

Mechanical Properties of Solids — CBSE Pattern Test 2

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 2 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · Mechanical Properties of Solids · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.
(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- Young's modulus is the ratio of
 - longitudinal stress to longitudinal strain
 - shearing stress to shearing strain
 - volumetric stress to volumetric strain
 - stress to strain rate
- The bulk modulus of a material is the ratio of
 - volumetric stress to volumetric strain
 - longitudinal stress to longitudinal strain
 - shearing stress to shearing strain
 - stress to strain
- The compressibility of a material is the reciprocal of its
 - bulk modulus
 - Young's modulus
 - rigidity modulus
 - stress
- Among solids, liquids and gases, the highest bulk modulus is possessed by
 - solids
 - liquids
 - gases
 - all about the same
- Poisson's ratio is the ratio of
 - lateral strain to longitudinal strain
 - longitudinal strain to lateral strain
 - stress to strain
 - shear strain to shear stress
- For a material that is nearly incompressible, Poisson's ratio is close to
 - 0.5
 - 0
 - 1
 - 1
- Poisson's ratio has
 - no unit

- (B) the unit pascal
 - (C) the unit N m^{-1}
 - (D) the unit J
8. When a wire is stretched, its diameter
- (A) decreases
 - (B) increases
 - (C) remains constant
 - (D) first increases then decreases
9. State Hooke's law.
10. What is compressibility?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. A steel wire of Young's modulus $2 \times 10^{11} \text{ N m}^{-2}$ is stretched to a strain of 10^{-3} . Find the energy stored per unit volume.
12. A spring of spring constant 200 N m^{-1} is stretched by 5 cm. Find the elastic energy stored in it.
13. A wire of length 3 m and diameter 1 mm is stretched by 3 mm. If Poisson's ratio is 0.25, find the decrease in its diameter.
14. A wire of radius 0.5 mm under a load of 5 kg shows an extension of 1 mm over 2 m. Find Young's modulus ($g = 10 \text{ m/s}^2$).

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Define the three elastic moduli — Young's, shearing and bulk — and give an expression and an application for each.
16. Derive an expression for the elastic potential energy stored per unit volume in a stretched wire in terms of Young's modulus and strain.
17. Explain the stress-strain curve for a ductile material and identify the elastic limit and yield point.
18. Define Poisson's ratio and show that it is dimensionless. State the significance of the two limiting values 0 and 0.5.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Discuss the practical applications of elastic behaviour in the design of beams, columns and crane cables, and explain the role of the factor of safety.
20. Describe an experiment to determine Young's modulus of a wire using Searle's method, and explain how the value is calculated from the measurements.

Answer Key (Marking Scheme)

- Q1 — (A) longitudinal stress to longitudinal strain. Q2 — (A) volumetric stress to volumetric strain. Q3 — (A) bulk modulus. Q4 — (A) solids.
- Q5 — (A) lateral strain to longitudinal strain. Q6 — (A) 0.5. Q7 — (A) no unit. Q8 — (A) decreases.
- Q9 — Within the elastic limit, stress is directly proportional to strain (stress = $Y \times$ strain).
- Q10 — The reciprocal of the bulk modulus: the fractional volume change per unit pressure applied.
- Q11 — $u = \frac{1}{2} \times 2 \times 10^{11} \times (10^{-3})^2 = 10^5 \text{ J m}^{-3}$.
- Q12 — $U = \frac{1}{2} \times 200 \times (0.05)^2 = 0.25 \text{ J}$.
- Q13 — longitudinal strain = 10^{-3} ; lateral strain = 2.5×10^{-4} ; $\Delta d = 2.5 \times 10^{-7} \text{ m}$.

Q14 — $A = \pi \times (0.5 \times 10^{-3})^2 \approx 7.85 \times 10^{-7}$; $Y = (50 \times 2)/(7.85 \times 10^{-7} \times 10^{-3}) \approx 1.27 \times 10^{11} \text{ N m}^{-2}$.

Q15 — Young's: longitudinal stress/strain (wires, cables); shearing: shear stress/shear strain (shafts); bulk: volumetric stress/strain (gases under pressure).

Q16 — $u = \frac{1}{2} \times \text{stress} \times \text{strain} = \frac{1}{2} Y (\text{strain})^2 = \frac{1}{2} Y (\Delta l/l)^2$.

Q17 — Linear region up to proportional limit, then elastic limit (reversible), yield point where plastic flow begins, then fracture at the breaking point.

Q18 — $\sigma = (\Delta d/d)/(\Delta l/l)$ is a ratio of strains, so it is dimensionless; $\sigma = 0$ means no lateral contraction, $\sigma = 0.5$ means volume is conserved (incompressible).

Q19 — Beams/columns sized so working stress stays well below yield; crane cables use high-Y steel; factor of safety = breaking stress/working stress (> 1) guards against overloading.

Q20 — Searle's apparatus: equal loads on the experimental wire and a reference wire, extension read by a vernier attached to a spirit level; $Y = Fl/(A\Delta l)$ from the load–extension graph slope.