Chapter-2

Physical Quantities and Measurement

STUDY NOTES

Physical Quantities:

- A physical quantity is a quantity that can be measured.
- Length, time, mass and temperature are the fundamental physical quantities.
- A physical quantity can be expressed as the combination of a numerical value and a unit. For example, the physical quantity mass can be quantified as n kg, where n is the numerical value and kg is the unit.

Measurement

Comparing an unknown quantity with some known quantity is called measurement.

Result of Measurement: The result of measurement has two parts; one part is the number and another part is the unit.

The known quantity which is used in measurement is called a unit.

For example; when you say that your height is 150 cm then the measurement of your height is being expressed in a number, i.e. 150 and a unit, i.e. centimetre.

Length

- It is the distance between two points
- Its SI unit is metre (symbol m)
- It is measured with the help of a metre ruler or a measuring tape.

Mass

- It is the quantity of matter contained in the body.
- Its SI unit is kilogram (symbol kg)
- It is measured using a beam balance or an electronic balance

Time

- It is the interval of occurrence of an event.
- Its SI unit is second (symbol s)
- It is measured with the help of a pendulum clock or a watch

Temperature

- It is a quantity which measures the hotness and coldness of a body
- Its SI unit is Kelvin (symbol K)
- It is measured using a thermometer.

Measurement of Volume

Volume

The space occupied by an object is called its volume

SI Unit of Volume

The SI unit of volume is cubic meter(m^3)

One cubic meter is the volume of a cube with each side 1m long

$1m^3 = 1m*1m*1m$

Relation between m^3 & cm^3

$1m^3 = 1m \times 1m \times 1m$

$= 100cm \times 100cm \times 100cm$

$= 1000000\ cm^3$

The volume of liquids is generally expressed in liter (symbol L)

$1000\ cm^3$ make one litre

i.e.,

$1000\ cm^3 = 1$litre

A measuring cylinder is used in a laboratory to measure the volume of a given liquid.

For this, proceed as follows

Select a cylinder that is large enough to hold the volume of liquid being measured.

Confirm that the tube is clean and dry. Unwanted particles or drops of liquid in the cylinder could throw off the measurement.

Density

The density of material shows the denseness of that material in a specific given area. A material's density is defined as its mass per unit volume.
Density is essentially a measurement of how tightly matter is packed together. It is a unique physical property for a particular object.

Examples

Iron, platinum, and lead are examples of dense materials. Many types of rock and minerals are examples of dense material. Materials that are dense are most likely to 'feel' heavy or hard.
In general, liquids are less dense than solids and gases are less dense than liquids. This is due to the fact that solids have densely packed particles, liquids are materials where particles can slide around one another, and gases have particles that are free to move all over the place.
Mathematically, the density of an object is expressed as follows:

Where,

- ρ is the density
- m is the mass
- V is the volume

Unit of Density

SI unit of density is kg/m^3, for convenience we use g/cm^3 for solids, g/ml^3 for liquids, and g/L for gases.

Determination of density of regular solid

To find the density of a regular solid by using formula, density = mass / volume
We proceed as follows

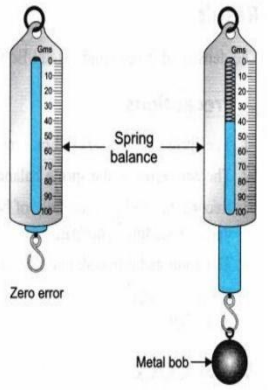
- Using a beam balance, measure the mass (m) of the solid
- Using the meter ruler, measure the length, breath and height of regular solid and find the volume V using the relation V =l×b×h
- Once we know the mass and volume, density is calculated using the relation d=M/V

Determination of density of irregular solid

Materials Required A spring balance, a measuring cylinder, a beaker with water, a metal bob (or anybody that is heavier than water and does not dissolve in water), a cotton string, a stand (optional).

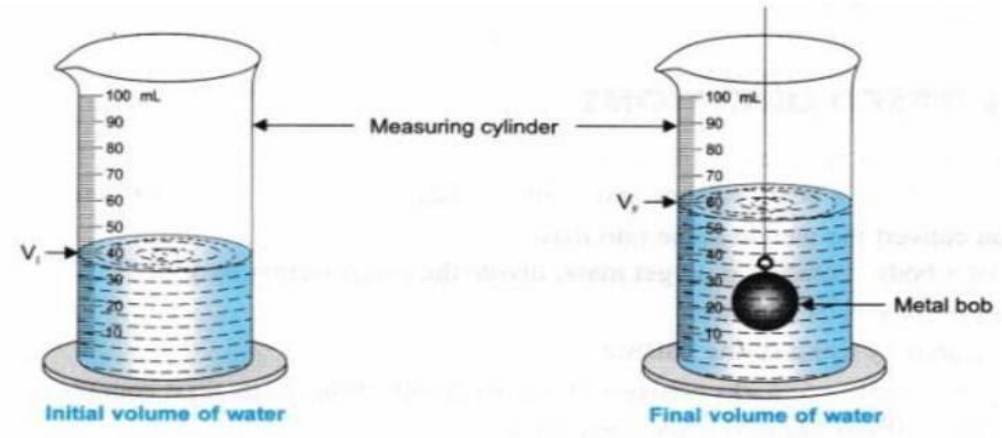
Procedure

1. Tie a metal bob (or any solid) with the string of cotton to the hook of the spring balance. The spring balance should be checked for any error. Let the zero error be



'x'.

2. Hold the spring balance (or tie it to the stand), suspended with the metal bob in air. Measure the weight of the bob. Let its weight be 'WF'
3. Pour the water in the measuring cylinder and record the initial volume of water, let it be ' V_1'
4. Suspend the metal bob into the measuring cylinder with water. The bob should not touch the base, nor the sides of the cylinder. The water level rises, measure the increased water level, let this volume be ' V_F'
5. Record all your observations in the observation table and do the calculation to find the density of a given solid metal bob



Determination of density of a liquid

To determine the density of a liquid, follow the procedure given below

Take a beaker, measure the mass of given beaker using a common beam balance. let the mass be M_1 gram.

Now take a measuring cylinder and pour given liquid in to a certain level say 50 Ml

Thus, volume of milk, V = 50 cm^3.

Transfer the liquid in to the empty beaker.

Measure its mass again. Let's its mass be M_2 gram

The difference between M1 and m2 will give the mass M of the liquid.

Thus mass of liquid M=(M_2-M_1) gram

Calculate the density of liquid using following relation

Density =Mass/Volume

Different substances have different densities.

Speed

Speed is defined as

The rate of change of position of an object in any direction.

Speed is measured as the ratio of distance to the time in which the distance was covered.

Speed is a scalar quantity as it has only direction and no magnitude.

Units of speed

Speed is measured as v=Distance/Time

where SI unit of distance is m and that of time is s.

Thus SI unit of speed is m/s.

Sometimes we measure distance in kilometre and time in hour then the unit of speed is kilometre per hour $km.h^{-1}$

How do you convert km/h to m/s?

SI unit of distance is a meter according to the International System of Units.

Conversion

We know that
1 km = 1000m
1 h = 3600 s
So 1km /h = 1000/3600 = 5/18 = 0.28 m/sec

So to convert km/h to m/s we multiply the given number by 5/18 or 0.28m/sec

Example

Speed of bicycle = 90 km/hr
To convert the speed into m/sec, we multiply by 5/18
Therefore, speed of bicycle = 90 × 5/18 m/sec = 25 m/sec

Factors affecting the turning of a body:

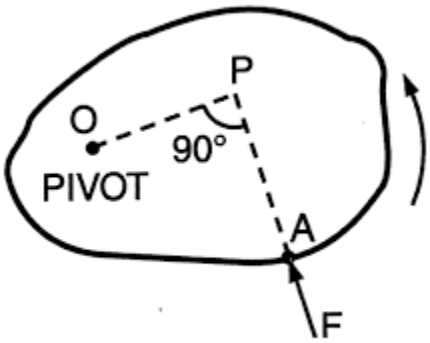
1. The magnitude of the force applied.
2. The perpendicular distance of the force from the pivoted point.

Examples:

- A person pushing a swing will make the swing rotate about its pivot.
- A worker applies a force to a spanner to rotate a nut.
- A person removes a bottle's cork by pushing down the bottle opener's lever.
- A force is applied to a door knob and the door swings open about its hinge.

Moment of a force:

The moment of a force is equal to the product of the magnitude of the force and the perpendicular distance of the force from the pivoted point.



Moment of a force

Moment of force about the point O

= F x OP

Unit of moment of force:

- SI unit: newton x metre
- CGS Unit: dyne x cm
- Nm = 10^7 dyne cm.
  - 1 kgf m = 9.8 Nm.
  - 1 gf cm = 980 dyne cm.

Pressure:

Thrust:

- The force acting normally on a surface is called thrust.
- SI unit of thrust: newton.

Effect of thrust:

- Smaller the area, larger is the effect.

Examples:

- If you stand on loose sand, your feet will sink deeply into sand, but when you lie on sand; your body does not sink much into the sand.

Definition of pressure:

- Pressure is defined as the thrust per unit area.
- P = Thrust/Area
- It is denoted by the letter P
- If the force increases, the pressure increases.
- If the area over which the force act decreases, the pressure increases.

Units of pressure:

- The SI unit of pressure is pascal.

  Pa

- It is the pressure exerted by a force of 1N acting over an area of 1 sq m.

- 1 pa = 1N/sq.m
- The atmospheric pressure is expressed in a unit atm
- 1 atm = 76 cm of mercury = 1.013×10^5 pa.

Factors affecting pressure:

1. On area of the surface on which thrust acts.
2. On magnitude of thrust acting on the surface.

Examples of pressure in our daily life:

- **It is easier to cut an apple with a knife.**

  The sharper the knife, the smaller is the area of contact.

  So, it exerts greater pressure, and it makes easier to cut that apple.

- **School bags have broad straps.**

  Because the area is more. So, it applies less pressure. So, the pain is less.

- **The tip of a sewing needle is very sharp.**

  So that it will have lesser area and it will exert more pressure and it will become easy to pierce a cloth.

- **Snow shoes stop you from sinking into snow.**

  Because their area of cross section is more. So they apply less pressure and prevent us from sinking into the snow.

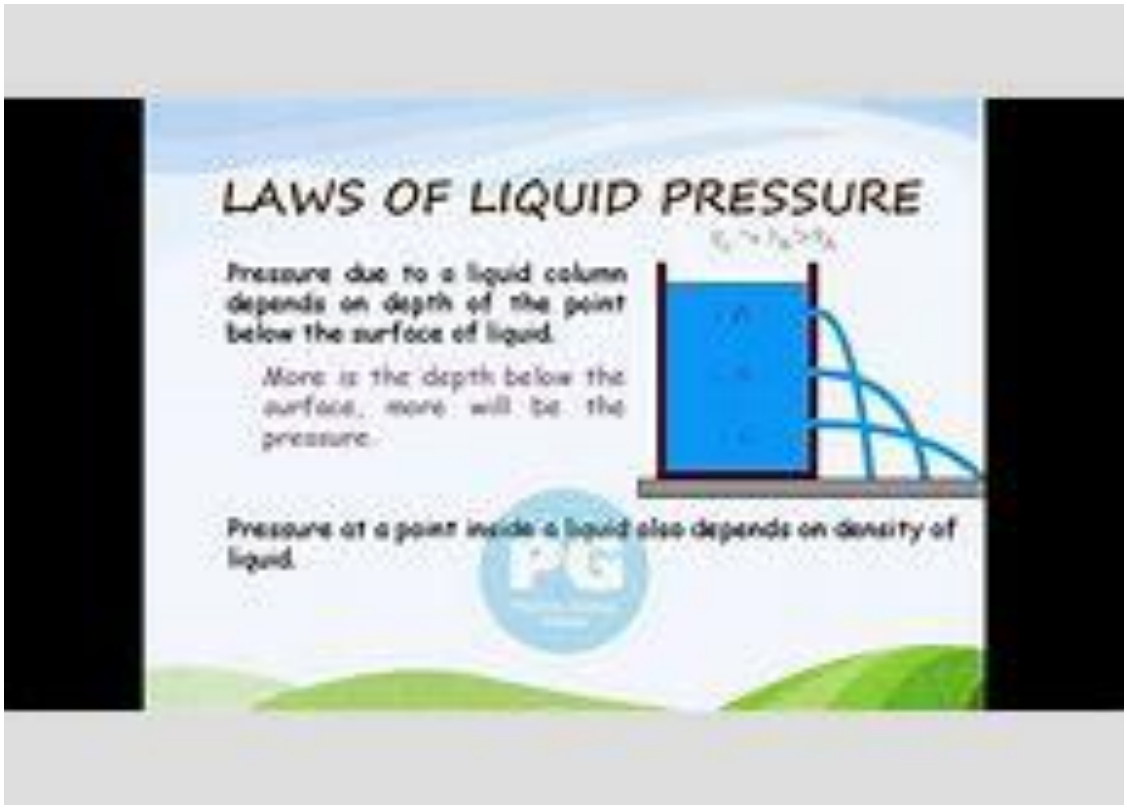
- **War tanks move on caterpillar tracks which are broad chain like covers on the wheels.**

  This causes a large increase in the area of

  Contact with the ground. Due to this, the pressure on the ground reduces so much that the tanks can even move on soft wet grounds without sinking.

Liquid Pressure

- The pressure exerted by liquid is called as liquid pressure.
- Activity to observe liquid pressure:



- A liquid exerts pressure in all directions.(downwards, upward, sideways.)
- The pressure is the same in all directions at the same depth.
- Pressure increases with depth.

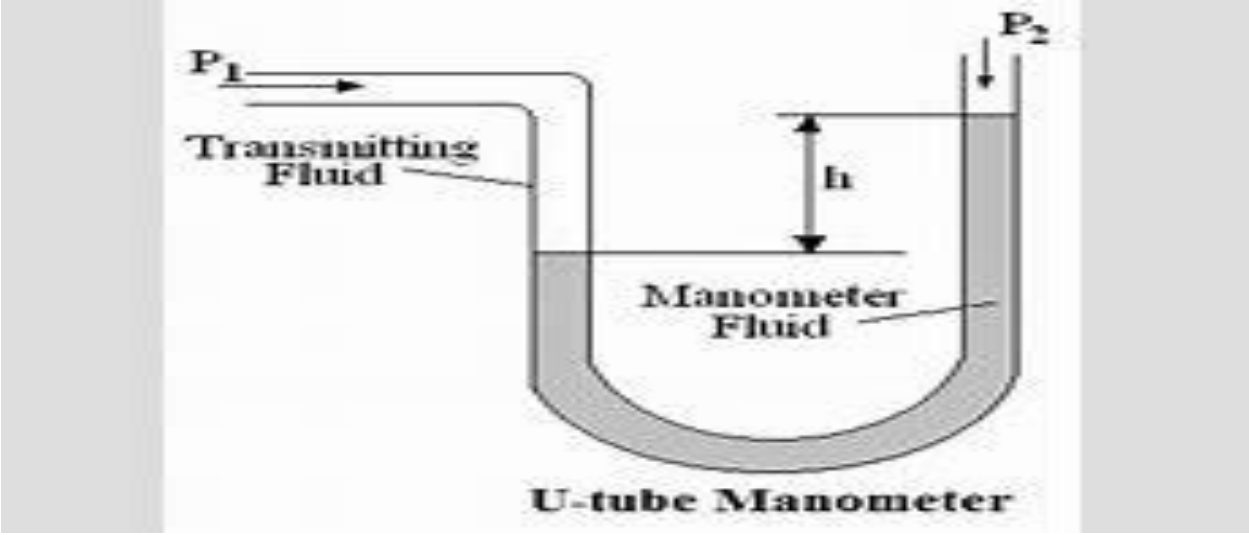
Factors affecting liquid pressure:

1. Height of the liquid column.
2. The density of the liquid.

Consequences of liquid pressure:

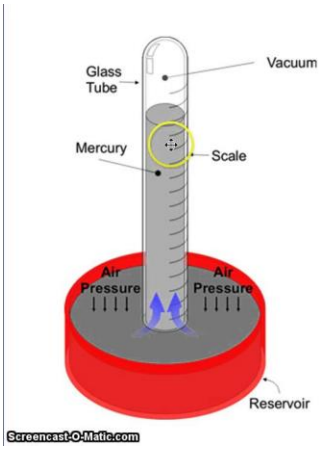
Thickness of walls of a dam is increased towards the bottom.

- Pressure is measured by using an instrument called a manometer.



Atmospheric Pressure:

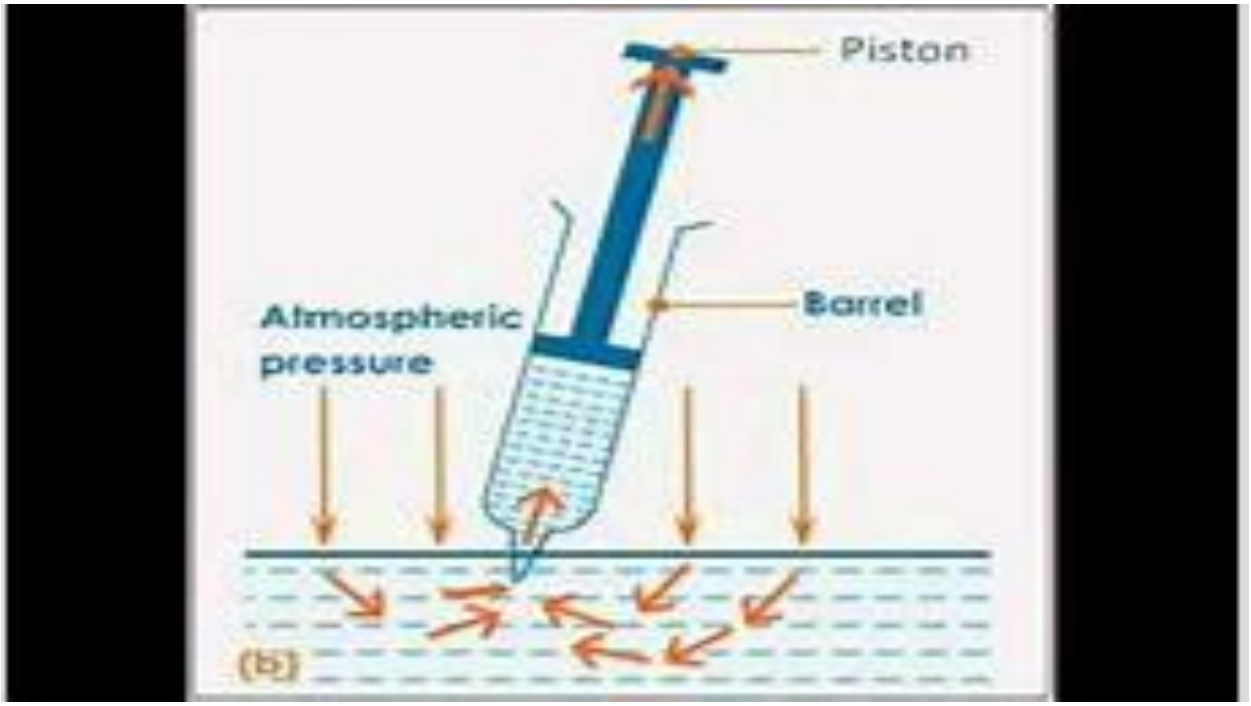
- Atmosphere: Earth is surrounded by air and this covering of air is known as the atmosphere.
- The force exerted by the atmosphere on unit area is called atmospheric pressure.
- It is measured by using a barometer



Barometer

- The drinking straw, The dropper, the syringe and different kinds of pumps use the fact: air exerts pressure.

When the air inside them is pushed out, atmospheric pressure forces the drink, ink or medicine into their barrels.



- The atmospheric pressure is maximum at sea level and reduces as we go higher up, since air becomes thinner.
- The rubber suction hooks stick to walls due to atmospheric presure.The cup is pressed against the smooth surface of a wall to drive out the air from underneath.