Resistance – opposition to force

Friction – force that opposes motion

Static Friction – the force required to start relative motion between two surfaces in contact

Kinetic Friction – the force required to maintain a constant speed between two surfaces in contact

Coefficient of Friction – the ratio of the maximum force (static or kinetic) of friction to the normal force between the surfaces in contact

Lubrication – reduces friction

Drag – the force that opposes motion when a solid object moves through a fluid or when fluid flows past an object Drag increases with speed

Streamline / Laminar flow – slow smooth flow of a fluid over a surface, in which the paths of the fluid do not cross

Turbulence / turbulent flow – irregular flow of a fluid over a surface, with eddies and whorls causing fluid to move in different directions

Fluid resistance (define with words) – a measure of the ability of an object to oppose the flow of fluid across the object's surface. Ratio of pressure drop to the volume flow rate

Fluid resistance formula $R = \frac{-\Delta P}{\dot{V}}$

Solve the formula using units

$$R = \frac{Pa}{ft^3/s} \qquad \boxed{R = \frac{Pa \cdot s}{m^3}}$$

Newton's Second Law - The acceleration of an object is directly proportional to the net force acting on the object and inversely proportional to the mass of the object

$$F = ma$$

gravitational acceleration - when gravity is the only force acting on the object and it accelerates in the direction of the force

$g = 9.8\ m/s^2$ $g = 32.2\ ft/s^2$

Normal force - force exerted by two surfaces being pressed together (normally the weight of the object) acts perpendicular to the surfaces

Stokes Law - the relationship between the drag force and speed for a speed for a small sphere moving through a viscous fluid.

frictional drag - drag produced between successive layers of fluid

terminal speed - the constant speed achieved by a falling object when the downward force of gravity equals the upward drag force

Viscosity – property of a fluid that describes the internal friction or opposition to relative motion within the fluid

Pressure drop

1. What is the difference between "streamline" and "laminar" flow?

2. What is the formula for Drag Resistance?

3. Re-arrange the equation to solve for the other 2 variables.

4. Water flows through a 10 foot pipe at a flow rate of 0.75 m^3/sec. It undergoes a pressure drop of 150 N/m^2. Find the resistance of the pipe.

$\frac{Kg \cdot m}{s^2 \cdot m^2} \times \frac{sec}{m^3}$ $\quad R = \frac{-\Delta P}{\dot{V}} = \frac{150 \frac{N}{m^2}}{0.75\ m^3/sec} = 200 \frac{Pa \cdot s}{m^3}$

5. The resistance in a fuel-transfer pipeline is 3 (lb/in^2) / (gal/min). The line is 6.75 inches in diameter. Fuel moves through the line at a volume flow rate of 650 gal/min. Find the pressure difference along the length of the pipeline.

$3 = \frac{-\Delta P}{650} = 1950 \frac{lb}{in^2}$

viscosity - property of a fluid that describes the internal friction or opposition to relative motion within the fluid

Poiseuille's law for a fluid in Laminar flow through a tube or pipe, the relationship between volume flow rate, pipe radius, Pressure drop, and length of pipe

Problem Solving

1. What is the difference between "streamline" and "turbulent" flow?

Streamline flow is smooth, slow flow
turbulent is irregular flow with whorls

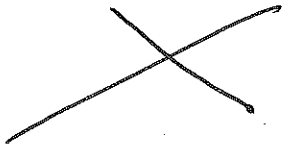
2. What is the formula for Drag Resistance?

$F = ma$ $F = \eta \frac{Av}{\Delta y}$ $F = 6\pi r v \eta$

3. Re-arrange the equation to solve for the other 2 variables.

$m = \frac{F}{a}$ $a = \frac{F}{m}$

4. A drag force of 15,000 lbs. is experienced by an airplane moving through the atmosphere at 250 miles per hour. What is the drag resistance on the airplane?



5. A steel drum which weighs 347.6 pounds is sitting on a steel floor.

a. Calculate the force needed to get it moving.

$F = \mu_s N$ $F = (.78)(347.6) = 271.13\ N$

b. Calculate the force needed to keep it moving.

$F = \mu_k N$ $F = (.58)(347.6) = 201.61\ N$

c. Calculate the force needed to move it if metal rollers are placed between the drum and the floor.