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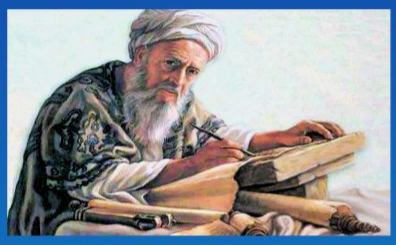
SEVEN MUSLIMS NOTES

PHYSICS 11

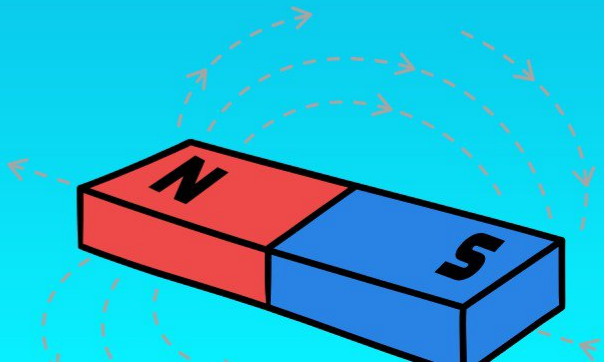


Al-Biruni (973–1048) calculated the Earth's radius and worked on the physics of planetary motion.

Best Regards to

Sir Muhammad Ali

(Physics Lecturer KIPS College)



CHAPTER 6

FLUID DYNAMICS

Q.1: Define fluid and fluid dynamics.

FLUID

"Anything that can flow is called fluid."

For example:

Liquids and gases

FLUID DYNAMICS

"The study of fluids in motion is called fluid Dynamics."

Q.2: Define viscosity. What do you understand by the term viscosity? Explain.

VISCOSITY

"Frictional effect between different layers of a flowing fluid is called viscosity."

Explanation:

Viscosity measures how much force is required to slide one layer of liquid over another layer. Substances that are thick have large coefficient of viscosity and vice versa.

Example:

Thick liquids like honey, oil are more viscous while thin liquids like water have small viscosity.

SI unit:

Its SI unit is Nsm^{-2} ($kgm^{-1}s^{-1}$)

Dimensions:

Its dimensions are [$ML^{-1}T^{-1}$]

Co- efficient of viscosity is denoted by symbol η from stokes law $F = 6\pi\eta rv$.

Q.3: Define Drag force and Stoke's law.

DRAG FORCE

"An object moving through a fluid experiences a retarding force called drag force, increases with the speed of the fluid."

STOKE'S LAW

According to stroke's law when a sphere of radius " r " moves through a fluid of viscosity " η " with speed " v ", the drag force acting on it is given as

$$F = 6\pi\eta rv$$

Q.4: On which factors does drag force depend?

DEPENDENCE OF DRAG FORCE

Drag force acting on an object depends upon:

1. Speed of the object

2. Viscosity of the liquid

3. Shape of the object

Q.5: Define terminal velocity. Also derive the expression for terminal velocity. (OR)

Define terminal velocity. Prove that terminal velocity is directly proportional to the square of the radius. (SWL. GI, DGK. GI, MLN. GII, FSD. GI, 2018) (LHR. GI, 2021) (MLN. GII, 2022)

TERMINAL VELOCITY

"The maximum constant velocity of an object falling vertically downward is called its terminal velocity."

Explanation

Consider a fog droplet falling vertically downward under the action of gravity.

The drag force acting on it is in upward direction. The net force on the droplet is then written as

Net force = weight – Drag force

As the droplet continues to fall down its speed increases causing increase in the drag force. There comes a point when weight of the drop and the drag force become equal and droplets start falling with constant velocity called **terminal velocity**.

$$W = F_d$$

$$mg = 6\pi\eta r v_t$$

$$v_t = \frac{mg}{6\pi\eta r} \quad \ldots\ldots\ldots (1$$

Density of drop is

$$\rho = \frac{m}{vol} = \frac{m}{\frac{4}{3}\pi r^3}$$

$$m = \frac{4}{3}\pi r^3 \rho$$

Use in equation 1

$$v_t = \frac{\frac{4}{3}\pi r^3 \rho g}{6\pi\eta r}$$

$$v_t = \frac{4\pi r^3 \rho g}{18\pi\eta r}$$

$$v_t = \frac{2r^2\rho g}{9\eta} \quad (\text{Expression for terminal velocity})$$

$$V_t \propto r^2 \qquad (\text{where } \frac{2\rho g}{9\eta} \text{ is constant})$$

Hence, terminal velocity is directly proportional to the square of radius of droplet.

Q.6: What is fluid flow? Define streamline and turbulent flow also.

FLUID FLOW

When a fluid is in motion, its flow can be

1. Streamline flow (laminar flow or steady flow)

2. Turbulent flow

STREAMLINE/LAMINAR FLOW

"The flow is said to be streamline flow or laminar flow, if every particle that passes a particular point, moves along exactly the same path as followed particles which passed that points earlier."

Example:

Blood through capillaries has laminar flow.

TURBULENT FLOW

"The irregular or unsteady flow of the fluid is called turbulent flow."

Example:

Flow of oil in pipelines, flow of honey.

Q.7: Write the properties of ideal flow.

IDEAL FLOW

Ideal flow follows the following properties

1.Non viscous

2.Steady flow

3.Incompressible

Any fluid that follows the above properties is called ideal flow.

Q.8: State and Explain equation of continuity.

EQUATION OF CONTINUITY

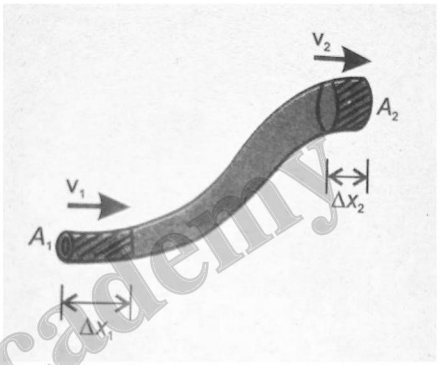
Statement:

"The product of cross sectional area of the pipe and the fluid speed at every point along the pipe remains same or constant."

This constant is called **volume per second or flow rate**.

Explanation:

Consider an ideal flow following through a non uniform pipe in time Δt, Δm_1 mass of the fluid enters the pipe from its lower end of area A_1 and travels displacement Δx_1 with velocity v_1. In the same time Δm_2 mass of the fluid leaves the pipe from its upper end of area A_2 and travels displacement Δx_2 with velocity v_2.



Mathematical derivation:

As density p of liquid is given as

$$\rho = \frac{\Delta m}{vol}$$

$$\Delta m = \rho \times vol$$

For lower end

$$\Delta m_1 = \rho \times A_1 \Delta x_1$$

Or

$$\Delta m_1 = \rho \times A_1 v_1 \times \Delta t$$

Similarly at upper end

$$\Delta m_2 = \rho A_2 v_2 \times \Delta t$$

Using law of conservation of mass

$$\Delta m_1 = \Delta m_2$$

$$\rho A_1 v_1 \Delta t = \rho A_2 v_2 \Delta t$$

$$A_1 v_1 = A_2 v_2$$

$$Av = \text{constant}$$

Q.9: Define flow rate.

FLOW RATE

"The volume of the fluid flowing per second is called flow rate."

$$\text{Flow rate} = \frac{\text{volume}}{\text{time}} = AV$$

Q.10: State and explain Bernoulli's equation.

BERNOULLI'S EQUATION

Statement:

According to the Bernoulli's equation

"The sum of Pressure, kinetic energy per unit volume and potential energy per unit volume for non viscous, incompressibility fluid flowing steadily through a non uniform pipe is constant."

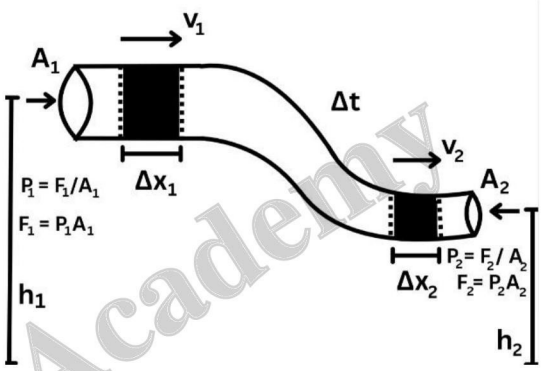
Explanation:

Let us consider the flow of a fluid to a non uniform pipe in time t. Let a force F_1 causes the liquid to move through a distance Δx_1 at upper end of the pipe then

$$w_1 = F_1\Delta x_1 = P_1A_1\Delta x_1$$

Similarly force F_2 causes the fluid to move through a distance Δx_2 at lower end of the pipe so

$$w_2 = -F_2\Delta x_2 = -P_2A_2\Delta x_2$$



$$\text{Total work done} = w = w_1 + w_2$$

$$w = P_1A_1\Delta x_1 - P_2A_2\Delta x_2$$

By using equation of continuity

$$A_1v_1 = A_2v_2$$

$$A_1v_1 \times t = A_2v_2 \times t$$

$$A_1\Delta x_1 = A_2\Delta x_2 = A\Delta x$$

$$= \text{Volume}$$

So

$$w = P_1v - P_2v$$

$$= (P_1 - P_2)v$$

$$w = (P_1 - P_2)\frac{m}{\rho} \qquad \left(\because \rho = \frac{m}{v}\right)$$

When fluid moves from upper to lower end of the pipe then

$$\Delta P.E = mgh_2 - mgh_1$$

$$\Delta k.E = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$\Delta E = \Delta P.E + \Delta k.E$$

$$\Delta E = mgh_2 - mgh_1 + \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

By work energy principle

$$W = \Delta E$$

$$(P_1 - P_2)\frac{m}{\rho} = mgh_2 - mgh_1 + \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$P_1 - P_2 = \rho gh_2 - \rho gh_1 + \frac{1}{2}Pv_2^2 - \frac{1}{2}Pv_1^2$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh_1 = P_2 + \frac{1}{2}Pv_2^2 + Pgh_2$$

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

Q.11: State Torricelli's theorem and write its relation.

TORRICELLI'S THEOREM

Statement

"The speed of afflux is equal to the velocity gained by the fluid and falling through a height $h_1 - h_2$ under the action of gravity."

Formula:

$$v_2 = \sqrt{2g(h_1 - h_2)}$$

Q.12: Drive the relation between speed and pressure of the fluid.

Statement:

"According to Bernoulli's equation where the speed is high pressure will be low."

Mathematically:

$$P_a + \frac{1}{2}\rho v_a^2 = P_b + \frac{1}{2}\rho v_b^2$$

Q.13: How a dynamic lift is produced in an Aeroplane?

A dynamic lift produced in an Aeroplane is due to the fact " Where the speed is high, the pressure will be low. The wing is designed to deflect the air so that the streamlines are closer together above the wing than below it. So where the streamlines are forced closer together, the speed is faster. Thus, air is traveling faster on the upper side of the wing than on the lower one. The pressure will be lower at the top of the wing and the wing will be forced upward.

Q.14: Define venturi relation.

VENTURI RELATION

Statement:

"Relation that is used to find the speed of flowing fluid is called venturi relation."

$$P_A - P_B = \frac{1}{2}\rho V_B^2$$

Q.15: Define venturi meter.

VENTURI METER

"The device that is used to measure speed of liquid flow is called venturi meter."

Blood Pressure

Important points to learn:

1. Blood is incompressible fluid. Density of blood is nearly equal to water.
2. High concentration nearly 50% of red cells makes its viscosity 3 to 5 times than that of water.
3. The pressure exerted by circulation of blood on the walls of the blood vessels is called **blood pressure**.
4. High blood pressure is **systolic** and low blood pressure is **diasystolic**.
5. The value of Systolic pressure is 120 torr and the value of diastolic pressure for normal human body is 75-80 torr.
6. Blood pressure is measured in torr or mm of Hg and 1 torr = $133.3\ Nm^{-2}$
7. Blood pressure is measured by an instrument which is called sphygmomanometer.
8. The instrument which detects the instant at which the external pressure becomes equal to the systolic pressure is called **Stethoscope**.