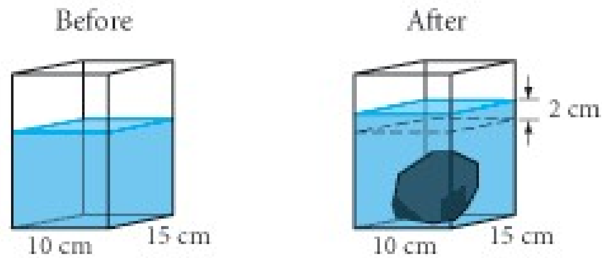
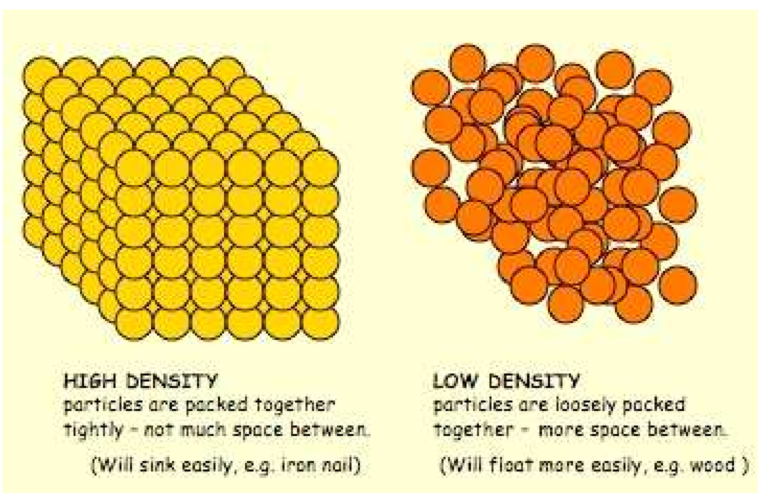
**Lesson 10.5 – Displacement and Density**

Displacement - The volume of the liquid that is displaced when an object is immersed in liquid is called the displacement of the object. This will also be the volume of the object.




Density - Density is the mass of the matter in a given volume.

density · volume = mass




Example 1:

A stone is placed in a 5 cm-diameter graduated cylinder, causing the water level in the cylinder to rise 2.7 cm. What is the volume of the stone?

The volume of the stone will be equal to the volume of the water it displaces in the cylinder.

$V = BH$

The base is a circle, so the area of the base (B) can be calculated using $A = \pi r^2$.

$A = \pi(2.5)^2$ **A circle with a 5-cm diameter has a radius of half of 5, or 2.5 cm.

$A = 6.25\pi$

$B = 6.25\pi$

$V = (6.25\pi)(2.7)$ **The height is the change in water level since that will tell us the amount of water displaced.

$\boldsymbol{V \approx 53.01}$ **cm$^3$**

Example 2:

A 141 g steel marble is submerged in a rectangular prism with base 5 cm by 6cm. The water rises 0.6 cm. What is the density of the steel?

The volume of the marble will be equal to the volume of the water it displaces in the prism.

$V = BH$

The base is a rectangle, so the area of the base (B) can be calculated using $A = bh$.

$A = (5)(6)$

$A = 30$

$B = 30$

$V = (30)(0.6)$ **The height is the change in water level since that will tell us the amount of water displaced.

$V = 18$ cm$^3$

density · volume = mass

density $\cdot \frac{18}{18} = \frac{141}{18}$

**Density** $\boldsymbol{= 7.83}$ **grams per cubic centimeter or** $\boldsymbol{7.83\ \frac{g}{cm^3}}$

Example 3:

A solid wood toy boat with a mass of 325 g raises the water level of a 50 cm-by-40 cm aquarium 0.3 cm. What is the density of the wood?

The volume of the toy boat will be equal to the volume of the water it displaces in the prism.

$V = BH$

The base is a rectangle, so the area of the base (B) can be calculated using $A = bh$.

$A = (50)(40)$

$A = 200$

$B = 200$

$V = (200)(0.3)$ **The height is the change in water level since that will tell us the amount of water displaced.

$V = 60$ cm$^3$

density · volume = mass

density · $60 = 325$

$\overline{\quad 60 \quad}$ $\overline{\quad 60 \quad}$

**Density = $\mathbf{5.42}$ grams per cubic centimeter or $\mathbf{5.42\ \frac{g}{cm^3}}$**

Example 4:

For Awards Night at Baddeck High School, the math club is designing small solid silver pyramids. The base of the pyramids will be a 2 in.-by-2 in. square. The pyramids should not weigh more than 2 ½ pounds. One cubic foot of silver weighs 655 pounds. What is the maximum height of the pyramids?

Since the base of the pyramids are measured in inches and the density is measured in cubic feet, we need to convert.

There are $12 \cdot 12 \cdot 12 = 1728$ cubic inches in a cubic foot.

655 pounds per cubic foot converts to $\frac{678}{1728} \approx .379$ pounds per cubic inch.

density · volume = mass

$$\frac{.379 \cdot \text{volume}}{.379} = \frac{2.5}{.379}$$

Volume $= 6.596$ cubic inches

$V = BH$

The base is a rectangle, so the area of the base (B) can be calculated using $A = bh$.

$A = (2)(2)$

$A = 4$

$B = 4$

$$\frac{6.596}{4} = \frac{(4)(H)}{4}$$

$1.65 = H$

**The maximum height of the pyramids is 1.65 inches.**

<u>Example 5:</u>

While he hikes in the Gold Country of northern California, Sid dreams about the adventurers that walked the same trails years ago. He suddenly kicks a small bright yellowish nugget. Could it be gold? Sid quickly makes a balance scale using his walking stick and finds that the nugget has the same mass as the uneaten half of his 330 g nutrition bar. He then drops the stone into his water bottle, which has a 2.5 cm radius, and notes that the water level goes up 0.9 cm. Has Sid struck gold?

The volume of the nugget will be equal to the volume of the water it displaces in the prism.

$V = BH$

The base is a circle, so the area of the base (B) can be calculated using $A = \pi r^2$.

$A = \pi(2.5)^2$

$A = 6.25\pi$

$B = 6.25\pi$

$V = (6.25\pi)(0.9)$ **The height is the change in water level since that will tell us the amount of water displaced.

$V \approx 17.67$ cm$^3$

density · volume = mass

$\text{density} \cdot 17.67 = 165$ **The mass is 165 because it is ½ of his nutrition bar that was 330 g

$$\frac{\text{density} \cdot 17.67}{17.67} = \frac{165}{17.67}$$

Density = 9.34 grams per cubic centimeter or $9.34\ \frac{g}{cm^3}$

Gold has a density of 19.30 $\frac{g}{cm^3}$, so he did not find gold.

| Metal | Density | Metal | Density |
|---|---|---|---|
| Aluminum | 2.81 g/cm$^3$ | Nickel | 8.89 g/cm$^3$ |
| Copper | 8.97 g/cm$^3$ | Platinum | 21.40 g/cm$^3$ |
| Gold | 19.30 g/cm$^3$ | Potassium | 0.86 g/cm$^3$ |
| Lead | 11.30 g/cm$^3$ | Silver | 10.50 g/cm$^3$ |
| Lithium | 0.54 g/cm$^3$ | Sodium | 0.97 g/cm$^3$ |