

CLASS 11 PHYSICS • CHAPTER 9

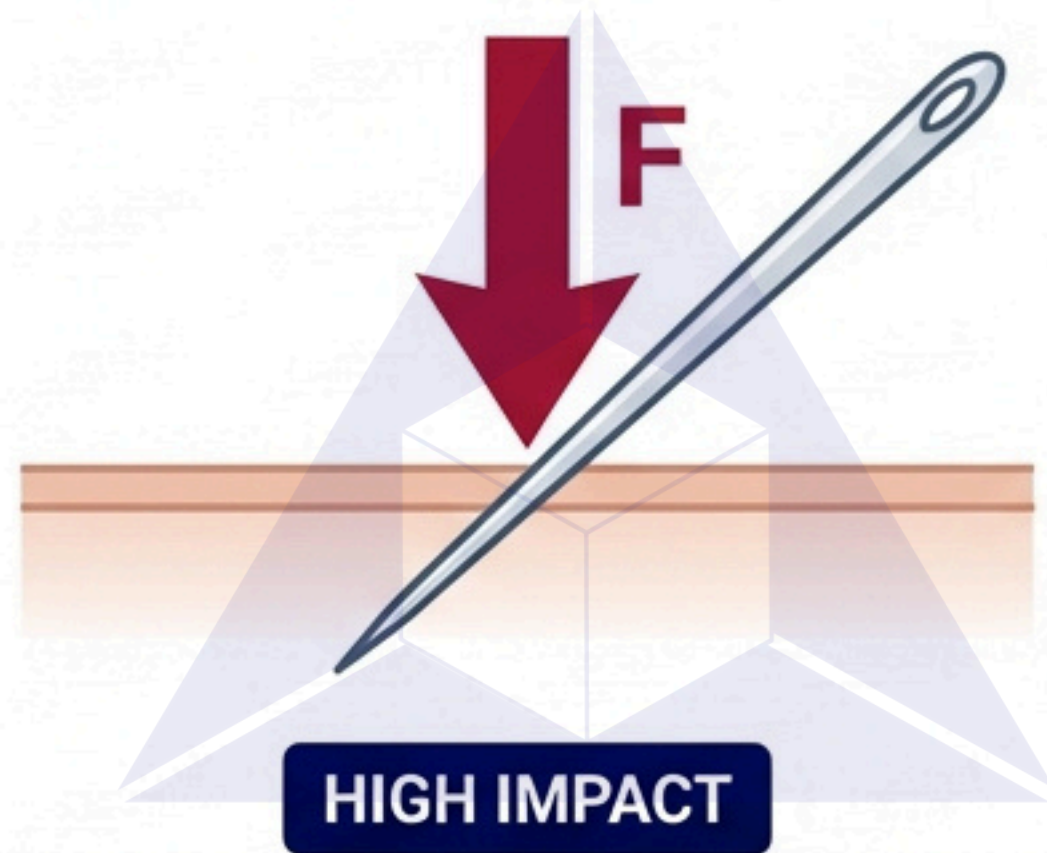
Mechanical Properties of Fluids: Pressure

Understanding normal force per unit area
and the behavior of fluids at rest.

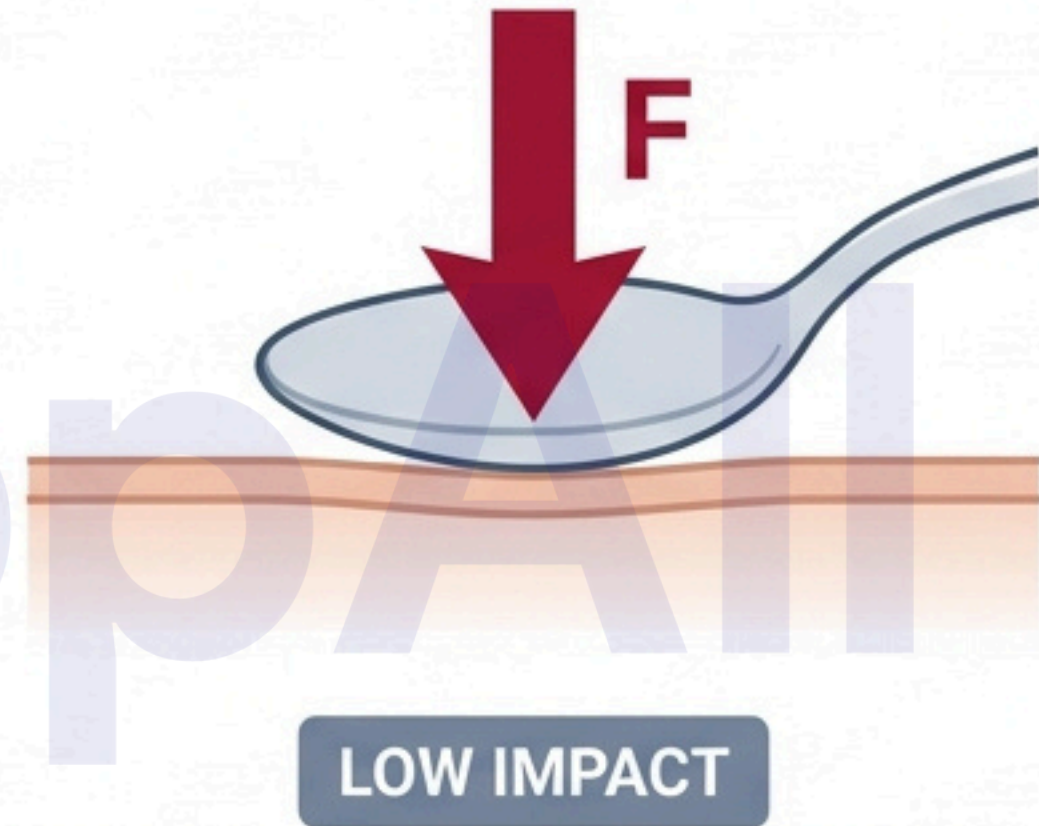


Same Force, Different Impact

Everyday experience shows that the impact of a force depends on its coverage area. The smaller the area on which a force acts, the greater the impact.



A needle pierces the skin because the force is concentrated on a tiny area.

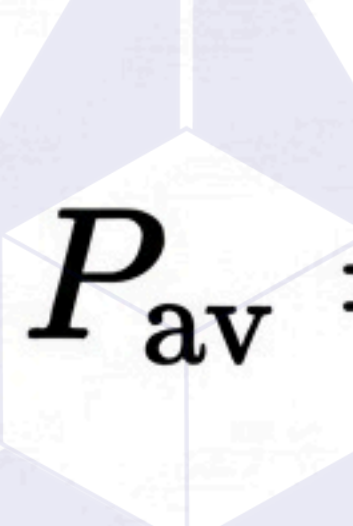


A blunt object leaves the skin intact because the same force is distributed over a larger area.

This physical impact is known as Pressure.

The Mathematical Definition

AVERAGE PRESSURE (Eq. 9.1)


$$P_{av} = \frac{F}{A}$$

F = Magnitude of **normal** force (N)

A = Area of contact (m²)

SI Unit: Pascal (Pa) or N m⁻² | Dimensions: [ML⁻¹T⁻²]

KEY CONCEPT

Pressure is a scalar quantity. We only consider the component of force perpendicular (normal) to the area.



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Measuring Pressure at a Specific Point

In fluids, pressure can vary from point to point.

By making the measuring area **infinitesimally small**, we define pressure at a specific point in a limiting sense.

$$\text{Eq. (9.2): } P = \lim_{\Delta A \rightarrow 0} \frac{\Delta F}{\Delta A}$$

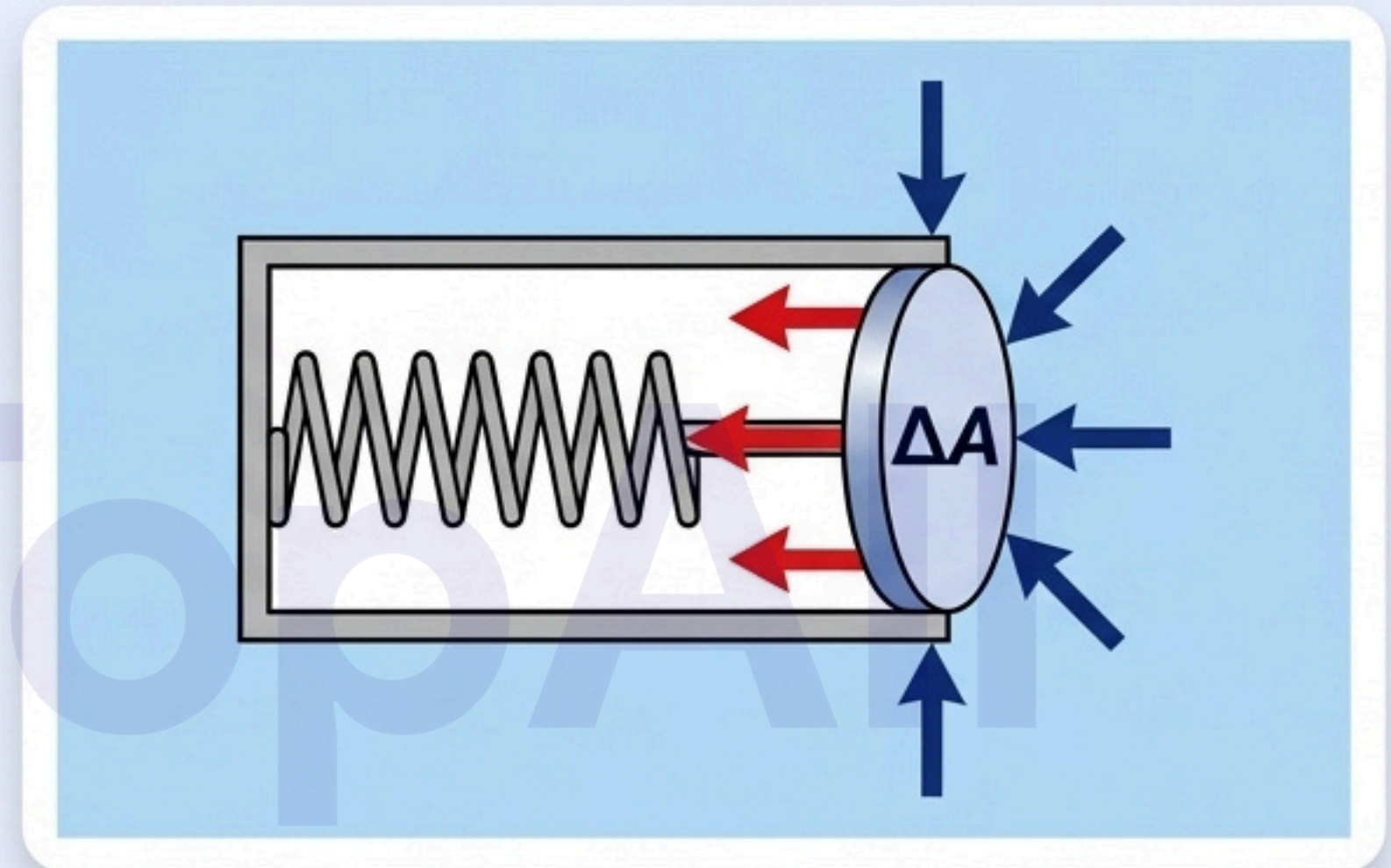


FIG 9.1(b) Idealised pressure-measuring device. An evacuated chamber with a calibrated spring balances the inward normal force of the fluid on a small piston of area ΔA .

Fluid Force is Always Perpendicular

When an object is submerged in a fluid at rest, the fluid exerts a force on its surface. This force is always normal (perpendicular) to the surface.

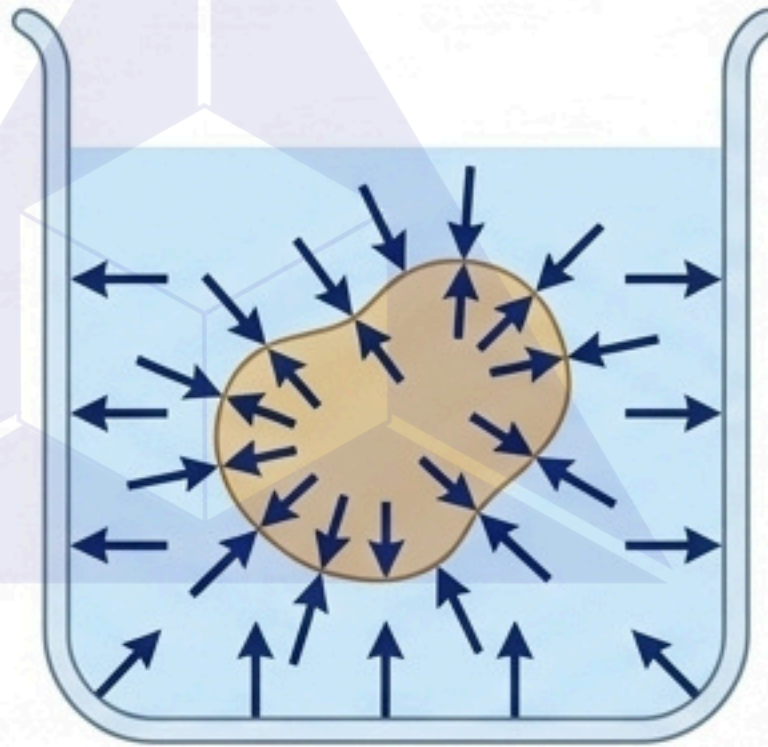
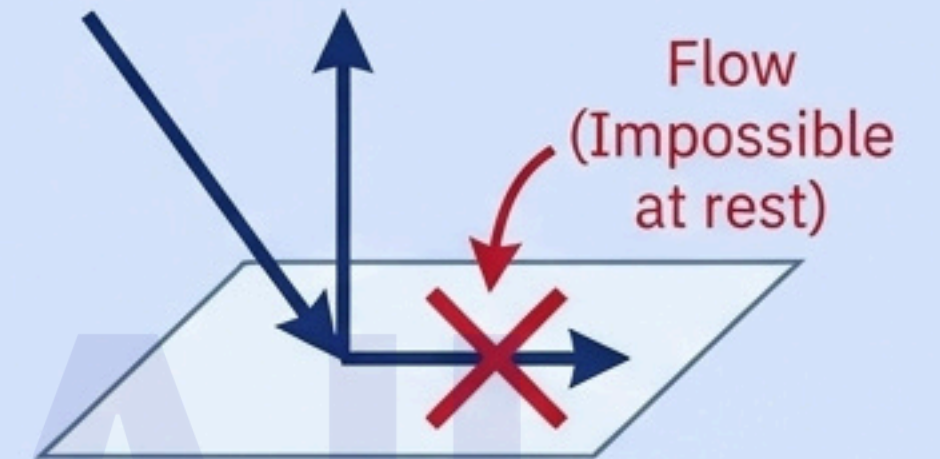


FIG 9.1(a)

Force is normal to surfaces at all points.

WHY?



If there were a parallel component of force, by Newton's Third Law, the object would exert a parallel force back. This would cause the fluid to flow. Since the fluid is at rest, parallel forces must be zero.

Density: The Indispensable Fluid Property



MASS DENSITY (Eq. 9.3)

$$\rho = \frac{m}{V} \text{ (Mass per unit volume)}$$

SI Unit: kg m^{-3} | Dimensions: $[\text{ML}^{-3}]$ | Positive Scalar Quantity

Liquids

Largely incompressible. Density (ρ) remains nearly constant at all pressures.

Gases

Highly compressible. Exhibit large variations in density with changes in pressure.

Reference: Density of water at 4°C is $1.0 \times 10^3 \text{ kg m}^{-3}$.

Section 9.2 Summary



KEY TAKEAWAYS

- **Pressure is a scalar:** It has no assigned direction, defined as normal force per unit area ($P = F/A$).
- **Fluid force is normal:** Fluids at rest strictly exert forces perpendicular to any contacting surface; otherwise, flow would occur.
- **Units to remember:** 1 Pascal (Pa) = 1 N m^{-2} . 1 atm = $1.013 \times 10^5 \text{ Pa}$.
- **Density dictates behavior:** Liquids are largely incompressible (constant ρ), while gases are highly compressible.

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