

Handout-3

Review of Fluid Mechanics Terminology

Aerodynamics: Aerodynamics is the study of the flow of gases.

Aerodynamics: The dynamics of bodies moving relative to gases, especially the interaction of moving objects with the atmosphere. Because the principal application of aerodynamics is the design of airplanes, air is the principal gas with which this science is concerned. Bernoulli's principle, which states that the pressure of a moving gas decreases as its velocity increases, has been used to explain the lift produced by a wing having a curved upper surface and a flat lower surface. Because the flow is faster across the curved surface than across the flat one, a greater pressure is exerted in the upward direction. Aerodynamics is also concerned with the drag caused by air friction, which is reduced by making the surface area of the craft as small as possible. At speeds close to the speed of sound, or Mach 1, there is also a large, sudden increase of drag, which has been called the sonic, or sound, barrier. Aerodynamics is also used in designing automobile bodies and trains for minimum drag and in computing wind stresses on bridges, buildings, and the like. The wind tunnel is one of the basic experimental tools of the aerodynamicist.

Aeronautics: Aeronautics is the mathematics and mechanics of flying objects, in particular airplanes.

Aeronautics: The design and construction of aircraft. The theory and practice of aircraft navigation.

Aerothermodynamics: The study of the thermodynamics of gases, especially at high relative velocities.

Bernoulli's equation: A statement of the conservation of energy in a form useful for solving problems involving fluids. For a non-viscous, incompressible fluid in steady flow, the sum of pressure, potential and kinetic energies per unit volume is constant at any point.

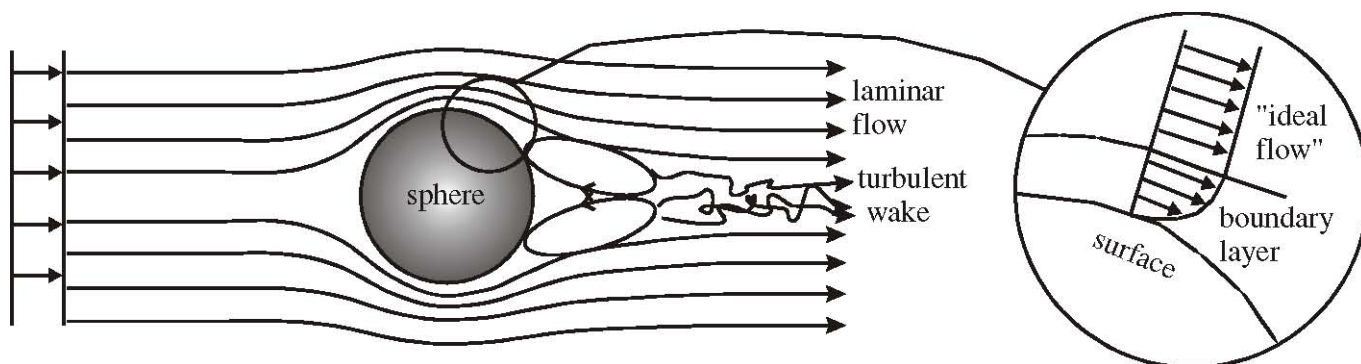
Boundary layer: The boundary layer is the layer of fluid in the immediate vicinity of a bounding surface.

Compressible Flow: Flow in which the fluid density varies appreciably with position or time, as is the case for many gas flows.

Drag (force): Drag is an aerodynamic force opposing the direction of motion. Drag can be due to surface viscosity (friction drag), pressure differences due to the shape of an object (form drag), lift acting on an finite wing (induced drag) and other energy loss mechanisms in the flow such as wave drag due to shock waves and inefficiencies in engines.

Euler equations: In fluid dynamics, the Euler equations govern the motion of a compressible, inviscid fluid. They correspond to the Navier-Stokes equations with zero viscosity.

External Flow: Flow around objects. An example is illustrated below.



Fluid: a substance that will deform continuously in response to a shear stress no matter how small the stress may be.

Hydraulics: Branch of engineering that studies the mechanical properties of fluids.

Hydraulics: Hydraulics is a branch of science and engineering concerned with the use of liquids to perform mechanical tasks.

Hydrostatics: Deals with the characteristics of fluids at rest, particularly with the pressure exerted by a fluid on an immersed body. Examples: dams, underwater gates, tunnels, etc..

Hydrokinetics: The study of liquids in motion, is concerned with such matters as friction and turbulence generated in pipes by flowing liquids and the use of hydraulic pressure in machinery.

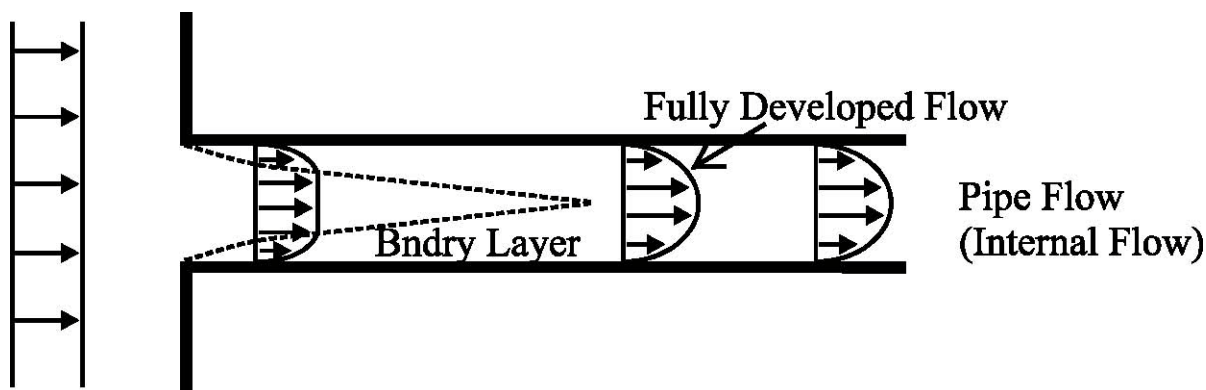
Hydrodynamics: Deals with the motion of fluids (especially, incompressible fluids), and the forces acting on solid bodies immersed in such fluids and in motion relative to them. Examples: ships, submarines, torpedoes, etc..

Hydrodynamics : Hydrodynamics is the fluid dynamics applied to liquids, such as water, alcohol, and oil.

Ideal Flow: A flow in which the dissipation of mechanical energy to heat (internal energy) is zero. Ideal flow is a good approximation for many real flows in which the dissipation of mechanical energy is low.

Incompressible Flow: Flow in which the fluid density is constant. Incompressibility is often a good approximation for liquid flows.

Internal Flow: Flow in conduits and channels, for example in a pipe or in a river bed. In internal flow, the fluid is confined by walls. An example is illustrated below.



Laminar Flow: Flow that occurs in laminas (layers). In qualitative terms, the flow is smooth and not chaotic. Laminar flow can be steady or dynamic (changing with time). In laminar flow, the path lines are layered.

Laplace's equation: Describes the behavior of gravitational, electric, and fluid potentials.

Lift (force): Lift consists of the sum of all the aerodynamic forces normal to the direction of the external airflow.

Mach number: When an object travels through a medium, then its Mach number is the ratio of the object's speed to the speed of sound in that medium.

Navier-Stokes Equations: The motion of a non-turbulent, Newtonian fluid is governed by the Navier-Stokes equation. The equation can be used to model turbulent flow, where the fluid parameters are interpreted as time-averaged values.

Newtonian Fluid: A fluid is Newtonian if viscosity is constant applied to shear force.

Non-Newtonian fluid: Non-Newtonian fluid viscosity changes with the applied shear force.

Normal Stress: Force per unit area that is exerted normal to the surface on which it acts.

Pressure is a normal stress.

Pressure: The pressure in a fluid is defined as *"the normal force per unit area exerted on a imaginary or real plane surface in a fluid or a gas"*

The equation for pressure can expressed as: $p = F / A$

Reynolds Number: The Reynolds Number, the non-dimensional velocity, is defined by the ratio of dynamic pressure (ρu^2) and shearing stress ($\mu u / L$)

- The Reynolds number is used for determine whether a flow is laminar or turbulent.

Shear Stress: Force per unit area that is exerted parallel to the surface on which it acts.

Shock wave: A shock wave is a strong pressure wave produced by explosions or other phenomena that create violent changes in pressure.

Steady Flow: A steady flow is one for which all time derivatives are zero. In other words, $\partial \mathbf{v} / \partial t = 0$, $\partial p / \partial t = 0$, $\partial \rho / \partial t = 0$ etc. Steady flow *does not* mean that acceleration of the fluid is zero, it only means that the conditions at a given point in space do not change with time.

Streamline: A streamline is the path that an imaginary particle would follow if it was embedded in the flow.

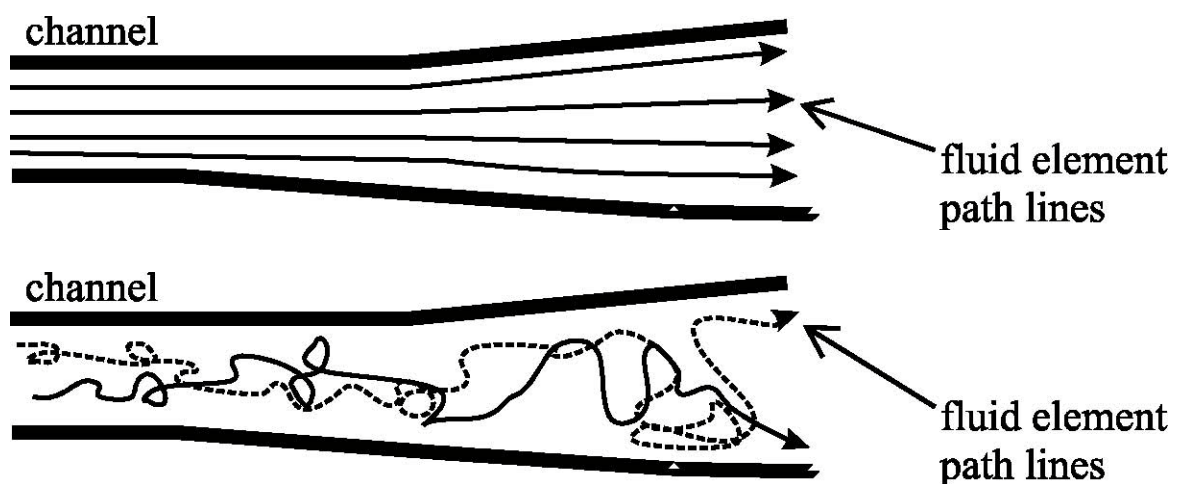
Supersonic Flow: Flow with speed above the speed of sound, $1,225 \text{ km/h}$ at sea level, is said to be supersonic.

Subsonic/supersonic flow: Flow in which the fluid velocity remains below the speed of sound (subsonic), or one in which the speed of sound is exceeded (supersonic).

Surface tension: Surface tension is a force within the surface layer of a liquid that causes the layer to behave as an elastic sheet.

Transonic Flow: Flow with speed at velocities just below and above the speed of sound is said to be transonic.

Turbulent Flow: A flow that is characterized by the presence of apparently random velocity fluctuations. Turbulent flow is chaotic, and can only be dynamic since the velocity at a point fluctuates, and therefore changes, with time. In other words, if you observe the velocity at a point \mathbf{r} as a function of time, you would see it change continuously in an apparently unpredictable manner.



Venturi: A Venturi is a system for speeding the flow of the fluid, by constricting it in a cone-shaped tube.

Viscosity: Viscosity (μ) is a fluid property that measures the fluid's resistance to shear stress.

For a "Newtonian fluid", viscosity is a proportionality constant between shear stress and the velocity gradient, as in the following expression: $\tau_{yx} = \mu (du/dy)$

Vorticity: Vorticity is defined as the circulation per unit area at a point in the flow field.

Classification of Fluid Motions

