HYDRAULICS & FLUID POWER SYSTEMS

1. Define Newton's law of viscosity.

Ans: Newton's Law of Viscosity defines the relationship between the shear stress and the rate of shear strain (or velocity gradient) in a fluid. It is a fundamental principle used to describe the flow behaviour of fluids, particularly in cases where the fluid is Newtonian, meaning its viscosity remains constant regardless of the shear rate

The equation for Newton's Law of Viscosity is:

$\tau = \eta (du/dy)$

Where:

τ is the shear stress

η is the dynamic viscosity of the fluid (in Pascal-seconds).

du/dy is the velocity gradient (rate of change of velocity with respect to distance in the direction perpendicular to the flow)

2. Define the terms (a) weight density and (b) viscosity

Ans: **a) Weight density:** Weight density (also known as specific weight) refers to the weight per unit volume of a substance. It represents the force exerted by gravity on a given volume of material and is typically expressed in units of force per unit volume (e.g., N/m^3 or lb/ft^3)

b) Viscosity: Viscosity is a property of a fluid that measures its resistance to deformation or flow. It quantifies the internal friction within the fluid as it flows. Higher viscosity means the fluid flows less easily (e.g., honey has higher viscosity than water)

i) **Dynamic Viscosity (η)**: Measures the fluid's resistance to flow under an applied force. It is expressed in units of Pa·s (Pascal-seconds) or $N·s/m^2$ (Newton-seconds per square meter).

ii) **Kinematic Viscosity (ν)**: The ratio of dynamic viscosity to the fluid's density. It is expressed in units of m^2/s (square meters per second)

3. Write any three differences between Pelton wheel and Francis turbine.

Ans: i) Pelton wheels are impulse turbines that work with high-head, low-flow conditions, using tangential water jets

ii) Francis turbines are reaction turbines that work with medium to low-head, high-flow conditions, involving radial and axial flow

4. Distinguish between Rotational flow and Irrotational flow.

Ans: Rotational Flow: In rotational flow, fluid particles exhibit rotation about their own axis as they move through the flow field. This means that the vorticity (or the local spinning motion) of the fluid is non-zero

Irrotational Flow: In irrotational flow, fluid particles do not rotate about their own axis as they move. The vorticity is zero, meaning there is no local spinning of the fluid particles

5. What is Cavitation? Mention the effects of Cavitation.

Ans: Cavitation is a phenomenon in fluid dynamics that occurs when the pressure in a fluid falls below its vapour pressure, causing the formation of vapour bubbles within the fluid. These vapour bubbles form in areas where the local pressure is low, such as in regions of high velocity or turbulence. When these vapour bubbles move into regions of higher pressure, they collapse or implode, creating intense localized shock waves

Effects of Cavitation:

i) Surface Erosion and Damage
ii) Reduced Performance
iii) Vibration and Noise
iv) Flow Instabilities
v) Damage to Bearings and Seals
vi) Loss of Thrust (in Propellers)

6. Function of Syphon and mention any three uses of Syphon.

Ans: A syphon is a device that uses gravity and atmospheric pressure to transfer liquids from one container to another, typically from a higher elevation to a lower one, without the need for a pump. Here are three common uses of a syphon

Uses of Syphon:

i) Transferring Liquids Between Containers
ii) Draining and Emptying Tanks or Pools
iii) Fuel Systems in Internal Combustion Engines

7. Define the term surface tension.

Ans: Surface tension is a physical phenomenon that occurs at the surface of a liquid, where the molecules experience a cohesive force pulling them together. This results in the liquid behaving like a stretched elastic membrane. It is caused by the intermolecular forces between the liquid molecules, which are stronger at the surface due to the absence of neighbouring molecules above them.

Surface tension causes the liquid to minimize its surface area, which is why small drops of liquid tend to form spherical shapes. It also enables insects like water striders to walk on water, as the surface tension supports their weight without breaking

8. Define Reynolds number and mention its significance.

Ans: The Reynolds number (Re) is a dimensionless quantity used to predict the flow regime of a fluid (whether the flow is laminar or turbulent). It is defined as the ratio of inertial forces to viscous forces in a fluid flow.

$$Re = \rho v L / \mu$$

where:

ρ is the fluid density
V is the fluid velocity
L is the characteristic length (such as the diameter of a pipe or the length of an object moving through the fluid)
μ is the dynamic viscosity of the fluid

Significance of Reynolds Number:

i) **Flow Characterization**: The Reynolds number helps determine whether a fluid flow is **laminar** (smooth and orderly) or **turbulent** (chaotic and irregular)

- **Laminar flow** occurs when Re is low (typically Re<2000Re < 2000Re<2000), where fluid moves in smooth layers
- **Turbulent flow** occurs when Re is high (typically Re>4000Re > 4000Re>4000), characterized by chaotic, swirling motion
- In the intermediate range (2000<Re<40002000 < Re < 40002000<Re<4000), the flow is often unstable and can transition between laminar and turbulent.

ii) **Design and Analysis**: In engineering applications, the Reynolds number is crucial in designing pipes, ducts, and other fluid systems. It helps engineers predict pressure drops, flow patterns, and heat transfer characteristics, which are important for efficient system operation

iii) **Scale Effects**: It is also significant in understanding the behaviour of fluids in different-sized systems, such as in scale models of aircraft or in experiments using small-scale pipes

9. State the functions of flow control valve.

Ans: A **flow control valve** is a device used to regulate the flow rate of a fluid in a pipeline or system. It helps to manage and control the volume and speed of the fluid as it moves through the system.

The functions of a flow control valve include:

i) Regulating Flow Rate
ii) Maintaining Pressure
iii) Preventing Flow Surge
iv) Improving System Efficiency
v) Protecting Equipment
vi) Flow Direction Control
vii) Flow Limiting for Process Control
viii) Temperature Control

10. State the continuity equation and write the mathematical expression of it.

Ans: The continuity equation is a fundamental principle of fluid dynamics, which expresses the conservation of mass for a fluid flowing through a closed system. It states that the mass flow rate of a fluid entering a control volume must be equal to the mass flow rate exiting the control volume, assuming there are no accumulations or losses of mass within the control volume

Mathematically, the continuity equation is expressed as:

$$A_1v_1=A_2v_2$$

where:

A_1&$A_2$are the cross-sectional areas of the fluid flow at two points (1&2)
v_1&v_2 are the fluid velocities at the respective points

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