Fluids

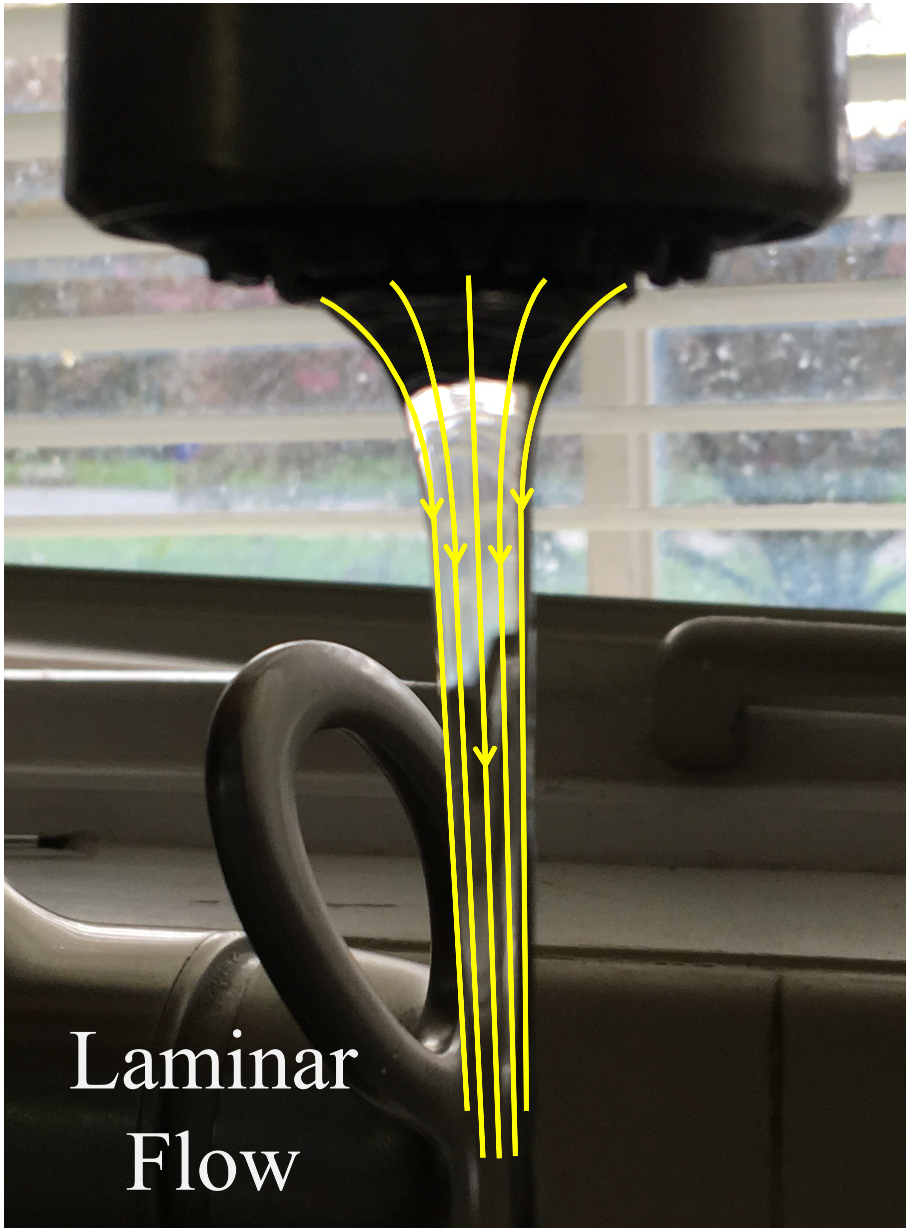
I. Statics
- density, specific gravity
- pressure, Pascal's principle
- buoyancy, Archimedes principle

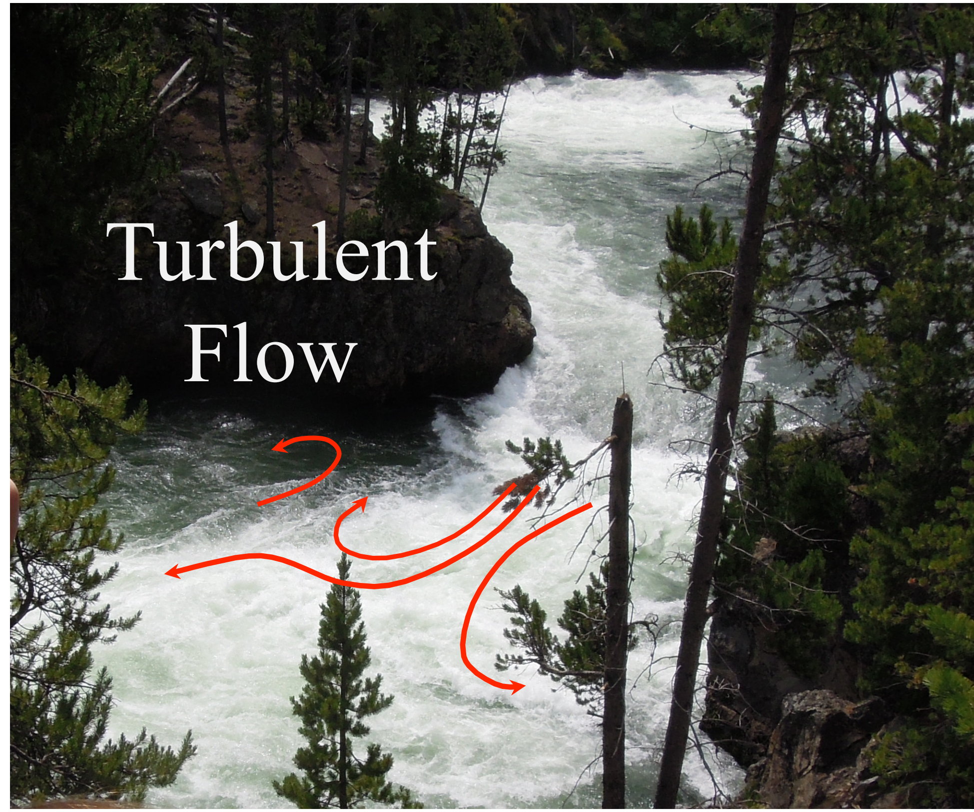
II. Dynamics
- laminar and turbulent flow
- flow rate and continuity
- Bernoulli's principle and equation

	The student will be able to:	HW:
1	Define and apply concepts of density, specific gravity, and pressure and solve related problems.	✓ 1 – 6
2	Define, distinguish, and apply concepts of absolute, atmospheric, and guage pressure and solve related problems including application of Pascal's principle and relationship with depth, density, and gravitational field.	✓ 7 – 14
3	Define and apply Archimedes principle and the concept of buoyancy and solve related problems.	✓ 15 – 19
4	Define and apply the concept of continuity of flow and conservation of matter and solve related problems.	20 – 21
5	State and apply Bernoulli's principle and equation and the conservation of energy and solve related problems.	22 – 29

Fluid Dynamics

- The flow of fluids and interactions with objects within a flow of fluid can be very complex.
- Flows that are smooth and regular with parallel "streamlines" (paths of motion) are said to be laminar and are easiest to model.
- Many flows involve chaotic whorls, eddies, vortices, etc. – difficult to predict and analyze. These types of flows are said to be turbulent and are very challenging to model.

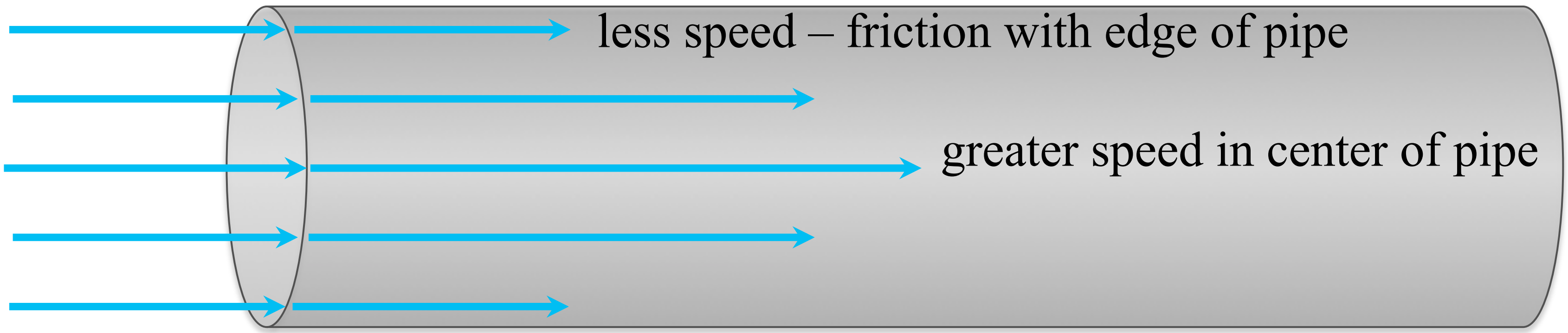




Streamlines are drawn tangent to velocity of particles at all points.

Viscosity

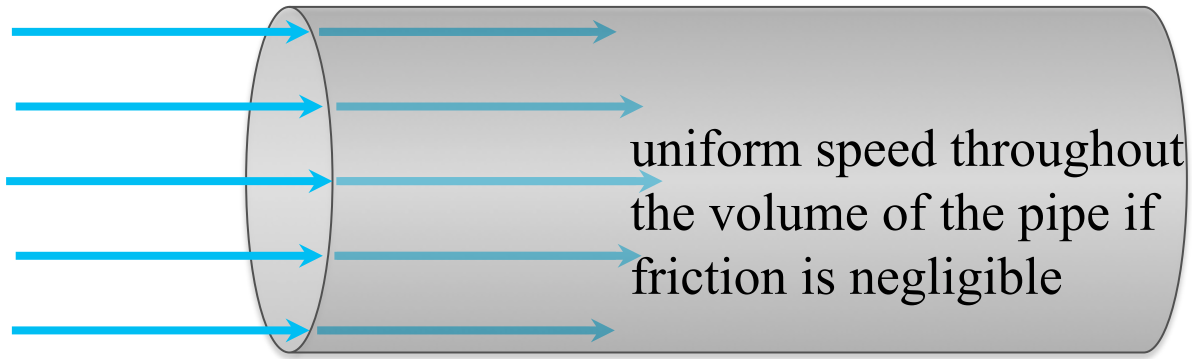
All fluids exhibit some degree of viscosity – a type of friction opposing relative flow along streamlines.



Adjoining "layers" of a laminar flow can move at different rates depending on viscosity. The layers interact, exerting forces on one another parallel to the direction of flow. Honey is 1.4 times greater density than water, but 10,000 times greater viscosity!

Negligible Viscosity

Some fluids, such as water and air, flow readily and the viscosity is small enough that it is often ignored.

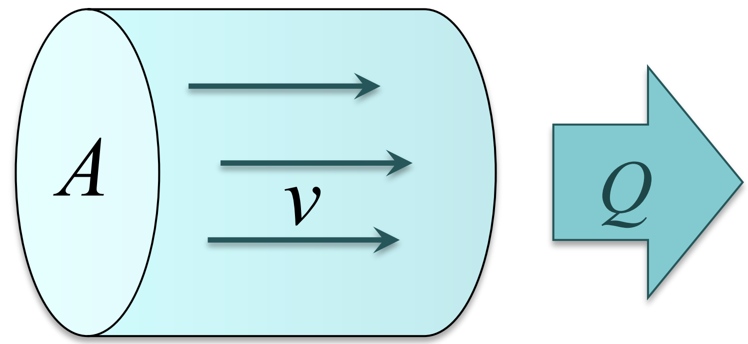


An ideal fluid with no viscosity would "slide" with no friction past the walls of the pipe such that the velocity of particles would be uniform throughout.

Flow Rate and Continuity

For a fluid with negligible viscosity, the volume flow rate is related to speed and area by:

$$Q = \frac{V}{t} = Av$$



where: Q = volume flow per unit time

V = volume

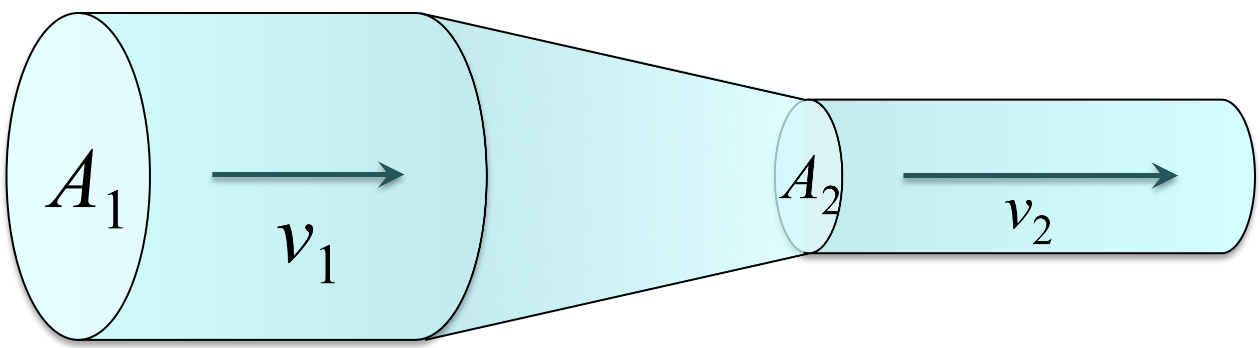
t = time

A = cross sectional area

v = speed

Flow Rate and Continuity

A flow constrained to differing channels or pipework will undergo change in velocity governed by the cross sectional area:



$$A_1 v_1 = A_2 v_2$$

This is a requirement for the conservation of matter! The flow is continuous – it has continuity.

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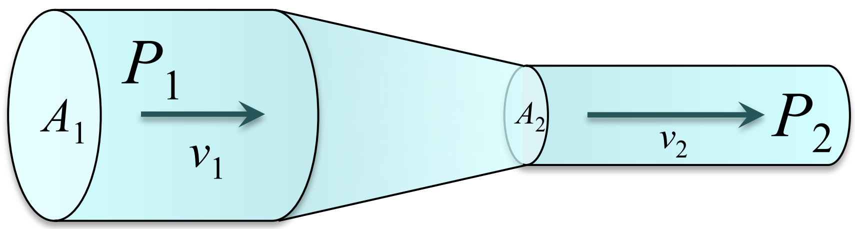
Bernoulli's Principle

- In flows that exhibit differences in the speed of particles it is found that pressure is greater where speed is slower and pressure is less where speed is faster. This is Bernoulli's Principle.



$$v_1 < v_2$$

$$P_1 > P_2$$

- This seems weird! But, consider the pipe shown where v_1 is less than v_2. What would happen to the direction of the flow if the pressure P_1 were also less? What about basic physics $F = ma$?

Bernoulli's Equation

A fluid flow between two locations can be analyzed by comparing relative energy and assuming no loss due to viscosity:

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g h_2$$

where: P = pressure

ρ = density of fluid

v = speed

g = gravitational field strength

h = vertical height