FLUID STATISTICS

A fluid is a substance with the tendency to flow .It can also be defined as a substance which continuously deforms when subjected to any external force.

Fluid statistics is therefore the study of fluids that are at rest.

Characteristics of a fluid

- A fluid has no definite shape ,it takes up the shape of the container
- The cohesive forces between the molecules are less
- A fluid is incompressible
- The molecular spacing is larger than that of solid and less than that of gasses

Continum approach

This approach is used to analyse the fluid system

Properties of a fluid

1.Density /Mass density(specific mass):

This is defined as the ratio of mass fluid to it's volume

Density=mass of fluid÷volume of fluid

The measuring unit is

$Kg/_m3$

2.Specific weight

W=weight of fluid÷volume of fluid

W=mg÷v

3.Specific volume(V)

This is the volume of fluid occupied by a unit mass

$\mu=v/m=1/p=m^3/kg$

4.Specific gravity

This is defined as the density of a fluid to the density of a standard fluid

Standard fluid = density of any liquid÷density of water

VISCOSITY

This is the property which makes a liquid resistant to movements on one layer.It is due to cohesion and molecular momentum exchange .

1.kinematic viscosity

It is defines as the ratio between dynamic viscosity of the density of a fluid

$1stoke=10^4{}_{mls}$

Newton's law of viscosity

This law states the sheer stress on a fluid element layers is directly proportional to the rate of shear strain.

Variation of viscosity with temperature

- Increase in temperature decreases the viscosity of liquid
- Increase in temperature increases viscosity of gases

Cohesion forces and molecular momentum transfer are responsible for viscous forces

Types of fluid

1.Ideal fluid

A fluid that does not have viscosity

2.Real fluid

It is a fluid with viscosity

3.Newtonian fluid

Fluids that obey the Newton's law of fluid

4.Non Newtonian fluid

It is a fluid in which shear stress strain

5. Ideal plastic fluid

Its a fluid which shear is more than the yield value and shearstress

Surface tension

This is the tensile force acting an the surfaces of liquids

It is denoted as σ

Unit is $_{n}/_{m^2}$

Examples of surface tension

- Small insects such ad a mosquito floating on water.
- A needle floating on water when it is horizontally placed.

Surface tension and capillarity

Cohesion and adhesion forces causes capillarity in liquid

Cohesion is the force of attraction between molecules that are similar .

Adhesion is the force of attraction between molecules that are unlike.

Surface tension is calculated force per unit length across an imaginary line.Capillarity is due to adhesion and cohesion forces

Ø =angle between surface tention with the vertical glass tube

Force acting downward direct=m×g

Weight of liquid =p×v×g

=p×q×πd²×h÷4

At equilibrium

H↑=4dcosØ÷pgd↓

Vapour pressure

Is pressure exerted by the vapour particle

Carination

This is the pressure resulting to collapsing of a material when a liquid is under low pressure

1.Pascal's law-pressure - inside a fluid is Similar throughout in all direction when the liquid is at rest

PX =Py=PZ

2.Hydrostatic law-rate of increase of pressure should be equal to a specific weight of fluid at a point

Types of pressure

1Atmospheric pressure

2.Gauge pressure

3. Vacuum pressure

4.Absolute pressure

Relationship between the different types of pressure

- Pabs=Patm+pgauge
- Pvac=Patm-Pabs

Pressure is measured in mm/hg

Pressure is measured with a monometer

FLUID KINEMATICS

A fluid can be a gas or a liquid

Fluid kinematics deals with the motion of fluid without considering the forces and moments which create the motion.

Tension(stress)is force per unit area.

Normal tension is on a perpendicular surface.

Shear tension is on a parallel surface.

Lagrangian description

This description flows track to the position and velocity of individual particles. It is named after an Italian mathematician Joseph Louis Lagrangian . It is based in newton's law

Eulerian description

Eularian description of fluid flow a control volume is defined by which flows in and out

Pressure field P=P(x,y,z,t)

It was named after a Swiss mathematician leohard Euler

Acceleration Fluid

Acceleration of a particle is the derived time of particle velocity

Particle velocity is the same as a fluid velocity

Material Derivative

Is the total derivate operator often denoted as D/Dt

Advective acceleration is non linear

Provides transformation between Lagrangian and Eularian frames

It is also known as total ,particle and substantial derivate

Flow visualization

Is visual examination of flow field features

Stream line

Is a curve that is everywhere tangent to the local velocity vectors

Path lines

Is the actual path travelled by a fluid particle over sometime period

Streamlines

Is the locus of fluid particle that have passed sequentially through a prescribed point in the flow

Timelines

Is a set of adjacent fluid that were marked as the the same

Comparison

Steady flow is stream line ,path lines and streak lines are identicles

Unsteady flow

Streamline are instantaneous picture of the flow field

Path lines and streak lines are flow patterns that have a history associated with them

Streak lines instaneous snapshot of a time integrated flow pattern

Path lines is time exposed flow path of an individual

Flowrate

This is the volume which passed per unit time

The symbol is Q

Kinematic description

In fluid mechanics an element may underground four fundamental types of motion

- Translation
- Rotation
- Linear strain
- Shear strain

Velocity -rate of translation

Angular velocity-rate of rotation

Linear strain rate-rate of linear strain

Shear strain rate-rate of shear strain

Translation and Rotation

Expressed in terms of velocity and derivate of velocity

The rate of translation vector is described as velocity vector

Rate of rotation

A point defined as the average rotation rate of two perpendicular lines that intersect at that point

Linear strain rate

Rate of increase in length per unit length

Volumetric strain rate should be zero

Shear strain rate

Half of the rate of decrease of thr angle between two initially perpendicular lines that intersects

Vorticity and Rationality

Is defined as the curl of the velocity vector

Vorticity is equal to twice the angular velocity of a fluid particle

Reynolds Transport Theorem

Is system is a region in space chosen in study .