

## Lect 3: Density

1. What is density?
2. How do you measure density?



## 6. Eureka! Volume & Density:

take notes at the top of the page



### What is density?



- ∨ Think about the many kinds of matter you come into contact with every day.
  - ∨ Wood, cement, aluminum, plastic, foam, liquids, steel, etc.
- ∨ In solids, we have huge differences.
- ∨ A block of steel and a block of aluminum may be the same size, but one has a lot more mass than the other.

### What is density?



- ∨ Density describes how much **mass** is in a given **volume** of a material.
- ∨ Steel has a high density; 7.8 grams of mass per cubic centimeter.
- ∨ Aluminum has a lower density; 2.7 grams/cm<sup>3</sup>.
- ∨ Liquids & gases are matter & have density too.

### Measuring Density

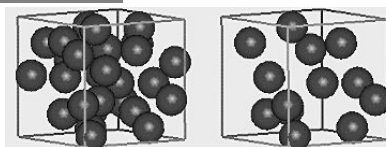
$$\text{Density (g/mL or g/cm}^3\text{)} \rightarrow D = \frac{m}{V}$$

Mass (kg or g)

Volume (mL or cm<sup>3</sup>)

- ∨ The more matter you place into a defined volume, the **denser** it becomes.
- ∨ For example, New York City is DENSELY populated because there are a lot of people in a small area.
- ∨ 20 people in an elevator is DENSER than 2 people in an elevator.
- ∨ Notice our units...cm<sup>3</sup>

### Which one is MORE dense?




- ∨ If each box has the same volume, and each ball has the same mass, which box would weigh more? Why?

### Which weighs more?

**100 pounds of lead or 100 pounds of feathers?**



Feathers



Lead

### Lead and Feathers


- ✓ Although 100 pounds of feathers may take up much more room than 100 pounds of lead, they both still weigh 100 pounds.
- ✓ The steel is heavier for its size, due to the fact that it is denser!!!
- ✓ Thus, a material such as feathers takes up much more room (volume) than a denser material such as steel, for the same mass or weight.

### Density of Common Materials

- ✓ Density is a property of materials - independent of shape or quantity.
- ✓ For example, a steel nail and a steel cube have different amounts of matter and therefore different masses.
- ✓ They also have different volumes.
- ✓ However, if you calculate density by dividing mass by volume, the result is the same for both the nail and the cube.


**Steel density**

**Steel cube**  
Volume: 1.0 cm<sup>3</sup>  
Mass: 7.8 g  
Density: 7.8 g/cm<sup>3</sup>



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**Nail**  
Volume: 1.6 cm<sup>3</sup>  
Mass: 12.5 g  
Density: 7.8 g/cm<sup>3</sup>



### Density of Common Materials

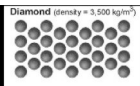
- Solids that are **strong**, such as steel, typically have **high** density.
  - High density means there are many atoms per cubic centimeter.
- **Soft** materials typically have **lower** density.
  - Solids with low density, such as cork or foam, are often used as cushioning material.
  - Low density means there are relatively large spaces between atoms.

Densities of Common Substances	
Substance	Density (g/cm <sup>3</sup> )
Mercury	13.60
Lead	11.34
Aluminum	2.70
Bone	1.85
Milk (whole)	1.03
Seawater	1.03
Water	1.00
Ice	0.92
Gasoline	0.73
Cork	0.24

### Why does density vary?

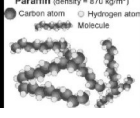
- The density of a material depends on two things:
  - the **individual mass** of each atom or molecule
  - on **how tightly** the atoms are packed
- A diamond is made of carbon atoms and has a density of 3,500 kg/m<sup>3</sup>.
- The carbon atoms in diamonds are closely packed.

Diamond (density = 3,500 kg/m<sup>3</sup>)



Carbon atom

Paraffin (density = 870 kg/m<sup>3</sup>)



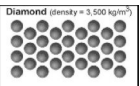
Carbon atom    Hydrogen atom

Molecule

### Why does density vary?

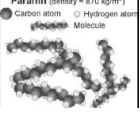
- ✓ Paraffin wax is mostly carbon, but the density of paraffin is only 870 kg/m<sup>3</sup>.
- ✓ The density of paraffin is low because the carbon atoms are mixed with hydrogen atoms in long molecules that take up a lot of space.

Diamond (density = 3,500 kg/m<sup>3</sup>)



Carbon atom

Paraffin (density = 870 kg/m<sup>3</sup>)



Carbon atom    Hydrogen atom

Molecule

## Calculating Density Problems

- ✓ Here are 3 density problems you are going to do with the video:  
Follow the video as we do them
- 1. A student determines the density of manganese to be  $5.54 \text{ g/cm}^3$ . If a sample had a mass of  $3.43\text{g}$  what was the volume?
- 2. A cube  $5.7\text{cm}$  on a side has a mass of  $630 \text{ g}$ . Find the Density!
- 3. The density of a gas is  $0.0043 \text{ g/cm}^3$ . Find the mass of  $280 \text{ cm}^3$  of this gas.

## Video 8. Density Calculations



## Calculating Density


$$\text{Density (g/mL or g/cm}^3\text{)} \rightarrow D = \frac{m}{V}$$

↖ Mass (kg or g)  
↙ Volume (mL or cm<sup>3</sup>)


- ✓ There are several different ways to find the density of an objects.
- ✓ It depends on the shape of the object.

## For the next few slides...


- You will NOT be completing the “You Try It”  
Simply follow along as volume is explained.




### Cubes & Rectangular Prisms




- **Find mass**
  - Use a **balance**
  - Units: **grams** or kg
- **Find volume**
  - Use a ruler
  - Measure all 3 **sides**: length, width, height
  - Units: **cm<sup>3</sup>**, m<sup>3</sup>, km<sup>3</sup>
  - Use this equation:  $\text{Volume} = \text{length} \times \text{width} \times \text{height}$   
 $V = l \times w \times h$
- **Density = mass / volume**
  - Units: **g/cm<sup>3</sup>**





### Cylinders



1. **Find mass**
2. **Find volume**
  - ✓ Use a ruler
  - ✓ Measure the height & **diameter**
  - ✓ Divide the diameter in half to find the **radius**
  - ✓ Units: cm<sup>3</sup>, m<sup>3</sup>, km<sup>3</sup>
  - ✓ Use this equation:  
 $\text{Volume of a cylinder} = 3.14 \times \text{radius}^2 \times \text{height}$   
 $V = \pi r^2 h$
3. **Density = mass / volume**
  - ✓ Units: g/cm<sup>3</sup>

## Irregular Objects

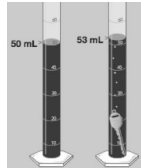
1. Find mass

2. Find volume

- ∨ **Displacement** method
- ∨ Fill a graduated cylinder with water.
- ∨ Drop the object in without splashing water.
- ∨ Calculate the change in volume!
- ∨ Units: mL, L

3. **Density = mass / volume**

- ∨ Units: g/mL



## 9. Finding Density:

Answer the questions at the bottom of your page

