Experiment No. 8

LIQUID PRESSURE

OBJECTIVES: To determine how liquid pressure varies with the

a. depth of the liquid
b. direction taken in the liquid
c. density of the liquid
d. cross-section of the containing vessel

MATERIALS: Two clear jars of different cross-sections but of almost the same height, U – tube manometer, liquids of different densities, pen and tape for calibration.

THEORY:

When a fluid is confined, it exerts a force **F** which is perpendicular to the walls of the container whose area is **A**. The pressure **p** which is exerted on the walls is defined as the force per unit area. The equation then is presented as

$$p=\frac{\vec{F}}{A}$$

The SI unit of pressure is the pascal (Pa) or 1 N/m^2. Other units are $dyne/cm^2$ and lb/in^2 in cgs and FPS system, respectively.

In a cylindrical water tank the pressure is exerted at all points within the water. The pressure is always normal to the surface of the wall and is independent of the shape of the container. This type of pressure which is caused by the weight of the liquid is called hydrostatic pressure. This pressure is dependent upon the **height** (**y**) of the liquid and its **weight density**. The formula is shown as

$$p=\rho g y$$

where:

ρ → is the mass density of the liquid,
g → is the gravitational acceleration, and
y → depth of the fluid

The mass density **ρ** of a liquid is practically constant since liquids are nearly incompressible, while for gasses, the density is comparatively small and the difference in pressure between two points is negligible if the change in elevation (Δy) is not very great. Due to its compressibility, the density of gasses cannot be considered constant.

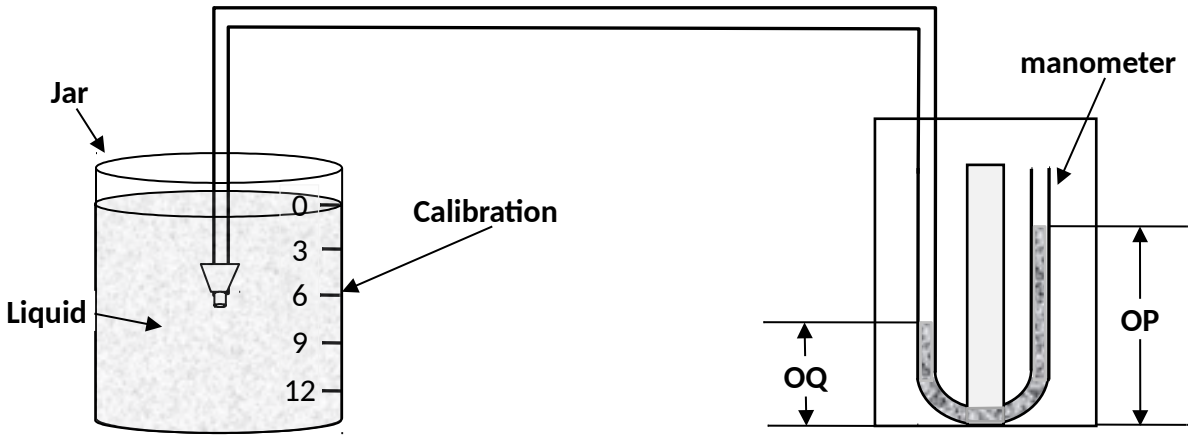
The difference between an unknown pressure and the atmospheric pressure is called **gauge pressure**, and the true pressure is called absolute pressure. The **absolute pressure** is equal to the atmospheric pressure **plus** the gauge pressure. In the case of liquids, the gauge pressure is the same as the liquid pressure. The equation is given by

$$p_{¿} = p_{atm} + \rho g y$$
$$p_{¿}$$

PROCEDURE:

Set the manometer for use. Note down the initial readings of the liquid levels OP (open arm) and OQ (closed arm) and record together with the difference OP – OQ.

DIAGRAM:



A. Variation of Liquid Pressure with Depth

1. Calibrate the smaller jar by 3 cm, with the 0 – mark placed below the mouth of the jar with provision fir the rise in the liquid as the probe is dipped.

2. Fill the jar with water up to the 0 – mark.

3. While keeping an eye on the water level in the manometer, dip the probe of the manometer (upside – down) into the jar of water so that its tip can be placed at 3 cm from the surface of the liquid.

4. At each depth, read and record the heights OP and OQ. Tabulate as shown in table A and complete the table.

B. Variation of Liquid Pressure with Direction Taken in the Liquid

1. Repeat procedure A, with the probe of the manometer directed sideways to the right.

2. Repeat procedure A with the probe of the manometer directed to the left.

3. Tabulate the data in table B and complete the table.

C. Variation of Liquid Pressure with Density

1. Repeat procedure A using kerosene, then cooking oil.

2. Tabulate the data in table C and complete the table.

D. Variation of Liquid Pressure with Density

1. Repeat procedure A using a jar of bigger cross – section.

2. Tabulate the data in table D and complete the table.

Name: _____ Date: _____

Course, Year, & Section: _____ Group No. : _____

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LIQUID PRESSURE

DATA AND DATA ANALYSIS:

Initial Readings: OP = _____ OQ = _____ OP – OQ = _____

A. Variation of Liquid Pressure with Depth

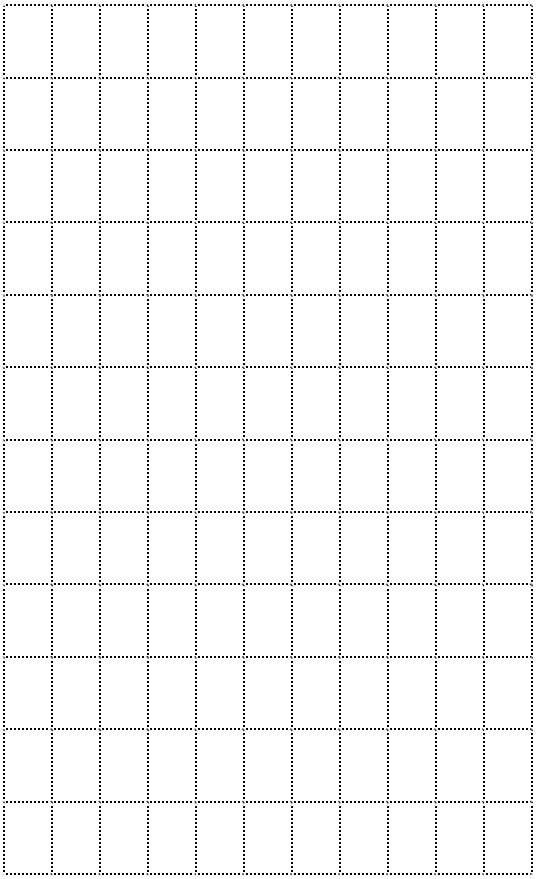
Table A: Liquid Pressure with Depth (Probe Down)

Depth, (cm)	OP, (cm)	OQ, (cm)	OP – OQ, (cm)
0			
3			
6			
9			

Construct an OP – OQ vs. Depth graph using the values in Table A. Describe the graph and discuss the relationship between liquid pressure and depth as indicated by it.

OP – OQ vs. Depth Graph

ANALYSIS AND INTERPRETATION OF GRAPH:



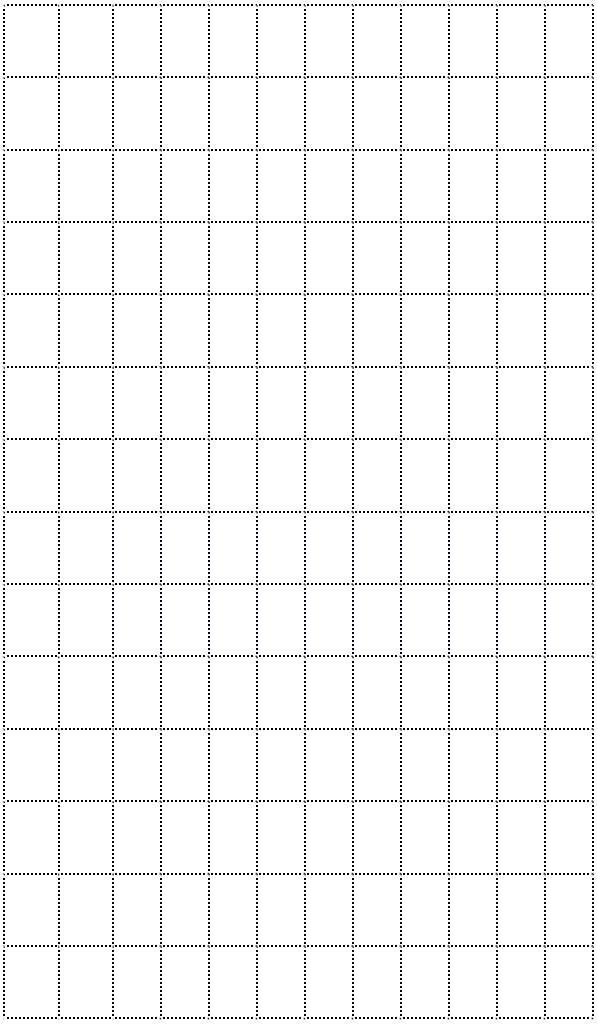
B. Variation of Liquid Pressure with Direction taken in the Liquid

Table B: Liquid Pressure with Direction

Probe Down (Copy Table A)				Probe					
				to the right			to the left		
Depth (cm)	OP (cm)	OQ (cm)	OP–OQ (cm)	OP (cm)	OQ (cm)	OP-OQ (cm)	OP (cm)	OQ (cm)	OP–OQ (cm)
0									
3									
6									
9									

Construct an OP – OQ vs. Direction graph at a particular depth using the values in Table B. Describe the graph and discuss the relationship between liquid pressure and direction taken in the liquid at the same depth as shown by the graph.

OP – OQ vs. Depth Graph



ANALYSIS AND INTERPRETATION OF GRAPH:

C. Variation of Liquid Pressure with Density

Table C: Liquid Pressure with Density

Water (Copy Table A)				Kerosene			Glycerin		
Depth (cm)	OP (cm)	OQ (cm)	OP–OQ (cm)	OP (cm)	OQ (cm)	OP-OQ (cm)	OP (cm)	OQ (cm)	OP–OQ (cm)
0									

3									
6									
9									

On one scale, construct an OP – OQ vs. Depth graph for the different kinds of liquids. How do the steepness of the graphs compare?

At one particular depth, construct an OP – OQ VS. Density graph using the values in table C. What relationship between liquid pressure and density does the graph indicate?

ANALYSIS AND INTERPRETATION OF GRAPH:

OP – OQ vs. Depth Graph

ANALYSIS AND INTERPRETATION OF GRAPH:

D. Variation of Liquid Pressure with Cross-section

Table D: Liquid Pressure with Cross-section

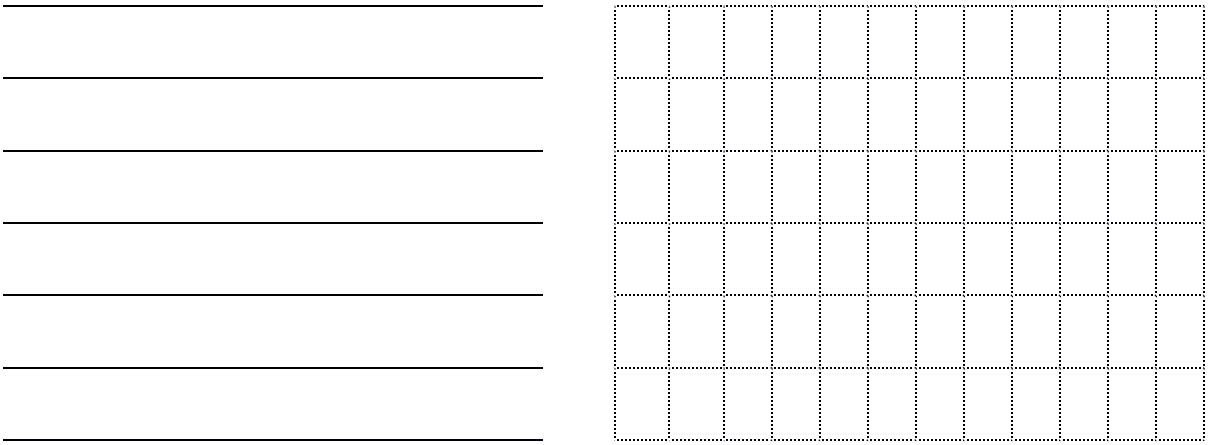
Small Cross-section (Copy table A)				Big Cross-section		
Depth (cm)	OP (cm)	OQ (cm)	OP – OQ (cm)	OP (cm)	OQ (cm)	OP – OQ (cm)
0						
3						
6						
9						

Compare the data obtained in table A using a smaller jar with that in table D using a bigger jar.

Construct an OP – OQ VS. Container Area graph at various depths. What relationship between liquid pressure and container size does the graph indicate?

OP – OQ vs. Depth Graph

ANALYSIS AND INTERPRETATION OF GRAPH:



CONCLUSION: (What factors affect liquid pressure and what kind of influence has each?)

QUESTIONS AND APPLICATIONS:

1. Why are dams so designed and constructed to have more massive base structures than tops?

2. What column of water can be supported by a pressure of 9.8×10^4 dynes/cm^2?

3. What pressure is exerted by a column of mercury 76 cm high? Density of mercury is 13.6 g/cc and gravitational acceleration is 980 cm/s^2.

4. A pail has a bottom 20 cm in diameter and a top 30 cm in diameter. If it is filled with water to a depth if 18 cm, what is the total force at the bottom?