3055 BA SANGAM COLLEGE

PH: 6674003/9264117 E-mail: basangam@connect.com.fj

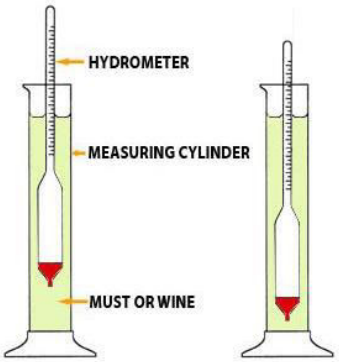
Worksheet 13

School: Ba Sangam College **Year/Level**: 11
Subject: Physics **Name:** _____

Strand	3 – Fluid Statics
Sub-strand	3.3 – Hydrometer and Pressure
Content Learning Outcome	Objective: • Define what a hydrometer is and describe how Archimedes principle is applied to it. • Describe the basic principles of pressure and use these principles to solve practical problems

HYDROMETER

Is an instrument used to measure the relative density of liquids.



- Hydrometer is made up of glass and consists of a cylindrical stem and a bulb weighted with **mercury or lead shot to make it float upright.**
- The liquid to be tested is poured into a tall container, often a graduated cylinder, and the hydrometer is gently lowered into the liquid until it floats freely.
- Hydrometer works on Archimedes principle that is a solid suspended in a fluid will be buoyed up by a force equal to the weight of the fluid displaced by the submerged part of the suspended solid.
- The lower the density of the substance, the farther the hydrometer will sink.

PRESSURE

- Is the force acting on unit area. It is given by:

$$P = \frac{F}{A}$$

Where: P – Pressure (Pa or N/m^2)
F – Force (N)
A- Area (m^2)

- S.I unit for pressure is Pascal (Pa) or Newton per square meter (N/m^2)
- $1Pa = 1\ N/m^2$

Example 1

If a force of 30N acts over an area of $0.5m^2$, what is the pressure on this area?

$$P = \frac{F}{A} = \frac{30}{0.5} = 60\ N/m^2$$

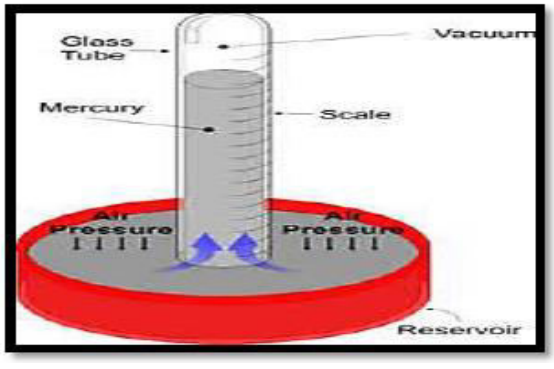
Example 2

If a pressure of 100KPa acts on an area of $2m^2$, what is the total force on this area?

$F = P \times A = 100{,}000 \times 2 = 200{,}000N = 200KN$

THE MERCURY BAROMETER

• Is a glass tube about 1 meter high with one end open and the other end sealed.



• The tube is filled with mercury.
• The glass tube sits upside down in a container, called the reservoir, which also contains mercury.
• The mercury level in the glass tube falls, creating a vacuum on the top.
• The barometer works by balancing the weight of mercury in the glass tube against the atmospheric pressure.
• If the weight of mercury is less than the atmospheric pressure, the mercury level in the glass tube rises.
• If the weight of mercury is more than the atmospheric pressure, the mercury level falls.

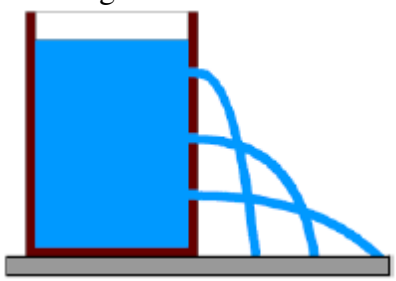
Note: A barometer is an instrument used to measure atmospheric (air) pressure and track weather systems.

Unit: Pascal (Pa)

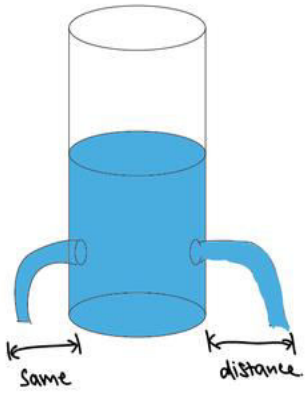
PRESSURE IN LIQUID

The Pressure In A Liquid Increases With Depth

The water gushes out but comes out faster from the holes nearer the bottom where the water is deeper and so the pressure of the water is greater.



• Pressure in liquid is the same horizontally.



Pressure due to the weight of a **liquid** of constant density is given by

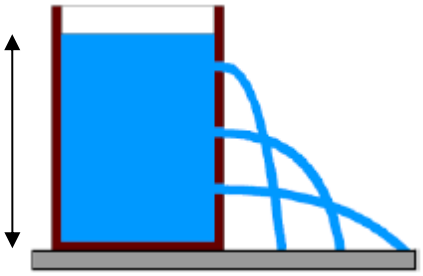
$$P = \rho g h$$

Where: ρ – density (kg/m^3)
g – gravitational acceleration (10 m/ s^2)
h- depth (m)

Note: Depth is measured from the top level of fluid not bottom.

Example

Maca fills a Milo tin with 7.5 cm of water as shown below. Three holes were made 2cm from each other. The top hole was made 1cm below the top level of water. The last bottom hole was made 2.5cm from the base of the tin. Density of water is 1000kg/m^3.



A B C

Calculate the pressure of water at the level from which stream

a) A falls
P = ρgh = 1000(10) (0.01) = 100Pa
b) B falls
P = ρgh = 1000(10) (0.03) = 300Pa
c) C falls
P = ρgh = 1000(10) (0.05) = 500Pa

ACTIVITY 1 **(17 marks)**

1. A girl weighing 60kg wearing high heel shoes stabilizes herself on a single heel. The heel is round with a diameter of

1.5cm. Calculate the pressure applied by the heel on the horizontal floor.

(3 marks)

2. A tank is filled with olive oil is of up to 1m height. Calculate the pressure exerted on the bottom of the tank.(Acceleration due to Gravity = 10 m/s^2, Density of water = 900 kg / m^3).

(2 marks)

3. Find the mass of water which will fit in a large tank measuring 2 m x 1 m x 20 cm. Density of water is 1000 kg/m^3 or 1.0 g/cm^3.

(2 marks)

4. What is the pressure on a surface when a force of 55N acts on area of $10cm^2$?
Note: $1cm^2 = 1 \times 10^{-4}m^2$

(2 marks)

5. A block of concrete weighs 900 N and its base is a square of side 3.0 m. What pressure does the block exert on the ground?

(2 marks)

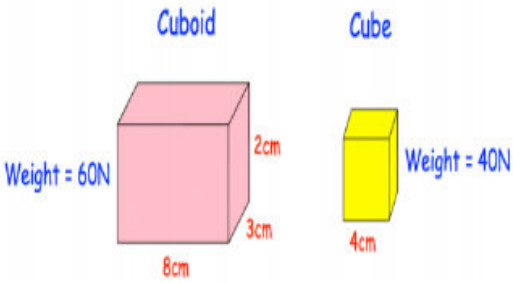
6. A man with a weight of 740 N is standing on one leg. His foot is exerting 2300 N/m^2 of pressure onto the ground. What is the surface area of the bottom of his foot?

(2 marks)

7. A shipping container is removed from a ship and placed on the ground. The area of the container in contact with the ground is $16m^2$ .The pressure exerted on the floor is 2480 N/m^2.What force is being exerted by the shipping container on the ground?

(2 marks)

8. The cuboid and the cube below are placed on the floor. The cuboid has a weight of 60N The cube has a weight of 40N



Which exerts a greater pressure on the ground? You must show your working.

Cuboid

$P = \frac{F}{A} = \frac{60}{0.08 \times 0.03} = 25{,}000Pa = 25KPa$

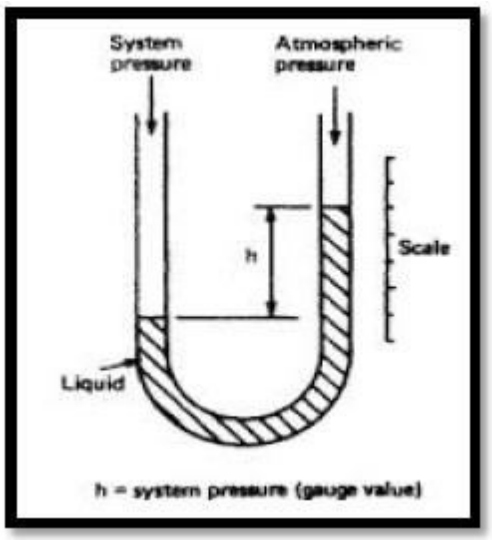
Cube

$P = \frac{F}{A} = \frac{40}{0.04 \times 0.04} = 25{,}000Pa = 25KPa$

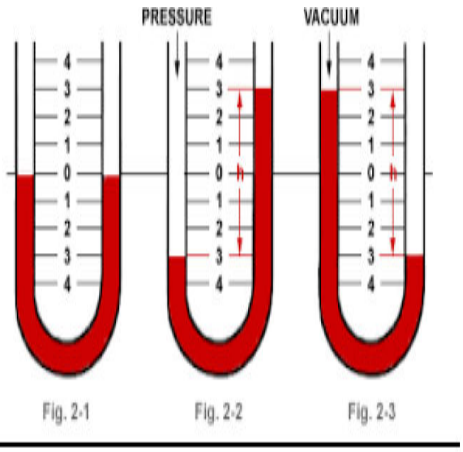
Both exact the same pressure. **(2 marks)**

U-Tube Manometer

- A manometer is a device that **measures pressure with a column of liquid.**
- A simple manometer consists of a U-shaped tube that contains a liquid. If the pressure on one surface of the liquid differs from the pressure on the other surface of the liquid, the liquid will move away from the source of greater pressure.
- Pressure can be calculated using: $P = \rho gh$



Measuring gas pressure by using manometer



• **Figure 2.1** - pressure of gas is equal to the atmospheric pressure.

$$P_{GAS} = P_{atm}$$

• **Figure 2.2** - pressure of gas is less than the atmospheric pressure.

$$P_{GAS} = P_{atm} - h$$

• **Figure 2.3** - pressure of gas is more than the atmospheric pressure.

$$P_{GAS} = P_{atm} + h$$

HYDRAULIC LIFT PRINCIPLE (Pascal's Law)

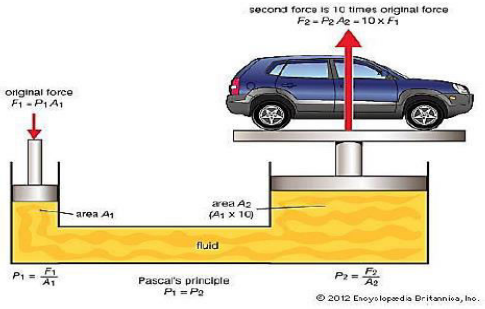
States that same pressure is transmitted from one piston to another through incompressible liquids.

ie

$$\mathbf{P_1 = P_2}$$

$$\frac{\mathbf{F1}}{\mathbf{A1}} = \frac{\mathbf{F2}}{\mathbf{A2}}$$

Hydraulic lift consists of a piston and a cylinder which is filled with a liquid such as oil or water as shown below.

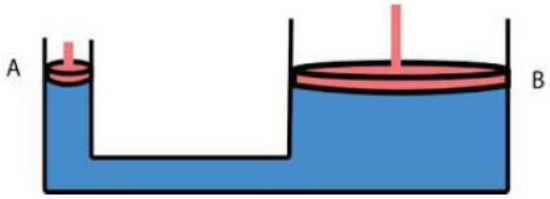


Note:

The area of piston (A_2) is much larger than the area of piston (A_1). This means a much larger force must be produced at Q. A small force applied at P results in a much larger force being produced at Q.

Example

The figure below shows two cylinders connected by a pipe. On each cylinder there is a weightless piston and the space below each piston is full of oil. The area of piston A is $4cm^2$ and the area of piston B is $1800cm^2$. A 6kg mass is placed on A.



a) What is the downward force on A?
F = mg = 6(10) = 60N

b) Calculate the pressure on the oil under A?
$P = \frac{60}{4} = \frac{60}{4\times10-4} = 150{,}000\ N/m^2$

c) Calculate the upward force on B?
$P_1 = P_2$
$F_2 = P_2 \times A_2 = 150{,}000 \times 0.18$
=27,000N
OR

$$\frac{F1}{A1} = \frac{F2}{A2}$$

$$\frac{60}{4\times10-4} = \frac{F2}{0.18}$$

$F_2 = 27{,}000N$

OR

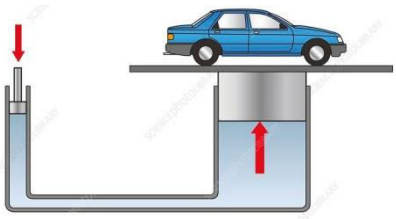
$$\frac{F1}{A1} = \frac{F2}{A2}$$

$$\frac{60}{4} = \frac{F2}{1800}$$

$F_2 = 27{,}000N$

ACIVITY 2 **(3 marks)**

The figure below shows a hydraulic jack used by Asco in order to lift Shivneel's car for the general servicing. The area of piston A is $10cm^2$ and the area of piston B is $2400cm^2$. A 200N force is applied to Piston A inorder to lift the car up.



d) What is the downward force on A?

(1 mark)

e) Calculate the pressure on the oil under A?

(1 mark)

f) Calculate the upward force on B?

(1 mark)

THE END