Exp.1

The Simple pendulum

Purpose :
To determine the acceleration of free fall by means of simple pendulum.

Apparatus :
1. Pendulum bob (a metal sphere with a hook attached or with a hole bored through its center.
2. Stopwatch .
3. meter scale
4. Stand and clamp

Theory

A simple pendulum may be described ideally as a point mass suspended by a massless
string from some point about which it is allowed to swing back and forth in a place. A
simple pendulum can be approximated by a small metal sphere which has a small radius
and a large mass when compared relatively to the length and mass of the light string from
which it is suspended. If a pendulum is set in motion so that is swings back and forth, its
motion will be periodic. The time that it takes to make one complete oscillation is

defined as the period T. Another useful quantity used to describe periodic motion is the frequency of oscillation. The frequency f of the oscillations is the number of oscillations that occur per unit time and is the inverse of the period, f = 1/T. Similarly, the period is the inverse of the frequency, T = l/f. The maximum distance that the mass is displaced from its equilibrium position is defined as the amplitude of the oscillation.

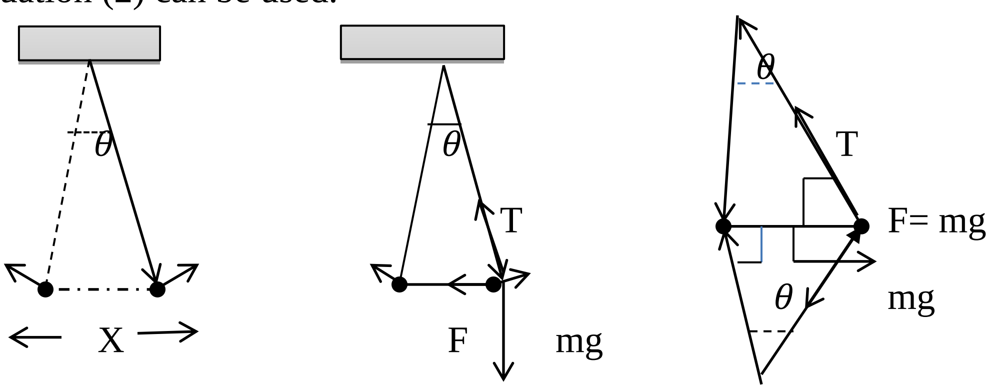
When a simple pendulum is displaced from its equilibrium position, there will be a restoring force that moves the pendulum back towards its equilibrium position. As the motion of the pendulum carries it past the equilibrium position, the restoring force changes its direction so that it is still directed towards the equilibrium position. If the restoring force F is opposite and directly proportional to the displacement x from the equilibrium position, so that it satisfies the relationship

$$F = - k x \qquad (1)$$

then the motion of the pendulum will be simple harmonic motion and its period can be calculated using the equation for the period of simple harmonic motion

$$T = 2\pi\sqrt{m/K} \qquad (2)$$

It can be shown that if the amplitude of the motion is kept small, Equation (2) will be satisfied and the motion of a simple pendulum will be simple harmonic motion, and Equation (2) can be used.



The restoring force for a simple pendulum is supplied by the vector sum of the gravitational force on the mass. mg, and the tension in the string, T. The magnitude of the restoring force depends on the gravitational force and the displacement of the mass from the equilibrium position. Consider Figure 1 where a mass m is suspended by a string of length *l* and is displaced from its equilibrium position by an angle θ and a distance x along the arc through which the mass moves. The gravitational force can be resolved into two components, one along the radial direction, away from the point of suspension, and one along the arc in the direction that the mass moves. The component of the gravitational force along the arc provides the restoring force F and is given by

$$F = - mg \sin\theta \qquad (3)$$

where g is the acceleration of gravity, θ is the angle the pendulum is displaced, and the minus sign indicates that the force is opposite to the displacement. For small amplitudes where θ is small, sinθcan be approximated by θ measured in radians so that Equation (3) can be written as

$$F = - mg\,\theta \ (4)$$

The angle θ in radians is *x* /*l*
, the arc length divided by the length of the pendulum or the radius of the circle in which the mass moves. The restoring force is then given by

$$F = - mg\, x/ l (5)$$

and is directly proportional to the displacement x and is in the form of Equation (1) where k = mg/ *l*.

Substituting this value of k into Equation (2), the period of a simple pendulumcan be found by

$$T = 2\pi\sqrt{\frac{m}{mg/l}} \qquad (6)$$

And

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad (7)$$

Therefore, for small amplitudes the period of a simple pendulum depends only on its length and the value of the acceleration due to gravity.

Apparatus :

1. Pendulum bob (a metal sphere with a hook attached or with a hole bored through its center.
2. Stopwatch .
3. meter scale . L
4. Stand and clamp .

Procedure :

1. Tie a meter length of the cotton to the pendulum bob and suspend the cotton from the jaws of the improvised vice , such as two small plates held in a clamp , or any other method of suspension .

2. Place a piece of paper with a vertical mark on it behind the pendulum so that when the latter is at rest it hides the vertical mark from the observer standing in front of the pendulum .

3. Set the pendulum bob swinging through a small arc of about 10° . with a stop-watch measure the time for 20 complete oscillation , setting the watch going when the pendulum passes the vertical mark and stopping it 20 complete later when it passes the mark in the same direction . Repeat the timing and record both times .

4. Measure the length (L) of the cotton from the point of suspension to the middle of the bob .

5. Shorten the length of the pendulum by successive amounts of 5 or 6 cm by pulling the cotton through the vice and for each length take two observation of the time for 20 oscillations .

Exp.2

The density of liquid

Purpose :
To determination the density of liquid by a loaded test tube

Apparatus :
1. test tube or boiling tube wide enough to allow weights to be placed
inside .
2. millimeter graph paper cut to make a scale.
3. 1 gm , 2 gm , and 5 gm weight .
4. a liquid , e.g. water or methylated spirit .
5. calipers , beaker , sand , and lead shot .

Theory :

The purpose of this experiment is to understand the meaning and significance of the density of a
substance. Density is a basic physical property of a homogeneous substance; it is an intensive property, which
means it depends only on the substance's composition and does not vary with size or amount. The determination
of density is a nondestructive physical process for distinguishing one substance from another. Density is the
ratio of a substance's mass to its own volume.

$$D = \frac{m}{V} = \frac{mass}{volume}$$

In the metric system the unit of density for a liquid or solid is measured in g/mL or g/cm3. The cm3 volume unit used with solids is numerically equal to mL volume unit used with liquids. That is, 1 mL = 1 cm3. In this experiment you will determine the density of several liquids and compare the physical properties of those liquids.

From the definition of the gram and the milliliter, we can see that one mL of water at 4 oC would have a mass of exactly one gram. The density of water, then, is one g/mL at 4 oC. Since the volume occupied by one gram of water varies slightly with temperature, the density also varies slightly with changes in temperature.

The mass of any object is determined by comparing its mass with the mass of known object or objects(*i.e.*, it is weighed). The volume of a liquid is measured using a graduated cylinder, a pipet, or some other volumetric apparatus.

The volume of a regular solid (e.g. a cube or a sphere) may be determined by measuring its dimensions and then calculating it using the correct mathematical formula. The difficulty in determining the volume of an irregular solid in this manner is obvious. The method commonly used is to measure the change in the volume of water when the object is immersed in the water. The object displaces a volume of water equal to its own volume. If the solid material is soluble in water, another liquid

Dependence of Density on Temperature

The density of all solid, liquid and gaseous materials depends on temperature.

Aside from temperature, the density of gaseous materials also depends on pressure. Gases are compressible at "normal" pressure; this means that air density changes when the air pressure changes.

The normal density is the density of a gas (or combination of gases) under normal physical conditions: temperature T = 0 °C, pressure p = 101.325 kPa.

A general rule is: The higher the temperature, the lower the density. Materials expand when heated; in other words: their volume increases. Therefore the density of materials will decrease as their volume increases. This is more noticeable in liquids than in solids, and especially in gases.

The change in density over a certain temperature interval can be calculated using the heat expansion coefficient; this will yield the change in volume of a material in relation to the temperature (see Appendix, page xx).

The following diagrams show the density of various substances calculated in relation to the

temperature – the x axes show density in intervals of 0.06 g/cm3 (except in the case of air).
As can be seen from these diagrams, temperature affects some substances more strongly than
others. For density determination, this means that – depending on the required accuracy of
measurement, of course – the test temperature must be set very precisely and kept constant.

Buoyancy Method

For high-precision measurement, another consideration besides the air buoyancy is the additional
buoyancy of the pan hanger wires, caused by the fact that the height of the liquid is increased
when the sample is immersed which means the wires are deeper under the surface than without the sample. (The buoyancy of the pan hanger assembly is not included in the density calculation if the weighing instrument is tared with the pan hanger assembly.) With the procedure for using the buoyancy method with the Density Determination Set, the wires of the pan hanger assembly are deeper under the surface of the water when the sample is immersed because the volume of the sample causes more liquid to be displaced. Because more of the wire is immersed, it causes more buoyancy; the additional buoyancy can be calculated and corrected for in the results.
The amount of volume by which the liquid increases in a container with diameter D corresponds to the volume V_{fl} in Figure 1

$$V_n = \frac{\pi\ D2}{4}x$$

The volume V_s of the sample is

$$V_s = \frac{m}{p}$$

These two volumes are identical, $V_{fl} = V_s$. Using the above equations and solving for h, the increase in height of the liquid, yields

$$x = \frac{m4}{\rho\pi D2}$$

$$p = \frac{4m}{\pi d2x}$$

Apparatus :

1. test tube or boiling tube wide enough to allow weights to be placed
inside .
2. millimeter graph paper cut to make a scale.

3. 1 gm , 2 gm , and 5 gm weight .
4. a liquid , e.g. water or methylated spirit .
5. calipers , beaker , sand , and lead shot .

Procedure :

1- cut and fold the graph paper as a lining to the inside of the test tube to serve as a suitable scale .
2- load the test tube with sand or lead short so that it floats vertically
in the liquid with the zero mark just immersed .
3- Note the depth of immersion $\mathbf{h_o}$ of the zero mark .
4- Add a 1gm weight to the test tube and record the new depth of immersion **h** of the zero mark .
5- Continue to add a 1gm weight to the test tube and measure the new depth of immersion each time .
6- Tabulate the recorded reading as shown in the table below:
7- Plot a graph with values of **x** (mm) as ordinates against corresponding values of the additional load **m (gm)** as abscissa .

EXP . 3

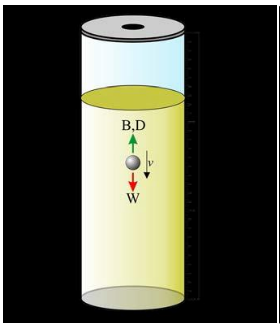
Viscosity of liquid

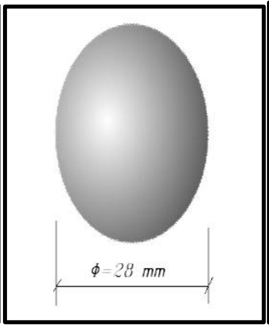
Purpose :

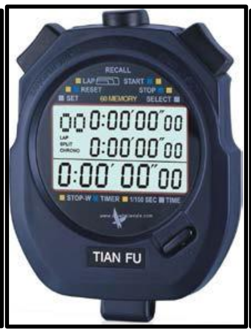
To determine the viscosity of the medium by using a small sphere falls
with constant terminal velocity.

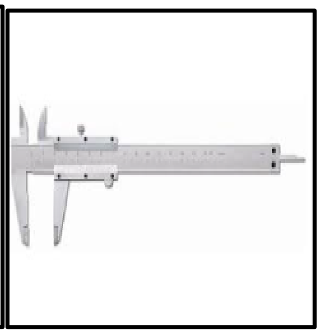
Apparatus :

1. A long glass tube about 50 cm long closed at one end .
2. Oil .
3. Meter scale .
4. Small sphere .
5. Rubber bands .
6. Magnet .
7. stop watch









<u>Theory</u>:

<u>**Viscosity** describes how a liquid resists the laminar movement of two neighboring layers.</u> This resistance to flow can be seen with gases, liquids and even solids.

Viscosityis a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress. In everyday terms (and for fluids only), viscosity is "thickness" or "internal friction". Thus, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity. Put simply, the less viscous the fluid is, the greaterits ease of movement (fluidity).

Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. For
example, high-viscosity felsic magma will create a tall, steep stratovolcano, because it cannot flow far before it
cools, while low-viscosity mafic lava will create a wide, shallow-sloped shield volcano. All real fluids (except superfluids) have some resistance to stress and therefore are **viscous**, but a fluid which has no resistance to shear stress is known as an **ideal fluid** or **inviscid fluid**.

Etymology

The word "viscosity" derives from the Latin word "viscum alba" for mistletoe. A viscous glue called birdlime was made from mistletoe berries and used for lime-twigs to catch birds.

Properties and behavior Overview

Laminar shear of fluid between two plates. Friction between the fluid and the moving boundaries causes the fluid to shear. The force required for this action is a measure of the fluid's viscosity. This type of flow is known as a Couette flow. In general, in any flow, layers move at In general, in any flow, layers move at In general, in any flow, layers move at viscosity arises from the shear stress between the layers that ultimately opposes any applied force.
The applied force is proportional to the area and velocity gradient in the fluid and inversely proportional to the distance between the plates.

Viscosity coefficients

Viscosity coefficients can be defined in two ways:

- **Dynamic viscosity**, also **absolute viscosity**, the more usual one (typical units Pa·s, Poise, P);
- **Kinematic viscosity** is the *dynamic viscosity* divided by the density (typical units m^2/s, Stokes, St).

Units

Dynamic viscosity

The usual symbol for dynamic viscosity used by mechanical and chemical engineers — as well as fluid dynamicists
— is the Greek letter mu (μ). The symbol η is also used by chemists, physicists, and the IUPAC.The SI physical unit of dynamic viscosity is the pascal-second (Pa·s), (equivalent to $N\cdot s/m^2$, or kg/(m·s)). If a fluid with a viscosity of one Pa·s is placed between two plates, and one plate is pushed sideways with a shear stress of one

pascal, it moves a distance equal to the thickness of the layer between the plates in one second. The cgs physical unit for dynamic viscosity is the *poise* (P), named after Jean Louis Marie Poiseuille. It is more commonly expressed, particularly in ASTM standards, as *centipoise* (cP). Water at 20 °C has a viscosity of 1.0020 cP or 0.001002 kg/(m·s).

$1\ P = 1\ g \cdot cm^{-1} \cdot s^{-1}$.

$1\ Pa \cdot s = 1\ kg \cdot m^{-1} \cdot s^{-1} = 10\ P$.

The relation to the SI unit is

$1\ P = 0.1\ Pa \cdot s$,

$1\ cP = 1\ mPa \cdot s = 0.001\ Pa \cdot s$.

Kinematic viscosity

In many situations, we are concerned with the ratio of the inertial force to the viscous force , the former characterized by the fluid density ρ.

This ratio is characterized by the

kinematic viscosity (Greek letter nu, v), defined as follows:

$$v = \frac{\mu}{\rho}$$

The SI unit of v is m^2/s. The SI unit of ρ is kg/m3.

The cgs physical unit for kinematic viscosity is the *stokes* (St), named after George Gabriel Stokes. It is sometimes

expressed in terms of *centiStokes*(cSt). In U.S. usage, *stoke* is sometimes used as the singular form.

$1\ St = 1\ cm^2 \cdot s^{-1} = 10^{-4}\ m^2 \cdot s^{-1}$.

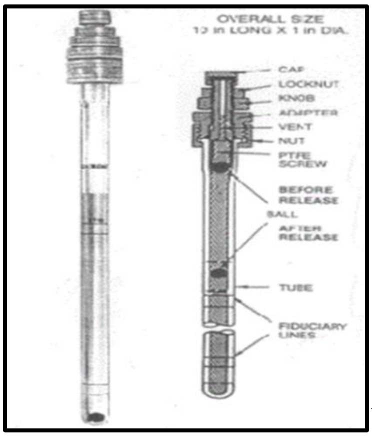
1 cSt = 1 mm2·s−1 = 10−6m2·s−1.

Water at 20 °C has a kinematic viscosity of about 1 cSt.

Viscosity can be determine *of liquid* followedusing an

1- Ostwald viscometer
2- Falling ball viscometer

Viscosity can be determine by falling ball viscometer



Viscosity is a fluid property defined as the fluid's resistance to an externally applied shear. From this definition, it is implied that a fluid will resist any change in form.

When a sphere is placed in an infinite incompressible Newtonian fluid, it initially accelerates due to gravity. After this brief transient period, the sphere achieves a steady settling velocity (a constant terminal velocity). For the velocity to be steady (no change in linear momentum), Newton's second law requires that the three forces acting on the sphere, gravity (F_G), buoyancy (F_B), and fluid drag (F_D) balance. These forces all act vertically and are as follows:

gravity: $F_G = -\frac{\pi}{6}\rho_p D_p{}^3 g$ (1)
buoyancy: $F_B = +\frac{\pi}{6}\rho D_p{}^3 g$ (2)
fluid drag: $F_D = \frac{\pi}{8}\rho V_p{}^2 D_p{}^2 C_D$ (3)

where ρ_p is the density of the solid sphere, ρ is the density of the fluid, D_p is the diameter of the solid sphere, g is the gravitational acceleration (9.8 m/s2), V_p is the velocity of the sphere, and C_D is the drag coefficient. The gravitational force is equal to the weight of the sphere, and the sign is negative because it is directed downward. The buoyancy force acts upwards and is equal to the weight of the displaced fluid. The drag force acts upwards and is written in terms of a dimensionless drag coefficient. The drag coefficient is a unique function of the dimensionless Reynolds number, Re. The Reynolds number can be interpreted as the ratio of inertial forces to viscous forces. For a sphere settling in a viscous fluid the Reynolds number is

$$Re = \rho V_p D_p / \mu \quad (4)$$

where μ is the viscosity of the fluid. If the drag coefficient as a function of Reynolds number is known the terminal velocity can be calculated. For the Stokes regime, Re<1, the drag coefficient can be determined either analytical (as will be shown later in the course) or empirically. Under these conditions C_D = 24/Re and the settling velocity is

$$V_p = g D_p^2 (\rho_p - \rho)/18\mu (5)$$

$$\mu = g D^2 (\rho - \sigma)/18V (5)$$

Procedure :

1. Adjust the distance between the rubber band .
2. Record the distance (h) between them . (about 30 cm).
3. Drop a sphere centrally down the jar & with stop-watch find the time it take to traverse the distance between the rubber band .
4. Obtain two values of the time of fall.
5. Repeat the experiment for different value of (h) & obtain two values of the time of fall for each new distance apart .

Reading :

Plot a graph with values of (h) cm as ordinates against the corresponding values of t(sec) as abscissa .
From the graph calculate the terminal velocity .
Slope = h / t = velocity (cm / sec)
Calculate the viscosity from equation (1)

EXP . 4

The surface tension

Purpose :
To calculate the surface tension of water by the capillary tube method
Apparatus :
1. Set of three capillary tubes .
2. Traveling microscope or glass scale .
3. Beaker .
4. stand and clamp .
5. thermometer .

Theory:

Is the interface between two materials physical properties change rapidly over distances comparable to the molecular separation scale.
Since a molecule at the interface is exposed to a different environment than inside the material, it will also have a different binding energy.
Than this upward force balances the person's weight.
Molecules sitting at a free liquid surface against vacuum or gas have weaker binding
than molecules in the bulk. The missing (negative) binding energy can therefore be viewed
as a positive energy added to the surface itself. Since a larger area of the surface contains
larger surface energy, external forces must perform positive work against internal surface
forces to increase the total area of the surface.Mathematically, the internal surface forces are
represented by surface tension, defined as the normal force per unit of length. This is quite
analogous to bulk tension (i.e. negative pressure), defined as the normal force per unit of area.

In homogeneous matter such as water, surface tension does not depend on how much the
surface is already stretched, but stays always the same. Certain impurities, called surfactants,
have dramatic influence on surface tension because they agglomerate on the surface and form
an elastic skin which resists stretching with increasing force.Best known among these are
soaps and detergents from which one can blow so beautiful bubbles. A lipid membrane also
surrounds every living cell and separates the internal biochemistry from the outside.

DEFINITION OF SURFACE TENSION

The surface tension γ is the magnitude F of the force exerted parallel to the surface of a liquid divided by the length L of the line over which the force acts:

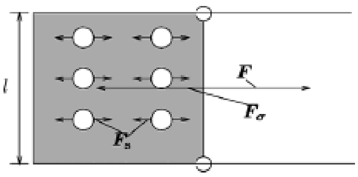
$$\gamma = \frac{F}{L}$$

SI Unit of Surface Tension: N/m

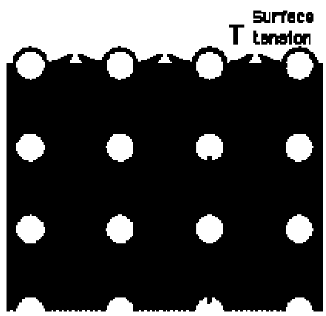
2.6.1 Definition of Surface Tension

- Definition

$$\boxed{\sigma = \frac{F_\sigma}{l}}$$



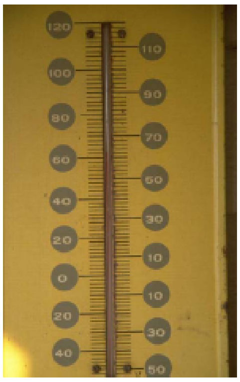
  - Quotient of **force** over **length**



- Term „tension“ bad choice
  - Commonly referred to as force per **area**
- More physical definition of surface tension
  - Product of **tension times length**
  - Scaling with
    - Surface density of (surface) force (tension) F_s / A
    - Perimeter of contact region l

2.6.1 Temperature Dependence

- Surface tension decreases with temperature
  - Empirical formula $\boxed{\sigma(T) = k(\tilde{T} - T)^n}$
  - $n \sim 2$
  - Surface tension strongly decreases with T
    - Phenomenon related to coexistance of two phases
    - Two phases „merge" towards increasing T
  - $\tilde{T}$ lies about 6 K below critical temperature T^*
    - e.g. T^* = 647.4 K for H_2O



Cohesion and Surface Tension

• Molecules liquid state experience strong intermolecular attractive forces. When those forces are between like molecules, they are referred to as cohesive forces.
• Molecule deep (greater than several molecular diameters ~ about 10-9 to 10-8 m) in the fluid are pulled equally in all directions by its neighbors, i.e. there is no net force on it.
• Those on the surface have no neighboring atoms above, and exhibit stronger attractive forces upon their nearest neighbors on the surface. This enhancement of the intermolecular attractive forces at the surface is called surface tension.

Adhesion and Surface Tension

The cohesive forces between liquid molecules are responsible for the phenomenon known as surface tension. The molecules at the surface do not have other like molecules on all sides of them and consequently they cohere more strongly to those directly associated with them on the surface.
This forms a surface "film" which makes it more difficult to move an object through the surface than to move it when it is completely submersed.
Surface tension is typically measured in dynes/cm, the force in dynes required to break a film of length 1 cm. Equivalently, it can be stated as surface energy in ergs per square centimeter. Water at 20°C has a surface tension of 72.8 dynes/cm compared to 22.3 for ethyl alcohol and 465 for mercury.

Methods of surface tension measurements

There are several surface tension measurements

1- Capillary rise method
2- Stallagmometer method – drop weight method
3- Wilhelmy plate or ring method
4- Dynamic method
5- Method analyzing shape of the hanging liquid drop or gas bubble
6- Maximum bulk pressure method

Capillary rise method

We have seen that surface tension arises because of the intermolecular forces of attraction that molecules in a liquid exert on one another. These forces, which are between like molecules, are called ***cohesive forces***. A liquid, however, is often in contact with a solid surface, such as glass. Then additional forces of attraction come into play. They occurbetween molecules of the liquid and molecules of the solid surface and, being between unlike molecules, are called ***adhesive forces***.
Consider a tube with a very small diameter, which is called a capillary. When a

capillary, open at both ends, is inserted into a liquid, the result of the competition
between cohesive and adhesive forces can be observed. For instance, Figure 5 shows a
glass capillary inserted into water. In this case, the adhesive forces are stronger than the
cohesive forces, so that the water molecules are attracted to the glass more strongly than
to each other. The result is that the water surface curves upward against the glass. It is
said that the water "wets" the glass. The surface tension leads to a force **F** acting on the
circular boundary between the water and the glass. This force is oriented at an angle φ,
which is determined by the competition between the cohesive and adhesive forces. The
vertical component of **F** pulls the water up into the tube to a height h. At this height the
vertical component of **F** balances the weight of the column of water of length h.

Figure shows a glass capillary inserted into mercury, a situation in which the
adhesive forces are weaker than the cohesive forces. The mercury atoms are attracted to
each other more strongly than they are to the glass. As a result, the mercury surface
curves downward against the glass and the mercury does not "wet" the glass. Now, in
contrast to the situation illustrated in Figure 5, the surface tension leads to a force **F**, the
vertical component of which pulls the mercury down a distance h in the tube. The
behavior of the liquids in both Figures is called ***capillary action***

$F_1 = 2\pi\, r\, \gamma \cos\theta$

$F_2 = W = \rho\, g\, \pi\, r^2 h$

In equilibrium (the liquid does not moves in the capillary)

$$F_1 = F_2$$

$$2\pi\, r\, \gamma \cos\theta = \rho\, g\, \pi\, r^2\, h$$

$$\gamma = \frac{rhpg}{2\cos\theta}$$

If the liquid completely wets the capillary walls the contact angle θ=0 and

$$\cos\theta = 1$$

$$= \frac{rhpg}{2}$$

Procedure :

1. Fill the beaker to overflowing with water so that the water level
stands up above the glass , as shown in fig (1) .
2. Hold the capillary tube in a clamp with its lower end immersed
in water .
3. Measure the height (h) to which the water level rises in the capillary tube above the level of the water in the beaker
4. Also , measure the internal diameter of the capillary tube by using a traveling microscope , ($d = d_1 - d_2$) (show fig (2)) .
5. Repeat all the measurement with the other capillary tubes .
6. Record the temperature of the water , because the surface tension changes with change in temperature .

EXP . 5

Boyle´s Law

Purpose :
Verify Boyle´s Law by measurement the pressure of the atmosphere .

Apparatus :
Glass tube containing mercury as shown .

Theory:

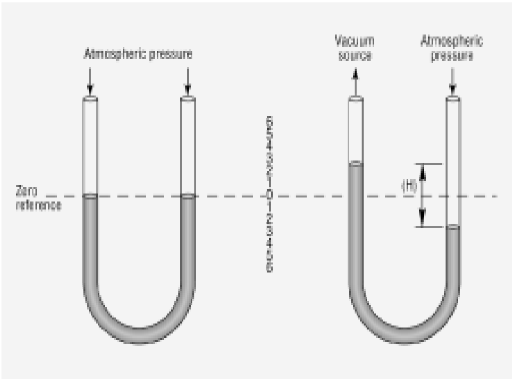
Boyle’s Law 1662
• The product of the volume and pressure of a given quantity of gas at a constant temperature is a constant. $P_1V_1 = P_2V_2$
• This is the defining property of gas as a state of matter!
• Two methods of demonstrating Boyle’s Law will be presented. Each method can be used to determine the magnitude of atmospheric pressure – an important and useful value

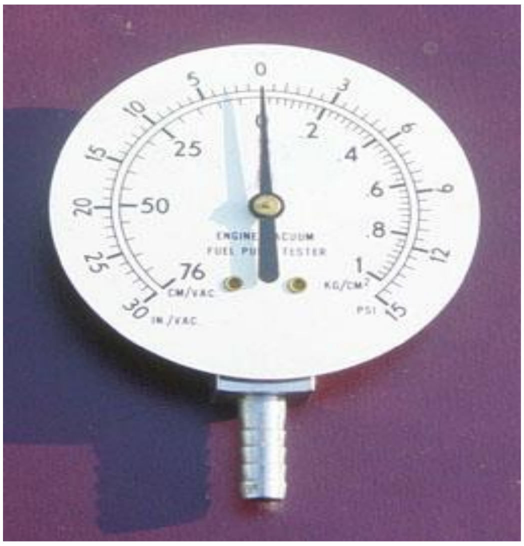
Measuring Pressure

1- U-tube manometers
2- Barometers

Barometers and U-tube manometers are devices used to measure pressure. In a barometer, the height of a column of mercury (in millimeters) equals the atmospheric pressure, in millimeters of mercury. (1 mm Hg = 0.133 kPa).
The tube of an open-ended manometer is open, at one end, to the atmosphere. Therefore, atmospheric pressure is being exerted on the column of mercury in that arm of the tube. If the height of the mercury in the open arm is greater than that in the other arm, the difference between the two heights must be added to the atmospheric pressure to find the pressure of the confined gas, in mm Hg. If the height in the open arm is Jess than that in the other arm, the difference

in height must be subtracted from the atmospheric pressure.
After you have calculated the pressure in millimeters of mercury, convert the answer to kilopascals by multiplying by the conversion factor 0.133$\frac{KPa}{mmHg}$





a b

Figure 1 (a) Measurement of vacuum by a U tube manometer

(b) Bourdon gage to measure pressures above and below atmospheric Pressure

<u>type of manometers are used</u>

1. Simple Manometer
2. Micromanometer
3. Differential manometer
4. Inverted differential manometer

Procedure :

1. keep the mercury levels X and Y in the same position . Record the scale reading of these levels and also the scale reading of (A) , the inside of the closed end of the tube (AB). This is the balance point (i.e. X=Y) .
2. Rising the tube CD (above the balance point) , and recored the scale reading of X and Y levels .
3. Take about four sets of reading over the balance point .
4. Now, lowering the tube CD below the balance point , and

record the scale reading of X and Y levels .
6. Take about four sets of reading below the balance point .

Readings and calculation :

1. Make the following table :

2. Plot a graph for the values of h(cm) as ordinates against the corresponding values of 1/L (cm^{-1}) as abscises .
3. If the plot of h against 1/L yields a straight line , Boyles law is verified and the negative intercept on the h-axis is numerically equal to B (atmospheric pressure ~ Barometric height =76 cm)
4. from the graph ; if h=0 , find the value of 1/L =?
B=76 cm .find the value of C/K from equation (1).

EXP . 6

Spectrophotometer

Purpose

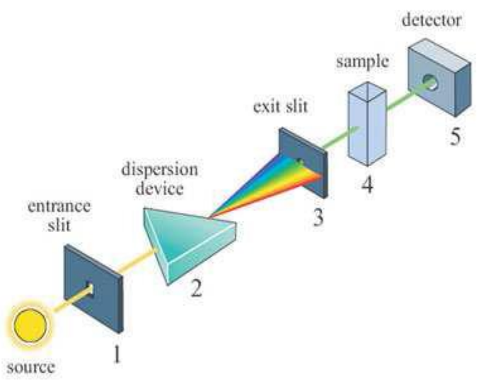
To prepare a calibration curve of $CuHCO_3$ from a series of standard solution to use it as a reference curve to obtain the absorbens(ε)and determination the concentration of unknownsample .

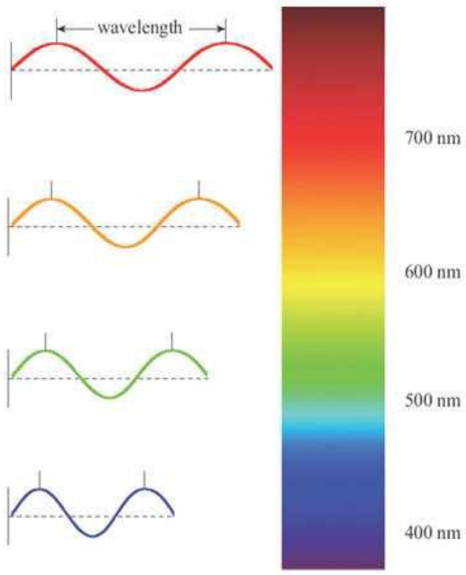
Apparatus

1- Spectrophotometer .
2- Blank Solution .
3- Stock solution .

Theory

A spectrophotometer is an instrument that determines how much light of a particular colour is absorbed by a liquid sample. The more there is of a coloured substance in the solution, the more light will be absorbed (i.e. the less light passes through the solution). After measuring how much light is absorbed by a series of solutions containing known concentrations of the coloured substance, you can draw a graph of this data and use it to calculate the concentration of that substance in an unknown sample from a measurement of how much light it absorbs.





When light falls on a liquid , some is reflected and the rest is partly and partly transmitted . Spectra Photometric method of analysis is usually concerned with measurement of the amount of light absorbed or with comparison of the absorption or transmission of two solution one of which is a standard of known composition .

Absorption Spectroscopic methods of analysis are based upon the fact that compounds ABSORB light radiation of a specific wavelength. In the analysis, the amount of light radiation absorbed by a sample is measured. The light absorption is directly related to the concentration of the colored compound in the sample.

The Beer-Lambert Law

The Beer-Lambert Law is illustrated in Figure. The Absorbance (or optical density) and
Transmission (or Transmittance) of light through a sample can be calculated by measuring
light intensity entering and exiting the sample,

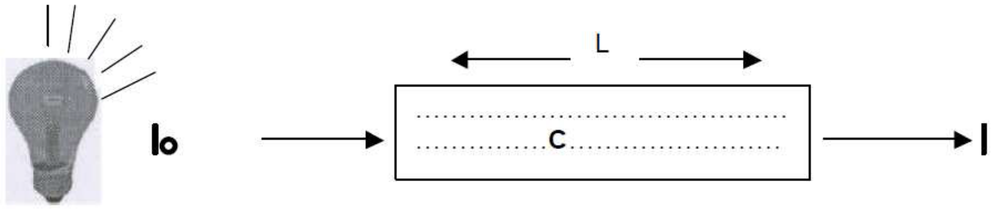


Figure: Light energy of Intensity I_0passes through a sample with
concentration 'C'. Some light energy is absorbed by the sample. The amount of light energy exiting the sample has IntensityI

The following terms are defined:
· Light Intensity entering a sample is "I_0"
· Light Intensity exiting a sample is "I"
· The concentration of analyte in sample is "C"
· The length of the light path in glass sample cuvette is "L" .
· "ε" is a constant for a particular solution and wave length

The Beer-Lambert Law is given by the following equations:
Light Absorbance (A) = $\log (I_0 / I) = \varepsilon CL = -\log T$
Light Transmission (T) = I/I_0

As Concentration (C) increases, light Absorption (A) increases, linearly.

The Percentage of transmission % = transmission Light × 100

There are two type of spectrophotometer

1- U.v which read absorbance for colorless solution wavelength (λ) 200 – 400nm .

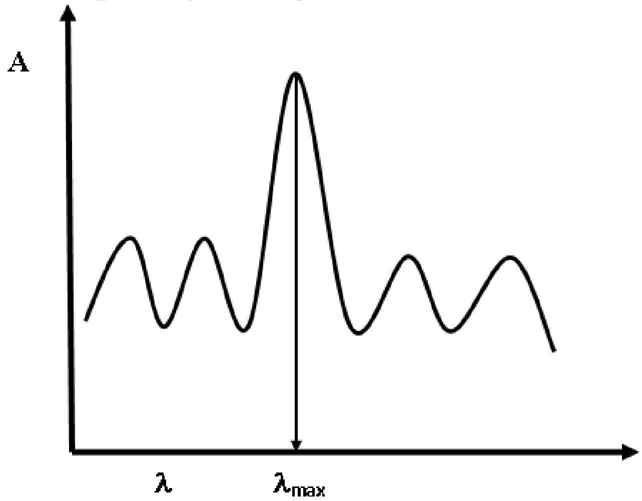
2- Visible which read absorbance for colored solution wavelength(λ)400-740 nm .

Absorption depend on: -

1- Concentration of sample .

2- Molecular Composition of sample .

3- Frequency of light .



Blank Solution is the medium which contains all the substance in the sampleexcept the active ingredient which required to be measured .

Procedure

1- Prepare 100 ml of (0.1M) $CuHCO_3$

2- From the stock solution of$CuHCO_3$prepare dilutionsolutions (0.01 , 0.02 , 0.03 , 0.04 , 0.05) M

3- Find the absorbance vs conc. of $CuHCO_3$ at λ_{420nm}

4- Apply the least square method to calculate the a (slope) andC(intersect point). Using regression .

5- Analysis equation to calculate y. y= b + ax

6- Draw the line of best fit curve result and calculation .