Properties of Matter – Cheat Sheet

Comprehensive Reference for Physics & Engineering Students

1. Elasticity

is the property of a body to regain its original shape and size after the deforming force is removed.* **Stress (σ)**: Restoring force per unit area.

$$\sigma = \frac{F}{A} \quad [\text{N/m}^2 \text{ or Pa}]$$

* **Strain (ϵ)**: Fractional change in dimension.

$$\epsilon = \frac{\Delta L}{L}, \quad \epsilon_v = \frac{\Delta V}{V}$$

* **Hooke's Law**: Within the elastic limit, stress is directly proportional to strain.

$$\sigma = E \cdot \epsilon$$

Elastic Moduli

* **Young's Modulus (Y)** (Longitudinal):

$$Y = \frac{FL}{A\Delta L}$$

* **Bulk Modulus (B)** (Volume):

$$B = -V\frac{\Delta P}{\Delta V} = -\frac{\Delta P}{\epsilon_v}$$

*(Compressibility $K = 1/B$)** **Rigidity Modulus (η)** (Shear):

$$\eta = \frac{F/A}{\theta} = \frac{FL}{A\Delta x}$$

* **Poisson's Ratio (σ or μ)**:

$$\mu = \frac{\text{Lateral Strain}}{\text{Longitudinal Strain}} = \frac{\Delta D/D}{\Delta L/L}$$

(Theoretical range: -1 to 0.5)

Elastic Potential Energy

stored per unit volume (u):

$$u = \frac{1}{2} \times \text{Stress} \times \text{Strain} = \frac{1}{2}Y\epsilon^2 = \frac{\sigma^2}{2Y}$$

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2. Surface Tension

tension arises from intermolecular cohesive forces at the liquid-gas interface.* **Definition**:

$$T = \frac{F}{l} \quad [\text{N/m or J/m}^2$$

* **Work Done (W)** in forming a drop/bubble:* Drop (1 surface): $W = T \cdot \Delta A = T(4\pi r^2)$* Bubble (2 surfaces): $W = T \cdot 2(\Delta A) = 8\pi r^2 T$* **Excess Pressure ($\Delta P$)**:* Cylindrical liquid drop: $\Delta P = \frac{T}{r}$* Spherical liquid drop: $\Delta P = \frac{2T}{r}$* Soap bubble (2 surfaces): $\Delta P = \frac{4T}{r}$* **Capillarity (Rise/Fall)**:

$$h = \frac{2T\cos\theta}{r\rho g}$$

where θ is the angle of contact, ρ is density, r is tube radius.

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3. Hydrostatics & Fluid Pressure

* **Pressure**:

$$P = \frac{F}{A}, \quad P = P_0 + \rho g h$$

* **Pascal's Law**: Pressure applied to an enclosed fluid is transmitted undiminished to every part of the fluid.* **Archimedes' Principle**:

Buoyant Force $F_b = V_{\text{submerged}}\rho_{\text{fluid}}g$ = Weight of displaced fluid

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4. Hydrodynamics (Fluid Dynamics)

* **Equation of Continuity** (Incompressible fluid):

$$A_1 v_1 = A_2 v_2 = \text{constant}$$

* **Bernoulli's Theorem** (Conservation of Energy):

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

* **Torricelli's Law** (Speed of efflux):

$$v = \sqrt{2gh}$$

* **Venturi Meter Velocity**:

$$v = \sqrt{\frac{2gh(\rho_m - \rho)}{\rho}}$$

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5. Viscosity

is the internal friction of a fluid that opposes relative motion between its layers.* **Newton's Law of Viscosity**:

$$F = -\eta A\frac{dv}{dx}$$

where η is the coefficient of viscosity.* **Poiseuille's Equation** (Capillary flow rate):

$$Q = \frac{\pi P r^4}{8\eta l}$$

* **Stokes' Law** (Drag force on a sphere):

$$F_d = 6\pi\eta r v$$

* **Terminal Velocity (v_t)**:

$$v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$$

where ρ is sphere density and σ is fluid density.

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6. Thermal Properties of Matter

* **Thermal Expansion**:* Linear: $\Delta L = L_0 \alpha \Delta T$* Area: $\Delta A = A_0 \beta \Delta T \quad (\beta \approx 2\alpha)$* Volume: $\Delta V = V_0 \gamma \Delta T \quad (\gamma \approx 3\alpha)$* **Heat Capacity Specific Heat**:

$$Q = mc\Delta T = C\Delta T$$

* **Latent Heat (L)**:

$$Q = mL$$

* **Heat Transfer Modes**:* **Conduction**: Fourier's Law

$$\frac{dQ}{dt} = -kA\frac{dT}{dx}$$

—* **Radiation**: Stefan-Boltzmann Law

$$E = \sigma_B e A T^4$$

Wien's Displacement Law: $\lambda_m T = b$