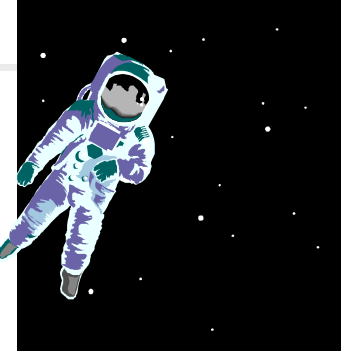




Chapter 4 Physics of Matter

Vacuum

- A vacuum exists in outer space.
- It is the absence of all matter.
- Vacuums are relative
- Even in outer space some matter exists
- But the amount is so small that a person would die if exposed to vacuum without a space suite

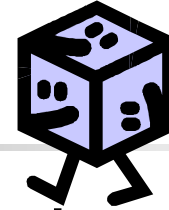




States of Matter

- Solid
- Liquid
- Gas
- Plasma

Solid



- **Solid** A rigid body, retains its shape unless distorted by a strong force..
Examples: rock, wood, plastic, iron

Liquid

- Flow readily,
- conform to the shape of their container.
- Have a well defined boundary (surface).
- More dense than gases.
- Examples water, beverages, blood, oil,...



Gas



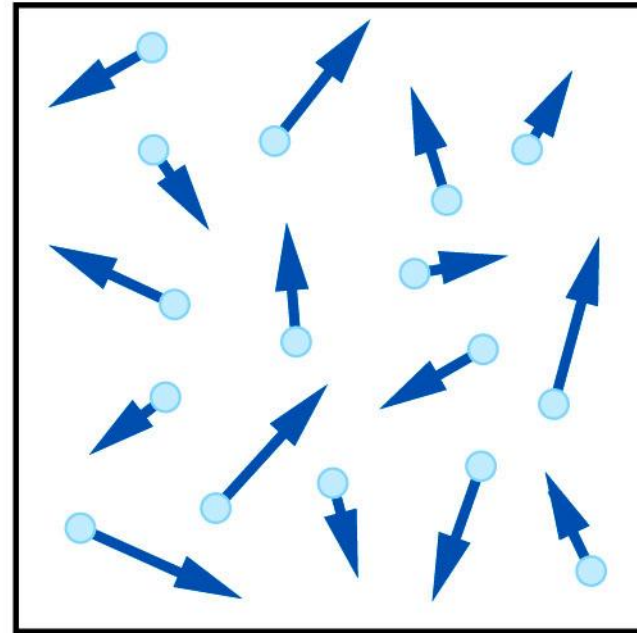
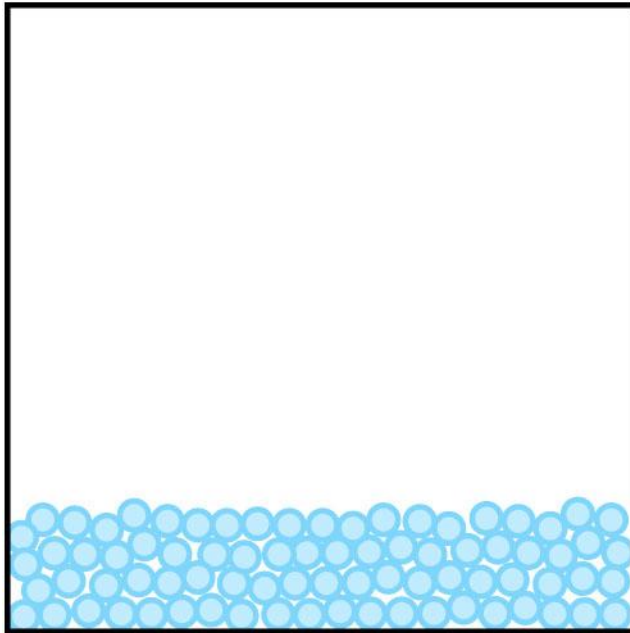
- Flow readily,
- conform to the shape and size of their container,
- do not have a well defined surface,
- can be compressed or expanded readily.
- Examples: air, carbon dioxide, helium, steam.

Inside Liquid vs Gas

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Liquid

Gas



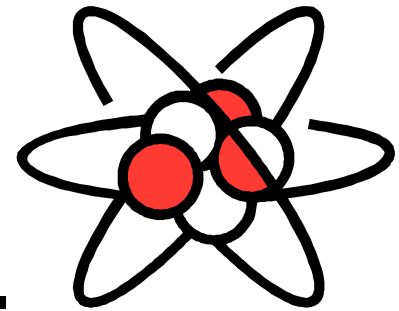
Plasma

- An ionized gas, often referred to as the fourth state of matter.
- It consists of positive ions and electrons
- interacts strongly with magnetic fields
- conducts electricity.
- Commonly exists only at higher temperatures or in strong electromagnetic fields
- Examples: Sun, candle flame, gases in operating fluorescent, neon, and vapor lights.



Structure or Particles of Matter

- **Greeks described smallest particles of matter as atoms.**
- **Now we know there are even smaller particles.**
- **Atoms are composed of**
 - **Electrons, protons and neutrons.**
 - **Protons and neutrons are in the center or nucleus of the atom**
 - **Electrons orbit around the nucleus**





Neutrons, Protons, Electrons

- **Neutron** Electrically neutral particle residing in the nucleus of an atom.
- **Proton** Positively charged particle residing in the nucleus of an atom.
- **Electron** Negatively charged particle, usually found orbiting the nucleus of an atom.



Elements

- One of over 115 different fundamental substances
- The simplest and purest forms of matter.
- All have the same type of Atom, specifically the same number of protons in the nucleus.
- Scientists are still discovering new elements so the number is always increasing.

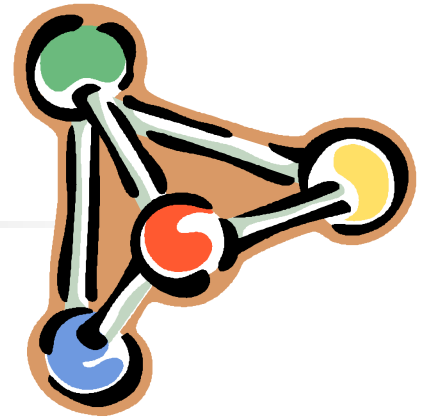


Examples of Elements

- Gold, Silver, Oxygen, Silicon, Nitrogen,....
- Nitrogen is the most abundant element. It makes up about 80% of our air.
- Silicon is also very abundant, since it occurs in sand, a compound of Silicon and Oxygen.

Molecule/Compound

- **Two or more atoms combine to form a molecule. If the atoms are different types it is a compound.**
- **A Compound is something composed of identical molecules of more than one type of atom or element. 2 or more elements combine chemically.**
- **E.G. SiO_2 Is a compound composed of molecules with Silicon and Oxygen atoms.**





Mixture

- No chemical reaction, thus not a compound
- Parts do not combine uniformly, they just intermix.
- Parts can be recovered individually.
- Example, Instant Cocoa: chocolate, sugar, and milk powder.

Solutions

- **A homogeneous mixture of two or more substances, which may be solids, liquids, gases, or a combination of these**
- **The parts break down into individual molecules, and intersperse, but do not combine.**
- **E.G. salt in water-salt water**





Suspensions

- A suspension has tiny particles, but many molecules in one particle.
- Not a chemical reaction, thus not a compound
- Their particles are larger than molecules thus not a solution.



Suspensions Examples

- Mayonaise, Gelatin, Butter, Ice Cream
Orange Juice
- see
[http://encyclopedia.thefreedictionary.com/Suspension+\(chemistry\)](http://encyclopedia.thefreedictionary.com/Suspension+(chemistry))

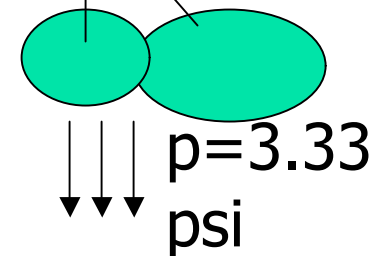
Pressure (p)



- The force per unit area for a force acting perpendicular to a surface. The force acting on a surface divided by its area.

- $P = \text{Force/Area} = F/A$
- Force on the floor = Weight = 100 lbs
- Area of shoes surface 30 sq.in.
- Pressure on the floor = $100/30 = 3.33\text{psi}$

$$F = wt = 100\text{lb}$$
$$A = 30\text{sq.in.}$$
$$P = 100/30$$



Pressure from spike heels

- Heel area = $.2 \times .2 \text{ in} = .04 \text{ sq.in}$
- Sole area = $2 \times 4 \text{ in} = 8 \text{ sq.in.}$
- Weight = 100 lbs.
- On Heel $P = 100 / .04 = 2500$ psi
- On Sole $P = 100 / 8 = 12.5 \text{ psi.}$



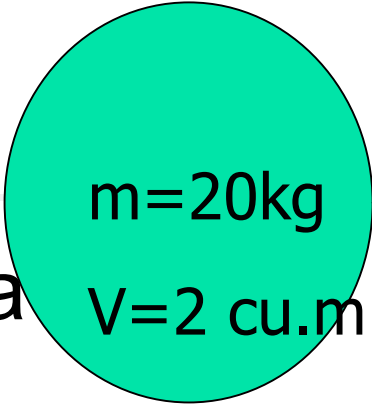


Equal Forces Unequal P

- **Note force is the same in both cases but the ratio of pressures is $2500/12.5 = 200$ to 1!**

Mass density (D)

- The mass per unit volume of a substance. The mass of a quantity of a substance divided by the volume it occupies.
- Mass density = mass/volume
- $D = m/V = 20\text{kg}/2\text{m}^3 = 10\text{kg}/\text{m}^3$


$$m = 20\text{kg}$$

$$V = 2 \text{ cu.m}$$



D of 2 x 2 x 4 m, 40KG Cube

- **D=?**
- **M= 40 kg,**
- **Cube of dimensions 2 x 2 x 4 m.**
 $V=lwh = 2 \times 2 \times 4 = 16$ cubic meters
- **$D = m/V = 40\text{Kg}/ 16 \text{ m}^3 = 2.5 \text{ kg}/ \text{ m}^3$**

Weight density (D_w)

- The weight per unit volume of a substance. The weight of a quantity of a substance divided by the volume it occupies.
- $D_w = W/V = \text{Weight/Volume}$
- $= 196 \text{ N}/2 \text{ cu.m} = 98 \text{ N/m}^3$


$$W=196 \text{ N}$$

$$V=2 \text{ cu.m}$$



D_w of 2 x 2 x 4 m, 40KG Cube

- $D_w = ?$
- $M = 40 \text{ kg}$, $W = 40 \times 9.8 = 392 \text{ N}$
- Cube of dimensions 2 x 2 x 4 m.
 $V = lwh = 2 \times 2 \times 4 = 16 \text{ cubic meters}$
- $D_w = W/V = 392\text{N} / 16 \text{ m}^3 = 24 \text{ N} / \text{m}^3$



Specific Gravity

- Relation between density of a material and density of water.
- Ratio D_x/D_w (Density of x divided by density of water).

What is the Specific Gravity of Concrete?



- Density of concrete = 2500 kg/m^3 ,
- Density of water = 1000 kg/m^3 .
- Specific Gravity of concrete =
- $D_x/D_w = 2500/1000$
- = 2.5. ***Note, no units on sp.gr!***



Pressure in Fluids

- **Pressure increases with depth!**
- Law of fluid pressure The (gauge) pressure at any depth in a fluid at rest equals the weight of the fluid in a column extending from that depth to the top of the fluid divided by the cross-sectional area of the column.



Law of fluid pressure

- The (gauge) pressure at any depth in a fluid at rest equals the weight of the fluid in a column extending from that depth to the top of the fluid divided by the cross-sectional area of the column.



Pressure in Water

- **Water weighs 62.5 lbs/cu.ft**
- **A cube 1 x 1 x 1 ft has a surface of 1 sq.ft.**
- **At a depth of 1 ft you have 62.5 lbs/sqft pressure**
- **Multiply depth in ft by 62.5 to find P**
- **20 ft, $P = 20 \times 62.5 = 1250$ lbs/sq.ft.**



Converting to lbs/sq.in

- **Gauges usually use lbs/sq.in**
- **1 sq.ft = 12in x 12 in = 144 sq.in.**
- **62.4 lbs/sq.ft = 62.4/144**
- **= .433 lbs/sq.in.**
- **Thus using psi: $p = 0.433 \text{ psi/ft} \times h(\text{ft})$**
- **At 20 ft. $P = .433 \times 20 = 8.66 \text{ psi.}$**



Gauge pressure vs total p

- measures difference between inside and outside pressure?
- see p. 141 and 142



Buoyant force

- The upward force exerted by a fluid on a substance partly or completely immersed in it.



Archimedes' Principle

- The buoyant force acting on a substance in a fluid at rest is equal to the weight of the fluid displaced by the substance.



Floating, Sinking, or Rising

- **Buoyant force greater than weight of object, object floats.**
- **Buoyant force less than weight, object sinks.**
- **Light object released from a submarine rises, if density less than water, otherwise sinks.**



Pascal's Principle

- Pressure applied to an enclosed fluid is transmitted undiminished to all parts of the fluid and to the walls of the container.

Problem Force from Pressure and Area

- Pressure = F/A then $F = P \times A$
- Side of can 8 x 10 inches?
- Area 8 x 10 = 80 sq in., $P=14.7\text{psi}$
- $F = 14.7 \text{ psi} \times 80 \text{ sq.in.} = 1176 \text{ lbs}$

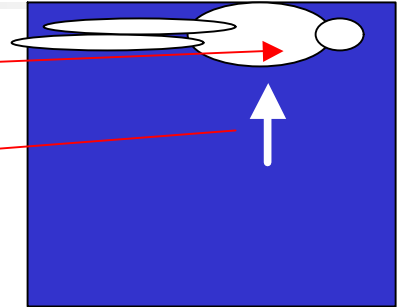


Mass from Density Problem

- $Dm = M/Vol$
- $M = Dm \times Vol$
- $Vol = 2m \times 3m \times 4m = 24 \text{ cu.m}$
- $Dm = 11,340\text{kg/cu.m}$
- $M = 11,340 \times 24 = 272,160 \text{ kg.}$

Buoyant Force Problem

- Swimmer's volume = 2 ft^3
- Buoyant Force, $\text{BF} = ?$
- $\text{BF} = \text{Wt of water he displaces}$
- = His Vol x density of water
(62.4 lbs/ft^3)
- $2 \text{ ft}^3 \times 62.4 \text{ lbs/ft}^3 = 124.8 \text{ lbs}$





Formulas Chapter 4

$p = F/A$ Pressure is Force divided by area perpendicular to the force

$$D_m = m/V$$

Mass density, $D_m = \text{mass, } m/\text{volume, } V$

$$D_w = w/V$$

Weight Density, $D_w = \text{weight, } w/\text{volume, } V$

$$F_b = W_{FD}$$

Archimedes' Principle: Buoyant Force = Weight of the fluid displaced

Special Case Equations

- $p = D_w h = D_m \times g \times h$ Gauge Pressure, p at a depth h in a liquid of wt density D_w or mass density D_m

- $p = 0.433 \text{ (psi/ft)} \times h \text{ (ft)}$ Gauge Pressure in psi underwater at a depth h in feet



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- [Back to Classes](#)
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