FLUIDS

Streamline flow	Turbulent flow
1) The smooth flow of a fluid, with velocity smaller than certain critical velocity (limiting value of velocity) is called streamline flow or laminar flow of a fluid.	1) The irregular and unsteady flow of a fluid when its velocity increases beyond critical velocity is called turbulent flow.
2) In a streamline flow, velocity of a fluid at a given point is always constant.	2) In a turbulent flow, the velocity of a fluid at any point does not remain constant.
3) Two streamlines can never intersect, i.e., they are always parallel.	3) In a turbulent flow, at some points, the fluid may have rotational motion which gives rise to eddies.
4) Streamline flow over a plane surface can be assumed to be divided into a number of plane layers. In a flow of liquid through a pipe of uniform cross sectional area, all the streamlines will be parallel to the axis of the tube.	4) A flow tube loses its order and particles move in random direction.

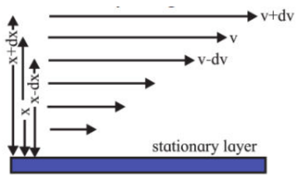
Critical Velocity and Reynolds Number:

$R_n = \frac{V_c \rho d}{\eta}$ where R_n = Reynolds number, V_c=critical velocity, η=coefficient of viscousity, ρ=density of fluid, d=diameter of tube

$R_n < 1000$, streamline flow
$R_n > 2000$, turbulent fluid
$1000 < R_n < 2000$, transition phase

Viscosity:
Viscousity is the property by virtue of which, the relative motion between different layers of the fluid experience a dragging force
In liquids drag is due to molecular cohesion and in gasses its due to collisions
In streamlline flow, Viscous drag is proportional to relative velocity.
According to Newtons law of viscosity,

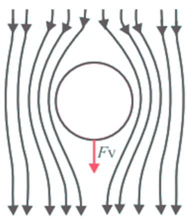
$$f \alpha A \frac{dv}{dx}$$
$$f = \eta A \frac{dv}{dx}$$



Where f= viscous force, A= area of the layer, dv/dx = velocity gradiet
η=coefficient of viscosity and is defined as viscous force per unit area per unit velocity gradient. S.I. Unit Ns/m²

Note: Fluid with no drag => where every layer is moving with same velocity e.g.liquid helium at 2K

Stokes Law:
The viscous force Fv acting on a small *sphere* falling through a viscous medium is directly proportional to the radius of the sphere (r), its relative velocity(v) through the fluid, and the coefficient of viscosity(η) of the fluid



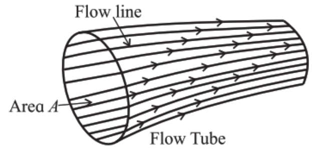
$$F_v \; \alpha \; \eta r v$$
$$F_v = 6\pi \eta r v$$

Terminal Velocity:
Consider a spherical body falling through a viscous fluid. The forces acting on it are
$mg = V.\rho_s.g = 4/3 \pi r^3 \rho_s g$ = its weight (downward)
$U = V.\rho_L.g = 4/3 \pi r^3 \rho_L g$ = upthrust (upwards)
F_v= viscous force (upwards) = 6πηrv
Net downward force = mg – U – Fv
till the net force exists velocity in downward direction keeps increasing and hence F_v keeps increasing. There will be a moment when net force =0 and then the body will sink with a constant velocity (Since net force=0). This contant velocity is called terminal velocity.
Then, $U + F_v = mg$

$$\frac{4}{3}\pi r^3 \rho_L g + 6\pi\eta r v = \frac{4}{3}\pi r^3 \rho_s g$$

$$Thus, v = \frac{2}{9}\frac{r^2 g(\rho_S - \rho_L)}{\eta}$$

Some terms:



Steady Flow : Measurable property like pressure or veelocity of a fluid at a given point is constant over time.

Flow Line : Path of an individual particle in a moving fluid

StreamLine : A curve whose tangent at any point in the flow is in the direction of the velocity of the flow at that point. Streamlines and flow lines are identical for a steady flow.

Flow tube : It is an imaginary bundle of flow lines bound by an imaginary wall. For steay flow, the fluid cannot cross the walls of a flow tube. Fluids in adjacent flow tubes cannot mix.

Laminar Flow or Streamline Flow : It is a steady flow in which adjacent layers of a fluid move smoothly over each other.(Reynolds Number< 1000)

Turbulent flow : It is a flow at a very high flow rate. There is not steady flow and the flow pattern keeps changing.(Reynolds Number > 2000)