



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ where needed. Neglect air resistance unless stated.

A. Very short answers - 1 mark each

1. Define elastic limit. Distinguish elasticity from plasticity.
2. Why is steel described as more elastic than rubber?
3. Define longitudinal stress and longitudinal strain, with units.
4. What does a negative sign signify in the definition of bulk modulus?
5. Define Poisson's ratio. Is it dimensionless?

B. Short answers / practice - 2 marks each

6. State Hooke's law and identify its range of validity.
7. Distinguish Young's modulus, bulk modulus and shear modulus.
8. Two wires of the same material and length have radii r and $2r$. Compare their extensions under equal loads.
9. A wire of area 2 mm^2 supports a 100 N load. Find its tensile stress.
10. A liquid contracts by 0.10% under an additional pressure of $2 \times 10^6 \text{ Pa}$. Find its bulk modulus.
11. Find strain for a 1 mm extension in a 1 m wire.
12. Is strain dimensionless?
13. Find stress for 200 N on 4 mm^2 .
14. Explain elastic fatigue with an example.
15. How does extension change when wire length doubles, other factors fixed?
16. How does extension change when cross-sectional area doubles?
17. Find energy stored when load rises gradually to 100 N and extension reaches 2 mm .
18. Does higher Young's modulus mean greater strain under equal stress?
19. Explain why a thick steel cable carries more load than a thin one.
20. Find Young's modulus for stress 10^8 Pa and strain 0.002 .

C. Application / reasoning - 3 marks each

21. A 2 m wire of area 1 mm^2 stretches by 1 mm under 100 N . Find its strain and Young's modulus.
22. Sketch a typical stress-strain curve for a ductile metal. Label proportional limit, elastic limit, yield region and fracture.
23. Compare ductile, brittle and elastomeric behaviour using suitable examples.
24. A wire of length 1 m and area 2 mm^2 has $Y = 2 \times 10^{11} \text{ Pa}$. Find its extension and stored energy under a gradually applied 200 N load.
25. A cube of side 0.10 m has its top face displaced by 0.2 mm under a tangential force of 400 N . Find shear stress, strain and modulus.
26. Why are structural beams often I-shaped? Explain using the role of bending and material distribution.

D. Extended practice - 5 marks each

27. Derive the expression for extension of a uniform wire under tension. Explain how a load-extension graph gives Young's modulus.
28. Derive the elastic energy stored in a stretched wire. Hence obtain energy density $= \frac{1}{2} \times \text{stress} \times \text{strain}$.
29. Two wires of equal length and area, with moduli Y and $2Y$, are joined end to end. Derive their total extension under force F and the equivalent Young's modulus.
30. A 2 m steel wire of radius 0.5 mm has $Y = 2 \times 10^{11} \text{ Pa}$ and breaking stress $8 \times 10^8 \text{ Pa}$. Find its extension under 100 N , maximum load and breaking strain within a linear model.

ANSWER KEY - Numerical / closed questions

- 5) Yes; ratio of transverse contraction strain to longitudinal extension strain. 8) 4:1. 9) $5 \times 10^7 \text{ Pa}$. 10) $2 \times 10^9 \text{ Pa}$. 11) 0.001. 12) Yes. 13) $5 \times 10^7 \text{ Pa}$. 15) It doubles. 16) It halves. 17) 0.10 J . 18) No; smaller strain. 20) $5 \times 10^{10} \text{ Pa}$. 21) 5×10^{-4} ; $2 \times 10^{11} \text{ Pa}$. 24) 0.5 mm ; 0.050 J . 25) $4 \times 10^4 \text{ Pa}$; 0.002 ; $2 \times 10^7 \text{ Pa}$. 29) Total extension $3FL/(2AY)$; equivalent modulus $4Y/3$. 30) 1.273 mm ; maximum load $\approx 628 \text{ N}$; breaking strain 0.004 .