4 PRESSURE

PRESSURE

OBJECTIVES

At the end the lesson, students should be able to:

- explain the concept of pressure;
- state some uses of pressure; and
- solve some simple problems on pressure.

CONCEPT OF PRESSURE

A sharp knife cuts through a yam tuber or a piece of meat faster than a blunt knife. It is easier to push a needle into a piece of wood than a six inches nail with the same force. The sharp knife or the needle penetrates the materials better than the blunt knife or the six inch nail because they exert greater force on a unit area.

Pressure is force acting normally on a unit area.

$$\text{Pressure} = \frac{\textit{Force}}{\textit{Area}}$$

The unit of pressure is Newton per metre squared (Nm^{-2}) or Pascal (pa). Pressure is a scalar quantity because it acts in all direction. The magnitude of pressure increases when:

â€¢ the size of the force is increased.

â€¢ the area of contact where the force acts is decreased.

When the force is constant, pressure changes as the area of contact changes; **sharp or pointed objects exert more pressure at the point of contact.** This is the reason they penetrate the surface in contact with them. They concentrate their weight (force) on a small area making penetration easier. On the other hand, objects with large surface area spread their weight (force) over a large area, reducing the pressure, therefore penetration is difficult.

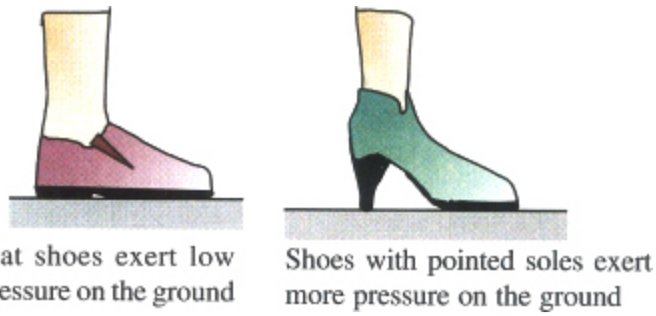


Figure 4.1: Pressure is high for small areas

The Figure 4.2 shows a box with the dimensions stated. If the weight of the box is 42 N, calculate the pressure exerted by the box in on the ground at each position.

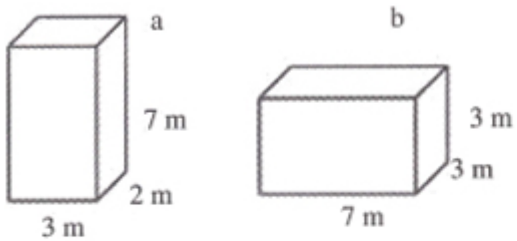


Figure 4.2: A box with its dimensions

Solution

Area of the box in contact with the ground (a) *=2mÃ—3m = 6m*^{2}

$$\text{pressure} = \frac{Force}{Area} = \frac{42}{6} = 7\,Nm^{-2}$$

Area of the box in contact with the ground (b) = 3 *m* Ã— 7 *m* = 21 *m*^{2}

$$\text{pressure} = \frac{Force}{Area} = \frac{42}{21} = 2\,Nm^{-2}$$

The pressure exerted by the box in position (a) is more than the pressure exerted by the box in position (b) because it is standing on a smaller base.

The same force produces more pressure when its weight is concentrated over a small area. Heavy objects stand on a large surface area to reduce pressure on the ground due to its large weight.

â€¢ Elephants have large feet to reduce pressure of its big weight on the ground to avoid sinking.

â€¢ Caterpillars and tractors have large tyres with large surface area to reduce pressure and avoid sinking on a soft soil.

â€¢ Standing on flat shoes reduces pressure more than standing on shoes with pointed heels.

â€¢ Carrying a heavy object with a wire is more painful than carrying the same object with a belt. The belt spreads the weight of the object over large area thereby reducing the pressure.

â€¢ Foundations of buildings are laid on large concrete base to spread the weight of the building in order to reduce its pressure on the ground. This prevents the building from sinking.

Summary

â€¢ Pressure is force acting normally on a unit area.

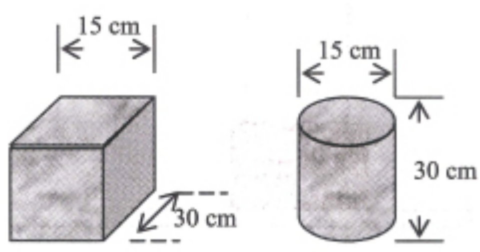
• $\text{Pressure} = \dfrac{\text{Force}}{\text{Area}}$

â€¢ The same force produces more pressure when its weight is concentrated over a small area. Heavy objects stand on a large surface area to reduce pressure due to its large weight on the ground.

â€¢ Sharp or pointed objects exert more pressure at the point of contact than objects with large surface area.

PRACTICE QUESTIONS 4a

1. (a) What is pressure?
   (b) Explain why:
      (i) caterpillars have very wide tyres.
      (ii) syringe needle pierces the body easier than the nip of a biro pen.
   (c) An elephant of total weight 40,000 N stands on four feet each with area of cross-section 0.16 m^2. Calculate the pressure exerted by the elephant on the ground when it stands on:
      (i) four legs;
      (ii) the last two legs.
2. (a) Define pressure and give its units.
   (b) Explain why a sharp point exerts more pressure on a surface than blunt surfaces.
   (c) Calculate the pressure exerted by each of the shapes below if each has a weight of 100N.
   (d) Explain why the cylinder exerts more pressure than the box.



3. (a) Define pressure and state its unit.
   (b) Explain the following:
      (i) It hurts more carrying a heavy bag with a string of wire.
      (ii) Farm tractors have wide tyres.
   (c) An elephant of mass 15000 kg stands on its four legs each of area 1.2 Ã— 10^{-2} m^2, calculate the pressure exerted by each leg of the elephant on the ground.

[g = 10 ms^{-2}]

PRESSURE IN LIQUIDS

OBJECTIVES

At the end of the lesson, students should be able to:

- state the laws of liquid pressure;
- calculate the pressure due to liquid column;
- calculate the column of liquid supported by atmospheric or air pressure;
- state the applications of liquid and air pressures;
- use the column of liquid supported by air or atmospheric pressure to calculate the density of a liquid.

When a body is immersed in a liquid, the weight of the liquid above the body exerts pressure on it. Deep-sea divers wear pressure suit to avoid being crushed by large pressure exerted on them inside the sea.

The laws of liquid pressure

1. The pressure of a liquid increases with depth: The deeper an object sinks in a liquid the more the pressure on it. This is because the weight of liquid above the object is increased. The increase in pressure of a liquid with depth is illustrated in figure 4.3.

A vessel with three holes A, B and C down the side is filled with water. Water rushes out from the holes, the deeper the hole under the water the greater the pressure and faster the water flows from the hole. The volume of water coming out per second from the hole A, is greater than the volume of water coming out per second from the holes B and C.

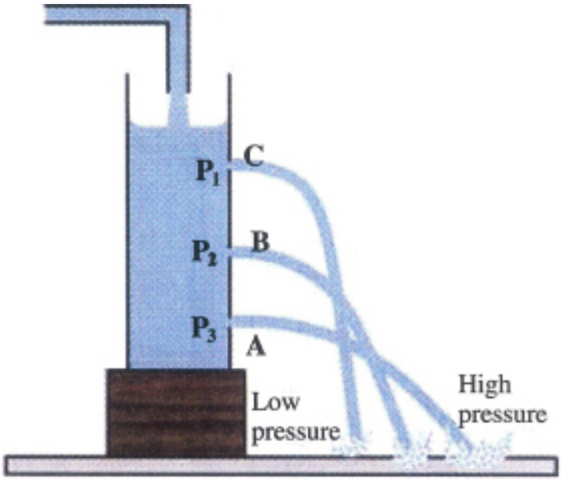


Figure 4.3 Variation of pressure with depth

This is because the pressure of water is greatest at P_3.

Dams and water reservoirs (tanks) are built with thicker concrete base because pressure of water is greater at the base than at the top.

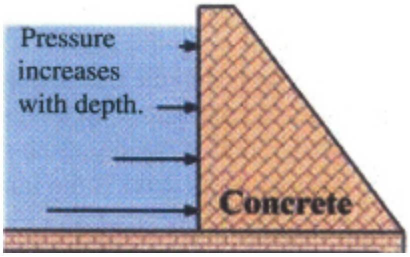


Figure 4.4 Dams are thicker at the base to withstand greater pressure at the base

2. **The pressure in a liquid at the same depth is the same in all directions:** The pressure in a liquid along a fixed depth is the same in any direction. This is confirmed by the experiment in Figure 4.5.

   A vessel with holes A, B and C at the same depth is filled with water. The volume of water flowing out of the holes per second is the same for the three holes. This is because pressure is the same for the three holes.

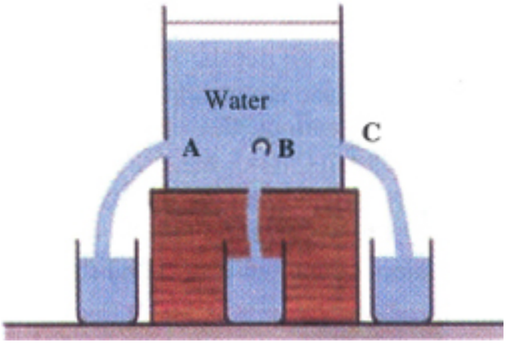


Figure 4.5: Pressure at the same depth is the same

3. **A liquid will always rise to the same level:** The rise of a liquid in a vessel does not depend on its shape but on the height of the liquid above a common base.

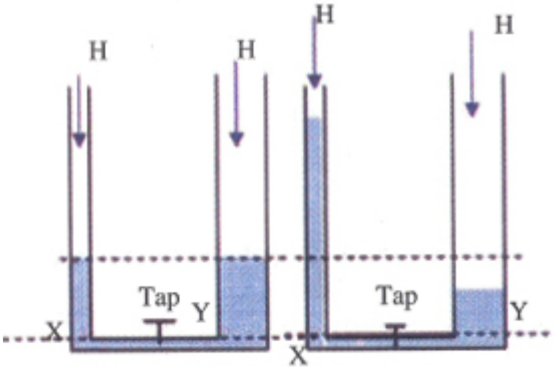


Figure 4.6a: Water rises to the same level when tap is opened

Figure 4.6 is a U-tube linked at the base with two arms of different sizes. The pressure of water is more at X than at Y because the height of water above X is greater than the height of water above Y. When the tap is opened, water flows from the tube X to Y until the level of water on both tubes are equal. This confirms that liquids will always rise to same height when poured into different vessels with a common base.

Figure 4.6b is pascal vases used to show that the rise of a liquid in a vessel does not depend on its shape or size but on the pressure at the base. Pascal vases have many vessels sharing a common base. When water is poured into one of the vessels, it rises to the same level (height) in the other vessels. This is because pressure at the base is the same for all the vessels.

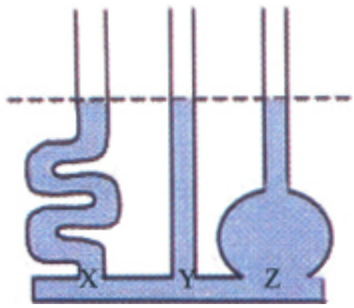


Figure 4.6b: Water rises to the same level in Pascal vessels

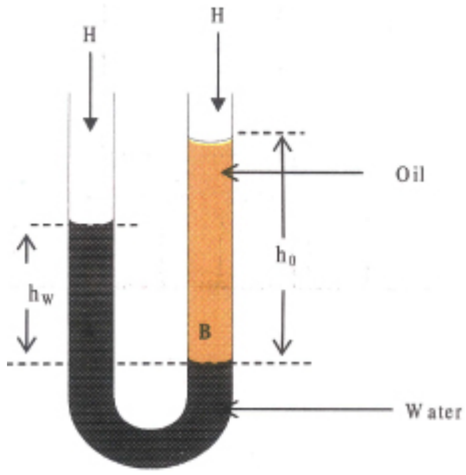


Figure 4.7: Oil rises higher than water because it is less dense

4. The pressure of a liquid depends on its density

Water and oil are poured into a U- tube. Water is poured into arm A of the U-tube while oil is poured into arm B of the U-tube. The oil forms a column above water as shown in Figure 4.7. The pressure is the same for both the oil and water at the same level as indicated by the line AB. The oil being less dense than water rises higher than water above the line AB. This confirms that at the same depth pressure increases with density.

Pressure of different liquids at the same depth varies according to their densities. The greater the density of a liquid the higher the pressure it exerts at a given depth. Pouring two liquids, which do not mix into the arms of a U- tube can prove this.

5. Pressure is transmitted uniformly in all directions in a liquid. Liquids unlike gases are incompressible. When pressure is exerted on a liquid enclosed in a vessel, it is transmitted to other parts of the liquid without loss. The transmission of pressure uniformly in all directions in a liquid is demonstrated by the experiments in Figure 4.8.

(i) Make holes on a pure water sachet or around a round bottom flask.

(ii) Exert pressure by squeezing the water sachet or by pushing in the piston.

(iii) Water rushes out uniformly in all directions from the water sachet or the round bottom flask.

Conclusion: Pressure is transmitted uniformly without loss in all directions in a liquid. This is called Pascalâ€™s law of equal transmission of pressure.

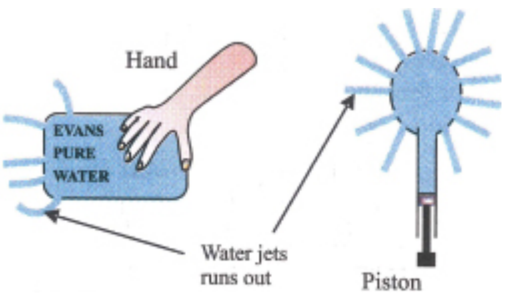


Figure 4.8: Pressure is transmitted equally in every direction

Pressures due to liquid column

The pressure (P) of a liquid of density ( ) at a depth (h) is measured by taking into consideration the force it exerts on the area of cross – section (A)

The weight of liquid pressing downwards on the area of the of cross-section (A) is given by

Weight of liquid = mass of liquid Ã— gravity

Mass of liquid = volume of liquid Ã— density

Weight of liquid = Volume of liquid Density of liquid Gravity

$$W = Ah \quad g$$

$$Pressure = \frac{Force}{Area} \Rightarrow P = \frac{Ah\rho g}{A}$$

$$P = h\rho g$$

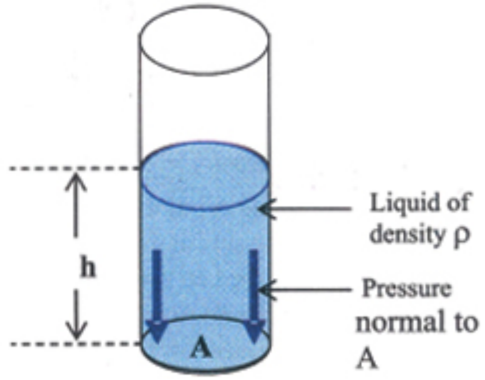


Figure 4.9: Weight of liquid exerts pressure at the base

The pressure of a liquid depends on its depth (h) below the liquid surface and the density *Ï* of the liquid.

Atmospheric (air) pressure

The earth and every object around its surface are surrounded by a layer of air called atmospheric or air pressure. All objects on the earthâ€™s surface are at the depth of a deep sea of air. The weight of air presses on every object on the earthâ€™s surface from all directions exerting high pressure on them. We do not feel the effect of the air pressure because the pressure inside our body balances the atmospheric (air) pressure outside.

The atmospheric or air pressure at sea level (the lowest level of earthâ€™s surface) is about 760 millimetre of mercury or 101000 Pascal. This is called standard or normal atmospheric pressure. Atmospheric pressure may vary in a location depending on weather conditions and the height of the place above the sea level.

Evidence of atmospheric or air pressure

1. **Collapse of an empty vessel when the inside pressure is reduced:** Using an empty vessel with a thin wall carry out the following simple experiments:
   1) Add a little amount of water into the vessel and boil for some minutes to drive out the air inside the vessel.
   2) Cover the vessel with a rubber lid and pour cold water on the vessel to condense the steam inside.

Observation: The vessel collapses as cold water is poured on it.

Explanation: Pouring cold water on the vessel condenses the steam; a partial vacuum is formed inside the vessel. The greater air pressure outside the vessel squeezes the vessel.

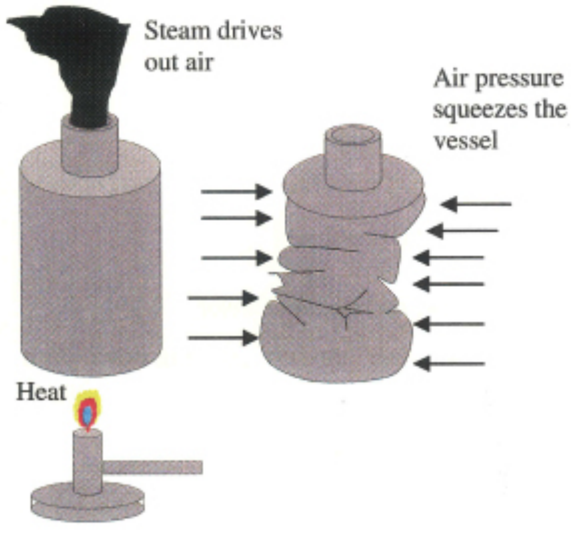


Figure 4.10a: Collapsing a vessel

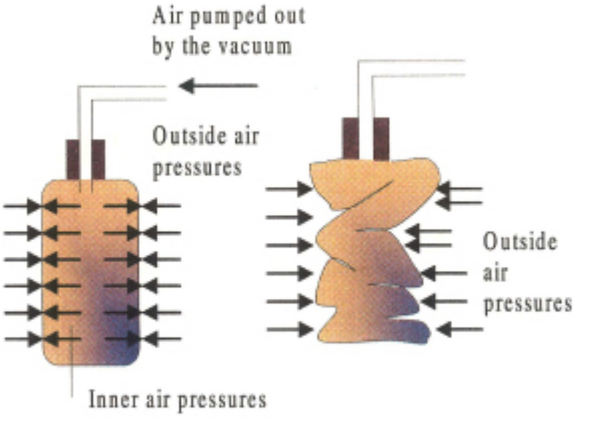


Figure 4.10b: Effect of air pressure on a thin walled vessel

Another way to show the effect of air pressure is illustrated in Figure 4.10b. A thin walled vessel is connected to a vacuum pump and the air inside pumped out. The pressure inside is reduced; the air pressure outside crushes the bottle.

2. Atmospheric or air pressure exerts large force

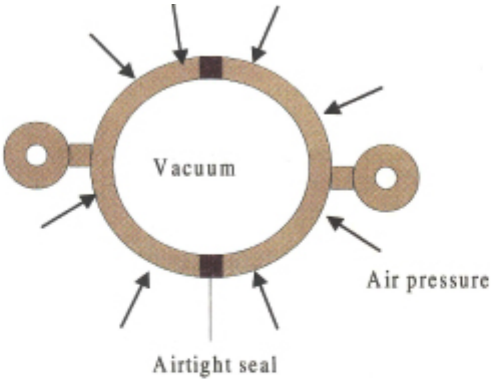


Figure 4.11: The force air pressure by Magdeburg hemisphere

The large force exerted by the atmospheric or air pressure was demonstrated in Magdeburg in 1654. Two large metal hemispheres joined with air tight seal to form a sphere with the air inside completely pumped out could not be pulled apart by two teams of horses. When the air was returned into the sphere, they were easily pulled apart.

3. Atmospheric or air pressure can support the weight of few centimetres of a liquid

Experiment

- â€¢ Fill a glass cup with water and place a thick paper cover on the top.
- â€¢ Hold the paper with your fingers and invert the glass cup.
- â€¢ Remove your fingers from the paper cover.

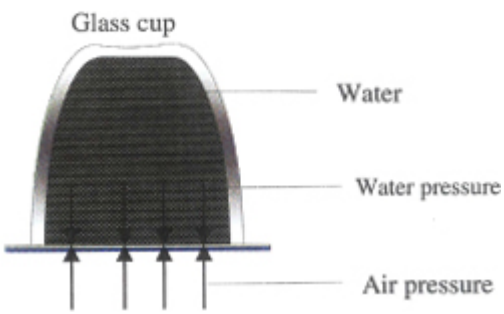


Figure 4.12: Air pressure supports few centimetres column of water

Observation: The paper cover remains in place despite the water pressure pressing down on it.

Explanation: The atmospheric or air pressure acting upwards on the paper cover is strong enough to support the water pressure pressing downwards on the paper.

Column of liquid supported by atmospheric (air) pressure

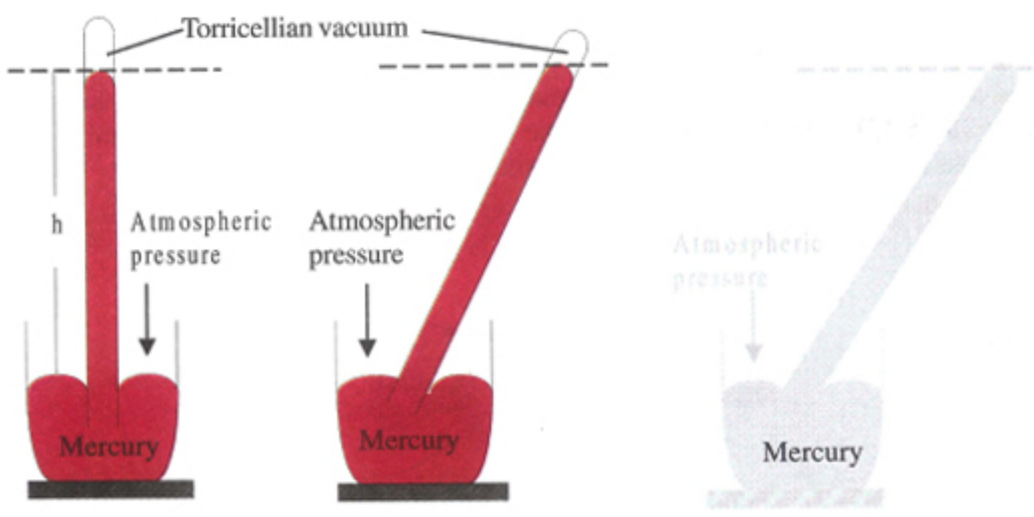


Figure 4.13: Simple barometer

Atmospheric or air pressure supports 760 mmHg column of mercury.

Experiment

- â€¢ Fill a uniform thick walled glass tube 1m long with mercury.
- â€¢ Invert the tube with mercury inside in a trough of mercury and allow it to stand upright.

Observation: Mercury level drops inside the glass tube until atmospheric or air supports a height of 760 mm above the mercury in the trough. *The height of mercury (760 mm) supported by air pressure is called standard or normal atmospheric pressure written as 760 mmHg. This is the pressure of the atmosphere at the sea level.* A vacuum (empty space) is formed above the mercury in the tube. This is called **torricellian vacuum.**

Tilting the tube does not change the height of mercury in the tube, it remains 760 mm above the mercury in the trough, but the vacuum above the mercury is reduced. If the tube is tilted further, mercury fills the whole tube showing that the space above the mercury is a true vacuum.

Atmospheric or air pressure supports about 10 m column of water at the sea level. The atmospheric pressure of 760 mmHg is about 101000 Pa or 101kPa.

Summary

- â€¢ **The laws of liquid pressure**
  - â€¢ The pressure of a liquid increases with depth.
  - â€¢ The pressure in a liquid at the same depth is the same in all directions.
  - â€¢ A liquid will always rise to the same level.
  - â€¢ The pressure of a liquid depends on its density.
  - â€¢ Pressure is transmitted uniformly in all directions in a liquid.
- â€¢ *The height of mercury (760 mm) supported by air pressure is called standard or normal atmospheric pressure written as 760 mmHg. This is the pressure of the atmosphere at the sea level.*
- â€¢ **Evidence of atmospheric or air pressure**
  - â€¢ Collapse of an empty vessel when the inside pressure is reduced.
  - â€¢ Atmospheric or air pressure can support the weight of a few centimetres of a liquid.
  - â€¢ Atmospheric or air pressure exerts large force.

PRACTICE QUESTIONS 4b

1. (a) What is pressure?

   (b) State the laws of liquid pressure.

(c) Explain why dams are thicker at the base than at the top.

(d) A dam is 12.5 m deep. If it holds a liquid of density 1250 kgm^{-3}, find the pressure at the base. [g = 10 ms^{-2}]

2. (a) Distinguish between force and pressure. State the unit of each.

(b) State **four** characteristics or laws of liquid pressure.

(c) Describe an experiment to show that pressure in a liquid increases with depth.

(d) A glass tube 1.5 m tall is filled with liquid of density 1080 kgm^{-3}. What is the pressure exerted on the base of the tube if the atmospheric pressure is 101 kPa? [g= 10 ms^{-2}]

3. (a) Explain the term, *â€œthe atmospheric pressure at the sea level is 760 mmHgâ€.*

(b) State two evidences of atmospheric pressure.

(c) State two instruments used to measure the atmospheric pressure.

4. (a) What is atmospheric pressure? State its unit in Pascal at the sea level.

(b) Explain why the atmospheric pressure decreases with increase in height from the sea level.

(c) Why is the inside of an aircraft pressurised?

(d) What would happen to the objects inside an aircraft in flight if the door is opened suddenly?

5. (a) What is atmospheric pressure?

(b) Describe an experiment to show that air exerts large pressure on a surface.

6. (a) Explain how to make a simple mercury barometer.

(b) A simple barometer supports 76 cm of mercury at the sea level, what is the atmospheric pressure in Pascal?

(c) How would the height be affected if:

(i) the tube tilted?

(ii) air bubbles were trapped in the tube?

(iii) a wider tube is used?

APPLICATION OF FLUID PRESSURE

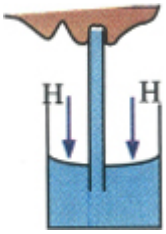
OBJECTIVES

At the end of the lesson, students should be able to:

- use atmospheric pressure to explain the working of the drinking straw, the siphon, the syringe and the pumps (the lift and force pumps).
- explain the principle of the hydraulic press, the hydraulic brake and the bicycle pump;
- use the idea that atmospheric pressure supports a given height of a liquid to measure densities of liquids.

The drinking straw

The drinking straw is one of the applications of air pressure. Sucking out air from the straw creates a partial vacuum in it. The atmospheric or air pressure pressing on the liquid surface forces it into the straw. The maximum height a liquid can lift up in the straw is the height the atmospheric pressure supports for the liquid. Water cannot rise to a height above 10 m in the straw. It is easier to suck water with a straw at the foot of the mountain than at the top because the atmospheric pressure is less at the mountain top.



The siphon

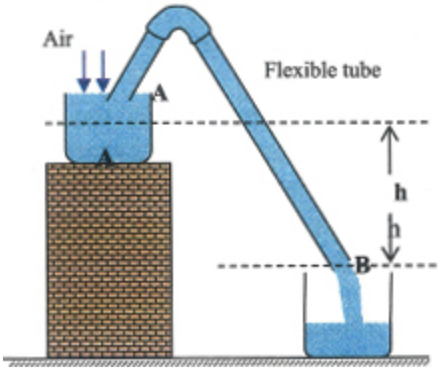


Figure 4.14: Siphon

The siphon works on the same principle as the drinking straw. When the air pressure in the flexible tube is evacuated, a vacuum is formed.

Atmosphere or air forces the liquid into the tube. The liquid is siphoned from the upper vessel to the lower vessel. The transfer of liquid is possible if the end **B** is below the end **A** of the tube and the height **h** between **A** and **B** is less than the height the air pressure supports for the liquid. The siphon cannot transfer water from the upper vessel to a lower vessel if **h** is more than 10 m.

The syringe

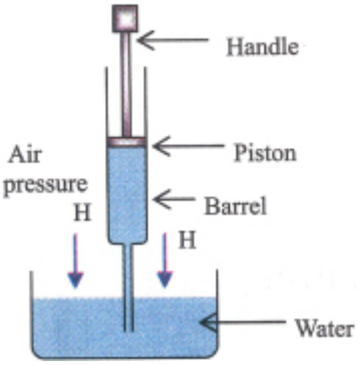


Figure 4.15: The syringe

The syringe Figure 4.15 consists of a barrel and a piston. When the nozzle of a syringe is dipped in a liquid and the piston pulled up, partial vacuum is formed inside the barrel. Air pressure pushes the liquid up the barrel through the nozzle. The pipette used in the laboratory sucks up water in the same way.

The lift pump

The lift pump is a syringe with special features. It has two valves A and B as shown in Figure 4.16. Valve A is at the lower end of the barrel, it opens to let in water into the barrel while the valve B is on the piston. Valve B opens to let out water from the barrel.

When the piston is pulled up (upward stroke) air is pumped out of the barrel, a partial vacuum is formed. Valve A opens and valve B closes. Atmospheric pressure forces water into the barrel through the nozzle. During the downward stroke, the piston is lowered, valve B opens to let out water while valve A closes.

The lift pump cannot pump up water from a well if the valve A is more than 10 m above the water level in the well.

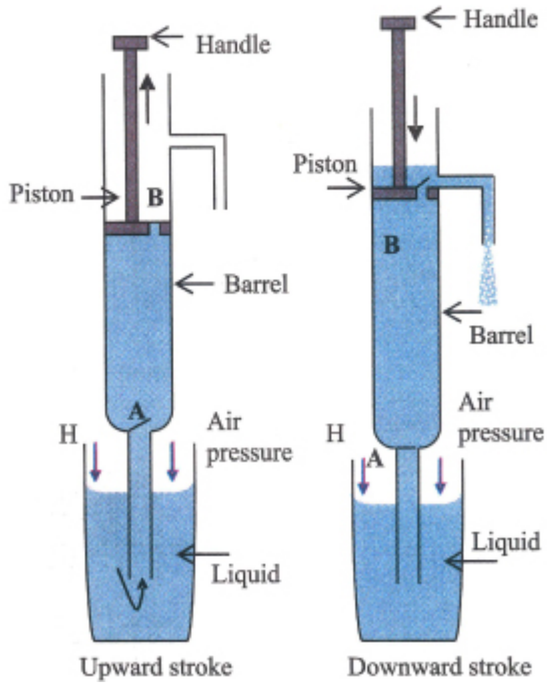


Figure 4.16: Action of a lift pump

The force pump

The force pump is a lift pump that supplies liquid continuously from the sprout. It consists of a piston tightly fitted to the barrel, two valves A and B and an air chamber C. When the piston is lifted up (upward stroke) a vacuum is formed in the barrel, valve A opens to allow liquid into the barrel while valve B remains closed. Atmospheric (air) pressure forces the liquid up the nozzle through the valve A into the barrel.

As the piston is pushed down (downward stroke), valve A closes while the valve B opens. Liquid is pushed into the air chamber C. The compressed air in the chamber causes a jet of liquid to rush out of the sprout.

Force pumps can lift water to any height above 10 m but the valve A must not be more than 10 m above the water level in the well.

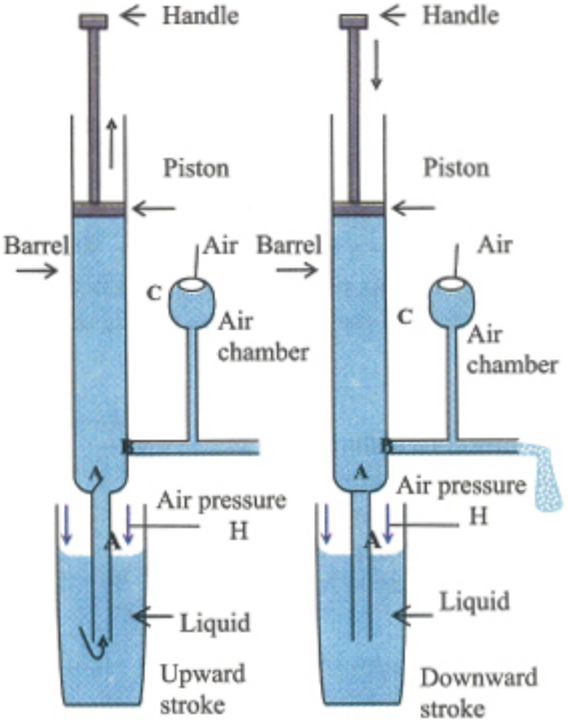


Figure 4.17: Action of a force pump

The bicycle pump

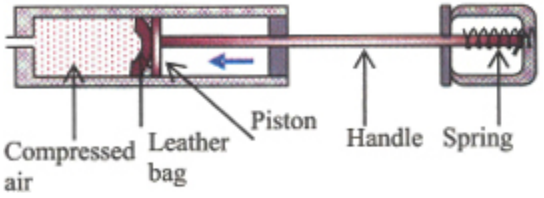


Figure 4.18: Bicycle pump

The bicycle pump has a piston moving inside a barrel with a flexible washer attached to the piston. Pushing the piston, it compresses the air inside the barrel, increasing its pressure above the atmospheric pressure. Air is forced into the tyre through the valve when the pressure of the air inside the barrel is greater than the pressure of air inside the tyre. As the piston is withdrawn, air pressure inside the barrel is lowered below the atmospheric pressure; air is forced into the barrel through the leather washer. During this process, the tyre valve remains closed. It is opened again to allow air into the tyre when the pressure inside barrel is more than the pressure in the tyre.

Hydraulic Press

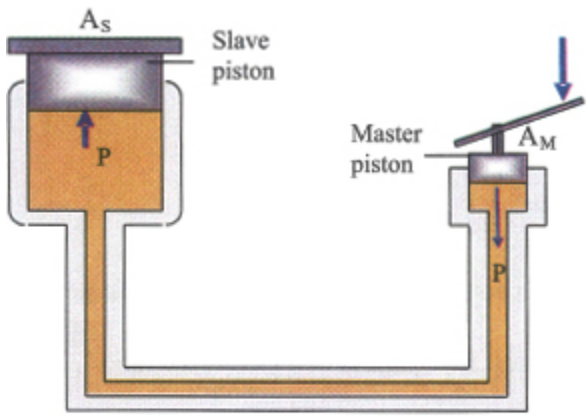


Figure 4.19: The working of a hydraulic press

The pressure of liquid is called hydraulic pressure. **Machines that operate on the principle of transmission of pressure equally in every direction are called hydraulic.** This includes the hydraulic press, the hydraulic brake and the hydraulic car jack. The hydraulic press has two pistons which are firmly fitted inside a drum containing a liquid. When a force is applied to the master piston with a smaller cross-sectional area, a large pressure is produced. *This pressure is transmitted through the liquid with no loss to the slave piston whose cross-sectional area is much greater than that of the master piston.* A large force is exerted on the slave piston to lift up a heavy load on it. Suppose the area of the cross-section of the master piston is 10 cm^2, if a force of 50 N is applied to it, the pressure on the liquid is 5 Ncm^{-2}.

$$pressure = \frac{force}{area} = \frac{50\ N}{10\ cm^{-2}} = 5\ N\ cm^{-2}$$

A pressure of 5 N cm^{-2} is transmitted to the base of the slave piston. If the area of cross-section of the slave piston is 1000 cm^2, then the force acting on its base is 5000 N.

Force = pressure Ã— area

F = 5 Ã— 1000 = 5000 N

A large force therefore is obtained by pushing down the master piston with a little effort.

The mechanical advantage (M.A.) of a hydraulic press is given by:

$$\text{M.A.} = \frac{load}{effort} = \frac{5000\ N}{50\ N} = 100.$$

The volume of liquid transferred from the master piston to the slave piston is the same and is given by:

Volume of liquid transferred

Volume $= D$ *Ã—* $A_m = d$ *Ã—* A_s

D = distance moved by the effort

d = distance moved by the load

A_m = area of the cross-section of the master piston and A_s = area of the cross-section of the slave piston.

The velocity ratio of the hydraulic press

$$\text{V.R.} = \frac{\textit{distance moved by the effort}}{\textit{distance moved by the load}}$$

$$\text{V.R.} = \frac{D}{d} = \frac{A_s}{A_m} = \frac{1000\,cm^2}{10\,cm^2} = 100$$

If friction is eliminated, the mechanical advantage of a hydraulic press will be equal to the velocity ratio. Higher mechanical advantage is obtained if the ratio $\frac{A_s}{A_m}$ is increased.

The hydraulic car brake

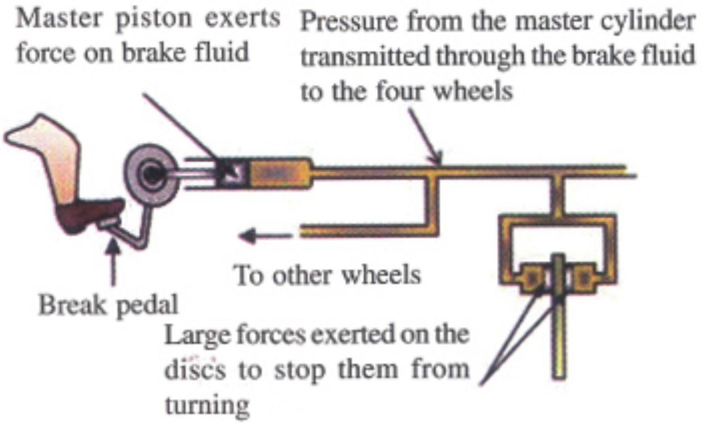


Figure 4.20: The hydraulic car brake

The hydraulic brake works on the principle of transmission of liquid pressure equally in every direction. When a force is exerted on the brake pedal by pressing on it, large pressure acts on the brake fluid in the master cylinder. The pressure is transmitted through the break fluid to the slave cylinder in each of the four wheels. This pressure exerts enough force on the piston of the slave cylinder to push the brake pads. The friction between the brake pads and the wheels stops them from turning.

To find the density of a liquid

Atmospheric or air pressure supports a height of liquid depending on its density. This is used in finding the density of other liquids. In Figure 4.21, mercury is carefully poured into a U-tube until the levels on both arms are equal. Oil and water are poured into the U- tube from both arms. The water rises above the oil in the U-tube because the density of water is less than the density of oil. The pressures at the base **O** for the oil and **W** for water are equal.

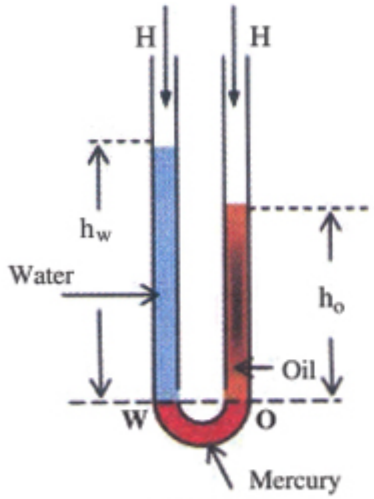


Figure 4.21

Pressure of oil at O = Pressure of water at W

$$H + h_o \rho_o g = H + h_w \rho_w g$$

$$\therefore h_o \rho_o = h_w \rho_w$$

$$\therefore \frac{h_o}{h_w} = \frac{\rho_w}{\rho_o}$$

The Hareâ€™s apparatus shown in Figure 4.22 is a better way to find the density of a liquid by comparing it with the density of water. The relative density of oil is given by:

$$\frac{{}_o}{{}_w} = \textit{relative density of oil} = \frac{h_w}{h_o}$$

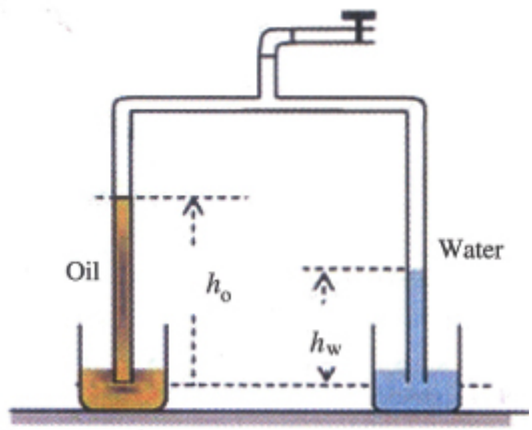


Figure 4.22: Measurement of relative density of a liquid by Hares apparatus

Summary

â€¢ Drinking straws, siphons, syringes and pumps work on the principle that atmospheric pressure pushes water through partially evacuated pipes.

â€¢ Atmospheric pressure supports only 10 m height of water; therefore, these devices cannot transfer water to any height above 10 m.

- â€¢ Hydraulic machines like hydraulics press and brakes work on the principle that pressure is transmitted equally in every direction.
- â€¢ The height of liquid supported by the atmospheric pressure is inversely proportional to the density of the liquid. This is used to measure the density of a liquid.

Practice Questions 4c

1 (a) State Pascal law of pressure transmission.

(b) The area of a master piston of a hydraulic press is 10 cm^2 and the area of the slave piston is 1000 cm^2. When an effort of 50 N is exerted on the master piston calculate the:

(i) pressure in the hydraulic fluid;

(ii) maximum weight the press can lift.

(c) If the efficiency of the hydraulic press is 90%, what weight is lifted by the hydraulic press?

2 (a) Draw a labelled diagram of a hydraulic car brake and explain how it works.

(b) In a hydraulic car brake the master piston has an area of 5 cm^2 while the area of the slave piston is 50 cm^2. When the driver presses on the brake pedal a force of 500 N is exerted on the master piston. Calculate the:

(i) pressure transmitted through the brake fluid;

(ii) force exerted by the slave piston on the brake pad.

Past questions

1. Which of the following about pressure in liquids is **NOT** correct?

   A. Pressure increases with depth.

   B. Pressure at a point is equal in all directions.

   C. Pressure at all points at the same level is the same.

   D. Pressure at a given depth increases with the density of the liquid.

   E. The applied pressure at a point is greater in the downward direction than in any of the other directions.

NECO

2. Which of the following statements about pressure is **not** correct? Pressure

   A. increases with an increase in surface area.

   B. decreases with an increase in surface area.

   C. increases with a decrease in surface area.

   D. increases with an increase in the applied force.

W.A.S.S.C.E

3. A man will exert the greatest pressure on a floor when he
   A. lies flat on his back.
   B. lies flat on his belly.
   C. stands on both feet.
   D. stands on one foot only.
   E. stands on the toes of one foot.

WASSCE

4. The pressure exerted by a liquid in a container is dependent on the
   A. mass of the liquid.
   B. cross sectional area of the container.
   C. volume of the liquid.
   D. density of the liquid.

W.A.S.S.C.E.

5. The pressure due to a liquid column partly depends on the
   A. height of the liquid.
   B. surface tension of the liquid.
   C. surface area of the liquid.
   D. viscosity of the liquid.

W.A.S.S.C.E.

6. An 80 mm column of a liquid is balanced by 120 mm column of water in a Hareâ€™s apparatus. Calculate the density of the liquid. (Density of water = 1000 kg $m^{-3)}$
   A. 1500 kg m^{-3}
   B. 666.7 kg m^{-3}
   C. 150.0 kg m^{-3}
   D. 66.7 kg m^{-3}

W.A.S.S.C.E.

7. A barometer can be used in determining the
   I height of a mountain
   II depth of a mine
   III dew point.
   Which of the following is/are correct?
   A. I, II, and III.
   B. II and III only.
   C. I and III only.
   D. I and II only.
   E. III only.

W.A.E.C.
(S.S.C.E.)

8. Which of the following statements about liquid pressure is **NOT** correct? The pressure

A. at a point in a liquid is proportional to the depth.
B. at any point in a liquid is the same at the same level.
C. is exerted equally in all directions at any point.
D. of a liquid at any point on the wall of its container acts in a direction perpendicular to the wall.
E. at a particular depth depends on the shape of the vessel.

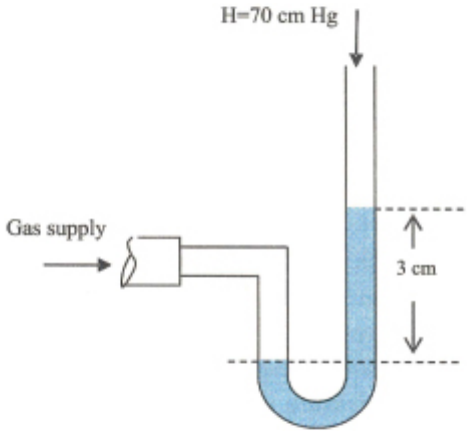
J.A.M.B.

9. The hatch door of a submarine has an area of 0.5 m^2; the specific gravity (relative density) of sea water is 1.03. Assume that g = 10 ms^{-2}, and neglect the atmospheric pressure. The force exerted by the sea water on the hatch door at a depth of 200 m is

A. 1.03Ã—$10^3 N$
B. 1.04Ã—$10^5 N$
C. 1.03Ã—$10^4 N$
D. 2.06Ã—$10^5 N$
E. 2.06Ã—$10^6 N$

J.A.M.B.

10.



The water manometer in the figure above is measuring the pressure of the gas supply. If the specific gravity (relative density) of mercury is 13.6 and the atmospheric pressure is 70 cm Hg, what is the total pressure of the gas supply in cm of water?

A. 67 cm
B. 73 cm
C. 949 cm
D. 952 cm
E. 955 cm.

J.A.M.B.

11. The areas of the effort and load pistons of a hydraulic press are 0.5 and 5m^2 respectively. If the force of 500 N is applied on the effort piston, the force on the load piston is

A. 10 N
B. 100 N
C. 500 N
D. 1000 N
E. 5000 N **J.A.M.B.**

12. A rectangular tank contains water to a depth of 2m. Calculate the pressure on the base.
A. 2.4Ã—$10^5 N$
B. 2.4Ã—$10^4 N$
C. 2.0Ã—$10^4 N$
D. 1.7Ã—$10^3 N$ **J.A.M.B.**

13. Which of the following devices are used to measure pressure?
I Aneroid barometer
II Hydrometer
III Hygrometer
IV Manometer
A. I and III
B. II and III
C. III and IV
D. I and IV **J.A.M.B.**

14. Which of these statements are correct for pressure in liquids?
I Pressure in liquid at acts equally in all directions.
II Pressure increases with depth.
III Pressure at a depth depends on the shape of the container.
IV Pressure at a same depth in different liquids are proportional to the densities of the liquids.
A. I, II, and III only.
B. I, II and IV only.
C. I, III and IV only.
D. II, III and IV only. **J.A.M.B.**

15. The atmospheric pressure due to water is what is the pressure at the bottom of an ocean 10 m deep? (Density of water = 1000 kg m^{-3} g = 10 ms^{-2})
A. 1.3Ã—$10^7 Nm^{-2}$.
B. 1.4Ã—$10^6 Nm^{-2}$.
C. 1.4Ã—$10^5 Nm^{-2}$.
D. 1.0Ã—$10^5 Nm^{-2}$. **J.A.M.B.**

16. At a fixed point below a liquid surface, the pressure downward is P_1 and the pressure upward is P_2. It can be deduced that
A. $P_1 > P_2$
B. $P_1 < P_2$

J.A.M.B.

C. $P_1 < P_2$

D. P_1â‰¥$_2$

17. Which of the following is most suitable as an altimeter?

A. A mercury barometer.

B. A Fortin barometer.

C. A mercury manometer.

D. An aneroid barometer.

J.A.M.B.

18. A pilot records the atmospheric pressure outside his plane as 63cm Hg while a ground observer records a reading of 75cm Hg as the atmospheric pressure on the ground. Assuming the density of atmosphere is constant; calculate the height of the plane above the ground. (Relative density of mercury =13.0 and that of air = 0.00013)

A. 1200 m

B. 6300 m

C. 7500 m

D. 13800 m

J.A.M.B.

19. Weightless vessel of dimensions 4m Ã— 3m Ã— 2m is filled with a liquid of density 1000 kg m^{-3} and sealed. What is the maximum pressure this container can exert on a flat surface? (g = 10 ms^{-2})

A. 9Ã—$10^4 Nm^{-2}$

B. 4Ã—$10^4 Nm^{-2}$

C. 3Ã—$10^4 Nm^{-2}$

D. 2Ã—$10^4 Nm^{-2}$

J.A.M.B.

20. A hydraulic press has a large circular piston of radius 0.8 m and a circular plunger (piston) of radius 0.2 m. A force of 500 N is exerted by the plunger. Find the force exerted on the piston.

A. 8000 N

B. 4000 N

C. 2000 N

D. 31 N

21. The figure below shows a lift pump with valves at **P** and **Q.** During the downward stroke of the piston,

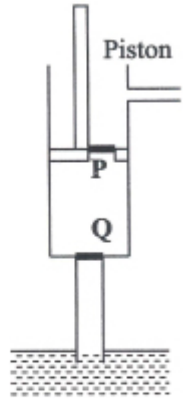
A. both valves are open.

B. **P** is open while **Q** is closed.

C. **P** is closed while **Q** is open.

D. both valves are closed.

J.A.M.B.



22. (a) (i) Define relative density.

(ii) List **three** characteristics of pressure in a liquid.

(b) The horizontal door of a submarine at a depth of 500 m has an area of 0.4 m^{-2}. Calculate force exerted by the sea water on the door at this depth. (Relative density of sea water = 1.03, atmospheric pressure = density of pure water = 1000 kg m^{-3}, g = $10ms^2$.)

W.A.S.S.C.E.

23. (a) (i) Define relative density of a solid.

(ii) Mention the instrument required to measure:

(a) the relative density of a liquid directly and state the law on which it operates.

(b) A body weighs 160 N in air and 120 N when totally immersed in a liquid of relative density 0.80. Calculate the relative density of the body.

(c) An open U-tube mercury manometer is used to measure the pressure of a gas. The mercury in the open tube is 0.60 m higher than that in the limb which is in contact with the gas.

(i) Draw a diagram of the manometer to illustrate the given information.

(ii) Calculate the pressure of the gas. [Density of mercury = 1.36Ã—10^4kg m^3; atmospheric pressure = 1.01Ã—10^5 Pa; g = 10 ms^{-2}]

WA.S.S.C.E.

24. (a) Distinguish between the terms *thrust* and *pressure.*

(b) (i) With the aid of a labeled diagram explain the working of a force pump.

(ii) State one advantage of the force pump over lift pump.

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