Class 11 Physics

Mechanical Properties Of Solids

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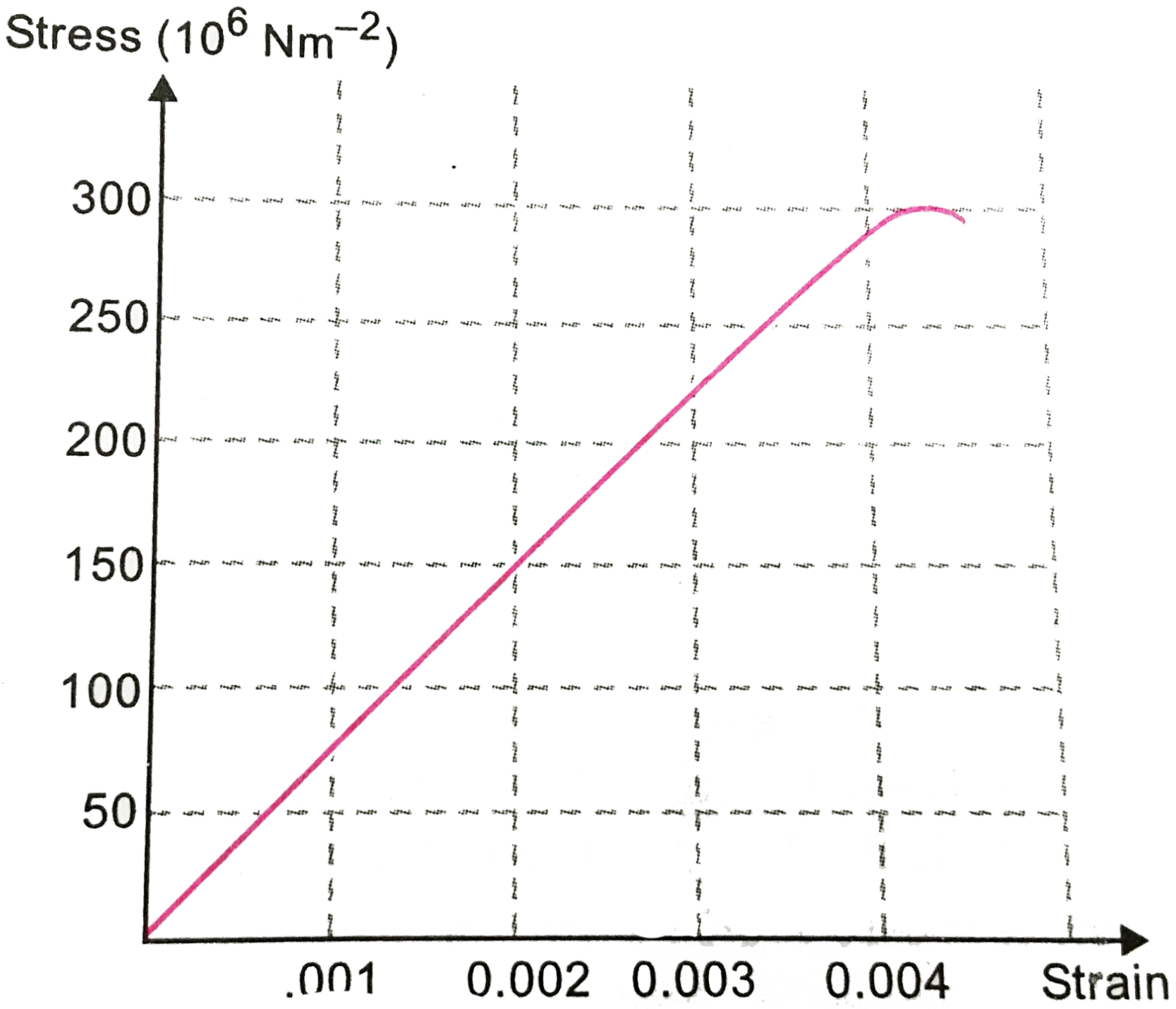
Exercise 9.1

A steel wire of length $4.7m$ and cross-sectional area $3 \times 10^{-6}m^2$ stretches by the same amount as a copper wire of length $3.5m$ and cross-sectional area of $4 \times 10^{-6}m^2$ under a given load. The ratio of Young's modulus of steel to that of copper is

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Exercise 9.2

Fig., shows the stress-strain curve for a given materal. What are (a) Young's modulus and (b) approximate yield strength for this material?

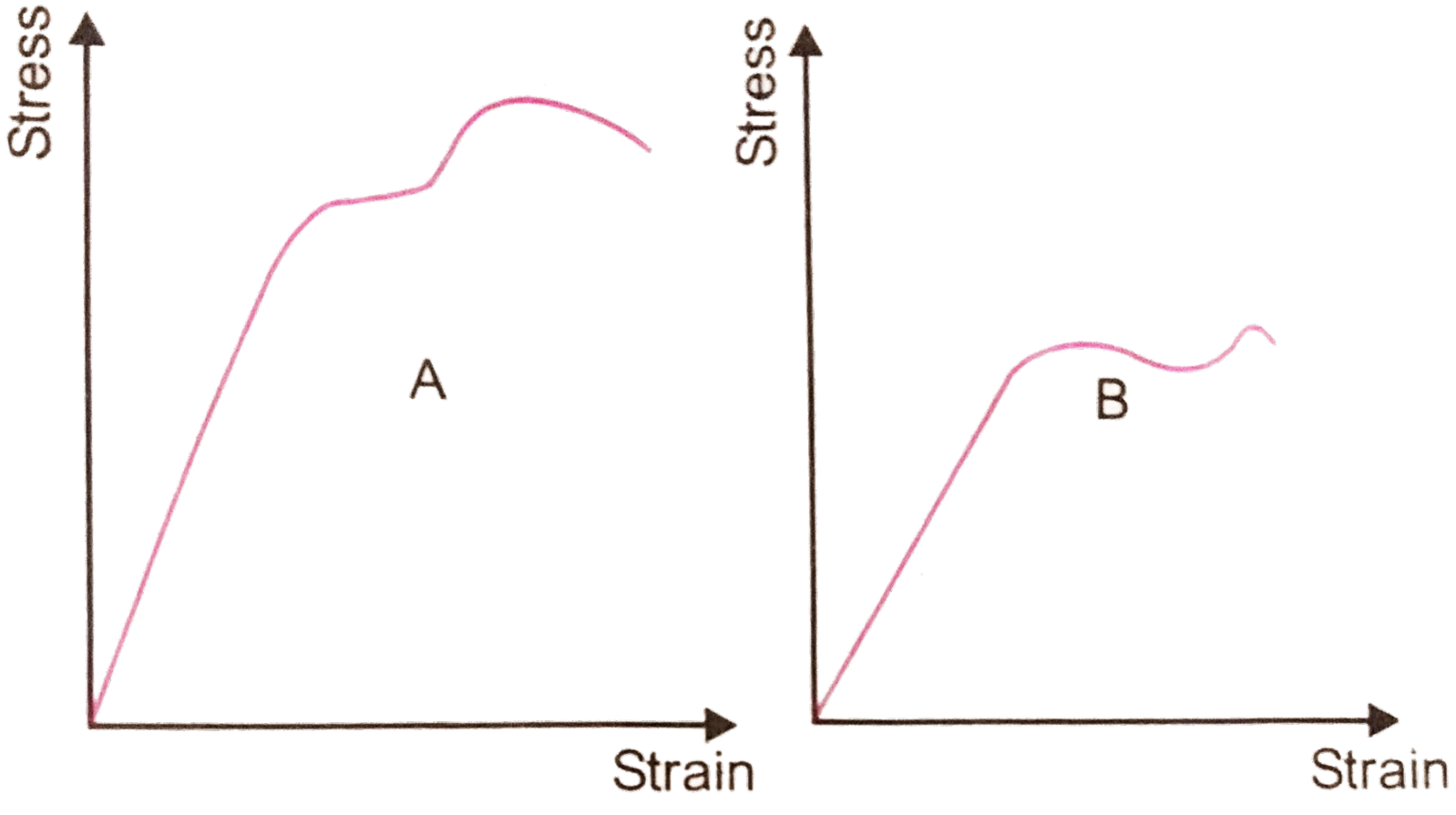


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Exercise 9.3

The stress versus strain graph for two materials A and B are shown in fig. the graph are on the same scale. ltbr. (a) Which material has greater Young's modulus?

(b) which of the two is stronger material?



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Exercise 9.4

Read each of the statement below carefully and state, with reasons, if it is true or false.

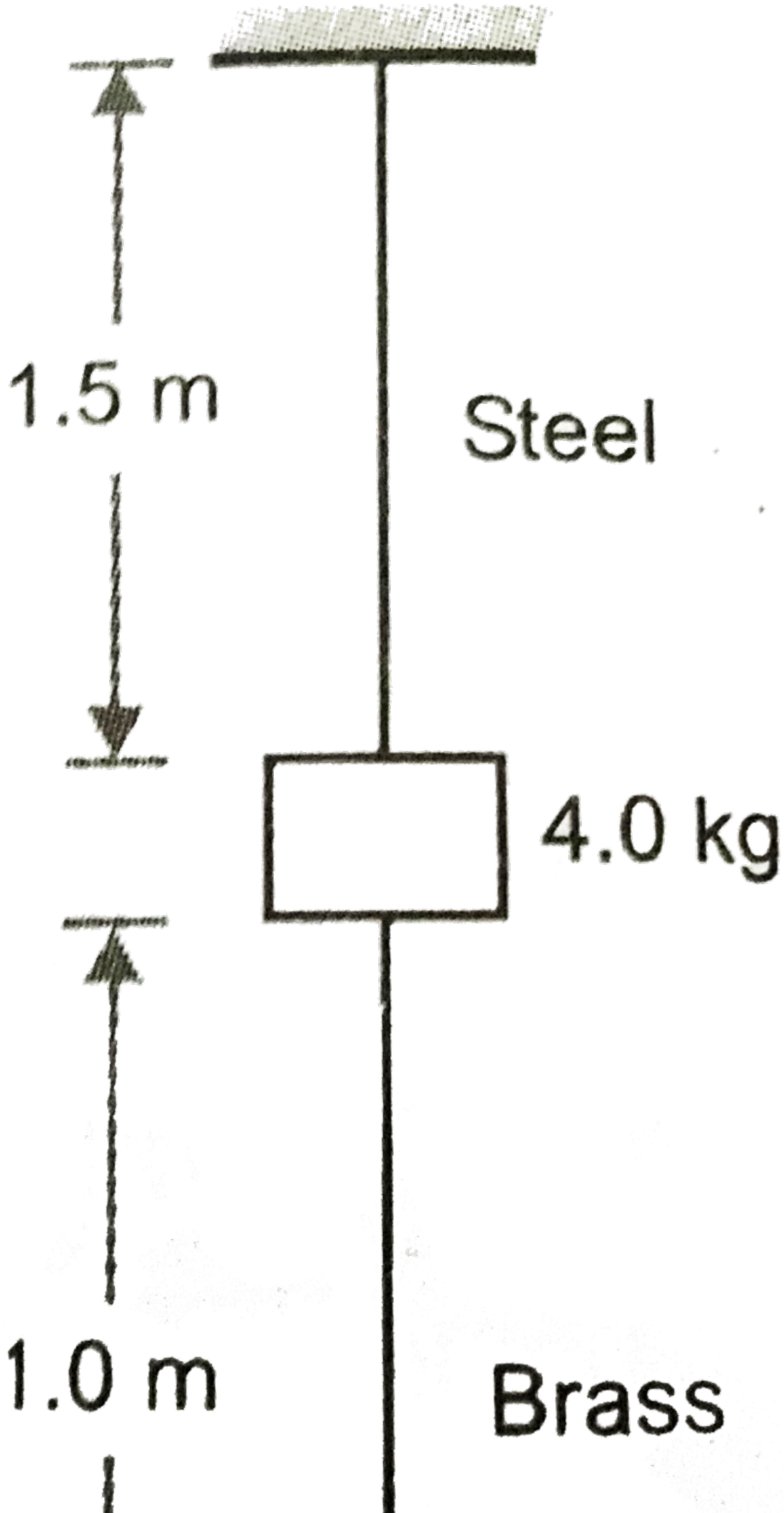
(a) The modulus of elasticity of rubber is greater than that of steel.

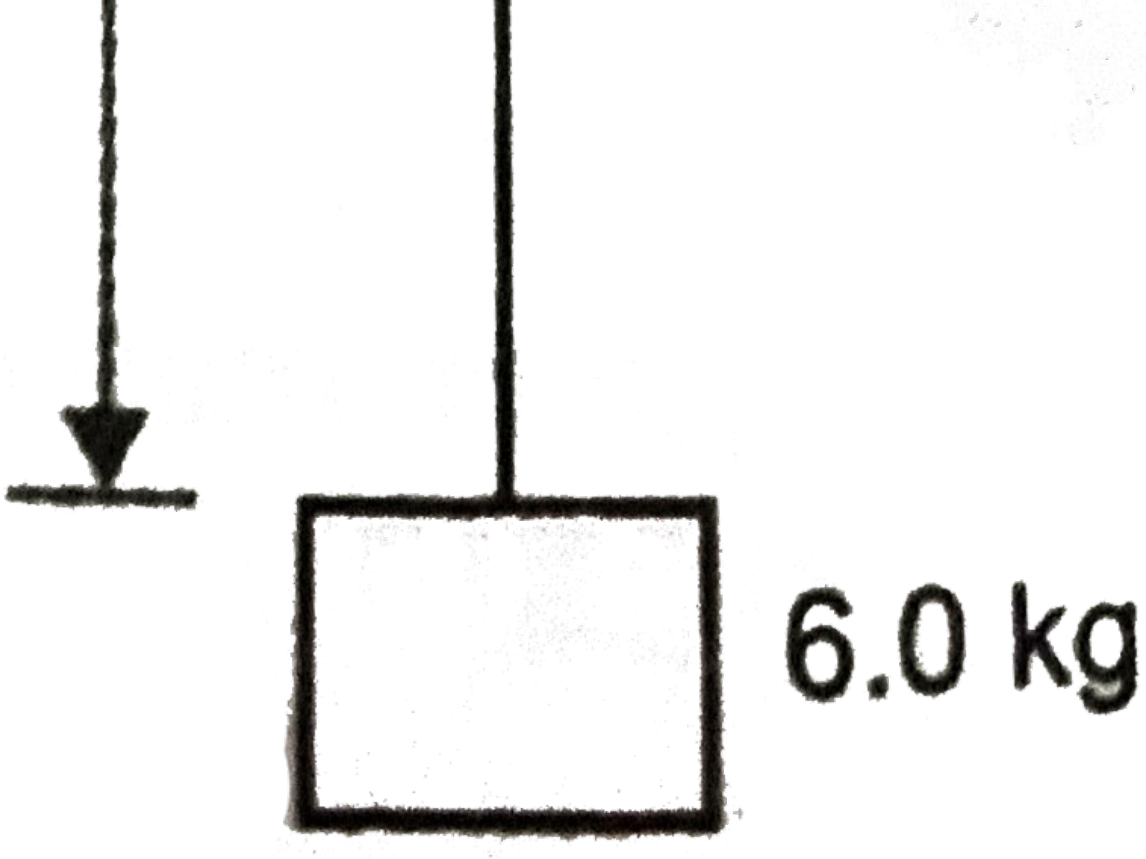
(b) the stretching of a coil is determined by its shear modulus.

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Exercise 9.5

Two wires of diameter 0.25 cm, one made of steel and the other made of brass are loaded as shown in fig. The unloaded length of steel wire is $1.5m$ and that of brass wire is 1.0m. Compute the elongations of the steel and the brass wires.





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Exercise 9.6

The edges of an aluminum cube are $10cm$ long. One face of the cube is firmly fixed to a vertical wall. A mass of $100kg$ is then attached to the opposite face of the cube. Shear modulus of aluminum is $25 \times 10^9 Pa$, the vertical deflection in the face to which mass is attached is

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Exercise 9.7

Four identical hollow cylindrical cloumns of steel support a big structure of mass 50.000 kg. the inner and outer radii of each column are 30 cm and 60 cm respectively. Assume the load distribution to be uniform , calculate the compressional strain of each column. the Young's modulus of steel is $2.0 \times 10^{11} Pa$.

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Exercise 9.8

A piece of copper having a rectangular cross section of $15.2 \times 19.1 mm$ is pulled in tension with 45,500N, force producing only elastic deformation. Calculate the resulting strain. Shear modulus of elasticity of copper is $42 \times 10^9 Nm^{-2}$.

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Exercise 9.9

A steel cable with a radius of 1.5 cm support a chairlift at a ski area.if the maximum stress is not to exceed $10^8 Nm^{-2}$, what is the maximum load the cable can support?

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Exercise 9.10

A rigid bar of mass 15 kg is supported symmetrically by three wires each 2 m long. Those at each end are of copper and middle one is of iron. Determine the ratio of their diameters if each is to have the same tension. Young's modulus of elasticity for copper and steel are $110 \times 10^9 Nm^{-2}$ and $190 \times 10^9 Nm^{-2}$ respectively.

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Exercise 9.11

A 14.5 kg mass, fastened to the end of a steel wire of unstretched length 1m, is whirled in a vertical circle with an angular velocity of $2rev.\ /s$ at the bottom of the circle. The cross-sectional area of the wire is $0.065cm^2$. Calculate the elongaton of the wire when the mass is at the lowest point of its path $Y_{steel} = 2 \times 10^{11} Nm^{-2}$.

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Exercise 9.12

Compute the bulk modulus of water from the following data : initial volume = 100.0 litre, pressure increase = 100.0 atmosphere. Final volume - 100.5 litre . (1 atmosphere = $1.013 \times 10^5 Pa$). Compare the bulk modulus of water that of air (at constant temperature). explain in simple terms why the ratio is so large.

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Exercise 9.13

What is the density of ocean water at a depth, where the pressure is 80.0 atm, given that its density at the surface is $1.03 \times 10^3 kgm^{-3}$? Compressibilty of water $= 45.8 \times 10^{-11} Pa^{-1}$. Given 1 atm. = $1.013 \times 10^5 Pa$.

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Exercise 9.14

Compute the fractional change in volume of a glass slab, when subjected to a hydraulic pressure of 10 atmosphere. Bulk modulus of elasticity of glass = $37 \times 10^9 Nm^{-2}$ and 1 atm = $1.013 \times 10^5 Pa$.

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Exercise 9.15

Determine the volume contraction of a solid copper cube, 10 cm on an edge when subjected to hydraulic pressure of $7 \times 10^6 Pa$. Bulk modulus of copper = 140 Gpa.

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Exercise 9.16

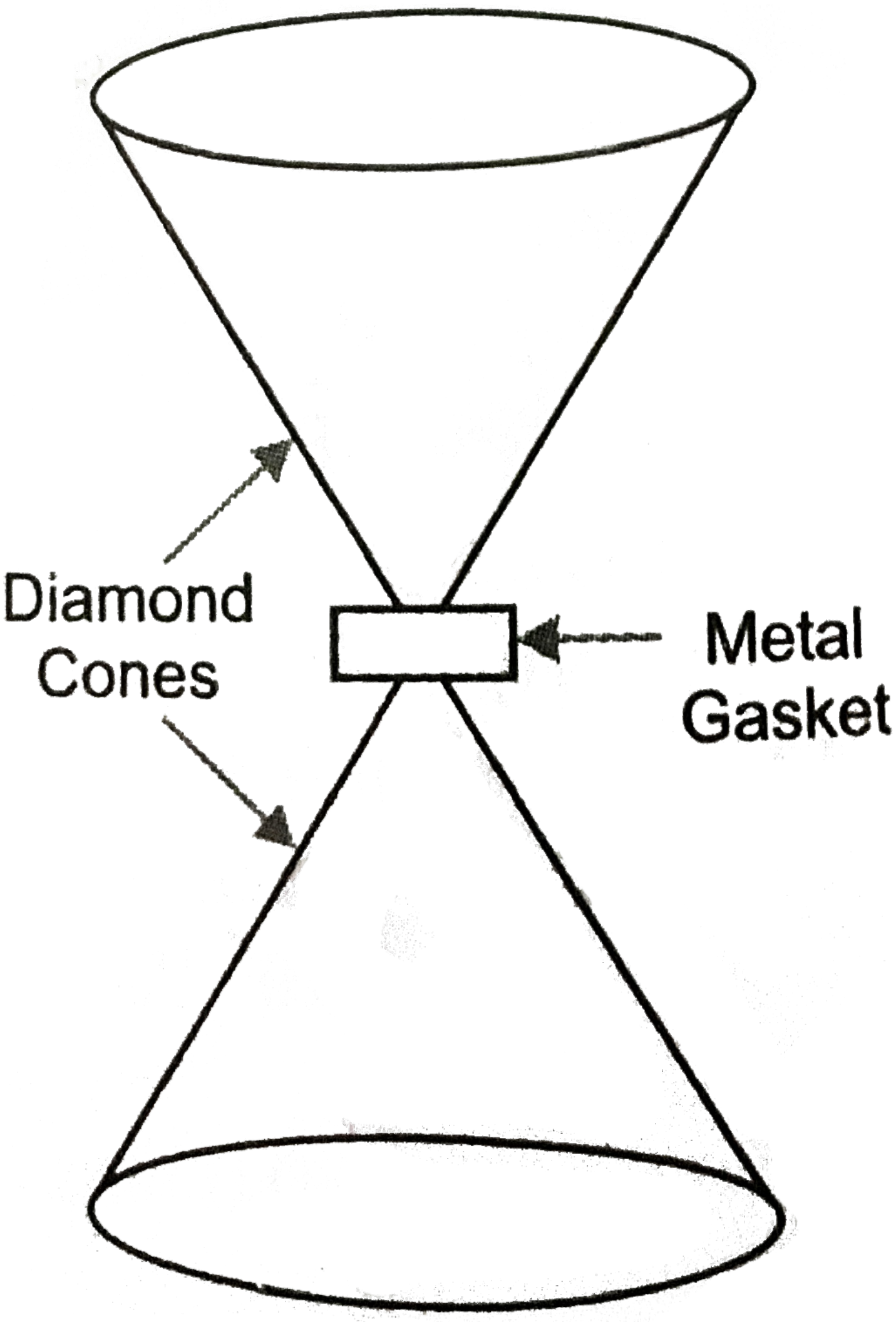
How much should the pressure on a litre of water be changed to compress it by 0.10%? Bulk modulus of elasticity of water = $2.2 \times 10^9 Nm^{-2}$.

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Exercise 9.17

Anvils made of single crystal of diamond , with shape as shown in

fig. are used to investigate behaviour of materials under very high pressure. Flat faces at the narrow end of the anvil have a diameter of 0.5 mm, and the wide ends are subjected to a compressional force of 50,000 N. What is the pressure at the tip of the anvil?



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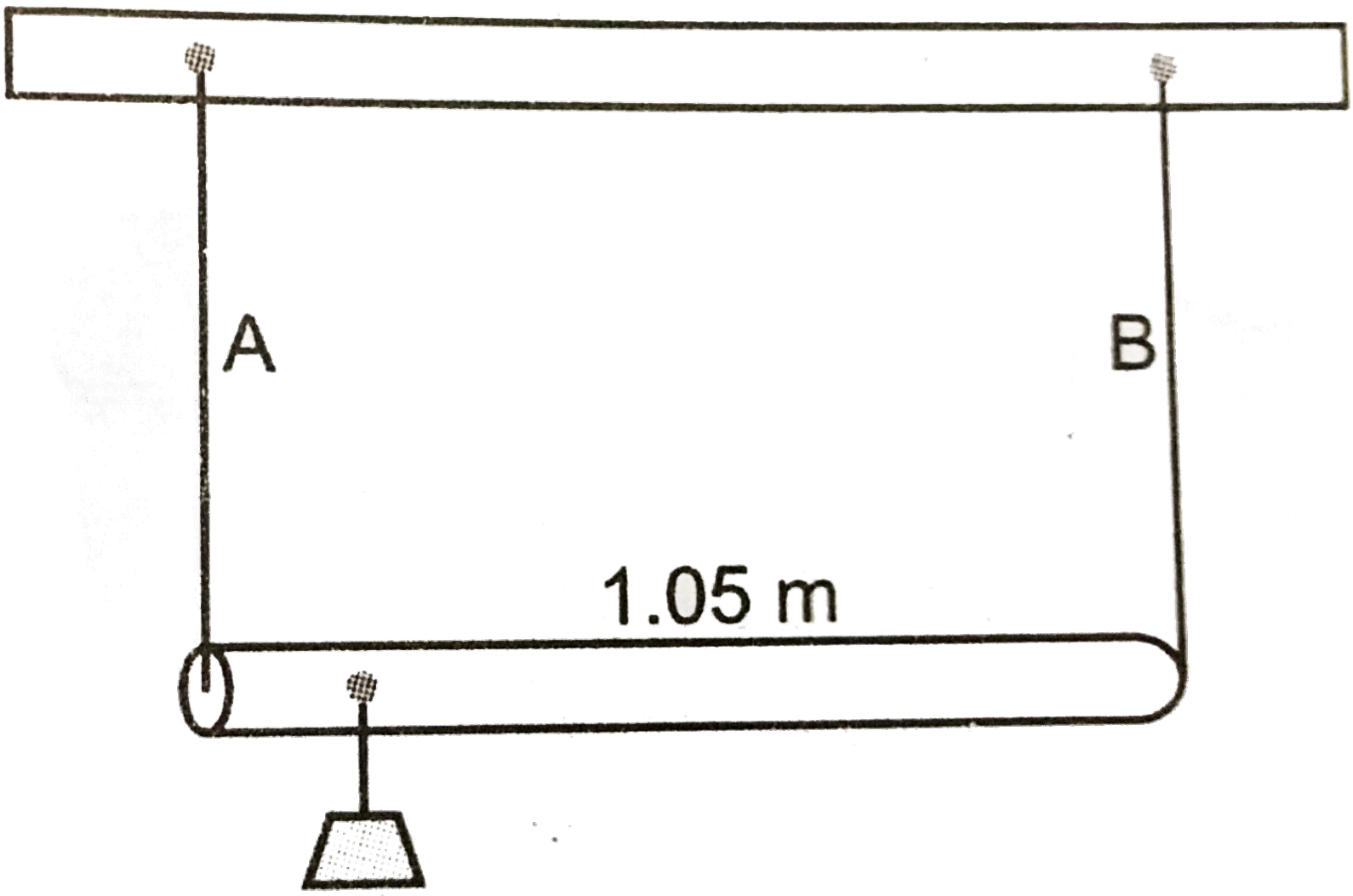
Exercise 9.18

A rod of length 1.05 m having negliaible mass is supported at its ends by two wires of steel (wire A) and aluminium (wire B) of equal lengths as shown in fig. The cross-sectional area of wire A and B are $1mm^2$ and $2mm^2$, respectively . At what point along the rod should a mass m be suspended in order to produce (a) equal stresses and (b) equal strains in both steel and aluminium wires.

Given,

$Y_{steel} = 2 \times 10^{11} Nm^{-2}$ and

$Y - (aluminium) = 7.0 \times 10^{10} N^{-2}$



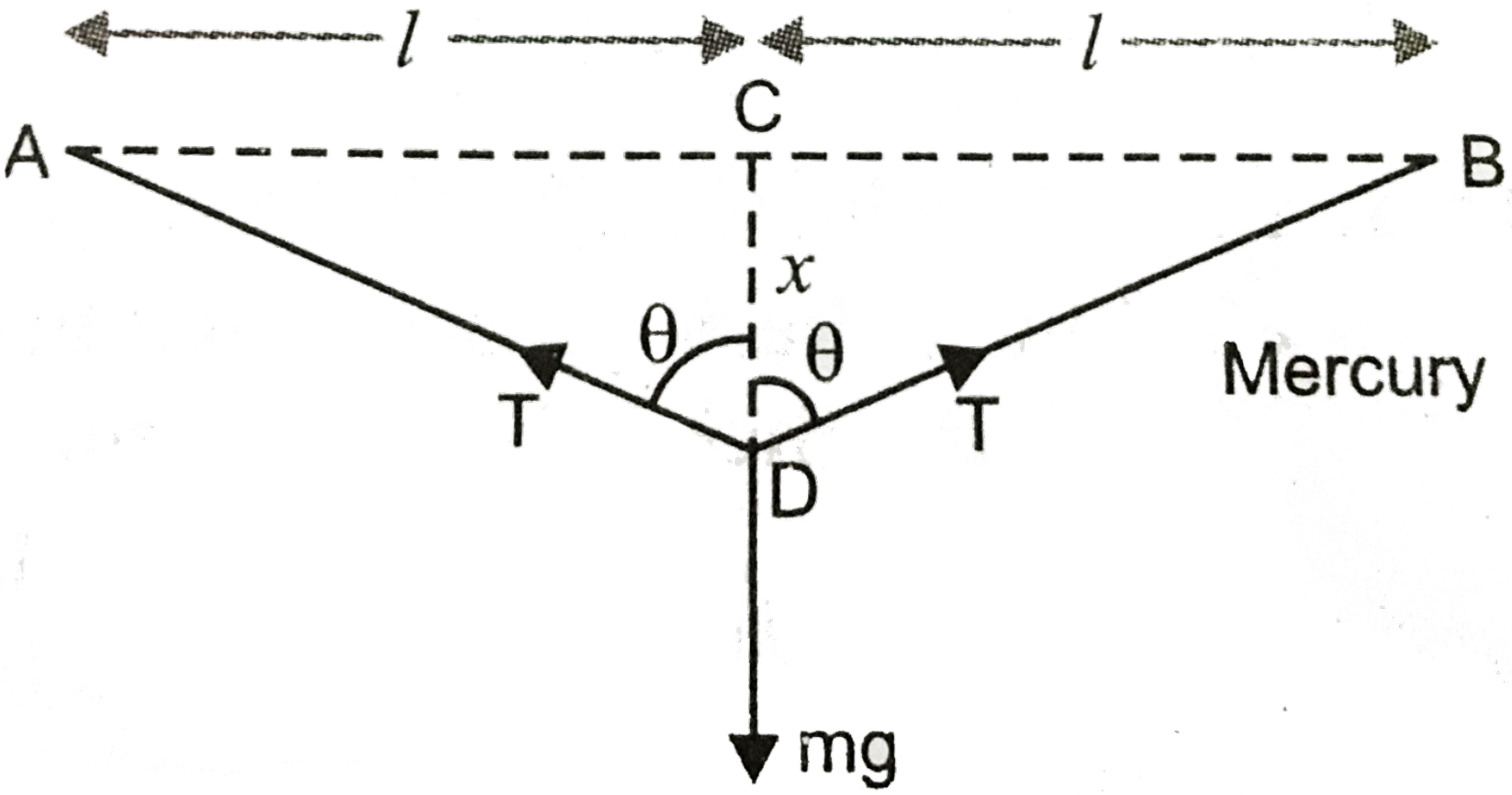
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Exercise 9.19

A mild steel wire of length 1.0 m and cross-sectional are $0.5 \times 10^{-20} cm^2$ is streached, well within its elastic limit, horizontally between two pillars. A mass of 100 g is suspended from the mid point of the wire, calculate the depression at the mid point.

$g = 10 ms^{-2}, Y = 2 \times 10^{11} Nm^{-2}$



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Exercise 9.20

Two strips of metal are riveted together at their ends by four rivets, each of diameter 6 mm. Assume that each rivet is to carry one quarter of the load. If the shearing stress on the rivet is not to exceed $6.9 \times 10^7 Pa$, the maximum tension that can be exerted by the riveted strip is

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Exercise 9.21

The marina Trench is located in the pacific ocean, and at one place it is nearly eleven km beneath the surface of water. The water pressure at the bottom of the Trench is about $1.1 \times 10^8 Pa$. A steel ball of initial volume $0.32 m^3$ is dropped into the ocean and falls to the bottom of the Trench. what is the change in the volume of the ball when it reaches to the bottom? Bulk modulus for steel = $1.6 \times 10^{11} Nm^{-2}$.

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Solved Example 1

A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate (a) stress, (b) elongation, and (c) strain on the rod. Young's modulus, of structural steel is $2.0 \times 10^{11} \mathrm{N m^{-2}}$.

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Solved Example 2

A Copper wire of length 2.2m and a steel wire of length 1.6m, both of diameter 3.0mm are connected end to end. When stretched by a load, the net elongation is found to be 0.70 mm. Obtain the load applied . Young's modulus of copper is $1.1 \times 10^{11} Nm^{-2}$ and Young's modulus of steel is $2.0 \times 10^{11} Nm^{-2}$.

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Solved Example 3

In a human pyramid in a circus, the entire weight of the balanced group is supported by the legs of a performero who is lying on his back (as shown in Fig. 9.5). The combined mass of all the persons performing the act, and the tables, plaques etc. involved is 60 kg.

Each thighbone (femur) of this performer has a length of 50 cm and an effective radius of 2.0 cm. Determine the amount by which each thighbone gets compressed under the extra load.



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Solved Example 4

A square lead slab of side 50 cm and thickness 10 cm is subjected to a shearing force (on its narrow face) of $9 \times 10^4 N$. The lower edge is riveted to the floor. How much will the upper edge be displaced?

(Shear modulus of lead $= 5.6 \times 10^9 Nm^{-2}$)

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Solved Example 5

The average depth of indian Ocean is about 3000 m. The fractional compression, $\frac{\triangle V}{V}$ of water at the bottom of the ocean is (Given Bulk modulus of the water $= 2.2 \times 10^9 Nm^{-2}$ and $g = 10ms^{-2}$)

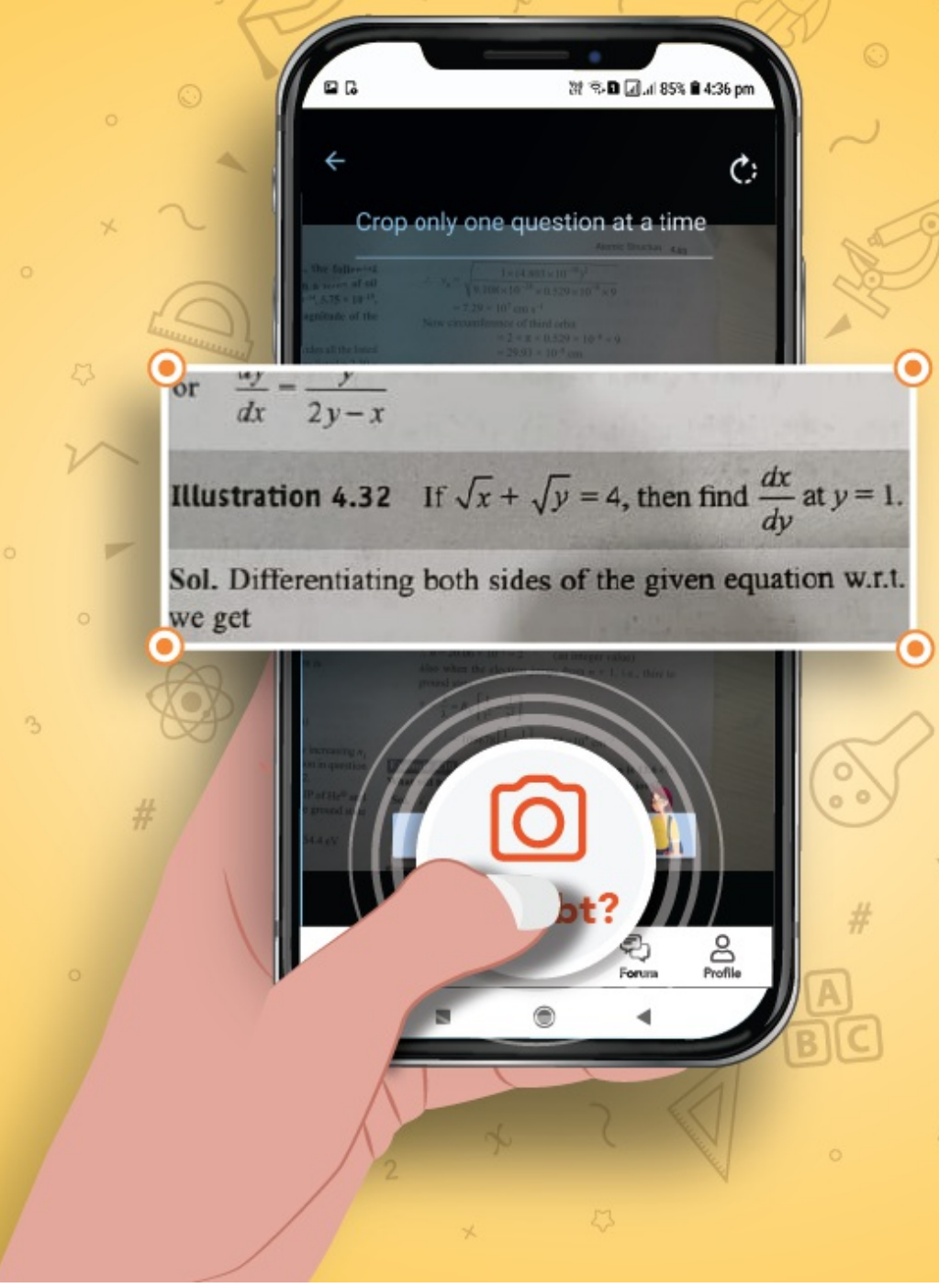
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