Exercise-4(A)

1. **Define the term thrust. State its S.I. unit.**
Solution:
Thrust is the force acting normally on a surface.
The S.I. unit of thrust is newton(N).

2. **What is meant by pressure? State its S.I. unit.**
Solution:
Pressure is the thrust per unit area of surface.
The S.I. unit of pressure is newton per metre^2

3. **(a) What physical quantity is measured in bar?**
(b) How is the unit bar related to the S.I. unit pascal?
Solution:
(a) The physical quantity that is measured in bar is pressure
(b) The relation between bar and pascal is as follows:
1 bar = 10^5 pascal

4. **Define one pascal (Pa), the S.I. unit of pressure.**
Solution:
One pascal can be defined as the pressure exerted on a surface of area 1m^2 by a force of 1N that acts normally on it. The S.I. unit of pressure is newton per metre^2

5. **State whether thrust is a scalar or vector?**
Solution:
Thrust is a vector quantity.

6. **State whether pressure is a scalar or vector?**
Solution:
Pressure is a scalar quantity.

7. **Differentiate between thrust and pressure.**
Solution:
The differences are as follows:

Thrust	Pressure
It is a force that acts normally on a surface	It is the thrust per unit area of surface
It is a vector quantity	It is a scalar quantity
S.I. unit is newton	Newton per metre^2

8. **How does the pressure exerted by a thrust depend on the area of surface on which it acts? Explain with a suitable example.**
Solution:
Surface of area and pressure are inversely proportional. The greater the surface area the lesser the pressure. For example: A bag with broad straps is easier to carry than a bag with thin straps. This is

because, broad straps have a larger surface area hence lesser pressure is acting on the shoulders.

9. Why is the tip of an allpin made sharp?

Solution:

It is sharpened so as to exert large pressure at the sharp end so that it can be driven effortlessly.

10. Explain the following:

(a) It is easier to cut with a sharp knife than with a blunt one.

(b) Sleepers are laid below the rails

Solution:

(a) It is because even a small thrust induces high pressure at the edges of a knife thus enabling a smoother experience comparatively

(b) In order for the pressure applied by the rails on the ground to become lesser, sleepers are laid below the rails.

11. What is a fluid?

Solution:

Any substance that can flow is known as a fluid.

12. What do you mean by the term fluid pressure?

Solution:

Fluid pressure is the pressure exerted by a fluid due to its weight in all the directions.

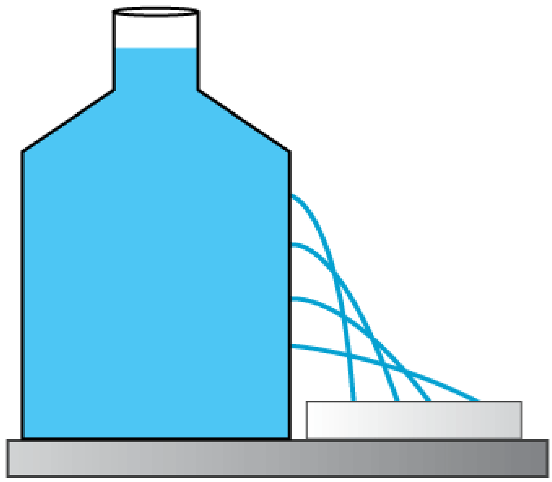
13. How does the pressure exerted by a solid and a fluid differ?

Solution:

They both differ in a way that when a solid exerts a pressure, it exerts only at the bottom, i.e., on the surface it is placed. When a fluid exerts pressure, it exerts in all the directions.

14. Describe a simple experiment to demonstrate that a liquid enclosed in a vessel exerts pressure in all directions.

Solution:



Liquid exerts presure at all points in all directions

The experiment explained below demonstrates how a liquid enclosed in a vessel exerts pressure in all directions:

Procedure:

- Fill a large plastic bottle or a can with water
- Set it on a horizontal surface
- Punch a few holes in the wall of the vessel at any point below the liquid surface

Observation

- Through each of the hole, water spurts out

Inference

- The spurting out of the liquid indicates that the liquid exerts pressure at every point on the walls of the can/bottle

15. State three factors on which the pressure at a point in a liquid depends.

Solution:

The factors on which the pressure at a point in a liquid depends are:

- Depth of the point below the free surface
- Density of liquid
- Acceleration due to gravity

16. Write an expression for the pressure at a point inside a liquid. Explain the meaning of the symbols used.

Solution:

The pressure at a point inside a liquid is given by:

$$P = P_0 + h \rho g$$

where P is the point where pressure is exerted in the liquid

P_0 is the atmospheric pressure

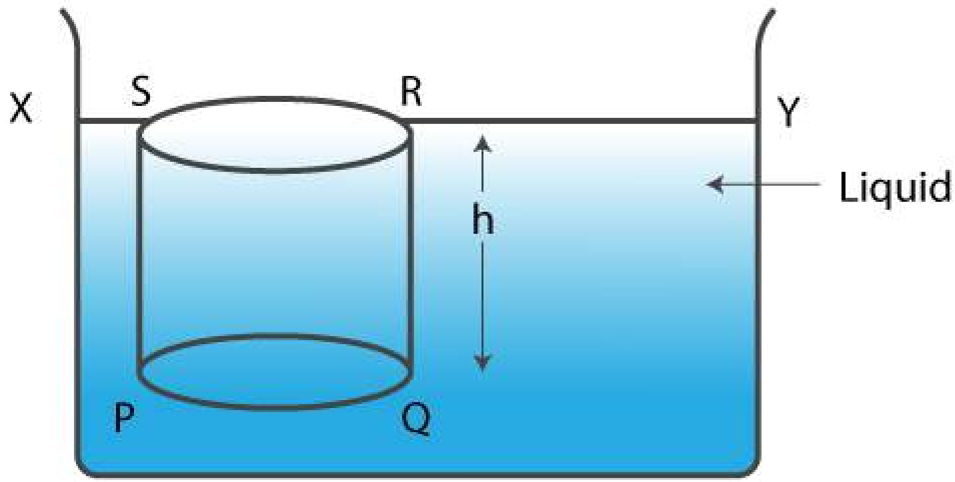
h is the depth of the point below the free surface

ρ is the density of the fluid

g is the acceleration due to gravity

17. Deduce an expression for the pressure at a depth inside a liquid.

Solution:



- Consider a vessel containing a liquid with density ρ.
- Allow the liquid to be stationary
- To calculate the pressure at a depth consider a horizontal circular surface PQ with area 'A', depth 'h' below the free surface XY of the liquid
- The pressure on surface PQ will be due to the weight of the liquid column above the surface PQ, liquid contained in cylinder PQRS of height h with PQ as its base and top face RS lying on the free surface XY of the liquid

  Thrust exerted on the surface PQ

  = weight of the liquid column PQRS

  = volume of liquid column PQRS x density x g

  = (Area of base PQ x height) x density x g

  = (A x h) ρ x g = A h ρ g

  The thrust obtained is exerted on the surface PQ of area A.

  Pressure P = thrust on surface/ area of surface

  P = A h ρ g/A = h ρ g

  Hence, Pressure = depth x density of liquid x acceleration due to gravity

18. How does the pressure at a certain depth in sea water differ from that at the same depth in river water? Explain your answer.

Solution:

Density of sea water is more compared to the density of river water because of dissolved salts in sea water. Hence, pressure at a particular depth in sea water is more than that at the same depth in river water.

19. Pressure at free surface of a water lake is P_1, while at a point at depth h below its free surface is P_2. (a) How are P_1 and P_2 related? (b) Which is more P_1 or P_2?

Solution:

(a) $P_2 = P_1 + h \rho g$

(b) $P_2 > P_1$

20. Explain why a gas bubble released at the bottom of a lake grows in size as it rises to the surface of lake.

Solution:

A gas bubble released at the bottom of a lake grows in size as it rises to the surface of lake because when the bubble is at the bottom of the lake, the total pressure exerted on it is the sum of pressure due to the water column and the atmospheric pressure. As the gas bubble rises, because of the decline in the depth, the pressure because of the water column declines.

According to Boyle's law, PV is equivalent to a constant hence the bubble grows in size because the pressure decreases.

21. A dam has broader walls at the bottom than at the top. Explain.

Solution:

Pressure exerted by a liquid is dependent on the depth in a way that it increases with greater pressure. That is to say, as the depth increases, pressure applied by water on the walls of the dam also increases. In order to withstand the great pressure, the walls are built thicker. Hence a dam has broader walls at the bottom than at the top.

22. Why do sea divers need special protective suit?

Solution:

It is due to the great pressure exerted on the diver's body at the depth of the sea. The total pressure exerted is much more than his blood pressure. Consequently, to withstand that sea divers require special protective suit.

23. State the laws of liquid pressure.

Solution:

Listed below are the five laws of liquid pressure:

(i) Inside the liquid, pressure increases with the increase in depth from its free surface

(ii) In a stationary liquid, pressure is same at all points on a horizontal plane

(iii) Pressure is same in all directions about a point inside the liquid

(iv) Pressure at same depth is different in different liquids. It increases with the increase in density of liquid

(v) A liquid seeks its own level.

24. A tall vertical cylinder filled with water is kept on a horizontal table top. Two small holes A and B are made on the wall of the cylinder, A near the middle and B just below the free surface of water. State and explain your observation.

Solution:

The liquid from hole B stretches to higher distance than from hole A on the horizontal surface which demonstrates that liquid pressure at a given point from the free surface increases with the depth of point.

25. How does the liquid pressure on a diver change if:

(i) The diver moves to the greater depth, and

(ii) The diver moves horizontally?

Solution:

(i) The liquid pressure increases on the diver as it moves to greater depth

(ii) When the diver moves horizontally, the pressure is unaffected.

26. State Pascal's law of transmission of pressure.

Solution:

Pascal's law states that the pressure exerted anywhere in a confined liquid is transmitted equally and undiminished in all directions throughout the liquid.

27. Name two applications of Pascal's law.

Solution:

Two applications of Pascal's law are:

- Hydraulic press
- Hydraulic jack

28. Explain the principle of a hydraulic machine. Name two devices which work on this principle.

Solution:

The principle of hydraulic machine is that a small force applied on a small piston is conveyed to generate a large force on the bigger piston.

Two devices that work on this principle:

- Hydraulic brakes
- Hydraulic press

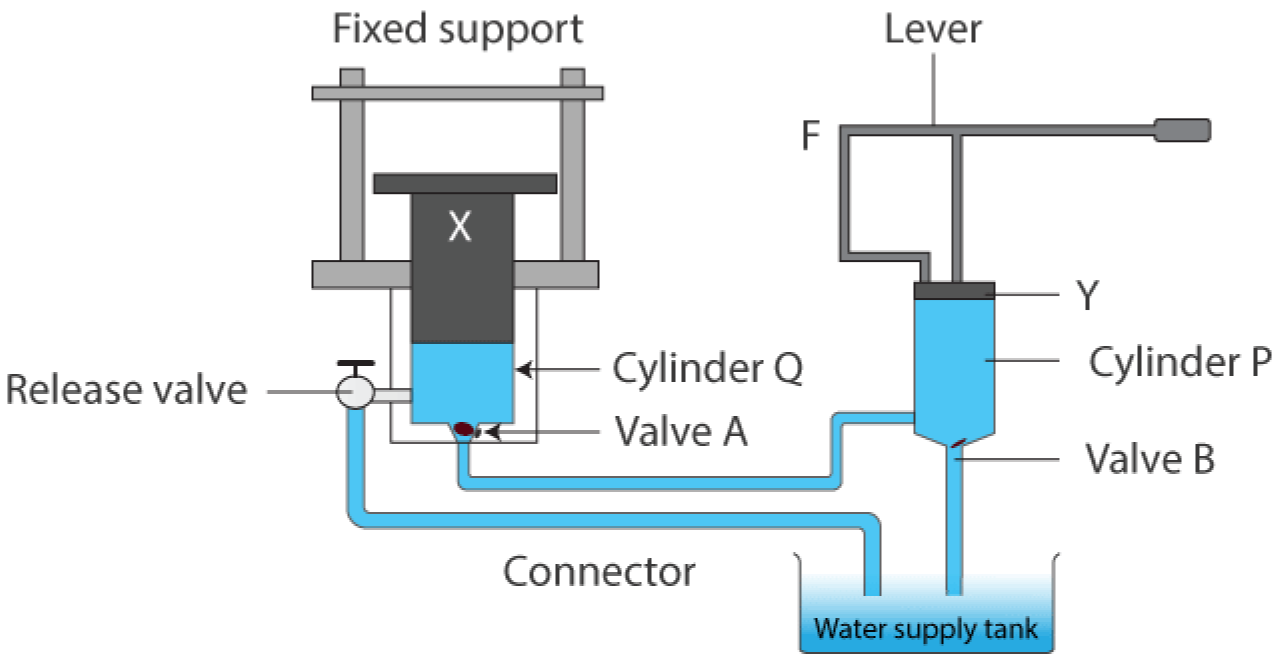
29. Name and state the principle on which a hydraulic press works. Write one use of the hydraulic press.

Solution:

The principle on which hydraulic press works is hydraulic machine.

Use of hydraulic press: It is used for pressing cotton bales and goods such as books, quilts etc.

30. The diagram in figure shows a device which makes use of the principle of transmission of pressure.



(i) **Name the parts labelled by the letters X and Y.**
(ii) **Describe what happens to the valves A and B and to the quantity of water in the two cylinders when the lever arm is moved down.**
(iii) **Give reasons for what happens to the valves A and B in part (ii).**
(iv) **What happens when the release valve is opened?**
(v) **What happens to the valve B in cylinder P when the lever arm is moved up?**
(vi) **Give a reason for your answer in part (v)**
(vii) **State one use of the above device.**

Solution:

(i) X – Press plunger
Y – Pump plunger

(ii) When the lever arm is moved down, valve A opens while valve B closes. Because of this water from cylinder P is propelled into the cylinder Q

(iii) Valve B closes. It is because of an increase in the pressure in cylinder P. The pressure is conveyed to the connecting pipe and when the pressure in the pipe is higher than the pressure in the cylinder Q, valve A discloses.

(iv) The ram plunger Q is lowered and water of the cylinder Q releases in the reservoir when the release valve is opened.

(v) The valve B opens upwards.

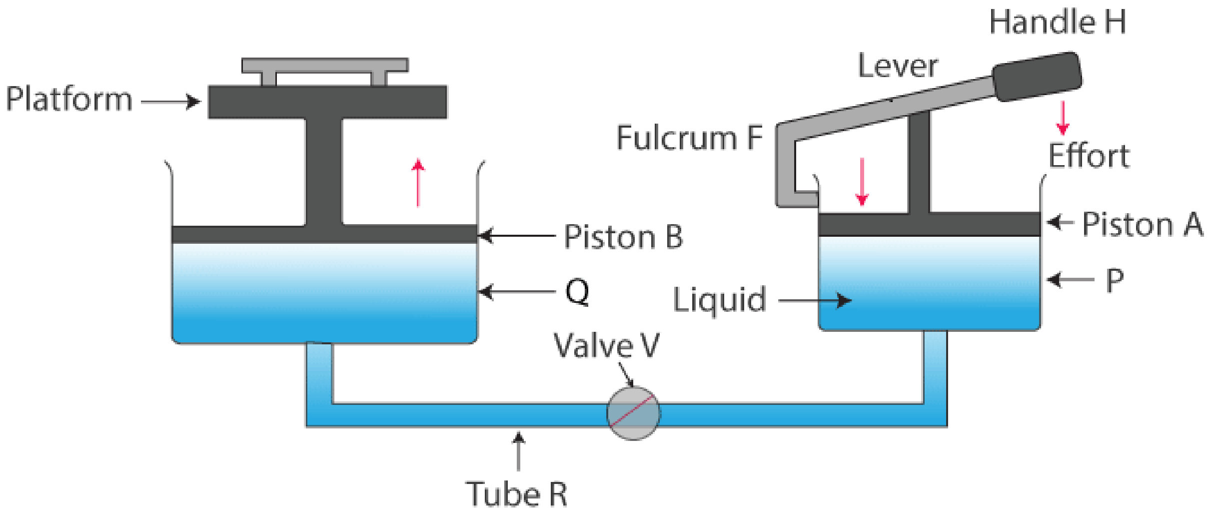
(vi) It is because the pressure in cylinder P decreases

(vii) One use – used for squeezing oil out of linseed and cotton seeds

31. Draw a simple diagram of a hydraulic jack and explain its working.

Solution:

When handle H of lever is pressed down by applying an effort, the valve V opens because of increase in pressure in the cylinder P. The liquid runs out from the cylinder P to the cylinder Q. As a result, the piston B rises up and it raises the car placed on the platform. When the car reaches the desired height, the handle H of lever is no longer pressed. The valve V gets closed (since the pressure on either side of the valve becomes same) so that the liquid may not run back from the cylinder Q to the cylinder P.



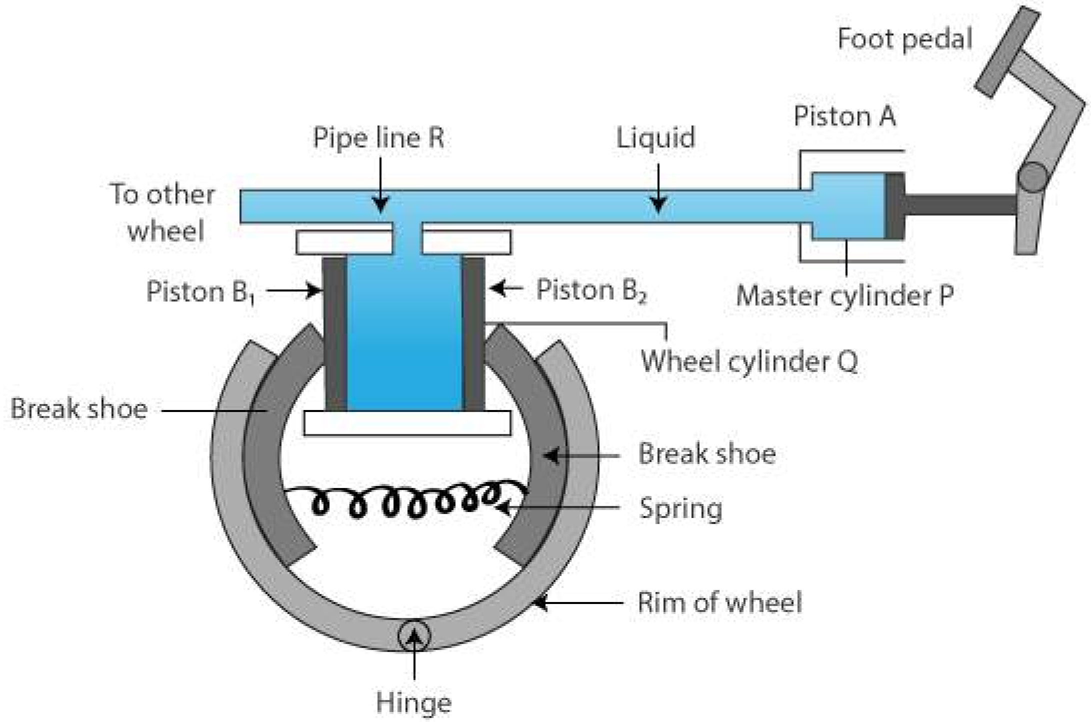
32. Explain the working of a hydraulic brake with a simple labelled diagram.

Solution:

To apply brakes, the foot pedal is pressed due to which pressure is exerted on the liquid in the master cylinder P, so liquid runs out from the master cylinder P to the wheel cylinder Q. As a result, the pressure is equally transmitted and undiminished through the liquid to the pistons B_1 and B_2 of the wheel cylinder because of which both pistons gets pushed outwards and brake shoes gets pressed against the rim of the wheel due to which the motion of the wheel retards.

As the pressure is transmitted through the liquid, equal pressure is exerted on all the wheels of the vehicle that are connected to the pipe line R.

When the pressure on the pedals is released, the liquid runs back from the wheel cylinder Q to the master cylinder P and the spring pulls the brake shoes to their original position and compels the pistons B_1 and B_2 to return back into the wheel cylinder Q. Hence, brakes are released.



33. Complete the following sentences:

(a) Pressure at a depth h in a liquid of density ρ is ___________

(b) Pressure is ________ in all directions about a point in a liquid

(c) Pressure at all points at the same depth is _________

(d) Pressure at a point inside a liquid is __________ to its depth.

(e) Pressure of a liquid at a given depth is _______ to the density of liquid.

Solution:

(a) h ρ g

(b) same

(c) same

(d) directly proportional

(e) directly proportional

Multiple choice type:

1. **The S.I. unit of pressure is:**
   (a) N cm^{-2}
   (b) Pa
   (c) N
   (d) N m^2
   Solution:
   (b) Pa
   Pressure is a scalar quantity.

2. **The pressure inside a liquid of density ρ at a depth h is:**
   (a) h ρ g

(b) h/ ρ g
(c) h ρ/ g
(d) h ρ
Solution:
(a) h ρ g

3. **The pressure P_1 at a certain depth in river water and P_2 at the same depth in sea water are related as:**
(a) $P_1 > P_2$
(b) $P_1 = P_2$
(c) $P_1 < P_2$
(d) $P_1 - P_2$ = atmospheric pressure
Solution:
(c) $P_1 < P_2$

4. **The pressure P_1 at the top of a dam and P_2 at a depth h from the top inside water (density ρ) are related as:**
(a) $P_1 > P_2$
(b) $P_1 = P_2$
(c) $P_1 - P_2 = h \rho g$
(d) $P_2 - P_1 = h \rho g$
Solution:
(d) $P_2 - P_1 = h \rho g$

Numericals:

1. **A hammer exerts a force of 1.5N on each of the two nails A and B. The area of cross section of tip of nail A is 2mm² while that of nail B is 6 mm². Calculate pressure on each nail in pascal.**
Solution:
Given:
Force acting on nail A is 1.5N, area = $2mm^2$
Expressing $2mm^2$ in metre
1mm=0.001m,
∴ $1mm^2$= 1mm x 1mm = 0.001m x 0.001m = 1×10^{-6} m^2
Pressure on B = Force/area
= $1.5/(2 \times 1 \times 10^{-6})$
= 7.5×10^5 Pa
Pressure on B
= $1.5/(6 \times 1 \times 10^{-6})$
= 2.5×10^5 Pa

2. **A block of iron of mass 7.5kg and of dimensions 12cm x 8cm x 10cm is kept on a table top on its base of side 12cm x 8cm. Calculate : (a) thrust and (b) pressure exerted on the table**

top. Take 1kgf = 10N.

Solution:

(a) To calculate thrust

Force = mass x acceleration due to gravity

= 7.5 x 10

= 75N

Area of the base = 12 x 8 = 96cm^2 or 0.0096m^2

(b) To calculate pressure exerted

Pressure = thrust/area

= 75/0.0096

= 7182.5 Pa

3. A vessel contains water up to a height of 1.5m. Taking the density of water 10^3 kg m^{-3}, acceleration due to gravity 9.8ms^{-2} and area of base vessel 100cm^2, calculate: (a) the pressure and (b) the thrust, at the base of vessel.

Solution:

(a) To calculate pressure:

Given: h=1.5m, ρ = 1000, g=9.8m/s^2

P = h ρ g

= 1.5 x 1000 x 9.8

= 14700 Pa

(b) To calculate the thrust at the base of the vessel:

Pressure = Force/area

⇨ Thrust = force = P x a

⇨ 14700 x 100 x 10^{-4}

⇨ 147N

4. The area of base of a cylindrical vessel is 300cm^2. Water (Density = 1000 kg m^{-3}) is poured into it up to a depth of 6cm. Calculate: (a) the pressure and (b) the thrust of water on the base. (g = 10m/s^2).

Solution:

(i) To calculate pressure

Given: density of water, ρ = 1000kg/m^3

g=10m/s^2

h = 6cm or 0.06m

We know that:

P = h ρ g

= 1000 x 0.06 x 10

= 600 Pa

(ii) Thrust of water on the base

Pressure = thrust / area

⇨ Thrust = force = P x a

= 6 x 10^{-2} x 1000 x 10 x area

= 6 x 10^{-2} x 1000 x 10 x 300 cm^2

= 6 x 10^{-2} x 1000 x 10 x 300 x 10^{-4} m^2

= 18N

5. **(a) Calculate the height of a water column which will exert on its base the same pressure as the 70cm column of mercury. Density of mercury is 13.6 g cm^{-3}.**
(b) Will the height of the water column in part (a) change if the cross section of the water column is made wider?

Solution:

(a) We know that the pressure exerted by the water column, P = h ρ g

Density of water = 1

As the pressure of water and mercury is same,

$h_w \rho_w g = h_m \rho_m g$

$h_w \times 1 \times g = h_m \rho_m g$

$h_w = h_m \rho_m$

$= \frac{70}{100} \times 13.6$

Height of the water column= 9.52m

(b) If the water column is made wider, the height of the water column will be unaffected.

6. **The pressure of water on the ground floor is 40,000 Pa and on the first floor is 10,000Pa. Find the height of the first floor. (Take: density of water = 1000kg m^{-3}, g=10m/s^2)**

Solution:

To find the height of the first floor:

Given: P_w on ground floor P_{wg}= 40,000Pa

P_w on first floor P_{wf} = 10,000Pa

From the formula of pressure,

P = h ρ g

In order to know the height of the first floor, let us calculate the difference in pressure

$P = P_{wg} - P_{wf}$

= 40000 – 10000

= 30000Pa

Substituting this value in the formula for pressure to calculate height;

P = h ρ g

30000 = 1000 x 10 x h

h = 3m

The height of the floor is 3m.

7. **A simple U tube contains mercury to the same level in both of its arms. If water is poured to a height of 13.6cm in one arm, how much will be the rise in mercury level in the other arm?**
Given: density of mercury = 13.6 x 10^3 kg m^{-3} and density of water = 10^3 kg m^{-3}

Solution:

Rise of water in the other side of the u-tube when water is added from one end depends on the density of water and mercury.

Given: Water poured to the height 13.6cm or 0.136m in one arm.

To find the rise at the other end of the u-tube:

Since it is a u-tube, pressure on both the arms is the same, hence:

Difference in pressure in the water column = difference in pressure in the mercury column

$$h_w \rho_w g = h_m \rho_m g$$

$h_m = h_w \rho_w / \rho_m$
$= 13.6 \times 10^3 / 13.6 \times 10^3$
$= 1cm$

∴ The other end of the u-tube will see a rise of 1cm in the mercury level.

8. In a hydraulic machine, a force of 2N is applied on the piston of area of cross section 10cm^2. What force is obtained on its piston of area of cross section 100cm^2?

Solution:

As per Pascal's law, When pressure increases, it uniformly increases through all the points when any force is exerted.

Pressure = force/ area

$(2N \times 10^{-4})/10 = (F \times 10^{-4})/ 100$

$2N = F/10$

$F = 20N$

9. What should be the ratio of area of cross section of the master cylinder and wheel cylinder of a hydraulic brake so that a force of 15N can be obtained at each of its brake show by exerting a force of 0.5N on the pedal?

Solution:

Consider the ratio of cross-section of the master cylinder and wheel cylinder be $X_1 : X_2$

Let the force applied on pedal be $F_1=0.5N$

And the force applied on brake shoe $F_2 =15N$

We know from the hydraulic machine,

Pressure on narrow piston = pressure on broader piston

$\frac{F_1}{X_1} = \frac{F_2}{X_2}$

⇨ $\frac{F_1}{F_2} = \frac{X_1}{X_2}$

⇨ $\frac{X_1}{X_2} = \frac{0.5}{15}$

⇨ $\frac{X_1}{X_2} = 1/30$

⇨ Hence, the ratio is 1:30

10. The areas of pistons in a hydraulic machine are 5cm^2 and 625 cm^2. What force on the smaller piston will support a load of 1250N on the larger piston? State any assumption which you make in your calculation.

Assumption: There is no friction and no leakage of liquid.

Solution:

Given:

Area of narrow piston = 5cm^2 = A_1, let force applied be F_1

Area of wider piston = 625cm^2 = A_2, let force applied be F_2 = 1250N

We know from the hydraulic machine,

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

⇨ $\frac{F_1}{5} = \frac{1250}{625}$

⇨ $F_1 = 10N$

11. (a) The diameter of neck and bottom of a bottle are 2cm and 10cm respectively. The bottle is completely filled with oil. If the cork in the neck is pressed in with a force of 1.2kgf, what force is exerted on the bottom of the bottle?
(b) Name the law/principle you have used to find the force in part (a)

Solution:

(a) Diameter of neck, d1=2cm
Diameter of bottom of bottle, d2=10cm
Force applied on the cork in the neck, F_1 = 1.2kgf
Force applied on the bottom of the bottle, F_2
We know from the principle of Hydraulic machine:
Pressure on neck = pressure on the bottom of bottle

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

⇨ $$\frac{1.2}{\pi(\frac{d1}{2})^2} = \frac{F_2}{\pi(\frac{d2}{2})^2}$$

⇨ $F_2 = \frac{1.2}{2^2} \times (10)^2 = 30$ kgf

(b) To find the force in part (a), Pascal's law is applied.

12. A force of 50kgf is applied to the smaller piston of a hydraulic machine. Neglecting friction, find the force exerted on the large piston, if the diameters of the pistons are 5cm and 25cm respectively.

Solution:

Comparing the diameter of narrow piston and broader piston = 5/25 or 5:25
= 25:625

Force exerted on narrow piston, F_1 = 50kgf
Consider F_2 to be the force exerted on the broader piston
We know from the principle of Hydraulic machine,
Pressure on narrow piston = pressure on broader piston

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

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

⇨ $50/F_2 = 25/625$
⇨ $F_2 = 1250$ kgf

13. Two cylindrical vessels fitted with pistons A and B of area of cross section $8cm^2$ and $320cm^2$ respectively, are joined at their bottom by a tube and they are completely filled with water. When a mass of 4kg is placed on piston A, find: (i) the pressure on piston A, (ii) the pressure on piston B, and (iii) the thrust on piston B.

Solution:

Given: Force applied on the narrow piston= 4kg
Area of cross section of A = $8cm^2$
Area of cross section of B = $320cm^2$

(i) Pressure on piston A = Thrust/area = 4/8 = 0.5 kg cm^{-2}

(ii) Pressure on piston A = pressure on piston B (as per Pascal's law)
∴ Pressure on piston B is 0.5 kg cm^{-2}

(iii) Thrust on piston B is acting in the upward direction, which is given by

⇨ Pressure/area

⇨ 4kg x (320/8)

⇨ 160kg

14. What force is applied on a piston of area of cross section 2cm^2 to obtain a force 150N on the piston of area of cross section 12cm^2 in a hydraulic machine?

Solution:

We know that pressure on smaller piston = pressure on wider piston in a hydraulic machine

∴ $P_1 = P_2$

⇨ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

⇨ $\frac{F_1}{2 \, x \, 10^{-4}} = \frac{150}{12 \, x \, 10^{-4}}$

⇨ $F_1 = 25N$

Exercise-4(B)

1. **What do you understand by atmospheric pressure?**
   Solution:
   Atmospheric pressure on the earth's surface is the thrust exerted per unit area on the earth surface due to column of air.

2. **Write the numerical value of the atmospheric pressure on the surface of the earth in Pascal.**
   Solution:
   The numerical value of the atmospheric pressure on the surface of the earth in Pascal is
   1.013×10^5 Pa.

3. **What physical quantity is measured in torr? How is it related to the S.I unit of the quantity?**
   Solution:
   The physical quantity that is measured in torr is atmospheric pressure. It is related to the S.I unit in the following way:
   1 torr=133.28Pa

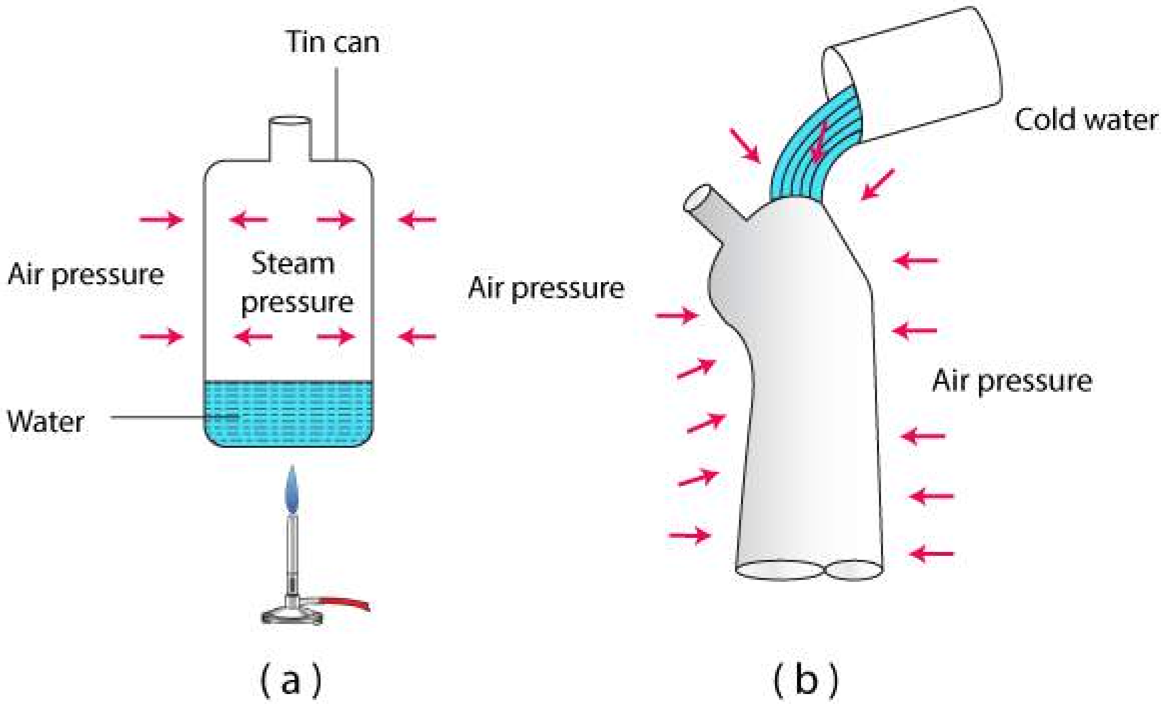
4. **Name the physical quantity which is expressed in the unit 'atm'. State its value in pascal.**
   Solution:
   The physical quantity is pressure that is expressed in the unit 'atm'. Some other units in which pressure can be expressed is bar, pascal etc.
   Value of 1 atm in pascal is 1×10^5

5. **We do not feel uneasy even under the enormous pressure of atmosphere above as well as around us. Give a reason.**
   Solution:
   It is because of our blood pressure which is fairly higher than the pressure in the atmosphere. The imbalance is managed by our blood pressure.

6. **Describe an experiment to demonstrate that air exerts pressure.**
   Solution:
   Aim:
   To demonstrate that air exerts pressure
   Procedure:
   - Use a thin can fitted with an airtight stopper, where the stopper is discarded and some water is boiled in the can.
   - Eventually we observe that steam occupies the space in the can by ousting air as observed in the figure (a).
   - Now the stopper is replaced tightly and parallely the can is removed from the flame.
   - The can is treated with some cold water
   - We observe that the can shrinks as seen in figure (b)
   - It is because the pressure as a result of the steam in the can is the same as the atmospheric

pressure outside the can as observed in the figure a.

- But when the can that is fitted with a stopper is treated with water, the steam present in the can condenses yielding water and water pressure at a lower pressure.
- As a result, the atmospheric pressure just out of the can tends to become more than the vapor pressure within the can.
- Subsequently, the atmospheric pressure present out of the can causes the can to shrink.



7. **Explain the following:**

(i) **A balloon collapses when air is removed from it.**

(ii) **Water does not run out of a dropper unless its rubber bulb is pressed.**

(iii) **Two holes are made in a completely filled sealed tin can to take out oil from it.**

Solution:

(i) When air leaves a balloon, the pressure inside is far lesser than the pressure outside the balloon. This is the reason why the balloon collapses.

(ii) It is because the pressure as a result of height column of the liquid in the dropper is lesser than the atmospheric pressure. When the dropper is pressed, the pressure inside the dropper is increased when this pressure becomes more than the atmospheric pressure, the liquid is expelled out of the dropper.

(iii) In a sealed and completely filled can, there is no air. When a hole is forced to expel oil out from the can, some of it comes out and because of the volume of air above the oil increases causing the pressure of air to decrease. However, if two holes are punched on the top cover of the can, the air present outside the can enters through one of the holes applying atmospheric pressure on the oil from within additionally with the pressure because of the oil column and is expelled out from the can through the other hole.

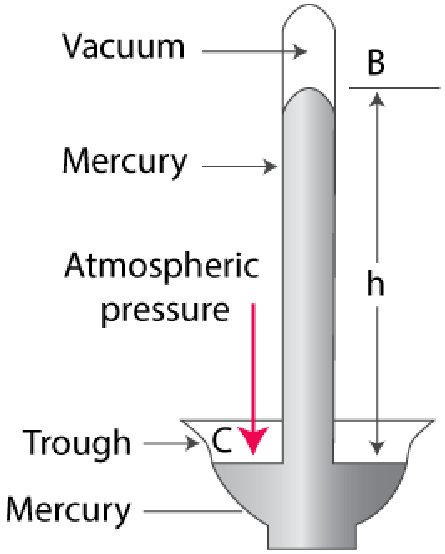
8. **Why does the liquid rise in a syringe when its piston is pulled up?**
Solution:
When a syringe's piston is drawing liquid, it is pulled up creating pressure inside which becomes lesser than the pressure outside (atmospheric pressure) that acts on the liquid. Hence, the atmospheric pressure compels the liquid to rise up in the syringe.

9. **How is water drawn up from a well by a water pump?**
Solution:
When the piston is pulled up in a water pump, the pressure inside the siphon declines and the atmospheric pressure acting on the water outside heightens which causes the atmospheric pressure to push the water up in the pump.

10. **A partially inflated balloon is placed inside a bell jar connected to a vaccum pump. On creating vaccum inside the bell jar, balloon gets more inflated. How does the pressure change: increase, decrease or remains same, inside the (a) bell jar and (b) balloon?**
Solution:
(a) The pressure changes in the bell jar, it decreases.
(b) The pressure changes in the balloon, it decreases.

11. **What is the purpose of a barometer?**
Solution:
The barometer is used to measure atmospheric pressure.

12. **What is a barometer? How is a simple barometer constructed?**
Solution:
A barometer is an instrument that is used to measure the atmospheric pressure.
A simple barometer can be constructed as follows:
- It uses a hard glass tube of length 1m that is closed at one end.
- Fill the tube completely with pure mercury such that no air bubble is present in the tube
- Seal the open end of the tube with thumb
- Tube is then turned upside down a few times in order to force out any air bubble that may have entered
- The complete set up is then inverted into a trough of mercury in a way that the open end of tube is completely immersed in mercury in the trough and the tube is standing vertically
- Take the thumb off in a way that no air enters the glass tube
- It is observed that the level of mercury in the tube falls till its height above the level of mercury in the trough becomes nearly 76cm

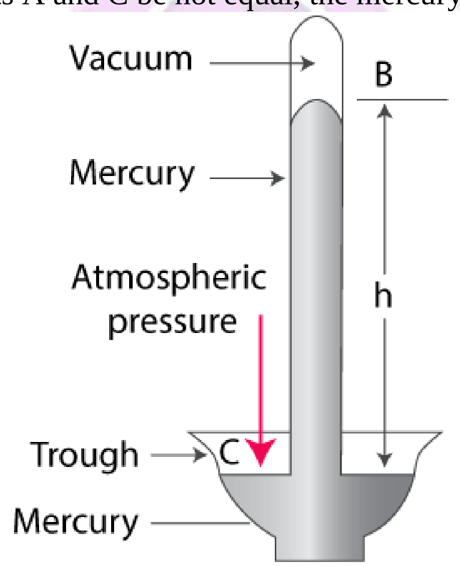


13. Explain how is the height of mercury column in the tube of a simple barometer, a measure of the atmospheric pressure.

Solution:

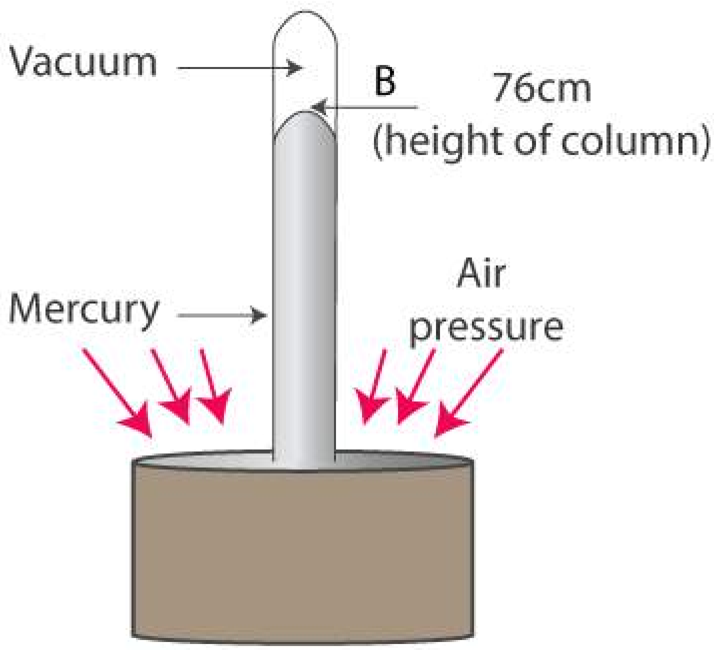
As observed in the figure, on the surface of mercury in the trough, at all points such as C, the only pressure that acts is atmospheric pressure. When the level of mercury in the tube becomes static, the pressure in the tube at point A which is at the same level of point C. The pressure at point A is because of the thrust of mercury column AB above it. Hence, the vertical height of the mercury column from the surface of mercury in the trough to the level in tube which is a measure of the atmospheric pressure.

The vertical of the mercury column in it is called the barometric height. Had the pressure at points A and C be not equal, the mercury level in the tube will not be static.



14. Illustrate with the help of a labelled diagram of a simple barometer that the atmospheric pressure at a place is 76cm of Hg.

Solution:



15. Why is the barometric height used as a unit to express the atmospheric pressure?

Solution:

The atmospheric pressure acts on the mercury surface in the trough which supports the vertical column of mercury. Thus, the barometric height is used as unit to express the atmospheric pressure.

16. What is meant by the statement 'the atmospheric pressure at a place is 76cm of Hg'? State its value in Pa.

Solution:

It means that at normal pressure and temperature, the height of the mercury column supported by the atmospheric pressure is 76cm, where 76cm of Hg=1.013 x 10^5Pa

17. How will you show there is vaccum above the surface of mercury in a barometer? What name is given to this vaccum?

Solution:

The space above mercury is an empty space and is known as 'Torricellian vaccum'. This can be observed by angling the tube so that the mercury completely fills the tube. When the mercury column becomes static again, it vaporizes immediately causing the air to apply pressure on the mercury column because of which the height of the barometer declines.

18. How is the barometric height of a simple barometer affected if

(a) Its tube is pushed down into the trough of mercury?

(b) Its tube is slightly tilted from vertical?

(c) A drop of liquid is inserted inside the tube?

Solution:

(a) If the tube is pushed down into the trough of mercury, the barometric height is unchanged.
(b) If the tube is slightly tilted from vertical, the barometric height is unchanged.
(c) If a drop of liquid is inserted inside the tube, the barometric height decreases.

19. State two uses of a barometer.

Solution:

The two uses of a barometer are:

- It can be used to measure the atmospheric pressure at a place
- It can be used for weather forecasting

20. Give two reasons for the use of mercury as a barometric liquid.

Solution:

Two uses of mercury as a barometric liquid are:

- The vapor pressure of mercury is negligible hence the vapors in the torricellian vaccum does not affect the barometric height
- Density of mercury is greater than any other liquid, hence 0.76m height of the mercury column is required to balance the normal temperature, whereas the usage of other liquids need a longer tube

21. Give two reasons why water is not a suitable barometric liquid.

Solution:

The two reasons why water is not a suitable barometric liquid are:

- The density of water is low hence 10.4m height of water column is required in order to balance the normal atmospheric pressure. However, it is not convenient to take a tube of height 10.4m for a barometer.
- The vapor pressure of water is high, the vapors in the vaccum space will make the reading inaccurate.

22. Mention two demerits of a simple barometer and state how they are removed in a Fortin barometer.

Solution:

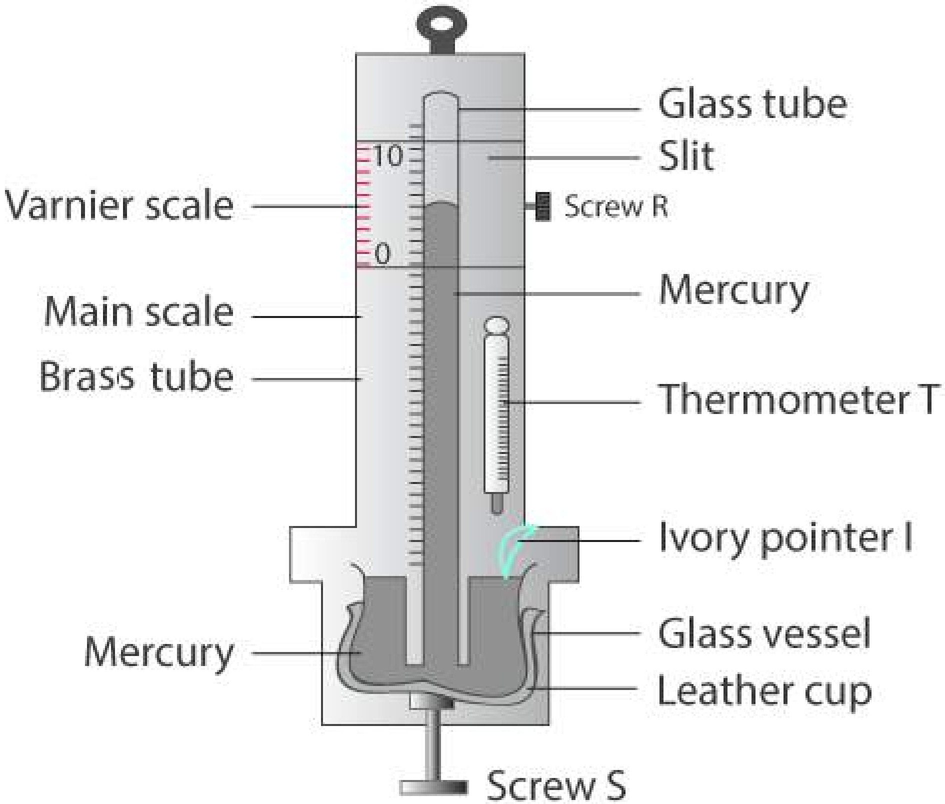
Demerits of a simple barometer are:

- There is no protection for the glass tube
- A scale cannot be fixed with the tube to measure the atmospheric pressure

The demerit of no protection for the glass tube is eliminated by enclosing the glass tube in a brass case and the next defect is rectified in Fortin’s barometer as it is provided with a vernier calipers in order to measure accurately.

23. Draw a simple labelled diagram of a Fortin barometer and state how it is used to measure the atmospheric pressure.

Solution:

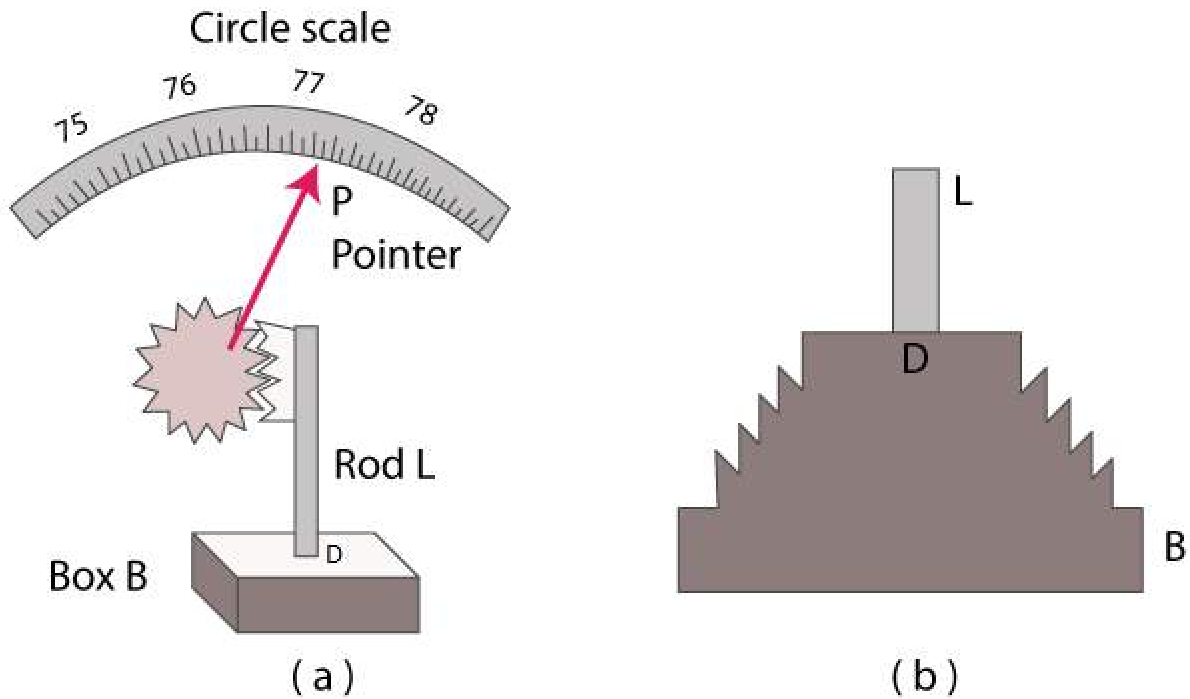


The leather cup is raised up or lowered down first to measure the atmospheric pressure, it is done using a screw S so that the ivory pointer I just touches the level of mercury in the glass vessel. The point of the mercury level in the barometer tube is observed using the main scale and the vernier scale. The addition of the vernier scale reading to the main scale reading yields barometric height.

24. What is an aneroid barometer? Draw a neat and labelled diagram to explain its construction and working.

Solution:

It is a barometer that has no liquid.



Construction:

- The figure shows the main parts which consists of a metabolic box B that is partially evacuated.
- Top D of the box is springy and is corrugated in form of diaphragm as seen in the figure.
- At the middle of the diaphragm, there is a thin rod L toothed to its upper end
- The teeth of rod fit well into the teeth of a wheel S attached with a pointer P that can move over a circular scale which is graduated and is calibrated initially with a standard barometer in order to read the atmospheric pressure directly in terms of the barometric height.

Working:

- When the atmospheric pressure increases, it presses the diaphragm D and the rod L gets depressed
- The wheel S rotates clockwise and pointer P moves to the right on the circular scale
- Simultaneously when the atmospheric pressure decreases, the diaphragm D bulges out as a result of which the rod L moved up and the wheel S rotates anti-clockwise
- Subsequently, the pointer shifts to the left and the pressure is read over the calibrated scale

25. State two advantages of an aneroid barometer over a simple barometer.

Solution:

Two disadvantages of an aneroid barometer over a simple barometer are as follows:

- Aneroid barometer is calibrated to directly read the atmospheric pressure
- It has no liquid and is portable

26. How is the reading of a barometer affected when it is taken to (i) a mine, and (ii) a hill?

Solution:

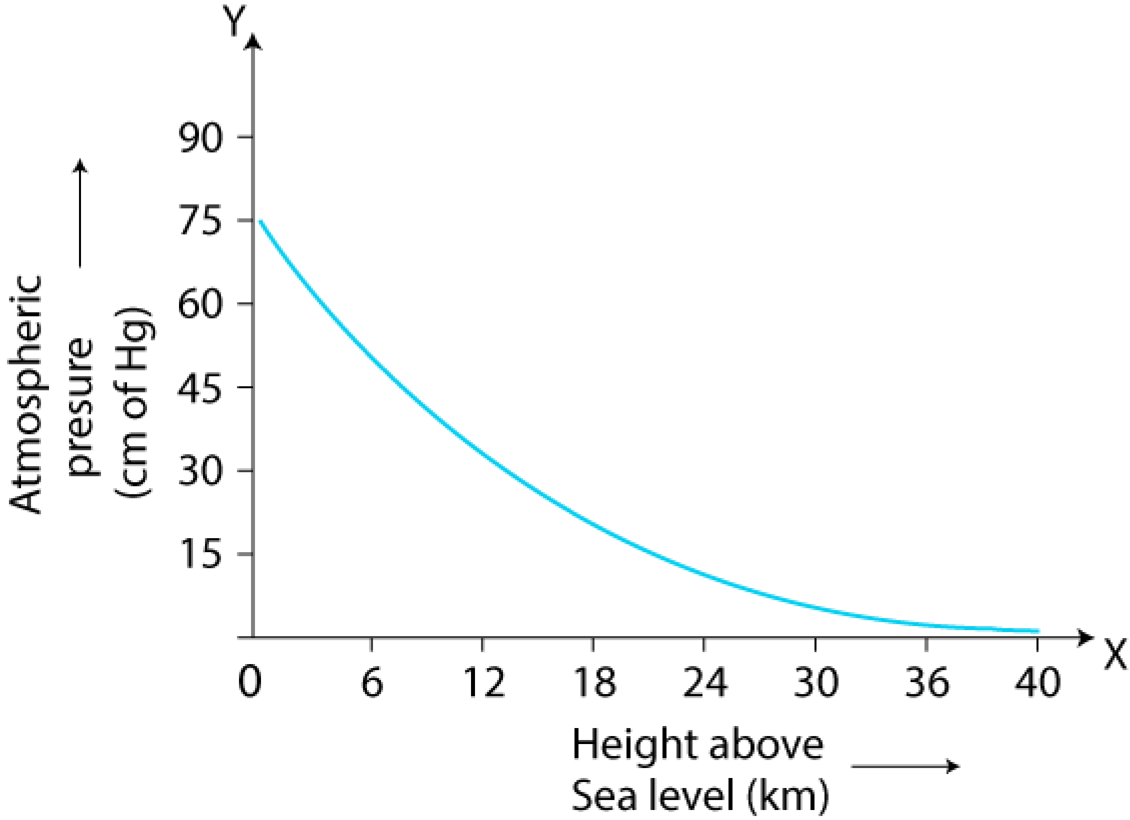
The reading can be affected in the following ways:

- A mine – the reading of a barometer increases in a mine
- A hill – the reading of a barometer decreases on a hill

27. How does atmospheric pressure change with altitude? Draw an approximate graph to show this variation.

Solution:

The atmospheric pressure changes with altitude. As the altitude increases, the pressure decreases.



28. State two factors which affect the atmospheric pressure as we go up.

Solution:

Two factors which affect the atmospheric pressure as we go up:

- Air density
- Height of air column

29. Why does a fountain pen leak at a high altitude?

Solution:

When fountain pen is taken to an altitude, the atmospheric pressure is low hence the excess pressure in the rubber tube forces the ink to leak out.

30. Why does nose start bleeding on high mountains?

Solution:

The atmospheric pressure is reasonably low on mountains. As a result of excess pressure of blood compared to the atmospheric pressure, nose starts bleeding.

31. What is an altimeter? State its principle. How is its scale calibrated?

Solution:

A device utilized in aircrafts to measure its altitude is an altimeter.

Its principle is as follows:

With an increase in the height above the sea level, the atmospheric pressure decreases. Thus, a barometer that measures the atmospheric pressure can be utilized in order to measure the altitude of a place above the sea level.

The scale of the altimeter is calibrated such that is graduates with the height increasing towards the left as the atmospheric pressure decreases with increasing height above the sea level.

32. What do the following indicate in a barometer regarding weather:

(a) Gradual fall in the mercury level

(b) Sudden fall in the mercury level

(c) Gradual rise in the mercury level?

Solution:

(a) The eventual fall in the level of mercury indicates that the moisture is increasing indicating the possibility of rain

(b) The sudden fall in the level of mercury indicates arrival of a storm or a cyclone

(c) The eventual rise in the mercury level indicates that the moisture level is decreasing representing dry weather.

Multiple choice type:

1. The unit torr is related to the barometric height as:

(a) 1 torr = 1cm of Hg

(b) 1 torr = 0.76cm of Hg

(c) 1 torr=1mm of Hg

(d) 1 torr=1m of Hg

Solution:

(c)1 torr=1mm of Hg

2. The normal atmospheric pressure is:

(a) 76m of Hg

(b) 76cm of Hg

(c) 76 Pa

(d) 76 Nm^{-2}

Solution:

(b) 76cm of Hg

3. The atmospheric pressure at earth surface is P_1 and inside mine is P_2. They are related as:

(a) $P_1 = P_2$

(b) $P_1 > P_2$
(c) $P_1 < P_2$
(d) $P_2 = 0$
Solution:
(c) $P_1 < P_2$

Numericals:

1. **Convert 1mm of Hg into pascal. Take density of Hg=13.6 x 10^3 kg m^{-3} and g=9.8 m/s^2**
Solution:
Given: density of Hg=13.6 x 10^3 kg m^{-3}, acceleration due to gravity =9.8 m/s^2, height of mercury column = 1mm or 0.001m
We know that pressure = h ρ g
= 0.001 x 13.6 x 10^3 x 9.8
= 133.28 Pa

2. **At a given place, a mercury barometer records a pressure of 0.70m of Hg. What would be the height of water column if mercury in barometer is replaced by water? Take density of mercury to be 13.6 x 10^3 kg m^{-3}**
Solution:
Given: density of Hg=13.6 x 10^3 kg m^{-3}, acceleration due to gravity =9.8 m/s^2, height of mercury column = 0.70m
We know that pressure = h ρ g
P = (0.7)(13.6 x 10^3)(9.8)
= 93.3 x 10^3 Pa
Consider 'h' to the height of the water column
P = h (density of water) g
93.3 x 10^3 = h x 1 x 10^3 x 9.8
h = 93.3/9.8
= 9.52m

3. **At sea level, the atmospheric pressure is 76cm of Hg. If air pressure falls by 10mm of Hg per 120m of ascent, what is the height of a hill where the barometer reads 70cm of Hg. State the assumption made by you.**
Solution:
Given: atmospheric pressure = 76cm of Hg
Pressure falls by 10mm of Hg per 120m of ascent => 1cm of Hg per 120m of ascent
Consider 'h' to be the height of the hill, given=> pressure at the hill = 70cm of Hg
∴ total fall in pressure = atmospheric pressure – pressure at the hill
= 76 – 70 = 6cm of Hg
Given the rate of fall in pressure is 1cm Hg for every 120m advancement in height
Hence for 6cm Hg, advancement in height is 6 x 120m = 720m
Thus, the height of the hill is 720m
The assumption made is that the atmospheric pressure falls linearly with ascent.

4. **At sea level, the atmospheric pressure is 1.04 x 10^5 Pa. Assuming g=10m/s^2 and density of air to be uniform and equal to 1.3kg m^{-3}, fint the height of the atmosphere.**

Solution:

Given: P = 1.04 x 10^5 Pa, g = 10m/s^2, density of air = ρ = 1.3 kg m^{-3}

Consider 'h' to be the height of the atmosphere,

We know that pressure = h ρ g

h = P / ρ g

$= \frac{1.04 \; x \; 10^5}{1.3 \; x \; 10}$ = 8000m

∴ Height of the atmosphere is 8000m

5. **Assuming the density of air to be 1.295 kg m^{-3}, find the fall in barometric height in mm of Hg at a height of 107m above the sea level. Take density of mercury = 13.6 x 10^3 kg m^{-3}**

Solution:

Density of air=1.295 kg m^{-3}

Consider 'h' to be the height above the level of sea

Pressure at height 'h' – pressure above the sea level = h ρ_{air} g

- ⇨ h ρ_{air} g = ρ_m g h_f - ρ_m g h_i
- ⇨ Change in the height = $\frac{\rho_{air} \, h}{\rho_m}$ = 1.295 x 10^7/13.6 x 10^3
- ⇨ 10mm of Hg