 cm, length 8 cm and separation between the plates of 4 mm is connected to a battery of 20 V. A dielectric slab of dielectric constant 5 having length 1 cm, width 4 cm and thickness 4 mm is inserted between the plates of parallel plate capacitor. The electrostatic energy of this system will be _______$\varepsilon_0 J$.

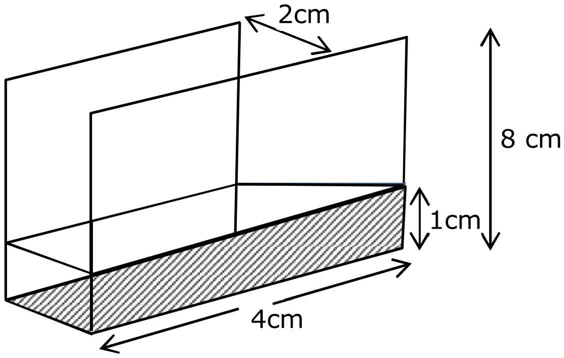
Sol. **240**

$V = \frac{1}{2}(C_{eq} V^2)$

$V = \frac{1}{2}\frac{\epsilon_0}{d}(KA_1 + A_2)V^2$

$V = \frac{\epsilon_0}{2} 2 \times 10^{-3} \left(\frac{5\times1\times4}{100\times100}\right)$

$\left(\frac{7\times4}{100\times100}\right)(20)^2$



$= \frac{\epsilon_0}{2} \frac{48}{2\times10^{-3}} \times \frac{20\times20}{100\times100} = 240\ \epsilon_0$

27. A wire of length 30 cm. stretched between rigid supports, has it' n^{th} and $(n+1)^{th}$ harmonics at 400 Hz and 450 Hz respectively. If tension in the string is 2700 N, it's linear mass density is __________kg/m.

Sol. **3**

$\frac{n+1}{2l}\sqrt{\frac{T}{\mu}} = 400$ ...(1)

$\frac{n}{2l}\sqrt{\frac{T}{\mu}} = 300$ ...(2)

or

$\frac{n}{n+1} = \frac{3}{4}$

So

N = 3

By 2

$300 = \frac{3}{2\times30\times10^{-2}}\sqrt{\frac{2700}{\mu}}$

μ = 3

28. A spherical soap bubble of radius 3 cm is formed inside another spherical soap bubble of radius 6 cm. If the internal pressure of the smaller bubble of radius 3 cm in the above system is equal to internal pressure of the another single soap bubble of radius r cm. The value of r is ________.

Sol. **2**

pressure difference

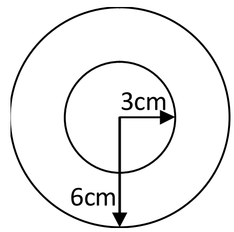
$\Delta P = P_1 + P_2$

$\frac{4T}{R} = \frac{4T}{r_1} + \frac{4T}{r_2}$

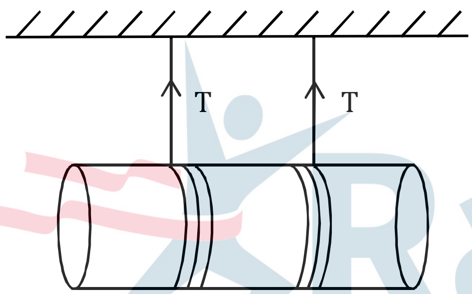
$\frac{1}{2} = \frac{1}{r_1} + \frac{1}{r_2}$

$\frac{1}{R} = \frac{1}{3} + \frac{1}{6}$

R = 2



29. A solid cylinder length is suspended symmetrically through two massless strings, as shown in the figure. The distance from the initial rest position, the cylinder should by unbinding the strings to achieve a speed of 4 ms^{-1}, is __________cm. (take = g = 10 ms^{-2})



Sol. **120**

Applying $a = \frac{Mg}{M+\frac{I}{R^2}}$

$a = \frac{Mg}{M+\frac{M}{2}} = \frac{2g}{3}$

And v = u + at

4 = 0 + $\frac{2}{3} \times 10t$

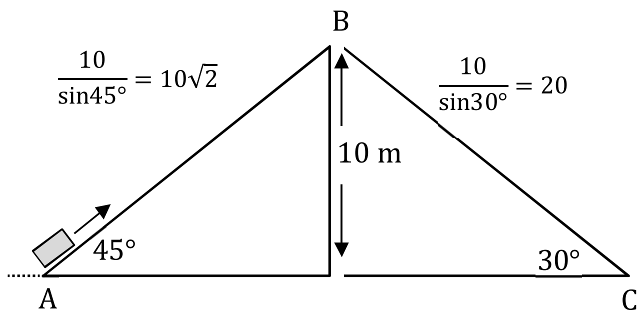
$t = \frac{3}{5}$

And $S = ut + \frac{1}{2}\, at^2$

$S = 0 + \frac{1}{2} \times \frac{20}{3} \times \frac{3}{5} \times \frac{3}{5}$

$S = 1.2\, m = 120\, cm$

30. Two inclined planes are placed as shown in figure. A block is projected from the point A inclined plane AB along its surface with a velocity just sufficient to carry it to the top point B at a height 10 m. After reaching the Point B the block sides shown on inclined plane BC. Time it takes to reach to the point C from point A is $t(\sqrt{2}+1)s$. The value of t is ________.



Sol. **2**

In upward motion

$\frac{1}{2} g \sin 45° \, t^2 = 10\sqrt{2}$

$\frac{1}{2} \times \frac{10}{\sqrt{2}} t_1^2 = 10\sqrt{2}$

$t_1 = 2$

In downward motion

$\frac{1}{2} g \sin 30° t^2 = 20$

$\frac{1}{2} \times \frac{10}{2} t_2^2 = 20$

$t_2 = 2\sqrt{2}$

Total time = $2(1+\sqrt{2})$

t = 2