10-1 Phases of Matter
The three common phases of matter are solid, liquid, and gas.
A solid has a definite shape and size.
A liquid has a fixed volume but can be any shape.
A gas can be any shape and also can be easily compressed.
Liquids and gases both flow, and are called fluids.

10-2 Density and Specific Gravity
The density $\rho$ of an object is its mass per unit volume:
$$\rho = \frac{m}{V} \quad (10-1)$$
The SI unit for density is $\text{kg/m}^3$. Density is also sometimes given in $\text{g/cm}^3$.
Water at $4^\circ C$ has a density of $1 \text{ g/cm}^3 = 1000 \text{ kg/m}^3$.

The specific gravity of a substance is the ratio of its density to that of water.

Which has a greater density?
- a cupful of water or a lakeful of water
- a kilogram of lead or a kilogram of feathers
- a single uranium atom or the world

Ch 10: Problem 2
- What is the approximate mass of air in a living room $4.8 \text{m} \times 3.8 \text{m} \times 2.8 \text{m}$?
  (Use Table 10-1 on pg. 256)

Ch 10: Problem 5
- A bottle has mass of 35.00 g when empty and 98.44 g when filled with water. When filled with another fluid, the mass is 88.78 g. What is the specific gravity of this other fluid?
Pressure in Fluids

- Pressure
  - force per unit area
  - a scalar
  - SI units are pascals:
    - $1 \text{ Pa} = 1 \text{ N/m}^2$

Pressure is the same in every direction in a fluid at a given depth; if it were not, the fluid would flow.

Which would you prefer?

- A 1-N force applied with an open, flat hand or a pin?
- A 400-N lady standing on your back with bare feet or high heels?
- Lying on a bed of 1000 nails or 1 nail?

Pressure in Fluids

Also for a fluid at rest, there is no component of force parallel to any solid surface – once again, if there were the fluid would flow.

The pressure at a depth $h$ below the surface of the liquid is due to the weight of the liquid above it.

\[ P = \rho gh \]  

Valid for any liquid whose density does not change with depth.

Pressure-depth Demo

- When blood pressure is measured, why must the jacket be held at the level of the heart?
10-4 Atmospheric Pressure and Gauge Pressure

At sea level the atmospheric pressure is about \( 1.013 \times 10^5 \text{ N/m}^2 \); this is called one atmosphere (atm).

Another unit of pressure is the bar:

\[ 1 \text{ bar} = 1.00 \times 10^5 \text{ N/m}^2 \]

Standard atmospheric pressure is just over 1 bar.

This pressure does not crush us, as our cells maintain an internal pressure that balances it.

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Ear pressure

• Depends on depth only
  – 3 meters below surface of pool vs. 3 meters below surface of lake
• Would pressure be greater swimming 3 m deep in the middle of the ocean or in a lake?

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Ch 10: Problem 12

• The gauge pressure in each of the four tires of an automobile is 240 kPa. If each tire has a footprint of 220 cm\(^2\), estimate the mass of the car.

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10-4 Atmospheric Pressure and Gauge Pressure

Most pressure gauges measure the pressure above the atmospheric pressure – this is called the gauge pressure.

The absolute pressure is the sum of the atmospheric pressure and the gauge pressure.

\[ P = P_A + P_{gauge} \]

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10-5 Pascal’s Principle

If an external pressure is applied to a confined fluid, the pressure at every point within the fluid increases by that amount.

This principle is used, for example, in hydraulic lifts and hydraulic brakes.

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10-6 Measurement of Pressure; Gauges and the Barometer

There are a number of different types of pressure gauges. This one is an open-tube manometer. The pressure in the open end is atmospheric pressure; the pressure being measured will cause the fluid to rise until the pressures on both sides at the same height are equal.
10-6 Measurement of Pressure; Gauges and the Barometer

Here are two more devices for measuring pressure: the aneroid gauge and the tire pressure gauge.

10-6 Measurement of Pressure; Gauges and the Barometer

This is a mercury barometer, developed by Torricelli to measure atmospheric pressure. The height of the column of mercury is such that the pressure in the tube at the surface level is 1 atm. Therefore, pressure is often quoted in millimeters (or inches) of mercury.

10-6 Measurement of Pressure; Gauges and the Barometer

Any liquid can serve in a Torricelli-style barometer, but the most dense ones are the most convenient. Why? This barometer uses water.

10-7 Buoyancy and Archimedes’ Principle

This is an object submerged in a fluid. There is a net force on the object because the pressures at the top and bottom of it are different.

The buoyant force is found to be the upward force on the same volume of water:

\[ F_B = F_2 - F_1 = \rho_F g A (h_2 - h_1) = \rho_F g A \Delta h = \rho_F V g = m_f g, \]

Archimedes’ Principle

- The buoyant force on an object immersed in a fluid is equal to the weight of the fluid displaced by that object.
Ch 10: Problem 27

What is the likely identity of a metal if a sample has a mass of 63.5 g when measured in air and an apparent mass of 55.4 g when submerged in water?

10-7 Buoyancy and Archimedes’ Principle

If the object’s density is less than that of water, there will be an upward net force on it, and it will rise until it is partially out of the water.

For a floating object, the fraction that is submerged is given by the ratio of the object’s density to that of the fluid.

This principle also works in the air; this is why hot-air and helium balloons rise.

Ch 10: Problem 25

A spherical balloon has a radius of 7.35 m and if filled with helium. How large a cargo can it lift, assuming that the skin and structure of the balloon have a mass of 930 kg? Neglect the buoyant force on the cargo volume itself.