

KARACHI EDU COACHING CENTER

Comprehensive Master Notes: Chapter 06

Advanced Fluid Dynamics & Work-Energy Frameworks: Detailed
Theoretical Breakdown, Derivations & Sindh Board Numericals.

Chapter Outline & Core Objectives

01. Fluid Flow Dynamics

Streamline vs turbulent flow, equation of continuity, and conservation laws.

02. Bernoulli's Principle

Derivation of pressure-velocity relations, Venturi meter, and Torricelli's theorem.

03. Viscosity & Stokes Law

Internal friction, drag forces, terminal velocity, and practical engineering applications.

Section 6.1: Equation of Continuity

Streamline Flow

Every particle passing a point follows exact same smooth path without crossing.

Conservation of Mass

Product of cross-sectional area (A) and flow speed (v) remains constant.



Continuity Equation Form

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

Section 6.2: Bernoulli's Derivation

Work–Energy Theorem Applied to Fluid Flow

Step 1: Net work done by pressure forces equals change in kinetic and potential energy across volume element.

Step 2: Formulating energy conservation per unit volume:

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

Sum of pressure energy, kinetic energy, and potential energy per unit volume remains invariant.

Section 6.3: Practical Applications

1 Torricelli's Theorem

Speed of efflux of liquid from an orifice at depth h is identical to free fall speed: $v = \sqrt{2gh}$.

2 Venturi Meter

Device used to measure fluid flow speed inside pipes using pressure drop across a constricted throat section.

3 Aerodynamic Lift

Higher air velocity over curved upper airfoil surface creates lower pressure, generating upward lift force.

Section 6.4: Viscosity & Stokes Law

Coefficient of Viscosity (η)

Measure of internal fluid friction; units are $\text{N} \cdot \text{s} / \text{m}^2$ or $\text{kg} / (\text{m} \cdot \text{s})$.

Stokes' Law Drag Force

$F_d = 6\pi\eta r v$ (for spherical bodies in viscous medium).

Terminal Velocity Formula

Constant maximum velocity attained when gravitational force equals sum of buoyant and viscous drag forces.

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

Section 6.5: Numerical & Exam Review

Solved Numerical Example

Water flows through a pipe of diameter 4 cm at 3 m/s. Find speed in a 2 cm diameter constriction section.

Solution: $A_1 v_1 = A_2 v_2$

$$(4)^2 \times 3 = (2)^2 \times v_2$$

Result: $v_2 = 12 \text{ m/s}$

Top Board MCQs & Short Qs

- State Bernoulli's principle and list its key limitations.
- Why do fast moving trains create a suction force toward the tracks?
- Dimension of coefficient of viscosity is $[\text{ML}^{-1} \text{T}^{-1}]$.

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Chapter 06 Mastery Achieved

Review complete. Prepare your queries for the upcoming doubt-clearing session.

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