CLASS 11 PHYSICS — FORMULA SHEET

Chapter 8 : Mechanical Properties of Solids (NCERT)

8.1 Stress and Strain

Quantity	Formula / Detail
Stress	Stress = Force ÷ Area = F/A ; SI unit N/m^2 (Pa); dimension $[M^1L^{-1}T^{-2}]$
Longitudinal (normal) stress	Force perpendicular to area; tensile (stretch) or compressive
Tangential (shear) stress	Force parallel to the surface
Hydraulic stress	Force applied uniformly from all sides (by a fluid)
Strain	Strain = change in dimension ÷ original dimension; dimensionless, no unit
Longitudinal strain	$\Delta L \div L$ (change in length per unit length)
Shear strain	$= \tan\theta \approx \theta$ (angular deformation, in radian)
Volume strain	$\Delta V \div V$ (change in volume per unit volume)

8.2 Hooke's Law & Stress–Strain Curve

Concept	Detail
Hooke's law	Within elastic limit: Stress ∝ Strain → Stress = E × Strain (E = modulus of elasticity)
Proportional limit	Up to here stress ∝ strain (Hooke's law obeyed)
Elastic limit / yield point	Beyond it, body does not regain original shape (permanent set)
Plastic region	Permanent deformation occurs
Ultimate tensile strength	Maximum stress a material can withstand
Fracture / breaking point	Material breaks
Elastomers	Stretch a lot, no linear region (e.g. rubber); large elastic range

8.3 Moduli of Elasticity

Modulus	Formula
Young's modulus (Y)	Y = Longitudinal stress ÷ Longitudinal strain = $(F\cdot L) \div (A\cdot\Delta L)$
Young's modulus (wire)	$Y = (F\cdot L) \div (\pi r^2\cdot\Delta L)$
Bulk modulus (B / K)	B = −Hydraulic stress ÷ Volume strain = $-P\cdot V \div \Delta V$
Compressibility	$k = 1 \div B$
Shear / Rigidity modulus (G / η)	G = Shear stress ÷ Shear strain = $F \div (A\cdot\theta)$
Units of all moduli	N/m^2 (Pa) — same as stress (strain is dimensionless)

8.4 Poisson's Ratio & Elastic Energy

Concept	Formula
Lateral strain	$= \Delta d \div d$ (change in diameter per unit diameter)

Concept	Formula
Poisson's ratio (σ)	σ = Lateral strain ÷ Longitudinal strain = −(Δd/d) ÷ (ΔL/L)
Range of σ	Theoretically −1 to 0.5 ; practically 0 to 0.5
Elastic potential energy	U = ½ × Stress × Strain × Volume
Energy density	u = U/Volume = ½ × Stress × Strain = ½ × Y × $(\text{strain})^2$
Energy in stretched wire	U = ½ × F × ΔL = ½ × (Y A ΔL^2) ÷ L

8.5 Applications & Important Facts

Concept	Detail
Elongation under own weight	ΔL = (Mg L) ÷ (2AY) = (ρ g L^2) ÷ (2Y)
Thermal stress (rod fixed)	Stress = Y α ΔT (α = coeff. of linear expansion)
Why hollow beams / I-shape	Greater rigidity per unit mass; resist bending better
Depression of a beam (loaded centre)	δ = (W L^3) ÷ (4 b d^3 Y) (rectangular beam)
Elastic after-effect	Delay in regaining original shape after stress removed
Elastic fatigue	Loss of strength due to repeated stress cycles

★ QUICK MEMORY AIDS & TRICKS

Stress vs strain	Stress = F/A (has units, Pa) ; Strain = change/original (no units).
Three moduli	Young's → length change ; Bulk → volume change ; Shear → shape change.
Hooke's law	Stress = E × Strain (only within the elastic limit).
Young's modulus wire	Y = FL/(AΔL). Thicker/longer setups change ΔL — keep units consistent.
Poisson's ratio	σ = lateral/longitudinal strain ; practical range 0 to 0.5.
Energy density	u = ½ × stress × strain = ½ Y $(\text{strain})^2$. Area under stress–strain graph.
Bulk & compressibility	k = 1/B. Gases most compressible, solids least.
Thermal stress	= Y α ΔT (independent of length, for a rigidly fixed rod).