**Q1. A steel wire of length 4.7 m and cross-sectional area 3.0 × $10^{-5}$ $m^2$ stretches by the same amount as a copper wire of length 3.5 m and cross-sectional area of 4.0 × $10^{-5}$ $m^2$ under a given load. What is the ratio of Young's modulus of steel to that of copper?**

**Solution:**

Length of the steel wire, $l_1$ = 4.7 m

Cross-sectional area of the steel wire, $a_1$ = 3.0 × $10^{-5}$ $m^2$

Length of the copper wire, $l_2$ = 3.5 m

Cross-section area of the copper wire, $a_2$ = 4.0 × $10^{-5}$ $m^2$

Change in length = $\Delta l_1 = \Delta l_2 = \Delta l$

Force applied in both the cases = F

Young's modulus of the steel wire:

$$Y_1 = \frac{F}{a_1}\frac{l_1}{\Delta l}$$

$$Y_1 = \frac{F}{30\times10^{-5}}\frac{4.7}{\Delta l} \quad \text{——(1)}$$

Young's modulus of the copper wire:

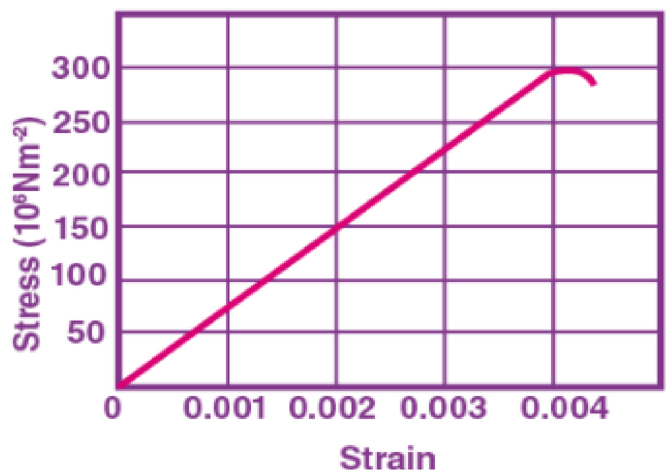
$$Y_2 = \frac{F}{a_2}\frac{l_2}{\Delta l}$$

$$Y_2 = \frac{F}{40\times10^{-5}}\frac{3.5}{\Delta l} \quad \text{——(2)}$$

Dividing (1) by (2), we get

$$\frac{Y_1}{Y_2} = \frac{4.7}{3.0\times10^{-5}} \times \frac{4.0\times10^{-5}}{3.5} = 1.79$$

**Q2. Figure below shows the strain-stress curve for a given material. What are (a) Young's modulus and (b) approximate yield strength for this material?**

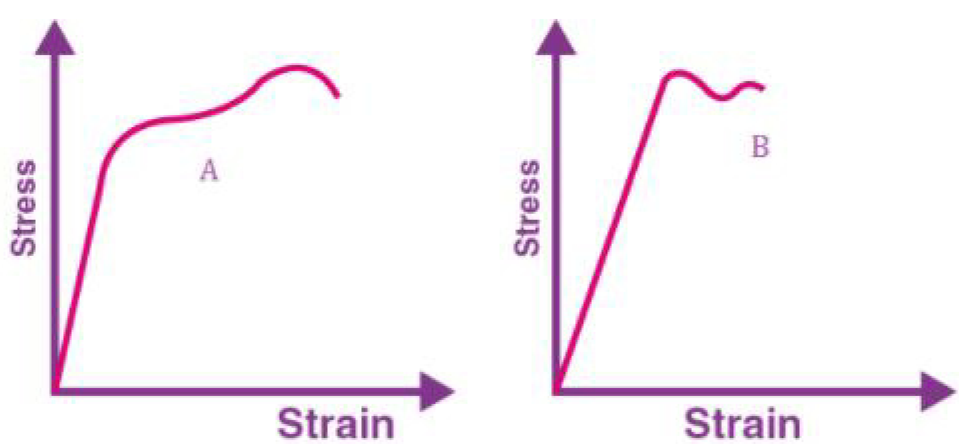



**Solution:**

Young's modulus, Y =Stress/Strain
=150 x $10^6$/0.002
= 150 x $10^6$/2 x $10^{-3}$
= 75 x $10^9$ $Nm^{-2}$
=75 x $10^{10}$ $Nm^{-2}$

(a)Yield strength of a material is the maximum stress that the material can sustain and retain its elastic property. From graph, the approximate yield strength of the given material
= 300 x $10^6$ $Nm^{-2}$
= 3 x $10^8$ $Nm^{-2}$.

**Q3. The stress-strain graphs for materials A and B are shown in the figure below.**




**The graphs are drawn to the same scale.**

**(a) Which of the materials has the greater Young's modulus?**
**(b) Which of the two is the stronger material?**

**Solution:**

Young's modulus = Stress/Strain

(a) From the graphs we can see that for the given strain, stress for A is greater than that of B. Therefore, Young's modulus of A is greater than B.
(b) Young's modulus is also a measure of the strength of the material. Young's modulus is greater for A, therefore material A is stronger than B.

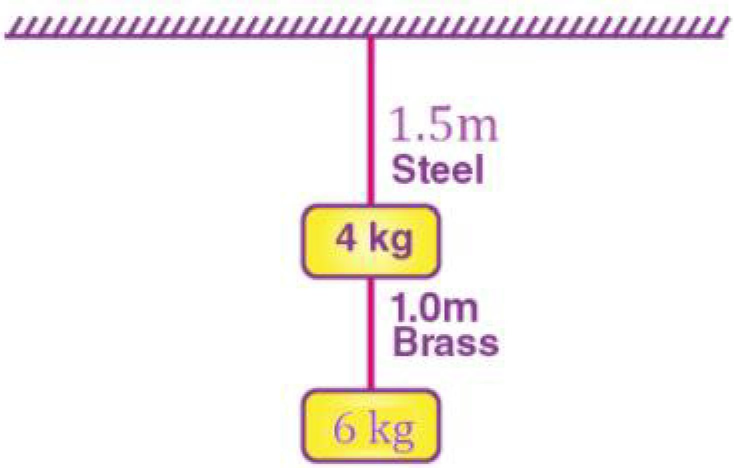
**Q4. Read the following two statements below carefully and state, with reasons, if it is true or false.**
**(a) The Young's modulus of rubber is greater than that of steel;**
**(b) The stretching of a coil is determined by its shear modulus.**

**Solution:**

( a ) True. Stretching a coil does not change its length, only its shape is altered and this involves shear modulus.

( b ) False. This is because, for the same value of stress, there is more strain in rubber than in steel. And as Young Modulus is an inverse of strain, it is greater in steel.

**Q5. 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 1.5 m and that of brass wire is 1.0 m. Compute the elongations of the steel and the brass wires. [Young's modulus of steel is 2.0 x $10^{11}$ Pa. (1 Pa = 1 N $m^2$)]**



**Solution:**

Diameter of the two wires, d =0.25m
Radius of the wires, r= d/2 =0.125cm
Unloaded length of the steel wire, $l_1$ =1.5m
Unloaded length of the brass wire, $l_2$ =1.0m

Force exerted on the steel wire:
$F_1$ = (4+6) g = 10×9.8 = 98N

Cross-section area of the steel wire, $a_1 = \pi r_1^2$

Change in length of the steel wire = $\Delta l_1$

Young's modulus for steel= 2.0 x $10^{11}$ Pa

$$Y_1 = \frac{F_1}{a_1}\frac{l_1}{\Delta l_1}$$

$$Y_1 = \frac{F_1}{\pi r_1^2}\frac{l_1}{\Delta l_1}$$

$$\Delta l_1 = \frac{F_1}{\pi r_1^2}\frac{l_1}{Y_1}$$

$$\Delta l_1 = \frac{9.8}{\pi(0.125\times10^{-2})^2}\frac{1.5}{2.0\times10^{11}}$$

= 1.49 x $10^{-4}$ m

Force of the brass wire, $F_2$ = 6 x 9.8 = 58. 8 N

Cross-section area of the brass wire, $a_2 = \pi r_2^2$

Change in length of the brass wire = $\Delta l_2$

Young's modulus of the brass wire = 0.91 x $10^{11}$ Pa

$$Y_2 = \frac{F_2}{a_2}\frac{l_2}{\Delta l_2}$$

$$\Delta l_2 = \frac{F_2}{\pi r_2^2}\frac{l_2}{Y_2}$$

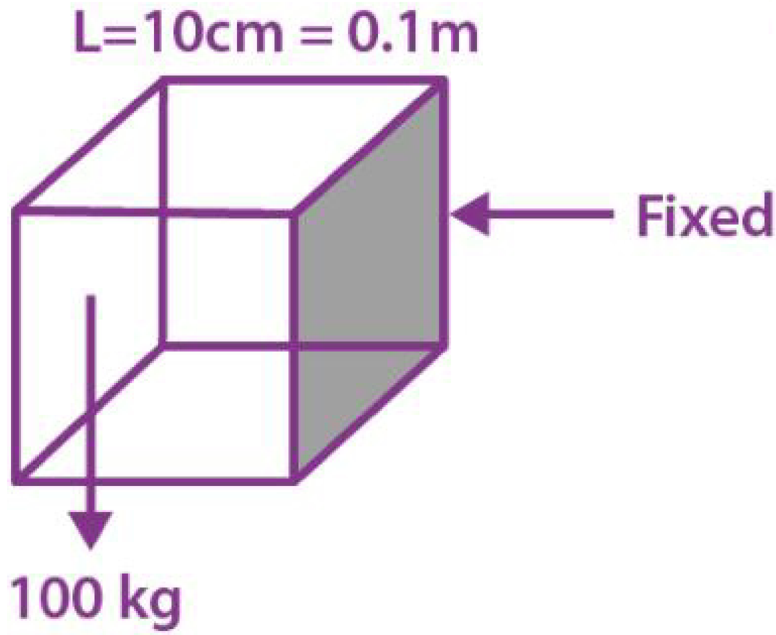
$$\Delta l_2 = \frac{58.8}{\pi(0.125\times10^{-2})^2}\frac{1}{0.91\times10^{11}}$$

= 1.3 x $10^{-4}$ m

Elongation of the steel wire is 1.49 x $10^{-4}$ m and that of brass is 1.3 x $10^{-4}$ m.

**Q6. The edge of an aluminium cube is 10 cm long. One face of the cube is firmly fixed to a vertical wall. A mass of 100 kg is then attached to the opposite face of the cube. The shear modulus of aluminium is 25 GPa. What is the vertical deflection of this face?**

**Solution:**




Edge of the aluminium cube, L = 10 cm =10/100= 0.1 m
Area of each face, A = $(0.1)^2$ = 0.01 $m^2$

Mass attached to the opposite face of the cube = 100 kg

Tangential force acting on the face, F = 100 kg = 100 x 9.8 = 980 N

Shear modulus, η = Tangential stress/Shearing strain

Shearing strain = Tangential stress/ Shear modulus

= F/Aη = 980/(0.01 x 25 x $10^9$) = 3.92 x $10^{-6}$

Since, Shearing strain = Lateral strain/Side of the cube

Lateral strain = Shearing strain x Side of the cube = 3.92 x $10^{-6}$ x 0.1

= 3.92 x $10^{-7}$ m ≈ 4 x $10^{-7}$ m

**Q7. Four identical hollow cylindrical columns of mild steel support a big structure of a mass 50,000 kg. The inner and outer radii of each column are 30 and 60 cm respectively. Assuming the load distribution to be uniform, calculate the compressional strain of each column.**

**Solution:**

Mass of the big structure, M = 50,000 kg

Total force exerted on the four columns= total weight of the structure=50000×9.8N

The compressional force on each column = Mg/4 = (50000×9.8)/4 N= 122500 N
Therefore, Stress = 122500 N
Young's modulus of steel, $Y=2\times10^{11}$ Pa

Young's modulus, Y= Stress/Strain

Strain = Young's modulus/Stress

Strain = (F/A)/Y

Inner radius of the column, r = 30 cm = 0.3 m
Outer radius of the column, R = 60 cm = 0.6 m
Where,
Area, $A=\pi(R^2-r^2)=\pi((0.6)^2-(0.3)^2) = 0.27\ \pi\ m^2$

Strain $=122500/[0.27 \times 3.14\times2\times10^{11}]=7.22\times10^{-7}$

Hence, the compressional strain of each column is $7.22\times10^{-7}$.

**Q8. A piece of copper having a rectangular cross-section of 15.2 mm × 19.1 mm is pulled in tension with 44,500 N force, producing only elastic deformation. Calculate the resulting strain?**

**Solution:**

Area of the copper piece, $A=19.1\times10^{-3}\times15.2\times10^{-3}=2.9\times10^{-4} m^2$

Tension force applied on the piece of copper, F=44,500 N

Modulus of elasticity of copper, $Y=42\times10^9\ Nm^{-2}$

Modulus of elasticity (Y) = Stress / Strain

=(F/A) / Strain
Strain = F/(YA)
$= 44500/(2.9\times10^{-4}\times42\times10^9)$
$= 3.65\times10^{-3}$

**Q9. A steel cable with a radius of 1.5 cm supports 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?**

**Solution:**

Radius of the steel cable, r=1.5 cm = 0.015 m

Cross-sectional area of the cable = $\pi r^2 = 3.14 \times (0.015)^2$

$= 7.06 \times 10^{-4}$ m

Maximum stress allowed on the steel cable = $10^8\ N/m^2$

Maximum load the cable can support = Maximum stress × Area of cross-section

$= 10^8 \times 7.06 \times 10^{-4}$

$= 7.065 \times 10^4$ N
Hence, the cable can support the maximum load of $7.065 \times 10^4$ N.

**Q10. A rigid bar of mass 15 kg is supported symmetrically by three wires each 2.0 m long. Those at each end are of copper and the middle one is of iron. Determine the ratios of their diameters if each is to have the same tension.**

**Solution:**

As the tension on the wires is the same, the extension of each wire will also be the same. Now, as the length of the wires is the same, the strain on them will also be equal.

Now, we know:

Y = Stress / Strain
$= (F/A)$ / Strain $= (4F/\pi d^2)$ / Strain . . . . . . . . . . ( 1 )
Where,
A = Area of cross-section
F = Tension force
d = Diameter of the wire
We can conclude from equation ( 1 ) that $Y \propto (1/d^2)$
We know that Young's modulus for iron, $Y_1 = 190 \times 10^9$ Pa
Let the diameter of the iron wire = $d_1$
Also, Young's modulus for copper, $Y_2 = 120 \times 10^9$ Pa
let the diameter of the copper wire = $d_2$
Thus, the ratio of their diameters can be given as :

$$\frac{d_1}{d_2} = \sqrt{\frac{Y_1}{Y_2}}$$

$$= \sqrt{\frac{190 \times 10^9}{120 \times 10^9}} = 1 : 25 : 1$$

**Q11. A 14.5 kg mass, fastened to the end of a steel wire of unstretched length 1.0 m, is whirled in a vertical circle with an angular velocity of 2 rev/s at the bottom of the circle. The cross-sectional area of the wire is 0.065 $cm^2$ . Calculate the elongation of the wire when the mass is at the lowest point of its path.**

**Solution:**

Mass, m = 14.5 kg

Length of the steel wire, l = 1 m

Angular velocity, v = 2 rev/s

Cross-sectional area of the wire, $A = 0.065 \times 10^{-4}\ m^2$

Total pulling force on the steel wire when the mass is at the lowest point of the vertical circle, $F = mg + mr\,\omega^2$

$= 14.5 \times 9.8 + 14.5 \times 1 \times (12.56)^2$
$= 2429.53$ N

Young's modulus = Stress / Strain

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

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

$\Delta l = (2429.53 \times 1)/(0.065 \times 10^{-4}) \times (2 \times 10^{11}) = 1.87 \times 10^{-3}$m
Hence, the elongation of the wire when the mass is at the lowest is $1.87 \times 10^{-3}$m.

**Q12. Compute the bulk modulus of water from the following data: Initial volume = 100.0 litre, Pressure increase = 100.0 atm (1 atm = $1.013 \times 10^5$ Pa), Final volume = 100.5 litre. Compare the bulk modulus of water with that of air (at constant temperature). Explain in simple terms why the ratio is so large.**

**Solution:**

Initial volume, $V_1 = 100.0$ litre $= 100.0 \times 10^{-3}$ m$^3$
Final volume, $V_2 = 100.5$ litre $= 100.5 \times 10^{-3}$ m$^3$

Change in the volume, $\Delta V = V_2 - V_1 = 0.5 \times 10^{-3}$ m$^3$

Pressure increase, $p = 100.0$atm$= 100 \times 1.013 \times 10^5$Pa

$= 101.3 \times 10^5$Pa
Bulk modulus of water $= p/(\Delta V/V_1) = pV_1/\Delta V$
$= 101.3 \times 10^5 \times 100 \times 10^{-3}/(0.5 \times 10^{-3})$
$= 2.026 \times 10^9$ Pa
Bulk modulus of air $= 1 \times 10^5$ Pa
Bulk modulus of water / Bulk modulus of air $= 2.026 \times 10^9/(1 \times 10^5)$

$= 2.026 \times 10^4$

The intermolecular force in the liquids is much larger than air as the distance between the molecules is much lesser in liquid than in air. Therefore, at the same temperature, strain for water is much more than air.

**Q13. What is the density of water at a depth where pressure is 80.0 atm, given that its density at the surface is $1.03 \times 10^3$ kg m$^{-3}$?**

**Solution:**

Let the depth be the alphabet 'd'.

Given,
Pressure at the given depth, $p = 60.0$ atm $= 60 \times 1.01 \times 10^5$ Pa
Density of water at the surface, $\rho_1 = 1.03 \times 10^3$ kg m$^{-3}$

Let $\rho_2$ be the density of water at the depth d.
$V_1$ be the volume of water of mass m at the surface.
Then, let $V_2$ be the volume of water of mass m at the depth h
and ΔV is the change in volume.
$\Delta V = V_1 – V_2$
$= m [ (1/\rho_1) – (1/\rho_2) ]$
∴ Volumetric strain = $\Delta V / V_1$
$= m [ (1/\rho_1) – (1/\rho_2) ] \times (\rho_1 / m)$
$\Delta V / V_1 = 1 – (\rho_1/\rho_2)$ . . . . . . . ( 1 )
We know, Bulk modulus, $B = pV_1 / \Delta V$
=> $\Delta V / V_1 = p / B$

Compressibility of water = ( 1/B ) = $45.8 \times 10^{-11}$ $Pa^{-1}$
∴ $\Delta V / V_1 = 60 \times 1.013 \times 10^5 \times 45.8 \times 10^{-11} = 2.78 \times 10^{-3}$ . . . . . ( 2 )

Using equation ( 1 ) and equation ( 2 ), we get:
$1 – (\rho_1/\rho_2) = 2.78 \times 10^{-3}$
$\rho_2 = 1.03 \times 10^3 / [ 1 – (2.78 \times 10^{-3}) ]$
$= 1.032 \times 10^3$ kg $m^{-3}$
Therefore, at the depth d water has a density of $1.034 \times 10^3$ kg $m^{–3}$.

**Q14. Compute the fractional change in volume of a glass slab, when subjected to a hydraulic pressure of 10 atm.**

**Solution:**

Given,

Pressure acting on the glass plate, p = 10 atm = $10 \times 1.013 \times 10^5$ Pa

We know,

Bulk modulus of glass, B = $37 \times 10^9$ $Nm^{–2}$
=> Bulk modulus, $B = p / (\Delta V/V)$
Where,
$\Delta V/V$ = Fractional change in volume
∴ $\Delta V/V = p / B$
$= [ 10 \times 1.013 \times 10^5] / (37 \times 10^9)$
$= 2.73 \times 10^{-4}$
Therefore, the fractional change in the volume of the glass plate is $2.73 \times 10^{–4}$.

**Q15. Determine the volume contraction of a solid copper cube, 10 cm on an edge, when subjected to a hydraulic pressure of $7.0 \times 10^6$ Pa.**

**Solution:**

Side of the copper cube, a = 10 cm

Therefore, Volume of the copper cube, $V = a^3 = 10^{-3}$ $m^3$

hydraulic pressure, p = $7.0 \times 10^6$ Pa

Bulk modulus of copper B = 140 G Pa = $140 \times 10^9$ Pa.

Bulk modulus, $K = -P/(\Delta V/V)$

We get the value of volume contraction as, $\Delta V = -PV/K$
$= -(7\times10^6 \times 0.001)/(140\times10^9)$

$= -0.05\times10^{-6} m^3$

**Q16.How much should the pressure on a litre of water be changed to compress it by 0.10%?**

**Solution:**

Volume of water, V=1 litre

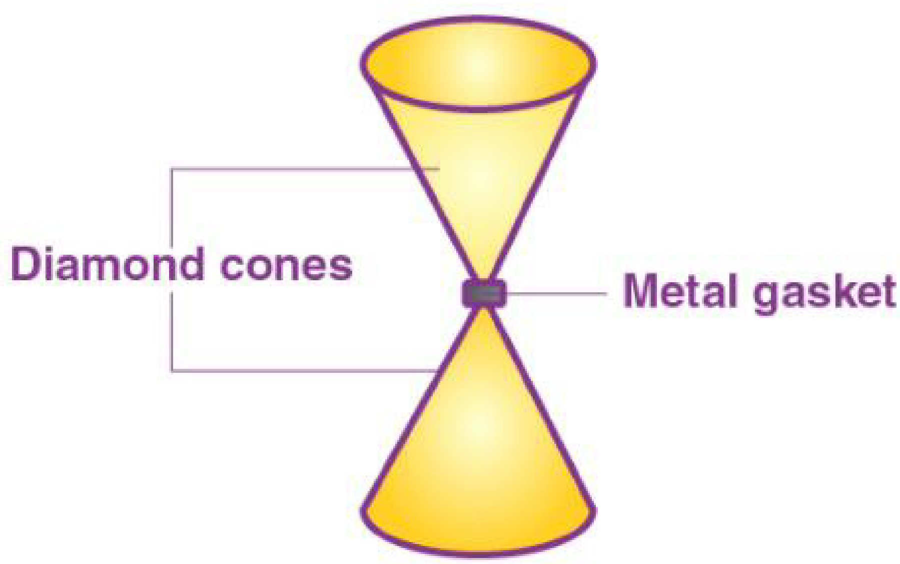
Water should be compressed by 0.10%
The fractional change in volume, $\triangle V/V = (0.1/100)\times1 = 10^{-3}$

Bulk modulus, $B = P/(\triangle V/V) = PV/\triangle V$
$P = B\times(\triangle V/V)$

Bulk modulus of water, $B = 2.2\times10^9$ Nm $^{-2}$

Pressure on water, $P = 2.2\times10^9 \times 10^{-3} = 2.2\times10^6$ Pa

**Q17. Anvils made of single crystals of diamond, with the shape as shown in the figure, are used to investigate the behaviour of materials under very high pressures. Flat faces at the narrow end of the anvil have a diameter of 0.50 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?**




**Solution:**

Flat faces at the narrow end of the anvil have a diameter, $d = 0.50 mm = 0.5\times10^{-3}$ m
Radius, $r = d/2 = 0.25\times10^{-3}$ m

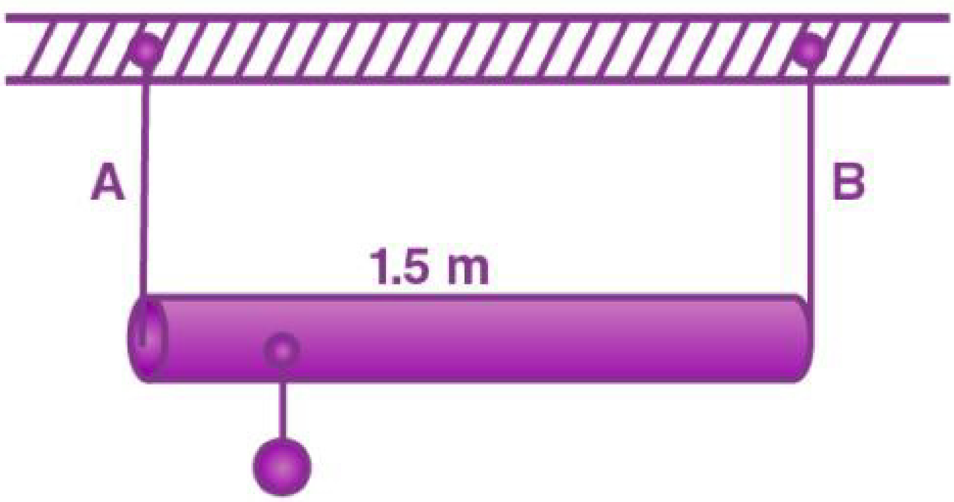
Compressional force, F=50000N
Pressure at the tip of the anvil:
P=Force/Area

Area = $\pi r^2 = 3.14 \times (0.25\times10^{-3})^2 = 0.1925 \times 10^{-6} m^2$

Pressure at the tip of the anvil = F/A

$= 50000/0.1925 \times 10^{-6}$
$=2.59\times10^{11}$ Pa

**Q18. A rod of length 1.05 m having negligible mass is supported at its ends by two wires of steel (wire A) and aluminium (wire B) of equal lengths as shown in the figure. The cross-sectional areas of wires A and B are 1.0 mm$^2$ and 2.0 mm$^2$, 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.**




**Solution:**

Given,

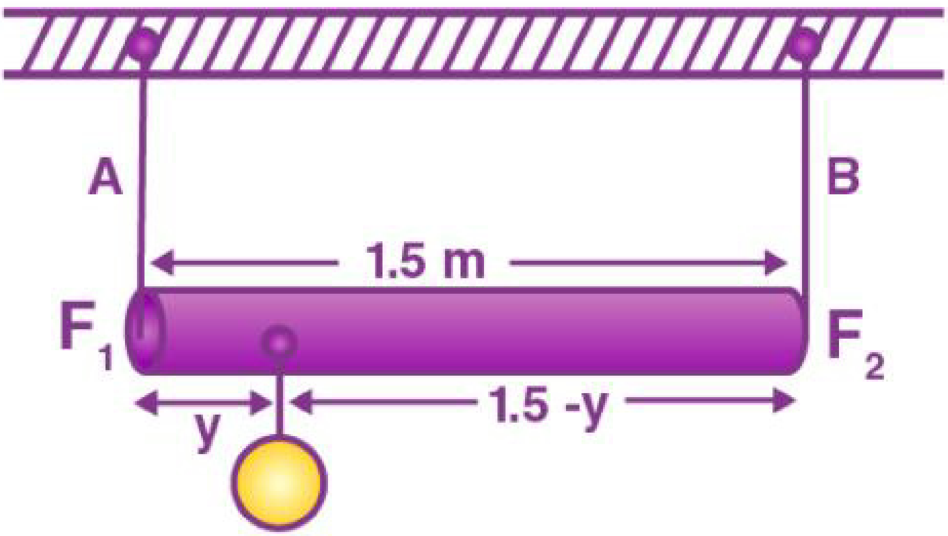
Cross-sectional area of wire A, $a_1 = 1.0 \text{ mm}^2 = 1.0 \times 10^{-6} \text{ m}^2$
Cross-sectional area of wire B, $a_2 = 2 \text{ mm}^2 = 2 \times 10^{-6} \text{ m}^2$

We know, Young's modulus for steel, $Y_1 = 2 \times 10^{11} \text{ Nm}^{-2}$
Young's modulus for aluminium, $Y_2 = 7.0 \times 10^{10} \text{ Nm}^{-2}$

( i ) Let a mass m be hung on the stick at a distance y from the end where wire A is attached.
Stress in the wire = Force / Area = F / a
Now it is given that the two wires have equal stresses ;
$F_1 / a_1 = F_2 / a_2$

Where,
$F_1$ = Force acting on wire A

and $F_2$ = Force acting on wire B
$F_1 / F_2 = a_1 / a_2 = 1 / 2$ . . . . . . . . . . . . . ( 1 )
The above situation can be represented as :




Moment of forces about the point of suspension, we have:
$F_1 y = F_2 (1.5 – y)$
$F_1 / F_2 = (1.5 – y) / y$ . . . . . . . . . . . ( 2 )
Using equation ( 1 ) and equation ( 2 ), we can write:
$(1.5 – y) / y = 1 / 2$
$2 (1.5 – y) = y$
$y = 1$ m

Therefore, the mass needs to be hung at a distance of 1m from the end where wire A is attached in order to produce equal stress in the two wires.

( ii ) We know,

Young's modulus = Stress / Strain
=> Strain = Stress / Young's modulus = ( F/a)/ Y
It is given that the strain in the two wires is equal :
$( F_1/a_1) / Y_1 = ( F_2/a_2) / Y_2$
$F_1 / F_2 = a_1Y_1 / a_2Y_2$
$a_1 / a_2 = 1 / 2$
$F_1 / F_2 = (1 / 2) (2 \times 10^{11} / 7 \times 10^{10}) = 10 / 7$ . . . . . . . . . . . . ( 3 )

Let the mass m be hung on the stick at a distance $y_1$ from the end where the steel wire is attached in order to produce equal strain

Taking the moment of force about the point where mass m is suspended :

$F_1y_1 = F_2 (1.5 – y_1)$
$F_1 / F_2 = (1.5 – y_1) / y_1$ . . . . . . . . . . . . ( 4 )

From equations ( 3 ) and ( 4 ), we get:
$(1.05 – y_1) / y_1 = 10 / 7$
$7(1.05 – y_1) = 10y_1$
$y_1 = 0.432$ m

Therefore, the mass needs to be hung at a distance of 0.432 m from the end where wire A is attached in order to produce equal strain in the two wires.

**Q19. 9 A mild steel wire of length 1.0 m and cross-sectional area 0.50 × 10$^{-2}$ cm$^2$ is stretched, 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 midpoint.**

**Solution:**

Given,

Water pressure at the bottom, p = 1000 atm = 1000 x 1.013 x $10^5$ Pa

p = 1.01 x $10^8$ Pa
Initial volume of the steel ball, V = 0.30 $m^3$

We know, bulk modulus of steel, B = 1.6 × $10^{11}$ $Nm^{-2}$

Let the change in the volume of the ball on reaching the bottom of the trench be ΔV.
Bulk modulus, B = p / (ΔV/V)
ΔV = pV / B
= [ 1.01 × $10^8$ × 0.30 ] / (1.6 × $10^{11}$ ) = 1.89 × $10^{-4}$ $m^3$
Hence, volume of the ball changes by 1.89 × $10^{-4}$ $m^3$ on reaching the bottom of the trench.

**Q20. Two strips of metal are riveted together at their ends by four rivets, each of diameter 6.0 mm. What is the maximum tension that can be exerted by the riveted strip if the shearing stress on the rivet is not to exceed 6.9 × 10$^7$ Pa? Assume that each rivet is to carry one-quarter of the load.**

**Solution:**

Diameter of the metal strips= 6mm = 6 x $10^{-3}$ m

Radius, r = 3 x $10^{-3}$ m;
Shearing stress on the rivet= 6.9 x $10^7$ Pa
Maximum load or force on a rivet
= Maximum stress x cross-sectional area
= 6.9 x $10^7$ x 3.14 x (3 x $10^{-3}$)$^2$ N = 1950 N
Maximum tension = 4 x 1950 N = 7800 N

**Q21. The Marina trench is located in the Pacific Ocean, and at one place it is nearly eleven km beneath the surface of the water. The water pressure at the bottom of the trench is about 1.1 × 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 the bottom?**

**Solution:**

Water pressure at the bottom of the trench, $p=1.1\times10^{8}$ Pa
Initial volume of the steel ball, $V=0.32m^3$
Bulk modulus of steel, $B=1.6\times10^{11}\ Nm^{-2}$

The ball falls at the bottom of the trench which is nearly 11 km beneath the surface of the water.

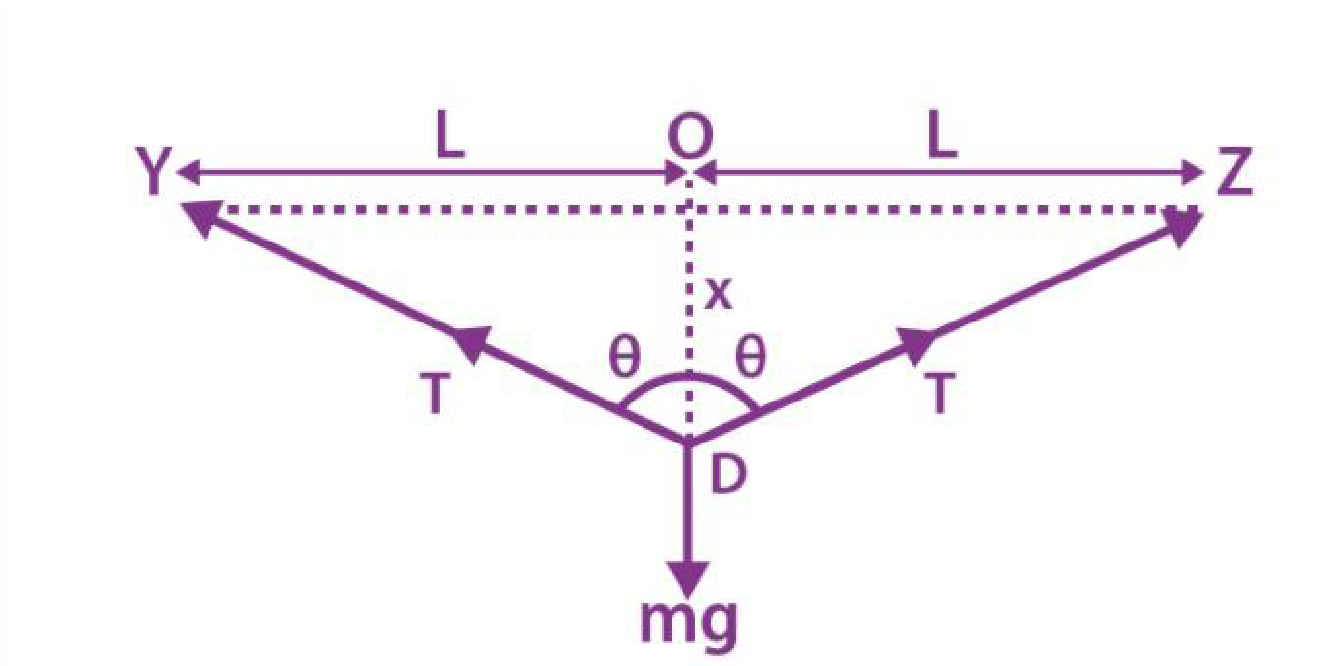
The volume change of the ball after reaching the bottom of the trench is $\triangle V$
Bulk modulus, $B=p/(\triangle V/V) = pV/\triangle V$
$\triangle V= pV/B$
$=(1.1\times10^{8}\times0.32)/(1.6\times10^{11})$
$= 0.352\times10^{8}/1.6\times10^{11}$

$= 0.22 \times 10^{-3}m^3$

The change in volume of the ball on reaching the bottom of the trench is $0.22 \times 10^{-3}m^3$

**Q22. A mild steel wire of cross-sectional area $0.60 \times 10^{-2}$ $cm^2$ and length 2 m is stretched ( not beyond its elastic limit ) horizontally between two columns. If a 100g mass is hung at the midpoint of the wire, find the depression at the midpoint.**

**Solution:**




Let YZ be the mild steel wire of length 2l = 2m and cross sectional area A = $0.60 \times 10^{-2}$ $cm^2$. Let the mass of m = 100 g = 0.1 kg be hung from the midpoint O, as shown in the figure. And let x be the depression at the midpoint i.e OD

From the figure;

ZO =YO = l = 1 m ;

M = 0.1 KG

ZD = YD = $(l^2 + x^2)^{1/2}$

Increase in length, $\Delta l$ = YD + DZ – ZY

= 2YD – YZ ( As DZ = YD)

$= 2(l^2 + x^2)^{1/2} - 2l$

$\Delta l = 2l( x^2/2l^2 ) = x^2 / l$

Therefore, longitudinal strain = $\Delta l / 2l = x^2/2l^2$ . . . . . . . . ( i )

If T is the tension in the wires, then in equilibrium 2Tcosθ = 2mg

Or, T = mg / 2cos θ

$= [ mg (l^2 + x^2)^{1/2}] / 2x = mgl / 2x$

Therefore, Stress = T / A = mgl / 2Ax . . . . . . . . . . . . ( ii )

$$Y = \frac{stress}{strain} = \frac{mgl}{2Ax} \times \frac{2l^2}{x^2}$$

$$= \frac{mgl^3}{2Ax^3}$$

$$x = l\left[\frac{mg}{YA}\right]^{\frac{1}{3}} = 1\left[\frac{0.1 \times 10}{20 \times 10^{11} \times 0.6 \times 10^{-6}}\right]^{\frac{1}{3}}$$

$= 9.41 \times 10^{-3}$ m.