PHYSICS

JEE and NEET Crash Course

Problem Solving Class

(Viscosity, Elasticity and Surface Tension)

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PQ13**Q 7**

Radius of a soap bubble is '*r*', surface tension of soap solution is *T*. Then without increasing the temperature, how much energy will be needed to double its radius :

(a) $4\pi r^2 T$

(b) $2\pi r^2 T$

(c) $12\pi r^2 T$

(d) $24\pi r^2 T$

PQ13S 7

Ans [D]

à $W = T\Delta A$

à $W = 2 \times 4\pi\left(R_1{}^2 - R_2{}^2\right)$

à $8\pi T[4r^2 - r^2]$

à $24\pi r^2 T$

There are two free surface of soap bubble (Inside and outside) so the surface tension acts on both the surfaces

PQ13**Q 10**

The amount of work done in forming a soap film of size $10\text{cm} \times 10\ cm$ is (Surface tension $\mathrm{T} = 3 \times 10^{-2}\ N/m$)

(a) $6 \times 10^{-4}\ J$

(b) $3 \times 10^{-4}\ J$

(c) $6 \times 10^{-3}\ J$

(d) $3 \times 10^{-4}\ J$

PQ13S 10

Ans [A]

$$E = T \times \Delta A$$

$$= 3 \times 10^{-2} \times 2(100 \times 10^{-4})$$

$$= 6 \times 10^{-4} J$$

It is important to take 2 here because when we form the soap film it has two free surfaces and surface tension acts on both free surfaces

PQ13**Q 14**

A long cylindrical glass vessel has a small hole of radius '*r*' at its bottom. The depth to which the vessel can be lowered vertically in the deep water bath (surface tension *T*) without any water entering inside is **:**

$(a)\,\frac{4T}{\rho r g}$ $(b)\,\frac{2T}{\rho r g}$

$(c)\,\frac{3T}{\rho r g}$ $(d)\,None$

PQ13S 14

Ans [B]

$$h\rho g = \frac{2T}{r}$$

$$h = \frac{2T}{r\rho g}$$

Water will not enter till excess pressure of the film become less than the pressure due to height

P-Q1101

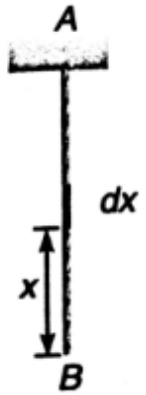
A bar of mass **m** and length **l** is hanging from point A. Find the increase in its length due to its own weight. The young's modulus of elasticity is **Y** and area of cross section is **A**

(A) $\Delta l = \frac{mgl}{2AY}$ (B) $\Delta l = \frac{mg}{AY}$

(C) $\Delta l = \frac{mgl}{AY}$ (D) $\Delta l = \frac{mgl}{2Y}$

P-Q1101-Solution

Ans [A] Consider a small section of dx of the bar at a distance x from B . The weight of the bar for a length x is



$$W = \left(\frac{mg}{l}\right)x$$

Elongation in section dx will be

$$dl = \left(\frac{W}{AY}\right)dx = \left(\frac{mg}{lAY}\right)xdx$$

Total elongation can be obtained by integrating this expression for x=0 to x=l

$$\therefore \quad \Delta l = \int_{x=0}^{x=l} dl = \left(\frac{mg}{lAY}\right)\int_{0}^{l} xdx$$

$$\therefore \quad \Delta l = \frac{mgl}{2AY}$$

Other simple way to think is

Take Mass m hanging at COM at length $l/2$ from point A

P-Q1104

A steel wire of length **4m** and diameter **5mm** is stretched **by 5 kg-wt** . Find the increase in its length if the young's modulus of steel is $\mathbf{2.4 \times 10^{12}}\ \boldsymbol{dyne / cm^2}$.

(A) 0.0041cm (B) 0.002cm

(C) 0.4cm (D) 0.2cm

P-Q1104-Solution

Ans [A]

$$here\ l = 4m = 400cm\ , 2r = 5mm$$

$$f = 5kg - wt = 5000g - wt = 5000 \times 980\ dyne$$

$$\Delta l = ?, Y = 2.4 \times 10^{12} dyne\ /\ cm^2$$

$$Y = \frac{F}{\pi r^2} \times \frac{l}{\Delta l}$$

$$\Delta l = \frac{Fl}{\pi r^2 Y}$$

$$= \frac{(500 \times 980) \times 400}{\left(\frac{22}{7}\right) \times (0.25)^2 \times 2.4 \times 10^{12}}$$

$$= 0.0041cm$$

Note that all the values of various variables are given in different units.. Convert all to same unit before applying formula

P-Q1136

Two wires of equal lengths are made of the same material. Wire A has a diameter that is twice as that of wire B. If identical weights are suspended from the ends of these wires, the increase in length is

(A) Four times for wire A as for wire B

(B) Twice for wire A as for wire B

(C) Half for wire A as for wire B

(D) One-fourth for wire A as for wire B

P-Q1136-Solution

Ans [D]

$$l = \frac{FL}{AY}$$

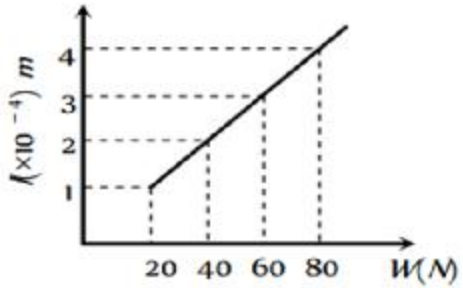
$$\Rightarrow l \propto \frac{1}{r^2}$$

F, L and Y are same here

$$\frac{l_A}{l_B} = \left(\frac{r_B}{r_A}\right)^2 = \left(\frac{r_B}{2r_B}\right)^2 = \frac{1}{4} \Rightarrow l_A = 4l_B \text{ or } l_B = \frac{l_A}{4}$$

P-Q1158

The adjacent graph shows the extension (Δl) of a wire of length $1m$ suspended from the top of a roof at one end with a load W connected to the other end. If the cross sectional area of the wire is $10^{-6} m^2$, calculate the young's modulus of the material of the wire



(A) $2\times10^{11}\ N/m^2$

(B) $2\times10^{-11}\ N/m^2$

(C) $3\times10^{-12}\ N/m^2$

(D) $2\times10^{-13}\ N/m^2$

P-Q1158-Solution

Ans [A]

From the graph, we can say that $l = 10^{-4} m, F = 20 N$

$$A = 10^{-6} m^2, L = 1m$$

$$\therefore \quad Y = \frac{FL}{Al} = \frac{20 \times 1}{10^{-6} \times 10^{-4}} = 20 \times 10^{10} = 2 \times 10^{11} N/m^2$$

P-Question

A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density $\rho_2 (\rho_2 < \rho_1)$. Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = kv^2$(k>0). The terminal speed of the ball is....

1) $\sqrt{\frac{Vg\rho_1}{k}}$ **2)** $\frac{Vg(\rho_1-\rho_2)}{k}$ **3)** $\sqrt{\frac{Vg(\rho_1-\rho_2)}{k}}$ **4)** $\frac{Vg\rho_1}{k}$

P-Solution

Ans [3]

$$\mathbf{mg} - F_B = F_v$$

$$\mathbf{V}\rho_1 g - \mathbf{V}\rho_2 g = kv^2$$

P-Question

Capillary tube is immersed vertically in water and the height of the water column is x. When this arrangement is taken into a mine of depth d, the height of the water column is y. If R is the radius of earth, the ratio $\frac{x}{y}$ is :

1) $\left(1-\frac{d}{R}\right)$ **2)** $\left(1-\frac{2d}{R}\right)$

3) $\left(\frac{R-d}{R+d}\right)$ **4)** $\left(\frac{R+d}{R-d}\right)$

P-Solution

Ans [1]

$$h \propto \frac{1}{g} \Rightarrow \frac{x}{y} = \frac{g_y}{g_x} = g\left(1 - \frac{d}{R}\right) = 1 - \frac{d}{R}$$

P-Question

The bulk modules of Ethanol, Mercury and water are given as 0.9, 25 and 2.2 respectively in units of $10^9 \mathrm{N}m^{-2}$. For a given value of pressure, the fractional compression in volume is $\frac{\Delta V}{V}$. Which of the following statements about $\frac{\Delta V}{V}$ for these three liquids is correct?

1) Ethanol > Water > Mercury

2) Water > Ethanol > Mercury

3) Mercury > Ethanol > Water

4) Ethanol > Mercury > Water

P-Solution

Ans [1]

$$\mathbf{B} = \frac{\boldsymbol{P}}{\frac{\boldsymbol{\Delta V}}{\boldsymbol{V}}}\mathbf{,\ for\ given\ value\ of\ p}$$

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

$$\frac{\boldsymbol{\Delta V}}{\boldsymbol{V}} = \frac{\mathbf{1}}{\boldsymbol{B}}$$

P-Question

An air bubble of radius 0.1cm is in a liquid having surface tension 0.06N/m and density $10^3 kg/m^3$ The pressure inside the bubble is $1100 Nm^{-2}$ greater than the atmospheric pressure. At what depth is the bubble below the surface of the liquid? (g = $9.8 ms^{-2}$)

1) 0.1 m

2) 0.15 m

3) 0.20 m

4) 0.25 m

P-Solution

Ans [1]

$$\Delta P = \frac{2T}{r} + h\rho g$$

P-Question

In an experiment, a small steel ball falls through a liquid at a constant speed of 10cm/s. If the steel ball is pulled upward with a force equal to twice its effective weight, how fast will it move upward?

1) 5 cm/s

2) Zero

3) 10 cm/s

4) 20 cm/s

P-Solution

Ans [3]

At constant speed net force = 0

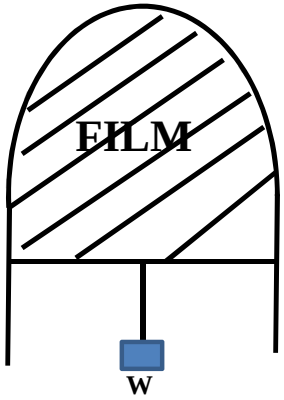
Neglecting $F_{bouancy}$ As it is a small sphere at v_{t_1}, F_{v_1}= mg

Case 1 : $v_1\downarrow \uparrow F_{v_1}$ at v_{t_2} F_{v_2} = (2mg-mg)

Case 2 : $v_2\uparrow$ $F_{v_2}\downarrow$ Þ $v_{t_2} = v_{t_1}$= 10 cm/s

P-Question

A thin liquid film formed between a U-shaped wire and lite slider, which supports a weight of $1.5\times10^{-2}N$ (see figure). The length of the slider is 30cm and its weight negligible. The surface tension of the liquid film is…… (AIEEE-2012)



1) $0.05Nm^{-1}$

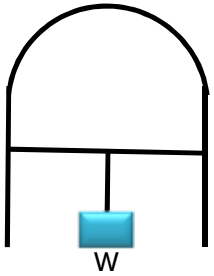
2) $0.025Nm^{-1}$

3) $0.0125Nm^{-1}$

4) $0.1Nm^{-1}$

P-Solution

Ans [2]



$$S.2l = W$$

$$S = \frac{w}{2l} = \frac{1.5 \times 10^{-2}}{2 \times 30 \times 10^{-2}} = 0.025\ N/m$$

P-Question

The work done increasing the size of a rectangular bubble from a radios of 3cm to 5cm is nearly [surface tension of soap solution= 0.03N/m] …. **[AIEEE-2011]**

1) 4π mJ

2) $0.2\ \pi$ mJ

3) $2\ \pi$ mJ

4) $0.4\ \pi$ mJ

P-Solution

Ans [4]

Workdone = T × increase in surface area

P-Question

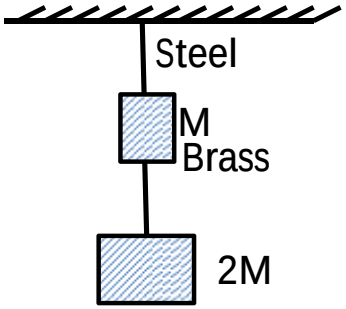
If the ratio of lengths, radii and young's moduli of steel and brass wires in the figure are a,b and c respectively, then the corresponding ratio of increase in their length is...

1) $\frac{2ac}{b^2}$

2) $\frac{3a}{2b^2c}$

3) $\frac{2a^2c}{b}$

4) $\frac{3c}{2ab^2}$



P-Solution

Ans [2]

$$\mathbf{e} = \frac{Fl}{Ay} = \frac{Fl}{\pi r^2} = \frac{mgl}{\pi r^2 y}$$

P-Question

A copper wire of length 10m and a steel wire of length 0.5m having equal cross sectional areas are joined end to end. The composite wire is stretched by a certain load which stretched the copper wire by 1 mm. If the young's moduli of copper and steel are respectively $10\times10^{11}Nm^{-2}$ and $20\times10^{11}Nm^{-2}$, the total extension of the composite wire is.....

1) 1.75 mm

2) 2.0 mm

3) 1.025 mm

4) 1.25 mm

P-Solution

Ans [3]

$$F_1 = F_2$$

$$\mathbf{e} \propto \frac{1}{y}$$

$$\mathbf{e} = e_1 + e_2$$