"For every minute you are angry, you lose 60 seconds of happiness." – Ralph Waldo Emerson

"Holding on to anger is like grasping a hot coal with the intent of throwing it at someone else; you are the one who gets burned." – Buddha

"Consider how much more often you suffer from your anger and grief than from those very things for which you are angry and grieved." – Marcus Aurelius

Reading: pages 281 – 307 (skip section 11.11)

Outline:

⇒ mass density
⇒ pressure
  definition
  atmospheric pressure
  nothing in physics sucks!
⇒ pressure variations with depth in a fluid
  barometer
⇒ Pascal’s principle (read on your own)
⇒ Archimedes’ principle
  buoyant force
⇒ fluids in motion
  ideal fluid (PowerPoint)
  equation of continuity
  Bernoulli’s principle
  applications of Bernoulli’s principle

Problem Solving

Some problems require you to know the definitions of pressure and density. Remember that if the pressure is uniform and the surface is a plane, then \( P = F/A \). If there are several surfaces, you may need to sum the forces vectorially to obtain the net force. Remember that each force is perpendicular to the surface on which it acts. In some cases, you may need to use Newton's second law to find the force.

To calculate the variation of pressure with depth in a static incompressible fluid, use
\[
P_2 = P_1 + \rho gh,
\]
where \( P_2 \) is the pressure at depth \( h \), \( P_1 \) is the pressure at the top of the fluid, and \( \rho \) is the density of the fluid.
Two fundamental Archimedes' principle problems involve finding the buoyant force on an object, either floating or completely submerged in an incompressible fluid, and deciding if an object floats or sinks. These and many other Archimedes' law problems start with the equations

\[ F_g = mg = (\rho g)V \]

for the force of gravity and

\[ F_b = \rho_f g V_s \]

for the buoyancy, where \( \rho \) is the density of the object, \( \rho_f \) is the density of the fluid in which it is wholly or partially immersed, \( V \) is the volume of the object, and \( V_s \) is the submerged volume. If the object is floating with no other forces acting, then \( \rho V = \rho_f V_s \).

For a fluid in motion, you should be able to relate the volume and mass flow rates to the dimensions of a tube of flow and to the fluid velocity. The volume flow rate gives the volume of fluid that passes a cross section per unit time and is given by \( Av \), where \( A \) is the cross-sectional area of the tube and \( v \) is the fluid speed. The mass flow rate is the mass of fluid that passes a cross section per unit time and is given by \( \rho Av \), where \( \rho \) is the fluid density. Notice that the mass flow rate is the product of the density and the volume flow rate.

For steady flow in a single tube of flow, the mass flow rate is the same in all parts of the tube. If the fluid is incompressible, the volume flow rate is also the same in all parts. If two tubes merge, the sum of the two mass flow rates in the merging tubes must equal to the mass flow rate in the final tube. If the fluid is incompressible, the same statement is true for the volume flow rates.

Bernoulli's equation is used to solve some problems. It relates conditions (density, fluid speed, pressure, and height above Earth) at one point in the steady flow of a nonviscous, incompressible fluid to conditions at another point. If you are given all but one of these quantities you can use Bernoulli's equation to solve for the unknown quantity.

Questions and Example Problems from Chapter 11

**Question 1**
A closed tank is completely filled with water. A valve is then opened at the bottom of the tank and water begins to flow out. When the water stops flowing, will the tank be completely empty, or will there still be a noticeable amount of water in it? Explain your answer.

**Question 2**
A steel beam is suspended completely under water by a cable that is attached to one end of the beam, so it hangs vertically. Another identical beam is also suspended completely under water, but by a cable that is attached to the beam so it hangs horizontally. Which beam, if either, experiences the greater buoyant force? Provide a reason for your answer. Neglect any change in water density with depth.
**Problem 1**
A pirate in a movie is carrying a chest (0.30 m \(\times\) 0.30 m \(\times\) 0.20 m) that is supposed to be filled with gold. To see how ridiculous this is, determine the weight (in newtons) of the gold. To judge how large this weight is, remember that 1 N = 0.225 lb.

**Problem 2**
An airtight box has a removable lid of area 1.3 \(\times\) 10\(^{-2}\) m\(^2\) and negligible weight. The box is taken up a mountain where the air pressure outside the box is 0.85 \(\times\) 10\(^5\) Pa. The inside of the box is completely evacuated. What is the magnitude of the force required to pull the lid off the box?

**Problem 3**
High-heeled shoes can cause tremendous pressure to be applied to a floor. Suppose that the radius of a heel is 6.00 \(\times\) 10\(^{-3}\) m. At times during a normal walking motion, nearly the entire body weight acts perpendicular to the surface of the heel. Find the pressure that is applied to the floor under the heel because of the weight of a 50.0 kg woman.
Problem 4
At a depth of 10.9 km, the Challenger Deep in the Marianas Trench of the Pacific Ocean is the deepest site in any ocean. Yet, in 1960, Donald Walsh and Jacques Piccard reached the Challenger Deep in the bathyscaphe Triete. Assuming that seawater has a uniform density of 1024 kg/m³, calculate the force the water would exert at a depth of 10.9 km on a round observation window of diameter 25 cm.

Problem 5
At a given instant, the blood pressure in the heart is $1.6 \times 10^4$ Pa. If an artery in the brain is 0.45 m above the heart, what is the pressure in the artery? Ignore any pressure changes due to blood flow.
Problem 6
A solid block is attached to a spring scale. When the block is suspended in air the scale reads 20.0 N; when it is completely immersed in water the scale reads 17.7 N. What is the (a) volume and (b) density of the block?

Problem 7
Only a small part of an iceberg protrudes above the water, while the bulk lies below the surface. The density of ice is 917 kg/m$^3$ and that of seawater is 1025 kg/m$^3$. Find the percentage of the iceberg’s volume that lies below the surface.
Problem 8
A water line with an internal radius of $6.5 \times 10^{-3}$ m is connected to a shower head that has 12 holes. The speed of the water in the line is 1.2 m/s. (a) What is the volume flow rate in the line? (b) At what speed does the water leave one of the holes (effective hole radius $= 4.6 \times 10^{-4}$ m) in the head?

Problem 9
Water flows through a pipe of radius 8.0 cm with a speed of 10.0 m/s. It then enters a smaller pipe of radius 3.0 cm. What is the speed of the water as it flows through the smaller pipe? Assume that the water is incompressible.
Problem 10
An airplane has an effective wing surface area of 16 m$^2$ that is generating the lift force. In level flight the air speed over the top of the wings is 62.0 m/s, while the air speed beneath the wings is 54.0 m/s. What is the weight of the plane?

Problem 11
Suppose that a 15 m/s wind is blowing across the roof of your house. The density of air is 1.29 kg/m$^3$. (a) Determine the reduction in pressure (below atmospheric pressure of stationary air) that accompanies this wind. (b) Explain why some roofs are “blown outward” during high winds.