4.2. Resistance in a Mechanical Fluid

Drag - the force that opposes motion when a solid moves through a fluid.

ex. boat moving through water
airplane flying through the air

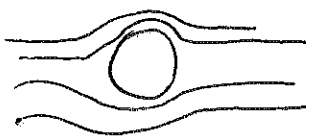
Drag only occurs when there is relative movement between an object and fluid.

Drag exerted depends on:

- speed of the object or fluid
- size/shape of the object
- physical properties of the fluid

Fluid flow can be described in two ways:

1. Laminar (streamlined): is a slow, smooth flow over a surface - path of individual particles do not cross



- Each path is called a streamline
- speed at the surface is zero
- speed increases as you move away from the surface

moving in layers which means laminates

- drag is produced by the friction between successive layers – frictional drag

2. Turbulent Flow - is irregular flow which whorls causing fluid to move in different directions.
   - Turbulence is produced by high speeds
     - shapes are not streamlined
     - sharp bends in the fluid

$W = -V\Delta P$ pressure in the wake is less than the fluid pressure in streamlined flow

a Force acts opposite the objects relative velocity ~ pressure drag

frictional drag increases linearly with speed.

pressure drag increase with the square of the speed (v^2)

Viscosity - the property which ~~causes~~ describes the internal friction within a fluid

η (eta) - greek letter which represents viscosity

$$\eta = \frac{F \Delta y}{A v}$$ Δy = thickness of fluid

$$F = F_{drag} = \eta \frac{A v}{\Delta y}$$

units $\eta \rightarrow$

SI	Eng
$\frac{N}{m^2} \cdot s$	$\frac{lb}{ft^2} \cdot s$ or $\frac{lb}{in^2} \cdot s$

Viscosity is similar to coefficient of friction from 4.1 ~ it is different for different liquids ~ see Table 4.2 pg. 188

Viscosity of most liquids decreases with temperature.

Viscosity of most gases increase with temperature

Stoke's Law

$$F_{drag} = 6\pi r v \eta$$

applies to a sphere moving through a fluid

Terminal Speed - the constant speed that occurs when the drag force equals gravitational force in falling objects.

Poiseuille's Law

$$\dot{V} = -\frac{\pi r^4}{8}\frac{\Delta P}{\eta L}$$

$$L = -\frac{\pi}{8} r^4 \frac{\Delta P}{\eta \dot{V}}$$

Example 4.6 pg 192

Fluid resistance decreases as pipe radius and cross sectional area increase.