01/ Fluid Properties

Objectives:

- Measurement of density and specific gravity.

Theoretical study:

Fluid Properties:

Density

Density is defined as the amount of mass of a substance contained per unit volume. $\rho = \frac{m}{V} \ [Kg.m^{-3}]$

It can be expressed as, specific weight or specific volume.

Specific Weight: Weight of fluid per unit of its volume.

$$\gamma = \frac{mg}{V} = \rho g \quad [N.m^{-3}]$$

Specific Volume: Volume of substance per unit of its mass.

$$V_S = \frac{1}{\rho} \quad [m^3.Kg^{-1}]$$

It must be taken into account that the density of a liquid is practically constant, since the volume occupied by a given mass of a liquid is almost invariable. But in the case of gases, density varies depending on the volume occupied (for a mass of such a gas). As a result of that, a liquid can be considered virtually incompressible (except when it is working in critical conditions), while gases are compressible.

Specific gravity or **relative density** of a fluid is defined as the Ratio of density of a substance to the density of pure water at 4°C; therefore, it has no units. SG = $\frac{\rho_{fluid}}{\rho_{water\ at\ 4°C}}$

Experimental study:

- take a beaker and measure its weight on the scale
- take 10 cc (cm^3) or ml of each liquids in the beaker.
- measure the weight on the scale again and deduce the weight of the liquid.
- calculate the density taking into account the universal units.

Tables and results

- Calculate specific gravity from the density value obtained.
- Record the results obtained in the plot below taking into account the values of the atmospheric pressure and the temperature at the moment the practical exercise was performed and take the same number of significant.
- Complete data in the following table:

Liquid	Density	Specific gravity	Specific Weight	Specific Volume
Ricinus oil refined				
Paraffin (extra pure)				
Olive oil (extra pure)				
Glycerol (extra pure)				
Acetone (extra pure)				
Vegetable oil				
Bingo machine liquid				
AmirClean dishwasher liquid				
Water				

02/ Pascal's Principale

Objectives:

- understand Pascal's law under an experiment.

Theoretical study:

The Definition of Pressure

Pascal gives us the definition of pressure, that P = F/A it is a force over an Area.

The SI unit is **'pascals (Pa)'**. 1 Pa = 1N/m^2 .

Pressure is something that exists in a fluid, it is everywhere equal, at a given height. And, pressure, being a force causes acceleration. Fluids will flow from a place of high pressure to a place of low pressure, by Newton's 2nd Law, it's a net force. And because of area difference, it is possible to establish a mechanical advantage. Either using hydraulic pressure (liquids) or pneumatic pressure (gases).

But, pressure can also be measured by depth, Pascal explains this too. P = ρgh means that pressure doesn't depend on area, only depth h and density ρ (usually constant), so we can use depth to predict pressure.

Experimental study:

Two syringes of unequal volumes are connected to each other by a plastic tube. The system is full of a green fluid. The syringes are representative of pistons, displaying the mechanical advantage of one over the other. PROCEDURE

-Record the initial volume of the fluid in each syringe.

-Record the top area of the syringes.

- Apply force using mass from a lab set.

-observe the amount of output force on the large syringe.

-Be careful not to spill fluid!!

-Change the height and repeat again.

	Surface (m^2)	Mass (*kg*)	weight (*N*)	Pressure (Pa)
syringe 1				
syringe 2				

03/ Measure liquid viscosity (Part 1): Viscometer

***Objectives**:*

-A direct measure of the dynamic viscosity using BROOKFIELD Dial Reading Viscometer LVT.

***Theoretical study**:*

The viscosity of a fluid is a physical quantity that characterizes its resistance to flow. It is measured in Pa.s (Pascal.second), is noted μ and depends strongly on the temperature for liquids.

The Brookfield Viscometer rotates a sensing element in a fluid and measures the torque necessary to overcome the visvous resistance to the induced movement. This is accomplished by driving the immersed element, which is called a ***spindle,*** through a beryllium copper spring.

The degree to which the spring is wound, indicated by ***red pointer***, is proportional to the viscosity.

***Experimental study**:*

***Equipment**:*

-BROOKFIELD Dial Reading Viscometer LVT.

-spindle N° 63.

-Factor Finder.

-liquids in beaker.

***part name**:*

Measurements:

-Adjust the level screw, so that the bubble on a horizontal scale is centred

-We take the spindle number 63 in LV series.

-Insert and center spindle in the beaker (test material) until the fluid's level is at the immersion groove on the spindle's shaft. With a disc-type spindle, it is sometimes necessary to tilt the spindle slightly while immersing to avoid trapping air bubbles on its surface. (You may find it more convenient to immerse the spindle in this fashion before attaching it to the Viscometer.)

-attached the spindle to the lower shaft. Lift the shaft slightly, holding it firmly with one hand while screwing the spindle on with the other (note **left-hand thread**). Avoid putting side thrust on the shaft.

-To make a viscosity measurement, select a speed and attached the spindle to the viscometer by screwing them to the male coupling nut. Note that the spindles and coupling have a **left-hand thread**. The lower shaft should be held in one hand (lifted slightly), and the spindle screwed to the left. The face of the spindle nut and the matching surface on the coupling nut shaft should be smooth and clean to prevent eccentric rotation of the spindle. Spindles can be identified by the number on the side of the spindle coupling nut.

-Allow time for the indicated reading to stabilize. The time required for stabilization will depend on the speed at which the Viscometer is running and the characteristics of the sample fluid. For maximum accuracy, readings below 10% should be avoided.

-For dial reading (the measurement), we press at the same time (motor switch pause-clutch lever).

-To convert Viscometer dial reading to centipoise (mPa.s) we use the factor finder.

- Switch the **MOTOR ON/OFF** switch to turn the motor "**OFF**" when changing samples.

-Remove spindle before cleaning with Acetone.

-Report Complete data in the following table:

Liquid	RPM	Dial reading % torque	Factor	Viscosity (cp)	Temp (°C)
Ricinus oil refined	12				
	30				
	60				
Paraffin (extra pure)	12				
	30				
	60				
Olive oil (extra pure)	12				
	30				
	60				
Glycerol (extra pure)	6				
	12				
	30				
Bingo machine liquid	6				
	12				
	30				
Amir dishwasher liquid	6				
	12				
	30				

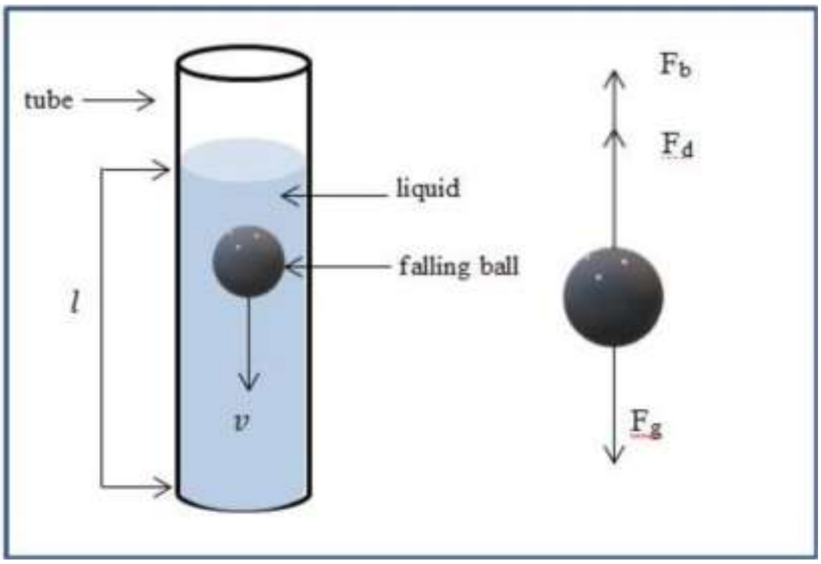
-Give your notes, and conclusion.

04/ Measure liquid viscosity (Part 2): Stoke's Law

Objectives:

-Measure the dynamic viscosity and kinematic viscosity of certain liquids by applying the stock law.

Theoretical study:



Consider a ball that is dropped into a column of fluid. The ball will eventually reach a constant terminal velocity at which acceleration has ceased. The surface and body forces acting on the ball are the drag force (F_d), buoyant force (F_b), and gravity force (F_g).

The viscous drag of a falling ball results in the creation of a restraining force (F) described by Stokes' law: $F_d = 6\pi\, \mu\, r\, v$

where is F_d the drag force, μ is the viscous friction, r is the radius of the falling ball, and v terminal ball velocity in liquid.

At velocity equilibrium state, the net force is zero, so the ball moves in a constant velocity called terminal velocity where the force equilibrium equation for the falling ball given by:

$$\overrightarrow{F_b} + \overrightarrow{F_d} + \overrightarrow{F_g} = \vec{0}$$

where F_b equal to ($\frac{4}{3}\pi r^3 \rho_{liquid}\, g$) and F_g equal to mg.

The only force acting downwards is the body force resulting from gravitational attraction.

By summing forces in the vertical direction, and combining all of the previous relationships that describe the forces acting on the ball in a fluid we can write the following expression:

$$\frac{4}{3}\pi r^3 \rho_{liquid}\, g + 6\pi\, \mu\, r\, v = m_{ball}\, g$$

So the equation of viscosity is:

$$\mu = \frac{D^2\,(\rho_{ball} - \rho_{liquid})}{18\, v}\, g$$

where D is ball diameter, ρ_{ball} is ball density, ρ_{liquid} is the liquid density and g is the earth gravity.

Experimental study:

The velocity of the falling ball in viscous liquid very important in several applications. In this study, we compute ball velocity in liquids. There is limitation condition must be taken into consideration and several important required tools.

Equipment:

The following items are used to perform the measurements and analysis:

- stopwatch.
- iron ball with density ρ_{ball}.
- A cylinder glass tube of length L and diameter (D).
- Liquids test are: Bingo machine liquid and Amir dishwasher liquid.

Measurements:

Fill in the following table:

Measurements		Results	Uncertainty
the inner radius R of the tube			
the distance AB of the tube			
the radius r of the ball			
the mass m of the ball			
the volume V_{ball} $\frac{4}{3}\pi r^3$			
the temperature of liquids	Bingo machine liquid		
	AmirClean dishwasher liquid		

The procedure steps to determine viscosity using the suggested system as follow:

- Drop the ball freely in the liquid without touching the wall, otherwise, repeated again.
- Start recording time for the motion of the free ball falling using the stopwatch, then finish the recording when the ball reaches the bottom of the tube.

- Complete data in the following table:

Time (s)					
Velocity v(m/s)					
Δv					
dynamic viscosity μ					
μ_{moy} (Pa.s)					
$\Delta\mu$					
kinematic viscosity ν					
ν_{moy} (m^2. S^{-1})					
$\Delta\nu$					

- According to this experiment, is Stokes' law well verified?
- Conclusion.

We give $g = 9.81 m/s^2$

05/ Archimedes' thrust

Objectives:

– Study the resultant fluid force acting on the body submerged in a fluid rest.

– find out what are the factors governing Archimedes' thrust

Archimedes' thrust

When a stationary body is completely submerged in a fluid, the resultant fluid force acting on the body is called the buoyant force. A net upward vertical force results because pressure increases with depth and the pressure forces acting from below are larger than the pressure forces acting from above. Archimedes Principle states that the buoyant force acting on the body immersed in fluid is equal to the weight of fluid displaced by the body.

This principle explains the loss of weight in a body immersed in fluid, which is equal to the weight of fluid displaced by it. The volume of fluid displaced by the floating body is just enough to balance its weight.

$$\boxed{F_B = \gamma \not{V}}$$

Where: F_B is the buoyant force, γ is the specific weight of the fluid and $\not{V}$ is the volume of the body.

Experimental study:

Equipment:

- A dynamometer.
- A solid with a hook
- A graduated test tube.

Measurements:

1/ Evolution of the Archimedes force as a function of the immersed volume:

A quantity of liquid is poured into the graduated cylinder so that the cylinder can completely immerse the solid, then the solid is partially immersed in the liquid and each time the immersed volume is noted.

For the different immersed volumes, the weight of the solid when it is suspended in the air (out of liquid) is measured as well as the weight when it is immersed using the dynamometer and the Archimedes thrust is calculated.

submerged Volume (m^3)	weight of solid excluding liquid (N)	weight of solid in liquid (N)	Archimedes thrust (N)	volume of liquid displaced (m^3)	weight of displaced liquid (N)

- Make a single graphic representation on graph paper of the Archimedes' thrust as a function of the immersed volume for the two liquids?
- Determine the density ρ of the two liquids from the slopes?

2/ Evolution of the Archimedes force as a function of the mass of the solid:

we will completely immerse solids with the same volume but a different mass, then we calculate the Archimedes thrust.

	mass (kg)	weight (N)	Volume (m^3)	Archimedes thrust (N)	volume of liquid displaced (m^3)	weight of displaced liquid (N)
solide 1						
solide 2						
solide 3						

— In conclusion, on what factors does Archimedes' thrust depend?

06/ Pressure loss measurement

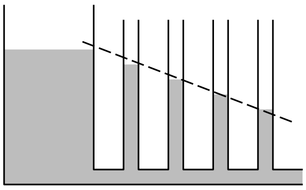
Objectives:

— study and measure the pressure loss along a tube with a constant section.

— measure the volume flow rate.

Theoretical study:

For a real liquid, we observe a regular decrease in pressure throughout the pipe.



Linear pressure losses in a pipe:

The linear pressure losses in a straight pipe of length L and diameter D are given by the following relationship: Head loss: $\mathrm{h_L} = \lambda \frac{L}{D} . \frac{v^2}{2g}$

where λ: coefficient of linear pressure losses. It is a dimensionless constant, a function of the Reynold's number (Re) of the flow. $Re = \frac{\rho\, v\, D}{\mu}$ Where, Re=Reynold's Number.

ρ = Density of fluid, v = Velocity of fluid, D = Diameter of pipe, μ= Viscosity of fluid.

The flow in a circular pipe is laminar for Re < 2000, turbulent for Re > 3000, and transitional in between.

That is,
$Re \lesssim 2000$ (2300) laminar flow
$2000 \lesssim Re \lesssim 3000$ transitional flow
$Re \gtrsim 3000$ (4000) turbulent flow

Laminar flow: $\lambda = \frac{64}{R_e}$

turbulent flow : The Blasius equation: $\lambda = 0{,}316 Re^{-0.25}$ for: $Re < 10^5$

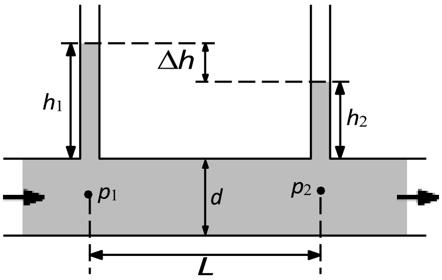
the volume flow rate for laminar flow through a horizontal pipe of diameter D and length L becomes:

$$Q_V = v.S = \frac{\Delta P.R^2}{8.L.\mu}.\pi R^2 = \frac{\Delta P.\pi R^4}{8.L.\mu} = \frac{\Delta P.\pi D^4}{128.L.\mu}$$

This equation is known as ***Poiseuille's law***.

Experimental study:

A tube with constant section of radius r = ….,
colored water, ruler, thermometer.



Measurements

Statics:

– Check the horizontality of the tube and the verticality of the capillary tubes (or vertical columns).

– Fill the bottle with colored water.

– Close the tube outlet and:

— Measure the heights h_1, h_2, h_3 and h_4 of the fluid in each vertical column.

h_1	h_2	h_3	h_4

— What do you observe?

Dynamics:

- Let the water flow into the horizontal tube at a low flow rate. Complete the table:

points	1—2	1—3	1—4
$L\,(m)$			
$\Delta h\,(m)$			
$\Delta p\,(Pa)$			
$Q_V\,(m^3/s)$			
$v\,(m/s)$			
Re			
λ			
$H_L\,(m)$			

– Plot the graph of the pressure losses in water as a function of the length L.

– Comment on your experimental results.

– Conclusion.