Class 25
Fluid Flow
Announcements

• Extra reading: Sections 9.7 through 9.9
• In particular:
  – Continuity equation
  – Bernoulli’s equation
  – Viscosity
  – Poiseuille’s law
• Read 10.1-10.3, I won’t talk much about it
Concepts overview

1. Fluid flow
   1. Continuity equation
   2. Bernoulli’s equation
Problem Solving Overview
Buoyancy

• When is it relevant?:
  – When an object is immersed in a fluid

• Archimedes principle:
  Bouyant force is ALWAYS equal to the weight of the fluid displaced
A lead weight is fastened on top of a large solid piece of Styrofoam that floats in a container of water. Because of the weight of the lead, the water line is flush with the top surface of the Styrofoam. If the piece of Styrofoam is turned upside down so that the weight is now suspended underneath it,

1. the arrangement sinks.
2. the water line is below the top surface of the Styrofoam.
3. the water line is still flush with the top surface of the Styrofoam.
A lead weight is fastened to a large solid piece of Styrofoam that floats in a container of water. Because of the weight of the lead, the water line is flush with the top surface of the Styrofoam. If the piece of Styrofoam is turned upside down, so that the weight is now suspended underneath it, the water level in the container

1. rises.
2. drops.
3. remains the same.
A boat carrying a large boulder is floating on a lake. The boulder is thrown overboard and sinks. The water level in the lake (with respect to the shore)

1. rises.
2. drops.
3. remains the same.
Fluid Flow

Concept of Continuity:

- **What goes in, must come out** (in the absence of accumulation or a leak)
- For a volume $\Delta V$ of fluid to flow into a pipe, a volume $\Delta V$ of fluid must flow out the other end in the same amount of time
- Trick: $\Delta V/\Delta t = Av$ ($A$ is area, $v$ is fluid velocity)
- Hence: $A_1v_1 = A_2v_2$
- **Physics: You know it makes sense!**
Consequences:

• If the cross-sectional area of a pipe/river/blood vessel/... decreases (A goes down) the speed of the fluid goes up!

• It also works for traffic on a highway and students rushing to get into class (because they love their physics so much)
Blood flows through a coronary artery that is partially blocked by deposits along the artery wall. Through which part of the artery is the flux (volume of blood per unit time) largest?

1. The narrow part.
2. The wide part.
3. The flux is the same in both parts.
Blood flows through a coronary artery that is partially blocked by deposits along the artery wall. Through which part of the artery is the flow speed largest?

1. The narrow part.
2. The wide part.
3. The flow speed is the same in both parts.
Two hoses, one of 20-mm diameter, the other of 15-mm diameter are connected one behind the other to a faucet. At the open end of the hose, the flow of water measures 10 liters per minute. Through which pipe does the water flow faster?

1. the 20-mm hose
2. the 15-mm hose
3. The flow rate is the same in both cases.
4. The answer depends on which of the two hoses comes first in the flow.
A blood platelet drifts along with the flow of blood through an artery that is partially blocked by deposits. As the platelet moves from the narrow region to the wider region, its speed

1. increases.
2. remains the same.
3. decreases.
Bernoulli’s equation

• Relationship between speed of fluid flow and pressure
  – Useful to go through the definition (see the book)
  – Eqn: \( P + \frac{1}{2} \rho v^2 + \rho gy = \text{constant} \)
Notes about Bernoulli’s equation

• Use this when you want to relate a pressure to a fluid velocity

• When \( v = 0 \), reduces to
  \[ \Delta P = \rho gy = \rho gh \]

• When \( h \) is not involved,
  \[ \Delta P = P_2 - P_1 = -\frac{1}{2} \rho (v_2^2 - v_1^2) \]
  – Note the minus sign, pressure is lower when fluid is moving faster
  – E.g. airplane flight and aneurism
A blood platelet drifts along with the flow of blood through an artery that is partially blocked by deposits. As the platelet moves from the narrow region to the wider region, it experiences

1. an increase in pressure.
2. no change in pressure.
3. a decrease in pressure.
Problem solving

• Peeing water tank