# Chapter Two

# Fluids

## (2-1) Fluids

Matter is usually said to exist in three phases: solid, liquid, and gas. Solids are hard bodies that resist deformations, whereas liquids and gases have the characteristic of being able to flow. A liquid flows and takes the shape of whatever container in which it is placed. A gas also flows into a container and spreads out until it occupies the entire volume of the container. A fluid is defined as any substance that can flow, and hence liquids and gases are both considered to be **fluids.**

We will treat the fluid from a macroscopic approach. That is, we will analyze the fluid in terms of its large-scale characteristics, such as its mass, density, pressure, and its distribution in space.

The study of fluids will be treated from two different approaches. First, we will consider only fluids that are at rest. This portion of the study of fluids is called **fluid statics or hydrostatics.** Second, we will study the behavior of fluids when they are in motion. This part of the study is called **fluid dynamics or hydrodynamics.**

## (2-2) Density

The **density** of a substance is defined as the amount of mass in a unit volume of that substance. We use the symbol **ρ** (the lower case Greek letter rho) to designate the density and write it as

$$\rho = \frac{m}{v} \qquad \dots\dots\dots\dots\dots\dots\dots (2-1)$$

A substance that has a large density has a great deal of mass in a unit volume, whereas a substance of low density has a small amount of mass in a unit volume. Density is expressed in SI units as $kg/m^3$, and occasionally in the laboratory as $g/cm^3$. Densities of solids and most liquids are very nearly constant but the densities of gases vary greatly with temperature and pressure.

**Example 1:** A person would like to design a water bed for the home. If the size of the bed is to be **2.2 m** long, **1.8 m** wide, and **0.3 m** deep, what mass and weight of water is necessary to fill the bed?
Answer:

$V = L \times W \times h$

$= 2.2 \times 1.8 \times 0.3$

$= 1.188\ \text{m}^3$

$m = \rho V$ (density of water=1 gm/cm$^3$= 1000 kg/m$^3$)

$= 1000 \times 1.188$

$= 1188\ \text{kg}$

$w_w = m\ g$

$= 1188 \times 9.8$

$= 11.6 \times 10^3\ \text{N}$

**Example 2:** A cylinder 3 cm in diameter and 3 cm high has a mass of 15 gm. What is its density?
Answer:

**Example 3:** A gold ingot is 50 cm by 20 cm by 10 cm. Find: a) its mass, b) its weight. Note that gold density equal to 19300 kg/m$^3$.

**Example 4:** Assume that the earth is a sphere. Compute the average density of the earth? Note that radius of earth **6371 km**, and the mass of earth **5.972x10$^{24}$ kg.**