Elasticity

Mechanical Properties of Solids

Stress and Strain

2010

1. **When a weight of 10kg is suspended from a copper wire of length 3m and diameter 0.4mm. Its length increases by 2.4cm. If the diameter of the wire is doubled, then the extension in its length will be**

   a) 7.6 cm b) 4.8 cm c) 1.2 cm d) 0.6 cm

2. **A force of $6 \times 10^6 Nm^{-2}$ required for breaking a material. The density ρ of the material is $3 \times 10^3 kgm^{-3}$. If the wire is to beak under its own weight, the length of the wire made of that material should be (taking $g = 20ms^{-2}$)**

   a) 20m b) 200m c) 100m d) 2000m

2008

3. **The breaking force for a wire of diameter D of a material is F. The breaking force for a wire of the same material of radius D is**

   a) F b) 2F c) $\frac{F}{4}$ d) 4F

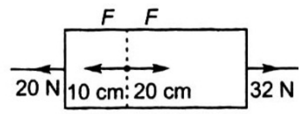
Young's, Bulk and Rigidity Modulus

2010

4. **The Young's modulus of brass and steel are respectively $1.0 \times 10^{11} Nm^{-2}$ and $2.0 \times 10^{11} Nm^{-2}$. A brass wire and a steel wire of the same length are extended by 1mm each under the same force. If radii of brass and steel wires are R_B and R_S respectively, then**

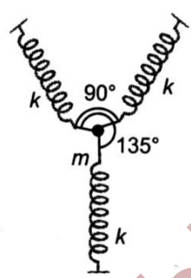
a) $R_S = \sqrt{2}R_B$ b) $R_S = \frac{R_B}{\sqrt{2}}$ c) $R_S = 4R_B$ d) $R_S = \frac{R_B}{2}$

5. Figure shows a uniform rod of length 30cn having a mass of 3.0kg. The strings shown in the figure are pulled by constant forces of 20N and 32N. Find the force exerted by 20cm part of the rod on the 10cm part. All the surfaces are smooth and the strings and pulleys are light



a) 36N b) 12N c) 64N d) 24N

6. A particle of mass m is attached to three identical massless springs of spring constant k as shown in the figure. The time period of vertical oscillation of the particle is



a) $2\pi\sqrt{\frac{m}{k}}$ b) $2\pi\sqrt{\frac{m}{2k}}$ c) $2\pi\sqrt{\frac{m}{3k}}$ d) $\pi\sqrt{\frac{m}{k}}$

7. For a given material, the young's modulus is 2.4 times that of rigidity modulus, then Poisson's ratio is

a) 0.2 b) 0.4 c) 1.2 d) 2.4

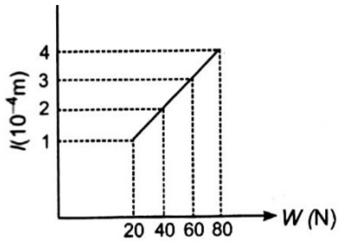
8. One-fourth length of a spring of force constant k is cut away. The force constant of the remaining spring will be

a) $\frac{3}{4}k$ b) $\frac{4}{3}k$ c) k d) 4k

2008

9. 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) $2\times10^{11} Nm^{-2}$ b) $2\times10^{-11} Nm^{-2}$ c) $3\times10^{-12} Nm^{-2}$ d) $2\times10^{-13} Nm^{-2}$

2007

10. The Young's modulus of the material of the wire of length L and radius r is Y Nm^{-2}. If the length is reduced to L/2 and radius r/2, the Young's modulus will be

a) Y/2 b) Y c) 2Y d) 4Y

11. An iron rod of length 2m and cross-sectional area of $50mm^2$ is stretched by 0.5mm, when a mass of 250kg is hung from its lower end. Young's modulus of iron rod is

a) $19.6\times10^{20} Nm^{-2}$ b) $19.6\times10^{18} Nm^{-2}$ c) $19.6\times10^{10} Nm^{-2}$ d) $19.6\times10^{15} Nm^{-2}$

2006

12. When a sphere is taken to bottom of sea 1km deep, it contracts by 0.01%. The bulk modulus of elasticity of the material of sphere is (given, density of water $= 1g\,cm^{-3}$)

a) $9.8\times10^{10} Nm^{-2}$ b) $10.2\times10^{10} Nm^{-2}$ c) $0.98\times10^{10} Nm^{-2}$ d) $8.4\times10^{10} Nm^{-2}$

2003

13. The Young's modulus of a wire of length (L) and radius (r) is Y. If the length is reduced to $\frac{L}{2}$ and radius to $\frac{r}{2}$, then its Young's modulus will be

a) $\frac{Y}{2}$ b) Y c) 2Y d) 4Y

Work Done in Stretching Wire

2008

14. When a metal wire elongates by hanging a load Mg on it, the gravitational potential energy of mass M decreases by Mgl. This energy appears

a) As elastic potential energy completely

b) As thermal energy completely

c) Half as elastic potential energy and half as thermal energy

d) As kinetic energy of the load completely

2007

15. If the tension on a wire is removed at once, then

a) It will break b) Its temperature will reduce

c) There will be no change in its temperature d) Its temperature increases

16. A wire is suspended by one end. At the other end a weight equivalent to 20N force is applied. If the increase in length is 1mm, the increase in the energy of the wire will be

a) 0.01J b) 0.02J c) 0.04J d) 1.00J

2006

17. Young's modulus of the material of a wire is Y. On a pulling the wire by a force F, the increase in its length is x. The potential energy of the stretched wire is

a) $\frac{1}{2}Fx$ b) $\frac{1}{2}Yx$ c) $\frac{1}{2}Fx^2$ d) None of these

18. What will be energy stored in a strained wire

a) $\frac{1}{2}\times$load x extension b) $\frac{1}{2}\times$ stress x strain c) $\frac{1}{2}\times$load x strain d) $\frac{1}{2}\times$ load x stress

Poisson's Ratio and Thermal Stress

2008

19. When a rod is heated but prevented from expanding, the stress developed is independent of

a) Material of the rod b) Rise in temperature c) Length of rod d) None of these

2004

20. Poisson's ratio cannot have the value

a) 0.1 b) 0.7 c) 0.2 d) 0.5

Key

1) **d**	2) **b**	3) **d**	4) **b**	5) **d**	6) **b**	7) **a**	8) **b**	9) **a**	
10) **b**	11) **c**	12) **a**	13) **b**	14) **c**	15) **d**	16) **a**	17) **a**	18) **a**	19) **c**
20) **b**									

Hints

Stress and Strain

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

$\therefore \frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2$

$l_2 = \frac{l_1}{4} = \frac{2.4}{4}$

$l_2 = 0.6cm$

2. Stress $= \frac{Force}{Area} = \frac{mg}{A} = \frac{V\rho g}{A} = \frac{LA\rho g}{A}$

$\therefore Stress = L\rho g$

Stress = $6\times10^{6}\,Nm^{-2}$; $\rho=3\times10^{3}\,kgm^{-3}$; $g=10ms^{-2}$

$$L=\frac{stress}{\rho g}=\frac{6\times10^{6}}{3\times10^{3}\times10}=2\times10^{2}=200m$$

3. $$Stress=\frac{Force}{Area}=\frac{Force}{\pi r^{2}}$$

Young's Bulk and Rigidity Modulus

4. $$\Delta L=\frac{FL}{YA}=\frac{FL}{Y\pi R^{2}}$$

$YR^{2}=$ Constant

$$\Rightarrow R_S=\frac{R_B}{\sqrt{2}}$$

5. Net force on the rod, f = 32 – 20 = 12 N

Acceleration $=\frac{f}{m}=\frac{12}{3}=4ms^{-2}$

F – 20 = m x a = 1 x 4

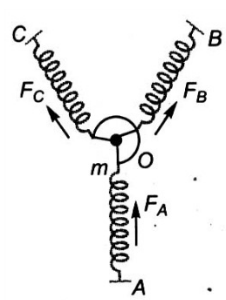
F = 4 + 20 = 24N

Similarly, $32-F=m'a=2\times4$

F = 32 – 8 = 24N

6. $F_{net}=F_A+F_B\cos45^0+F_C\cos45^0=ky+2ky'\cos45^0$

$=ky+2k(y\cos45^0)\cos45^0$ = 2ky



Also, $F_{net}=k'\,y\Rightarrow k'\,y=2ky$

$\Rightarrow k'=2k$

$$T = 2\pi\sqrt{\frac{m}{k'}} = 2\pi\sqrt{\frac{m}{2k}}$$

7. $\sigma = -\frac{\Delta d / d}{\Delta L / L} = \frac{Y}{2\eta} - 1$

But,, $Y = 2.4\eta$

$\therefore \sigma = \frac{2.4\eta}{2\eta} - 1 = 0.2$

8. $k \propto \frac{1}{l}$

$k' = \frac{4}{3}k$.

9. $l = 10^{-4} m$, F = 20N ; $A = 10^{-6} m^2$, L = 1m

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

10. Concept

11. $Y = \frac{longitudinal\ stress}{longitudinal\ strain} = \frac{Mgl}{Al}$

L =2m, $A = 50 mm^2 = 50 \times 10^{-6} m^2$

L = 0.5mm $= 0.5 \times 10^{-3} m$, M = 250kg

$\therefore Y = \frac{250 \times 9.8 \times 2}{50 \times 10^{-6} \times 0.5 \times 10^{-3}} = 19.6 \times 10^{10} Nm^{-2}$

12. Bulk modulus $B = \frac{\Delta p.V}{-\Delta v}$

$\frac{-\Delta v}{V} = \frac{0.01}{100} = 10^{-4}$

$\Delta p = h\rho g = 10^3 \times 1 \times 10^3 \times 9.8$

$\Delta p = 9.8 \times 10^6$

$B = \frac{9.8 \times 10^6}{10^{-4}} = 9.8 \times 10^{10} Nm^{-2}$

13. Concept

Work Done in Stretching Wire

14. Decrease in potential energy = Mgl

    Elastic potential energy stored in stretched wire $= \frac{1}{2} \times Mgl$

    $\therefore$ Energy appearing as heat $= Mgl - \frac{1}{2}Mgl = \frac{1}{2}Mgl$

15. Concept

16. Increase in energy $= \frac{1}{2} \times 20 \times 1 \times 10^{-3}$ = 0.01J

17. $U = \frac{1}{2} \times stress \times strain$

    $\therefore U = \frac{1}{2} \times F \times x \Rightarrow U = \frac{1}{2}Fx$

18. Concept