Board – ICSE	Class- 9th	TOPIC – PRESSURE

1. Briefly describe an experiment to prove:

(i) Pressure in fluids is directly proportional to depth.

(ii) Pressure in fluids is directly proportional to the density of fluid.

(iii) Fluids exert same pressure in all directions.

Ans. (i) Take a thistle funnel and from its stem cut its funnel. To this funnel attach a thin rubber membrane. On the other side of funnel attach a long plastic tube, connected to U-tube containing coloured water such that the level of water is same in both the limbs.

(ii) Lower the funnel in any fluid to different depths. It is observed that the difference of levels of liquid in U-tube increases with the depth. Thus, the pressure in liquids is directly proportional to the depth.

(iii) Lower the above funnel first in water, then in brine and finally in alcohol to the same depth. Record the pressure in each case.

It is noticed that pressure is least in case of alcohol, but increases as the density of liquid increases. Thus, pressure is directly proportional to density.

(iii) Hold the above funnel with its membrane pointing

(a) Vertically upward

(b) Vertically downward

(c) sideways, at the same depth in a fluid. It is observed that pressure of fluid does not change as long as the depth remains the same. Thus, the liquids exert same pressure in all directions at a given point.

2. State three factors which determine the pressure of a fluid at a given point within the fluid.

Ans. Pressure of a liquid at a given point ∝ depth

∝ density of fluid

∝ acceleration due to gravity

3. How does the fluid pressure on a balloon changes when:

(a) balloon rises up from a height of 200 m to a height of 500 m?

(b) balloon moves horizontally at a height 200 m?

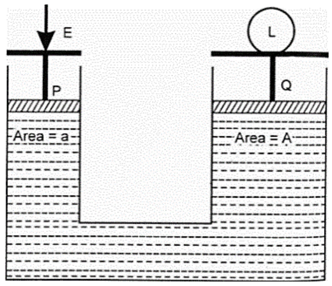
(c) balloon is brought down on the surface of earth?

Ans. (a) The fluid pressure decreases as the vertical height of air column as measured from above decreases.

(a) The fluid pressure remains the same as the vertical height does not change.

(b) The fluid pressure increases as the vertical height of air as

4. The diagram alongside is a simplified version of hydraulic press. Answer the following questions?



(i) Name and state the principle of hydraulic press.

(ii) What is the pressure exerted on the piston P?

(iii) What is the pressure throughout the fluid?

(iv) What is the pressure exerted by the fluid on piston Q?

(v) What is the thrust on the piston Q?

(vi) Calculate the mechanical advantage of pressure from the above data.

Ans. (i) Pascal's Law: Where any pressure is applied to any part of a boundary of a confined liquid (fluid), it is transmitted equally in all directions, irrespective of the area on which it acts, and acts always at right angles to the surface of containing vessel.

(ii) Pressure on piston P $=$ Force Area $= \frac{E}{a}$

(iii) Pressure exerted by fluid $= \frac{E}{a}$

[As pressure is transmitted equally in all directions]

(iv) Pressure exerted on piston Q $=$ Pressure in fluid $= \frac{E}{a}$

(v) Thrust (force)acting on piston Q in upward direction $=$ Force $\times$ area

$$= \frac{E}{a} \times A.$$

(vi) Force (thrust) acting on piston in downward direction = L

$$\therefore L = \frac{E}{a} \times A$$

$$\text{or } = \frac{L}{E}$$

$$MA = \frac{\text{Area of piston Q (A)}}{\text{Area of piston P (a)}}$$

5. (a) What do you understand by the term atmospheric pressure?

(b) What is the cause of atmospheric pressure?

(c) State the numerical value of atmospheric pressure at sea level in

(i) cm of mercury

(ii) pascals

(iii) bars.

Ans. (a) The thrust per unit area exerted by air on the surface of earth is called atmospheric pressure.

(a) It is the weight of air (thrust), which is responsible for the atmospheric pressure.

(b) (i) The atmospheric pressure at sea level is 76 cm of mercury.

(ii) The atmospheric pressure at sea level is 101300 pascals.

(iii) The atmospheric pressure at sea level is 1.013 bar.

6. Explain the following:

(a) Why is water not a suitable barometric liquid?

(b) Why is mercury used as a barometric liquid?

(c) Name two factors which do not affect barometric height at a given place.

(d) Name four factors which affect barometric height at a given place.

Ans.(a) (i) Water barometer will support 10.34 m of water at sea level. It is impractical to have such a long tube.

(ii) Water vaporises under vacuum conditions and hence water barometer will never show true atmospheric pressure.

(b) (i) The vapour pressure of mercury is almost negligible under vacuum conditions. Thus, mercury barometer shows true atmospheric pressure.

(ii) Mercury is the densest liquid (13.6 g cm^{-3}) at room temperature. Thus, a short column of mercury can exert as much pressure as atmosphere.

(iii) Mercury does not wet the sides of glass and can be had in pure state.

(c) (i) Barometric height is independent of area of cross-section of barometric tube.

(ii) Barometric height is independent of angle to which barometer tube is held.

(d) (i) Barometric height changes with change in temperature.

(ii) Barometric height changes with change in humidity in air.

(iii) Barometric height changes, if mercury is impure.

(iv) Barometric height changes, if tube is not dry.

7. (a) Draw a neat fully labelled diagram of aneroid barometer.

(b) Explain how aneroid barometer is used for

(i) Forecasting weather (ii) As an altimeter.

Ans. A = Flat spring

B = Evacuated box

C = Central levers

DEFG = System of levers

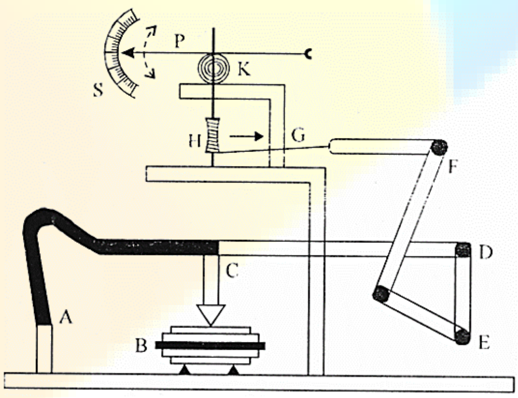
G = Metallic chain

H = Pulley

K = Hair spring

P = Pointer

S = Graduated scale



(a) (i) If the barometric height on a particular day is less than normal height, it shows fall in pressure. If fall in pressure is steep it could mean dust storm or rain. However, if there is gradual drop in pressure, it means that weather will change from normal to windy. If there is no change in height, it is fair weather. If there is a rise in barometric height it means dry or anticyclonic weather.

(ii) Altimeter: It has been established that for a vertical rise of 105 m, the barometric height drops by 1 m. This fact is used in the construction of altimeter, where fall in length of mercury column is calibrated as height of a place.

8. The base of a cylindrical vessel measures 300 cm^2. Water is poured into it up to the depth of 6 cm. Calculate the pressure on the base of vessel.

Ans. h = 6 cm = 0.06 m; ρ = 1000 kg m^{-3}; g = 10 ms^{-2}

P = hρg = 0.06 m × 1000 kg m^{-3} × 10 ms^{-2} = 600 Pa.

9. 66,640 Pa pressure is exerted by 0.50 m vertical column of a liquid. If g = 9.8 N kg^{-1}, calculate density of the liquid.

Ans. P = 66,640 Pa; h = 0.50 m; g = 9.8 N kg^{-1}; ρ = ?

$$\rho = \frac{P}{hg} = \frac{66,640}{0.50 \times 9.8}$$

= 13,600 kg m^{-3}.

10. Atmospheric pressure at sea level is 76 cm of mercury. Calculate the vertical height of air column exerting the above pressure. Assume the density of air 1.29 kg m^{-3} and that of mercury is 13,600 kg m^{-3}. Why is the height calculated by you far less than actual height of atmosphere?

Ans. h_{Hg} = 0.76 m; ρ_{Hg} = 13,600 kg m–3; ρ_{air} = 1.29 kg m–3, h_{air} =?

h_{air} × 1.29 kg m^{-3} = 0.76 m × 13,600 kg m^{-3}

$$h_{air} = \frac{0.76 \times 13600}{1.29} m = 8012.40 m = 8.0124 km.$$

In the above question it is assumed that density of air is a constant quantity. However, in actual practice density of air decreases rapidly with gain of height. Thus, actual height of atmosphere is far greater than calculated height.

11. The atmospheric pressure is 10^5 N m^{-2} and density of water is 10^3 kg m^{-3}. Calculate the depth of water at which pressure is double than atmospheric pressure.

Ans. Let the atmospheric pressure = P

∴ 2P = P + [$h_w \times \rho_w \times g$]

P = $h_w \times \rho_w \times g$

105 N m^{-2} = h_w × 1,000 kg m^{-3} × 10 ms^{-2}

∴ h_{water} = 10 m.

12. A metal plate of length 1.5 m and width 0.2 m is placed 40 cm below alcohol of density 800 kg m^{-3}. If the atmospheric pressure is 80 cm of mercury, calculate the force experienced by the plate. [Density of mercury is 13,600 kg m^{-3} and g = 10 ms^{-2}].

Ans. Surface area of plate = 1.5 m × 0.2 m = 0.3 m^2

Pressure due to air only = h_{Hg} × ρHg × g = m × 13,600 kg m^{-3} × 10 ms^{-2}= 108,800 Pa.

Pressure due to alcohol only = $h_{alc} \times r_{alc}$ × g = 0.40 m × 800 kg m^{-3}× 10 ms^{-2} = 3,200 Pa.

∴ Total pressure acting on plate = (108,800 + 3,200) = 1,12,000Pa.

∴ Force acting on plate = P × a = 1,12,000 × 0.3 = 33,600 N.

13. A glass slab of dimensions 10 cm × 10 cm × 4 cm and weight 8 N rests with its sides 10 cm × 10 cm in contact with the top of the table. Calculate the pressure exerted. If the slab is tilted and allowed to rest on the surface on side 10 cm × 4 cm, will the pressure increase, decreases or remain the same?

Ans. Force on the table = 8 N

Area of the side of the glass slab in contact with table = 10 x 10 = 100 cm^2 = 0.01 m^2

Pressure on the table $= \frac{\text{Force}}{\text{Area}} = \frac{8}{0.01} = 800\text{Pa}$

When the slab is tilted, the area of the side of the glass slab in contact with the table = 10 × 4=40 cm^2 = 0.004 m^2

$$\text{Pressure on the table } \frac{\text{Force}}{\text{Area}} = \frac{8}{0.004} = 2000\text{Pa}$$

14. A cube of side 5 cm is placed inside a liquid. The pressure at the centre of one face of cube is 10Pa. Calculate the thrust exerted by the liquid on this face

Ans. Side of cube = 5 cm

Pressure at the centre of one face of cube is = 10 Pa

Area of one face, A = 5 cm × 5 cm = 25 cm^2 = 25 × 10^{-4} m^2

Thrust exerted by the liquid on this face is F = P × A = 10 Pa × 25 × 10^{-4} m^2

F = 2.5 × 10^{-2} N

15. In a hydraulic machine, the two pistons are of area of cross section in the ration 1:10. What force is needed on the narrow piston to overcome a force of 100N on the wider piston?

Ans. Given, A_1:A_2=1:10, F_1=?, F_2=100N

By the principle of hydraulic machine

Pressure on narrow piston=Pressure on wider piston

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\therefore F_1 = F_2 \times \frac{A_1}{A_2} = 100 \times \frac{1}{10} = 10\text{N}$$