PHYSICS

Mechanical Properties of Solids

Speed TEST 8

Chapter-wise

No. of Questions	Maximum Marks	Time
30	120	1 Hour

GENERAL INSTRUCTIONS

- This test contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solutions provided at the end of this book.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

1. Two wires A and B are of the same material. Their lengths are in the ratio 1 : 2 and the diameter are in the ratio 2 : 1. If they are pulled by the same force, then increase in length will be in the ratio

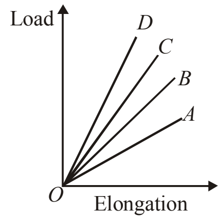
(a) 2 : 1 (b) 1 : 4 (c) 1 : 8 (d) 8 : 1

2. For a constant hydraulic stress on an object, the fractional change in the object volume $\left(\frac{\Delta V}{V}\right)$ and its bulk modulus (B) are related as

(a) $\frac{\Delta V}{V} \propto B$ (b) $\frac{\Delta V}{V} \propto \frac{1}{B}$

(c) $\frac{\Delta V}{V} \propto B^2$ (d) $\frac{\Delta V}{V} \propto B^{-2}$

3. The load versus elongation graphs for four wires of same length and made of the same material are shown in the figure. The thinnest wire is represented by the line



(a) OA

(b) OC

(c) OD

(d) OB

4. A metal wire of length L_1 and area of cross-section A is attached to a rigid support. Another metal wire of length L_2 and of the same cross-sectional area is attached to the free end of the first wire. A body of mass M is then suspended from the free end of the second wire. If Y_1 and Y_2 are the Young's moduli of the wires respectively, the effective force constant of the system of two wires is

(a) $\frac{(Y_1Y_2)A}{2(Y_1L_2+Y_2L_1)}$ (b) $\frac{(Y_1Y_2)A}{(L_1L_2)^{1/2}}$

(c) $\frac{(Y_1Y_2)A}{Y_1L_2+Y_2L_1}$ (d) $\frac{(Y_1Y_2)^{1/2}A}{(L_2L_1)^{1/2}}$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

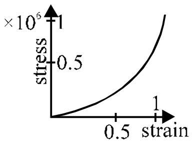
5. Choose the wrong statement.
(a) The bulk modulus for solids is much larger than for liquids.
(b) Gases are least compressible.
(c) The incompressibility of the solids is due to the tight coupling between neighbouring atoms.
(d) The reciprocal of the bulk modulus is called compressibility.

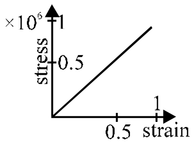
6. K is the force constant of a spring. The work done in increasing its extension from l_1 to l_2 will be
(a) $K(l_2 - l_1)$ (b) $\frac{K}{2}(l_2 + l_1)$
(c) $K(l_2^2 - l_1^2)$ (d) $\frac{K}{2}(l_2^2 - l_1^2)$

7. A steel wire of length l and cross sectional area A is stretched by 1 cm under a given load. When the same load is applied to another steel wire of double its length and half of its cross section area, the amount of stretching (extension) is
(a) 0.5 cm (b) 2 cm (c) 4 cm (d) 1.5 cm

8. A cube at temperature 0ºC is compressed equally from all sides by an external pressure P. By what amount should its temperature be raised to bring it back to the size it had before the external pressure was applied. The bulk modulus of the material of the cube is B and the coefficient of linear expansion is a.
(a) P/B α (b) P/3 B α (c) 3 $\pi\alpha$/B (d) 3 B/P

9. Stress Vs strain for the elastic tissue of the aorta, the large tube (vessel) carrying blood from the heart, will be : [stress is proportional to square of the strain for the elastic tissue of the aorta]

(a)


(b)


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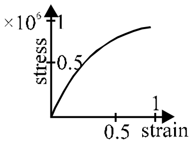
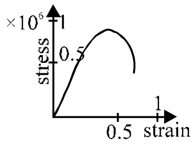


(d)


10. In materials like aluminium and copper, the correct order of magnitude of various elastic modului is:
(a) Young's modulus < shear modulus < bulk modulus.
(b) Bulk modulus < shear modulus < Young's modulus
(c) Shear modulus < Young's modulus < bulk modulus.
(d) Bulk modulus < Young's modulus < shear modulus.

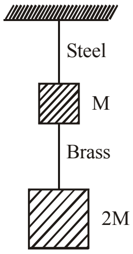
11. An elastic string of unstretched length L and force constant k is stretched by a small length x. It is further stretched by another small length y. The work done in the second stretching is :
(a) $\frac{1}{2}ky^2$ (b) $\frac{1}{2}k(x^2 + y^2)$
(c) $\frac{1}{2}k(x + y)^2$ (d) $\frac{1}{2}ky(2x + y)$

12. Steel ruptures when a shear of 3.5×10^8 N m^{-2} is applied. The force needed to punch a 1 cm diameter hole in a steel sheet 0.3 cm thick is nearly:
(a) 1.4×10^4 N (b) 2.7×10^4 N
(c) 3.3×10^4 N (d) 1.1×10^4 N

13. Copper of fixed volume 'V; is drawn into wire of length 'l'. When this wire is subjected to a constant force 'F', the extension produced in the wire is 'Δl'. Which of the following graphs is a straight line?
(a) Δl versus $\frac{1}{l}$ (b) Δl versus l^2
(c) Δl versus $\frac{1}{l^2}$ (d) Δl versus l

RESPONSE GRID					
	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ
	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	

14. 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 lengths is :



(a) $\dfrac{3c}{2ab^2}$

(b) $\dfrac{2a^2c}{b}$

(c) $\dfrac{3a}{2b^2c}$

(d) $\dfrac{2ac}{b^2}$

15. The Poisson's ratio of a material is 0.5. If a force is applied to a wire of this material, there is a decrease in the cross-sectional area by 4%. The percentage increase in the length is:

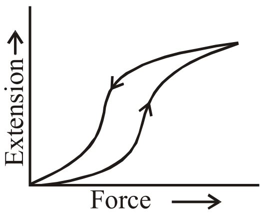
(a) 1% (b) 2% (c) 2.5% (d) 4%

16. The end of a uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W_1 is suspended from its lower end. If s is the area of cross-section of the wire, the stress in the wire at a height $\frac{3L}{4}$ from its lower end is :

(a) $\dfrac{W_1}{s}$ (b) $\dfrac{W_1 + \frac{W}{4}}{s}$

(c) $\dfrac{W_1 + \frac{3W}{4}}{s}$ (d) $\dfrac{W_1 + W}{s}$

17. The diagram shows a force-extension graph for a rubber band. Consider the following statements :



I. It will be easier to compress this rubber than expand it

II. Rubber does not return to its original length after it is stretched

III. The rubber band will get heated if it is stretched and released

Which of these can be deduced from the graph:

(a) III only (b) II and III (c) I and III (d) I only

18. When a 4 kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches by 2 cms. The work required to be done by an external agent in stretching this spring by 5 cm will be ($g = 9.8$ m/sec^2)

(a) 4.900 joule (b) 2.450 joule

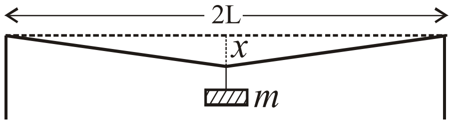
(c) 0.495 joule (d) 0.245 joule

19. A circular tube of mean radius 8 cm and thickness 0.04 cm is melted up and recast into a solid rod of the same length. The ratio of the torsional rigidities of the circular tube and the solid rod is

(a) $\dfrac{(8.02)^4 - (7.98)^4}{(0.8)^4}$ (b) $\dfrac{(8.02)^2 - (7.98)^2}{(0.8)^2}$

(c) $\dfrac{(0.8)^2}{(8.02)^4 - (7.98)^4}$ (d) $\dfrac{(0.8)^2}{(8.02)^3 - (7.98)^2}$

20. A mild steel wire of length 2L and cross-sectional area A is stretched, well within elastic limit, horizontally between two pillars. A mass m is suspended from the mid point of the wire. Strain in the wire is



(a) $\dfrac{x^2}{2L}$ (b) $\dfrac{x}{L}$ (c) $\dfrac{x^2}{L}$ (d) $\dfrac{x^2}{2L}$

21. Two wires A and B of same material and of equal length with the radii in the ratio 1 : 2 are subjected to identical loads. If the length of A increases by 8 mm, then the increase in length of B is

(a) 2 mm (b) 4 mm (c) 8 mm (d) 16 mm

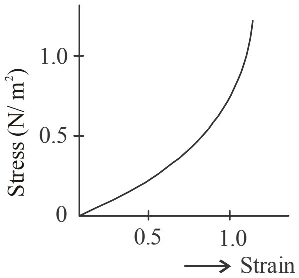
RESPONSE GRID					
	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ		

22. Select the correct statement(s) from the following.
I. Modulus of rigidity for a liquid is zero
II. Young's modulus of a material decreases with rise in temperature
III. Poisson's ratio is unitless
(a) I only (b) II only (c) I and II (d) I, II and III

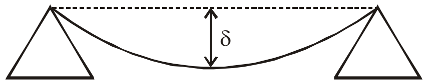
23. The upper end of a wire of diameter 12mm and length 1m is clamped and its other end is twisted through an angle of 30°. The angle of shear is
(a) 18° (b) 0.18° (c) 36° (d) 0.36°

24. A structural steel rod has a radius of 10 mm and length of 1.0 m. A 100 kN force stretches it along its length. Young's modulus of structural steel is 2×10^{11} Nm^{-2}. The percentage strain is about
(a) 0.16% (b) 0.32% (c) 0.08% (d) 0.24%

25. The graph given is a stress-strain curve for
(a) elastic objects
(b) plastics
(c) elastomers
(d) None of these



26. A beam of metal supported at the two edges is loaded at the centre. The depression at the centre is proportional to



(a) Y^2 (b) Y (c) 1/Y (d) $1/Y^2$

27. The length of an elastic string is a metre when the longitudinal tension is 4 N and b metre when the longitudinal tension is 5 N. The length of the string in metre when the longitudinal tension is 9 N is
(a) $a - b$ (b) $5b - 4a$ (c) $2b - \frac{1}{4}a$ (d) $4a - 3b$

28. A thick rope of density ρ and length L is hung from a rigid support. The Young's modulus of the material of rope is Y. The increase in length of the rope due to its own weight is
(a) $(1/4)\, \rho g L^2/Y$ (b) $(1/2)\, \rho g L^2/Y$
(c) $\rho g L^2/Y$ (d) $\rho g L/Y$

29. A metal rod of Young's modulus 2×10^{10} N m^{-2} undergoes an elastic strain of 0.06%. The energy per unit volume stored in J m^{-3} is
(a) 3600 (b) 7200 (c) 10800 (d) 14400

30. For the same cross-sectional area and for a given load, the ratio of depressions for the beam of a square cross-section and circular cross-section is
(a) $3 : \pi$ (b) $\pi : 3$ (c) $1 : \pi$ (d) $\pi : 1$

RESPONSE GRID					
	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ
	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	

PHYSICS CHAPTERWISE SPEED TEST-8

Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			

Net Score = (Correct × 4) – (Incorrect × 1)

Speed Test-8

1. **(c)** We know that Young's modulus

$$Y = \frac{F}{\pi r^2} \times \frac{L}{\ell}$$

Since Y, F are same for both the wires, we have,

$$\frac{1}{r_1^2}\frac{L_1}{\ell_1} = \frac{1}{r_2^2}\frac{L_2}{\ell_2}$$

or, $$\frac{\ell_1}{\ell_2} = \frac{r_2^2 \times L_1}{r_1^2 \times L_2} = \frac{(D_2/2)^2 \times L_1}{(D_1/2)^2 \times L_2}$$

or, $$\frac{\ell_1}{\ell_2} = \frac{D_2^2 \times L_1}{D_1^2 \times L_2} = \frac{D_2^2}{(2D_2)^2} \times \frac{L_2}{2L_2} = \frac{1}{8}$$

So, $\ell_1 : \ell_2 = 1 : 8$

2. **(b)** $B = \frac{\Delta p}{\Delta V / V} \Rightarrow \frac{1}{B} \propto \frac{\Delta V}{V}$ [Δp = constant]

3. **(a)** From the graph, it is clear that for the same value of load, elongation is maximum for wire *OA*. Hence *OA* is the thinnest wire among the four wires.

4. **(c)** Using the usual expression for the Young's modulus, the force constant for the wire can be written as $k = \frac{F}{\Delta l} = \frac{YA}{L}$ where the symbols have their usual meanings. Now the two wires together will have an effective force constant $\left[\frac{k_1 k_2}{k_1 + k_2}\right]$. Substituting the corresponding lengths and the Young's moduli we get the answer.

5. **(b)** Solids are least compressible whereas gases are highly compressible.

6. **(d)** At extension l_1, the stored energy $= \frac{1}{2}Kl_1^2$

At extension l_2, the stored energy $= \frac{1}{2}Kl_2^2$

Work done in increasing its extension from l_1 to l_2

$$= \frac{1}{2}K(l_2^2 - l_1^2)$$

7. **(c)** Young's modulus of elasticity is

$$Y = \frac{F/A}{\Delta L / L}$$

$$\therefore \Delta L = \frac{FL}{AY}$$

So, $\Delta L \propto \frac{L}{A}$

$$\therefore \frac{\Delta L_2}{\Delta L_1} = \frac{L_2}{L_1} \times \frac{A_1}{A_2} = \frac{2}{1} \times \frac{2}{1} = 4$$

$\Delta L_2 = 4 \times \Delta L_1 = 4 \times 1 = 4$ cm

8. **(b)** Bulk modulus B =

and $\Delta V = \gamma V \Delta T = 3\alpha.V.T$ or $\frac{-V}{\Delta V} = \frac{1}{3\alpha.T.}$ ...(2)

From eqs. (1) and (2), $B = P/(3\alpha.T)$ or $T = \frac{P}{3\alpha B}$

9. **(a)**

10. **(c)** Poisson's ratio, $\sigma = \frac{\text{lateral strain}(\beta)}{\text{longitudinal strain}(\alpha)}$

For material like copper, $\sigma = 0.33$

And, $y = 3k(1 - 2\sigma)$

Also, $\frac{9}{y} = \frac{1}{k} + \frac{3}{n}$

$y = 2n(1 + \sigma)$

Hence, $n < y < k$

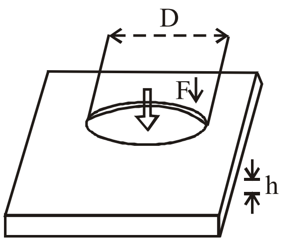
11. **(d)** $W_1 = \frac{1}{2}kx^2$

and $W_2 = \frac{1}{2}k(x+y)^2$

$\therefore$ $W = W_2 - W_1 = \frac{1}{2}k(x+y)^2 - \frac{1}{2}kx^2$

$= \frac{1}{2}ky(2x + y)$

12. **(c)**



Shearing strain is created along the side surface of the punched disk. Note that the forces exerted on the disk are exerted along the circumference of the disk, and the total force exerted on its center only.

Let us assume that the shearing stress along the side surface of the disk is uniform, then

$$F > \int_{\text{surface}} dF_{max} = \int_{\text{surface}} \sigma_{max} dA = \sigma_{max} \int_{\text{surface}} dA$$

$$= \int \sigma_{max}.A = \sigma_{max}.2\pi\left(\frac{D}{2}\right)h$$

$$= 3.5 \times 10^8 \times \left(\frac{1}{2} \times 10^{-2}\right) \times 0.3 \times 10^{-2} \times 2\pi$$

$$= 3.297 \times 10^4 \simeq 3.3 \times 10^4 \text{ N}$$

13. **(b)** As $Y = \frac{\frac{F}{A}}{\frac{\Delta l}{l}} \Rightarrow \Delta l = \frac{Fl}{AY}$

V

Therefore $\Delta l = \dfrac{Fl^2}{VY} \propto l^2$

Hence graph of Δl versus l^2 will give a straight line.

14. (c) According to questions,

$$\frac{\ell_s}{\ell_b} = a,\ \frac{r_s}{r_b} = b,\ \frac{y_s}{y_b} = c,\ \frac{\Delta \ell s}{\Delta \ell_b} = ?$$

As, $y = \dfrac{F\ell}{A\Delta\ell} \Rightarrow \Delta\ell = \dfrac{F\ell}{Ay}$

$$\Delta\ell_s = \frac{3mg\ell_s}{\pi r_s^2 . y_s}\quad [\because F_s = (M + 2M)g]$$

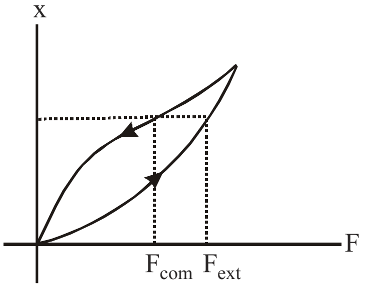
$$\Delta\ell_b = \frac{2Mg\ell_b}{\pi r_b^2 . y_b}\quad [\because F_b = 2Mg]$$

$$\therefore\ \frac{\Delta\ell_s}{\Delta\ell_b} = \frac{\dfrac{3Mg\ell_s}{\pi r_s^2 . y_s}}{\dfrac{2Mg.\ell_b}{\pi r_b^2 . y_b}} = \frac{3a}{2b^2C}$$

15. (d) $\dfrac{\Delta r / r}{\Delta l / l} = 0.5 = \dfrac{1}{2}, \dfrac{\Delta r}{r} = \dfrac{1}{2}\dfrac{\Delta l}{l}$

16. (c)

17. (c)



From the figure, it is clear that

$F_{com} < F_{ext.}$

18. (b) $K = \dfrac{F}{x} = \dfrac{4 \times 9.8}{2 \times 10^{-2}} = 19.6 \times 10^2$

Work done $= \dfrac{1}{2} 19.6 \times 10^2 \times (0.05)^2 = 2.45 J$

19. (a) $C_1 = \dfrac{\pi\eta(r_2^4 - r_1^4)}{2\ell}, C_2 = \dfrac{\pi\eta r^4}{2\ell}$

Initial volume = Final volume

$$\therefore\ \pi[r_2^2 - r_1^2]\ell\rho = \pi r^2 \ell\rho$$

$$\Rightarrow r^2 = r_2^2 - r_1^2 \Rightarrow r^2 = (r_2 + r_1)(r_2 - r_1)$$

$$\Rightarrow r^2 = (8.02 + 7.98)(8.02 - 7.98)$$

$$\Rightarrow r^2 = 16 \times 0.04 = 0.64 \text{ cm} \Rightarrow r = 0.8 \text{ cm}$$

$$\therefore \frac{C_1}{C_2} = \frac{r_2^4 - r_1^4}{r^4} = \frac{[8.02]^4 - [7.98]^4}{[0.8]^4}$$

20. (a)

21. (a) Ratio of radii $r_1 : r_2 = 1:2$

Ratio of area, $A_1 : A_2 = \pi r_1^2 : \pi r_2^2$

$A_1 : A_2 = 1 : 4$

Now, $Stress_1 : Stress_2 = 4 : 1$

So, $Strain_1 : Strain_2 = 4 : 1$

$\therefore\ \dfrac{l_1}{l_2} = \dfrac{4}{1} \Rightarrow 4l_2 = l_1 = 8$

$\therefore\ l_2 = 2$ mm

Increase in length of *B* is 2 mm.

22. (d)

23. (b) $r\theta = \ell\phi \Rightarrow \phi = \dfrac{r\theta}{\ell} = \dfrac{6\text{mm} \times 30°}{1\text{m}} = 0.18°$

24. (a) Given: $F = 100\,\text{kN} = 10^5\,\text{N}$

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

$\ell_0 = 1.0\,\text{m}$

radius $r = 10\,\text{mm} = 10^{-2}\,\text{m}$

From formula, $Y = \dfrac{\text{Stress}}{\text{Strain}}$

$$\Rightarrow\ \text{Strain} = \frac{\text{Stress}}{Y} = \frac{F}{AY}$$

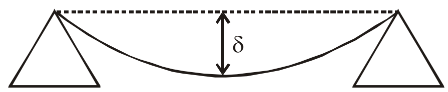
$$= \frac{10^5}{\pi r^2 Y} = \frac{10^5}{3.14 \times 10^{-4} \times 2 \times 10^{11}}$$

$$= \frac{1}{628}$$

Therefore % strain $= \dfrac{1}{628} \times 100 = 0.16\%$

25. (c) The given graph does not obey Hooke's law. and there is no well defined plastic region. So the graph represents elastomers.

26. (c)



For a beam, the depression at the centre is given by,

$$\delta = \left(\frac{f\,L}{4Ybd^3}\right)$$

[f, L, b, d are constants for a particular beam]

i.e. $\delta \propto \dfrac{1}{Y}$

27. (b) Using Hooke's law, $F = kx$ we can write

$4 = k(a - \ell_0)$ … (i)

and $5 = k(b - \ell_0)$ … (ii)

If ℓ be the length under tension 9N, then

$9 = k(\ell - \ell_0)$ … (iii)

After solving above equations, we get

$\ell = (5b - 4a)$.

28. (b)

29. (a) $U / \text{volume} = \dfrac{1}{2} Y \times \text{strain}^2 = 3600\ \text{J m}^{-3}$

30. **(a)** $\delta = \dfrac{W\ell^3}{3\,YI}$, where W = load, ℓ = length of beam and I is geometrical moment of inertia for rectangular beam,

$I = \dfrac{bd^3}{12}$ where b = breadth and d = depth

For square beam b = d

$\therefore\ I_1 = \dfrac{b^4}{12}$

For a beam of circular cross-section, $I_2 = \left(\dfrac{\pi r^4}{4}\right)$

$\therefore\quad \delta_1 = \dfrac{W\ell^3 \times 12}{3\,Y b^4} = \dfrac{4\,W\ell^3}{Y b^4}$ (for sq. cross section)

and $\delta_2 = \dfrac{W\ell^3}{3\,Y(\pi r^4/4)} = \dfrac{4\,W\ell^3}{3Y(\pi r^4)}$

(for circular cross-section)

Now $\dfrac{\delta_1}{\delta_2} = \dfrac{3\pi r^4}{b^4} = \dfrac{3\pi r^4}{(\pi r^2)^2} = \dfrac{3}{\pi}$

($\because b^2 = \pi r^2$ i.e., they have same cross-sectional area)