Hydrostatic pressure and its applications

Physics

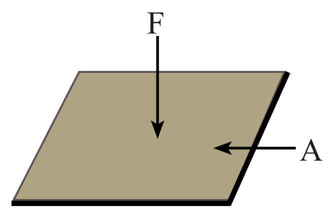
15

15.1 Pressure

Let us review what you have previously learnt about the pressure experienced by surfaces due to solid objects.
Pressure is the force acting on a unit area.

$$\text{Pressure} = \frac{\text{Perpendicular force applied } (F)}{\text{area (A)}}$$

The unit of pressure is Newtons per square meter (Nm^{-2}). As a tribute to the French scientist Blaise Pascal, this unit has been named as the Pascal (Pa).



$$1 \text{ N m}^{-2} = 1 \text{ Pa}$$

Since pressure has only a magnitude, it is a scalar.

Example 1

A cubic shaped box is placed on a table. If the weight of the box is 400 N and the area of the bottom of the box is 0.2 m^2, find the pressure exerted on the surface of the table under the box.

$$\begin{aligned}\text{Pressure} &= \frac{\text{Force}}{\text{Area}}\\ &= \frac{400 \text{ N}}{0.2 \text{ m}^2}\\ &= 2000 \text{ Pa}\end{aligned}$$

Example 2

The pressure exerted by a pile of soil distributed over an area of 8 m^2 of the ground is 150 Pa. What is the force exerted on the ground due to the pile of soil?

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

$$\begin{aligned}\text{Force} &= \text{Pressure} \times \text{area} \\ &= 150\ \text{N m}^{-2} \times 8\ \text{m}^2 \\ &= 1200\ \text{N}\end{aligned}$$

15.2 Hydrostatic pressure

Pressure is exerted not only by solids, liquids also exert pressure. When we place a solid object on a table, a pressure is exerted on the table because the force acting on the table due to the weight of the object spreads over the total contact area between the object and the table.

Similarly, a pressure is exerted on the bottom of a container because, the force acting on the bottom of the container due to the weight of the liquid spreads over the bottom surface of the container. The pressure is exerted by the liquid not only on the bottom of the vessel. The vertical walls of the vessel will also experience the pressure. Apart from this, there are many more characteristics of pressure due to liquids (hydrostatic pressure). Let us investigate these characteristics of hydrostatic pressure.

If you make some holes in a polythene bag, fill it with water and hold it as shown in Figure 15.1, what would you observe? You will observe that water exits through all the holes. Each of these holes exist at a different side of the bag. Water exits from through every hole because water pressure exists at the position of every hole. From this experiment you will observe that the water pressure acts in every direction.

Figure 15.1 – Polythene bag with holes filled with water

Take a plastic bottle with a height of about 25 cm, make several holes at the same level near the bottom and fill it with water. You will see water exiting the bottle as shown in Figure 15.2. You will notice that the horizontal distance traveled by water coming out of every hole is the same. This is because the pressure at the same level of a liquid is the same.

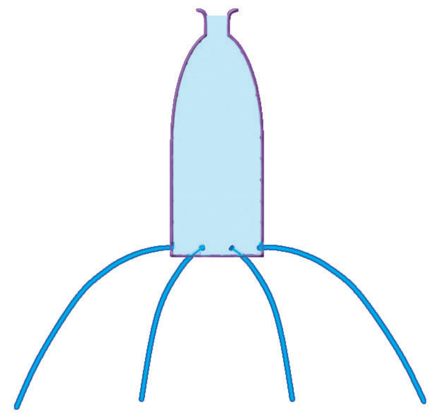


Figure 15.2 – Set-up for comparing the hydrostatic pressure at the same level

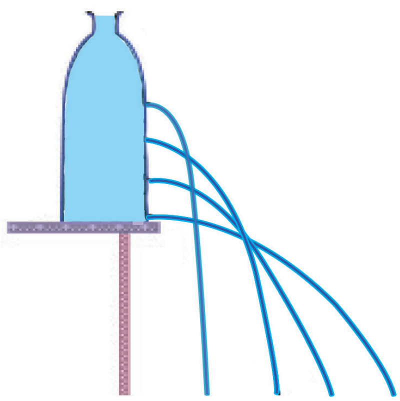


Figure 15.3 - Variation of the pressure with the height of the liquid column

Now let us find out how the height of the water column in a vessel affects the pressure. Make a set of approximately equally spaced holes from top to bottom of a plastic bottle with a height of about 25 cm and fill it with water. Hold the bottle at some height from the ground level as shown in Figure 15.3 and observe how the streams of water leave the bottle.

You will observe that the speed of the streams of water coming from lower holes is greater than the speed of water coming from upper holes. Water exiting a hole has a higher speed when the pressure near that hole is higher. Therefore, it can be concluded that the pressure in a liquid increases with the depth of the liquid.

Let us engage in Activity 15.1 in order to find out how the pressure of a liquid depends on the shape of the liquid column.

Activity 15.1

Dependence of liquid pressure on the shape of the water column

Find five transparent tubes having various shapes as shown by *a*, *b*, *c*, *d* and *e* in Figure 15.4. Fix them to a PVC tube with closed ends as shown, and fill the system with water. Record the vertical heights of the water columns in each tube.

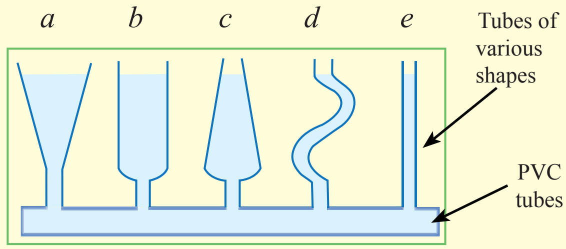


Figure 15.4 - Investigating the dependence of the shape of the water column on the liquid pressure

Tube	Vertical height of water column (cm)
a	
b	
c	
d	
e	

You will notice that the height of the liquid column of each of the tubes is the same. It is clear from the above experiments that the pressure at the equal levels of a liquid is the same. Therefore the pressure at the places where all the tubes are fixed to the PVC tube is also equal. The height of the liquid column of each of the tube is being the same, we can conclude that the pressure due to a liquid column depends only on the height of the liquid column and not on the amount of liquid or the shape of the liquid column.

According to our studies so far on pressure due to a liquid, the liquid pressure has the following characteristics.

(i) The pressure at a certain point in a liquid depends on the height of the liquid column above that point. Pressure increases with the height of the liquid column.

(ii) The pressure at the same level of a liquid is the same.

(iii) At a given point in a liquid, the pressure is the same in all directions.

(iv) Liquid pressure depends on the vertical height of the liquid column. It does not depend on the shape of the liquid column.

If the height of the liquid column is h and the density of the liquid is ρ, the weight of the liquid column above a unit area of the bottom surface of the container is $h\rho g$. Since this weight spreads over a unit area, the liquid pressure at the bottom is $h\rho g$. This result is true not only for the pressure at the bottom but for any other depth of a container. If there is a liquid column of height h above any point in a liquid as shown in Figure 15.5, then the liquid pressure P at that point is given by,

$$P = h\,\rho\,g$$

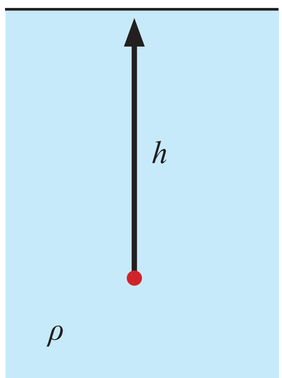


Figure 15.5 - Pressure at a point situated at a depth h in a liquid

When the unit of h is meters (m), the unit of ρ is $kg\ m^{-3}$ and the unit of g is $m\ s^{-2}$, the unit of pressure (P) exerted by the liquid column is $N\ m^{-2}$. As mentioned before, the commonly used unit of pressure, the Pascal (Pa), is defined as $1\ N\ m^{-2}$.

Example 1

At a certain location, the depth of a certain point in a lake is 1.5 m. Find the pressure exerted by the water at the bottom of the lake at this location. (Density of water = $1000\ kg\ m^{-3}$, $g = 10\ m\ s^{-2}$)

Pressure $= h\,\rho\,g$

$= 1.5\ m \times 1000\ kg\ m^{-3} \times 10\ m\ s^{-2}$

$= 15\ 000$ Pa

Example 2

The depth of a certain region of the sea is 10 m. Find the pressure exerted at this region by the sea water. (Density of sea water = $1050\ kg\ m^{-3}$, $g = 10\ m\ s^{-2}$).

Pressure $= h\,\rho\,g$

$= 10\ m \times 1050\ kg\ m^{-3} \times 10\ m\ s^{-2}$

$= 105\ 000$ Pa

15.3 Transmission of pressure through liquids

Liquids do not get compressed by forces exerted on them. Therefore, the pressure exerted at one point in a liquid can be transmitted to another point in the liquid.

A machine constructed to operate based on this principle is known as hydraulic press. Figure 15.6 illustrates the working principle of a hydraulic press

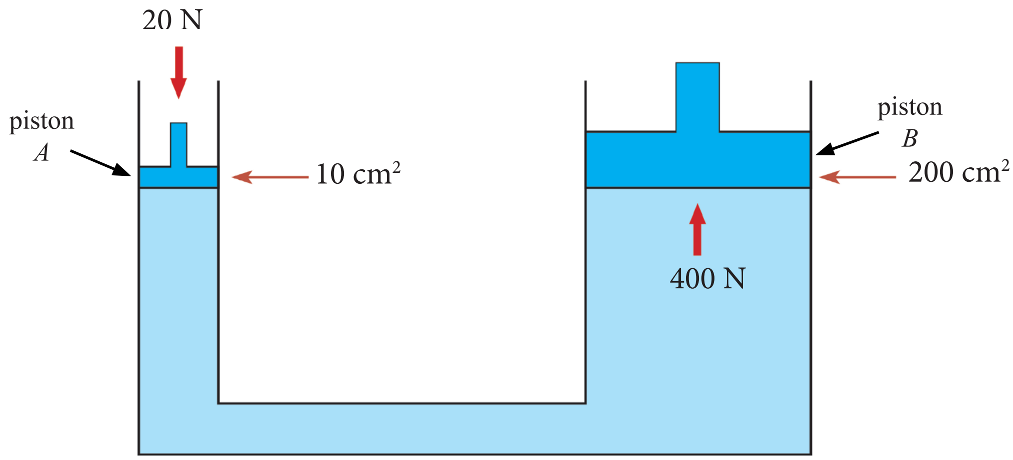


Figure 15.6 - Hydraulic press

It consists of a liquid volume trapped by two pistons *A* and *B* on either side of a cylindrical liquid columns. Assume that the area of piston *A* is 10 cm^2 and the area of piston *B* is 200 cm^2. If a force of 20 N is applied on piston *A*, the pressure it exerts on the liquid,

$$P = \frac{F}{A} = \frac{20\ N}{10^{-3}\ m^2}$$
$$= 2 \times 10^4\ N\ m^{-2}$$
$$= 20\ 000\ N\ m^{-2}$$
$$= 2\ N\ cm^{-2}$$

This pressure is transmitted to piston *B* through the liquid. Therefore, pressure at piston *B* is also 2 N cm^{-2}. That is, the fluid exerts a force of 2 N vertically upwards on each 1 cm^2 of piston *B*. Therefore the total force exerted on the total area of 200 cm^2 of piston *B* is 400 N (2 x 200). It is possible to transmit a force of 400 N to the larger piston from a total force of 20 N acting on the smaller piston because it is possible to transmit pressure through the liquid. (Since the forces acting on the pistons of liquid pressure machines are very high compared to the force due to the weight of the liquid column, the force exerted by the liquid column is not considered in calculations).

Hoists used to lift vehicles in motor vehicle maintenance stations and service stations as the one shown in Figure 15.7, is a machine constructed to operate based on the principle of pressure transmission.

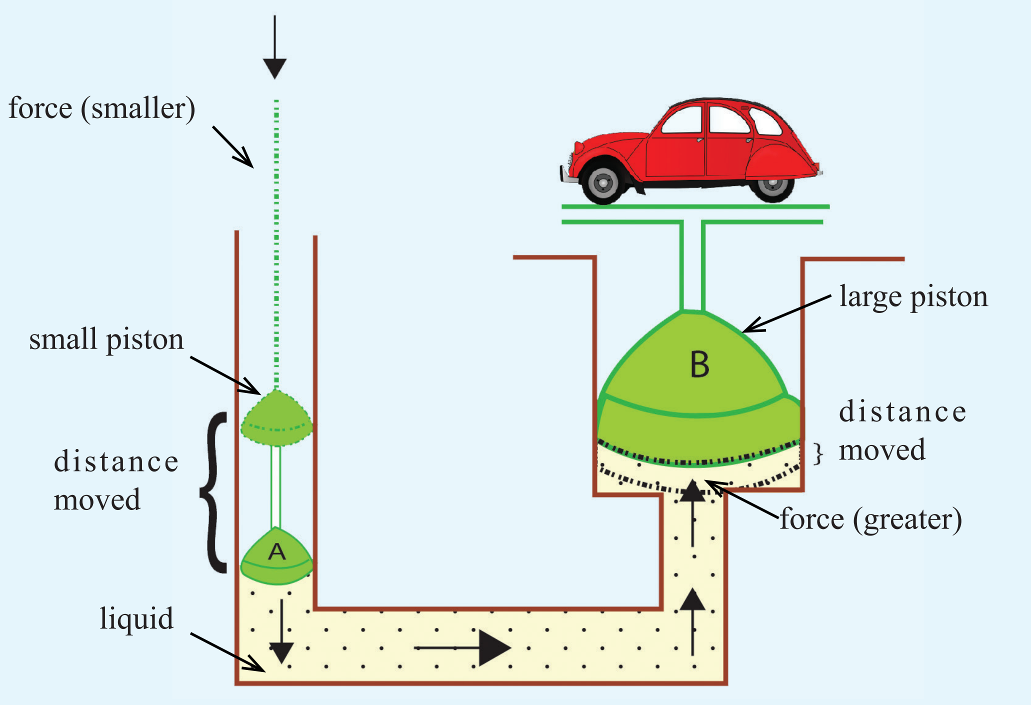


Figure 15.7 - A hoist used to lift vehicles

The hoist is constructed in such a way that the pressure generated in the oil through the small force applied on the large piston is transmitted to the large piston through the oil, transmitting a force equal to the weight of the vehicle placed on the large piston. This force lifts the vehicle.

A jack is used to lift one side of a vehicle when a wheel of the vehicle needs to be detached. Out of the many types of jacks available, the type that is most frequently used is the hydraulic jack. such a jack shown in the figure 15.8 . The hydraulic jack also operates on the principle of pressure transmission.

Here also a force is applied on a small piston. The pressure caused in the oil by this force is transmitted to the large piston through the oil, lifting one side of the vehicle.

Figure 15.8 – Hydraulic jack

Another instance where the principle of liquid pressure transmission is applied is the break system in vehicles. Its principle is shown in figure 15.9.

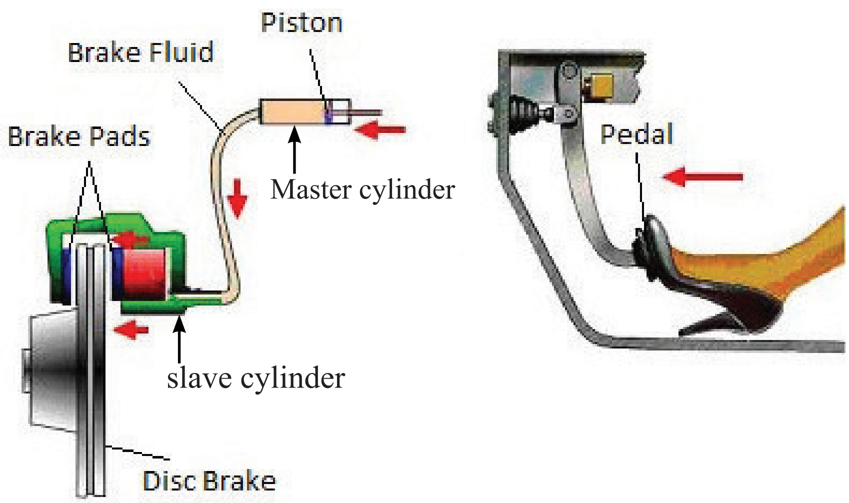


Figure 15.9 – Vehicle break system

In the break system of a vehicle, when the driver applies a force on the break-pedal, it is transmitted to the piston in the master cylinder. This force exerts a pressure on the oil inside the cylinder. This pressure is then transmitted through the oil to the slave cylinder near the wheel. Then the brake-pads connected to the slave cylinder are pressed to apply a pressure on the break-discs or break-drums. Since the cross-sectional area of the slave cylinder is larger than that of the master cylinder, the force applied on the break-pads by the slave cylinder is greater than the force applied by the driver on the break-pedal.

Exercise 15.1

(1) The pressure exerted at the bottom of a container due to a liquid inside it is 1500 Pa. What is meant by "the pressure is 1500 pa"?

(2) Find the pressure exerted by a mercury column of height 10 cm. (Density of mercury is 13600 kg m^{-3}).

(3) The depth of a pond is 1.5 m. Calculate the pressure caused by the water at the bottom of the pond.

(4) The depth at a certain point in the sea is 1 km. Find the pressure exerted by sea water at the bottom of the sea at that point. (Density of sea water is 1050 kg m^{-3}.)

(5) A tank with a length 5 m, width 3 m and depth 2 m is filled with a liquid of density 800 kg m^{-3}.
   (a) What is the pressure at the bottom of the tank due to the liquid ?
   (b) What is the force acting on the bottom of the tank due to that pressure?

15.4 Pressure due to gases

Similar to solids and liquids, gases also exert pressure. There are two ways in which a pressure can be produced by a gas. One is the pressure caused by the weight of a column of gas, similar to the pressure caused by a column of liquid. The atmospheric pressure is produced this way. The other way that a gas can give rise to a pressure is when a compressed gas attempts to expand. From the activity described below you can easily see that a compressed a gas causes a pressure.

Activity 15.2

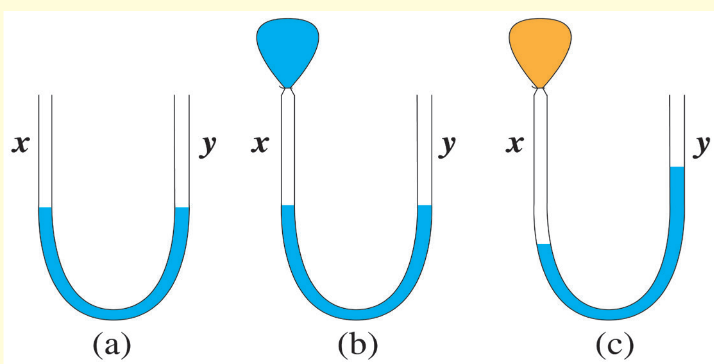


Figure 15.10 – Investigation on gas pressure

- Pour water into a U-tube as shown in Figure 15.10(a). Then the water levels in the two arms *X* and *Y* would become equal.

- Tie the opening of an air filled balloon with a piece of thread making sure that it can be easily untied.

- Next, connect it to the arm *X* of the U-tube as shown in Figure 15.14(b) and tie it with another piece of thread.

- Now slowly undo the knot on the balloon. After removing the knot, you will be able to see that the water level in arm *X* goes down while the water level in arm *Y* goes up. (Figure 15.10(c))

Since the pressure at all points on the same level of a liquid is the same, the liquid levels that are equal before connecting the balloon show that the pressures above the water levels of the two arms are equal.

By filling a balloon with air, we try to restrict a large amount of air inside a limited volume. That is, we compress the air. When we connect the balloon filled with compressed air to arm *X*, the water levels are no longer the same. The higher water level in arm *Y* than the water level in arm *X* shows that the pressure in arm *X* at the liquid surface is higher than the pressure in arm *Y* at the liquid surface. The reason for the higher pressure in arm *X* is the additional pressure exerted on the liquid by the compressed air in the balloon.

Atmospheric Pressure

Earth's atmosphere extends to hundreds of kilometers above the surface of the earth. Similar to the pressure produced at any point inside a container filled with water by the water above that point, a pressure exists at any point in the atmosphere due to the weight of the air above that point. This pressure is known as the atmospheric pressure.

The atmospheric pressure was measured for the first time by the Italian scientist Torricelli. The instrument he used for that purpose is shown in Figure 15.11.

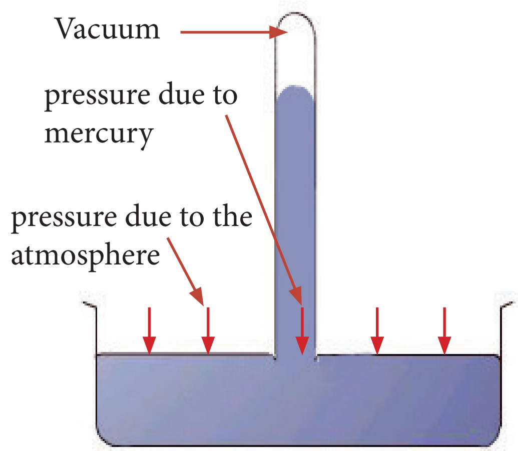


Figure 15.11 – Mercury barometer

This instrument can be made of a glass tube, about one meter long, with one closed end. The tube is filled with mercury, turned upside down while making sure that no air enters the tube, and then immersed in a container of mercury as shown in figure 15.11. When the tube is mounted in up-right position as shown in figure, it would be possible to see that the mercury column in the tube drops by several centimeters, leaving an empty space above the mercury column. The height of the mercury column left inside the tube is about 76 cm.

Torricelli understood that all the mercury in the tube does not flow down to the container because the atmospheric pressure keeps pushing on the mercury surface exposed to the outside. However, the atmospheric pressure is sufficient to balance the pressure of a mercury column with height of 76 cm. Therefore, the height of the mercury column is a measure of the atmospheric pressure. Because no air can enter the space above the mercury column, that space must be a vacuum.

We know that any two points at the same level of a liquid have the same pressure. Accordingly, since the pressure on the mercury surface outside the tube is equal to the atmospheric pressure, a point inside the tube at the same level should also have the atmospheric pressure. By considering the height of the mercury column, the pressure at the point inside the tube can be calculated using the formula $P = h\rho g$. Therefore, the atmospheric pressure must be equal to $h\rho g$.

However, as a convenient unit for measuring pressure, the height of the mercury column is often used. If the experiment is done at the sea level, the height of the mercury column would be 76 cm. If the tube is immersed further into the container with mercury, the height of the mercury column would remain at 76 cm. The space above the column would be reduced in height. If we incline the tube, even though the physical length of the mercury would increase, the vertical height of the mercury column would remain at 76 cm.

While the atmospheric pressure at the sea level is 76 cm Hg, as we move up from the sea level, the height of the air column decreases and the atmospheric pressure decreases. For example, the atmospheric pressure at the top of Everest is about 25 cm Hg. In addition, the atmospheric pressure can change according to the weather.

The instrument constructed using mercury in order to measure the atmospheric pressure is known as the mercury barometer.

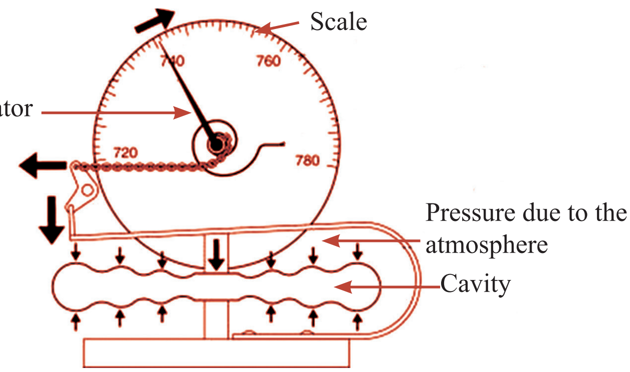


Figure 15.12 – Aneroid barometer

In addition, there are barometers that do not contain a liquid. They are known as aneroid barometers. Figure 15.12 shows an aneroid barometer without a liquid. It has a cavity bounded by thin metallic walls in which air has been evacuated. When the pressure outside barometer varies, the shape of the walls of the cavity also varies. An indicator attached to the cavity walls rotates with the variations of the shape of the walls. The pressure can be read out from an attached scale.

Applications of the atmospheric pressure in daily life

(I) Drinking with the use of a straw

When we drink using a straw, we suck the air inside the straw and that air enters the mouth, reducing the pressure inside the straw. The pressure at the liquid surface outside the straw is at the atmospheric pressure while the pressure inside the straw is less than the atmospheric pressure. Therefore the atmospheric pressure pusheds the liquid in the glass into the tube and the liquid moves up through the straw.

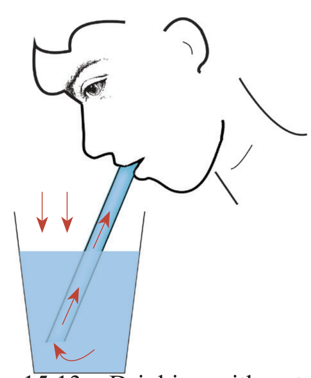


Figure 15.13 – Drinking with a straw

(II) Removing the water in a tank using the siphon method

Figure 15.14 illustrates the use of the siphon method to draw water from the tank *A* situated at a higher level to the tank *B* situated at a lower level. Initially, the tube has to be filled with water and one end pressed with a finger so that water does not flow out and then the tube should be lowered down to of *A*. Thereafter, when the finger is removed, water starts to flow to tank *B* from tank *A*.

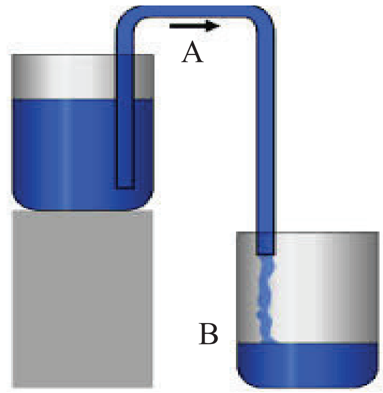


Figure 15.14 – Syphon method

The pressure at the end of the tube in *A* is equal to the sum of the pressures due to the water column in *A* above the end of the tube and the atmospheric pressure. Since the end of the tube in *B* is exposed to the atmosphere, the pressure there is equal to the atmospheric pressure. Therefore, the higher pressure in tank *A*, pushes the water to the other end of the tube at tank *B* which has a lower pressure.

(III) Action of the rubber sucker

When a rubber sucker is pressed onto a glass surface as shown in Figure 15.15, most of the air between the two surfaces is removed leaving only a little air in between the sucker and the glass surface. Then, since the pressure inside the rubber sucker is less than the atmospheric pressure outside, the sucker is held pressed to the surface by the atmospheric pressure. The rubber sucker would function properly only if there is no air flow between the edge of the sucker and the glass surface.

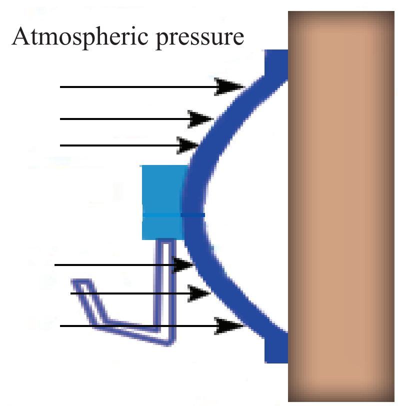


Figure 15.15 – Rubber sucker

Example

(1) The atmospheric pressure at sea level is 76 cm Hg. Taking the density of mercury as 13600 kg m^{-3} acceleration due to gravity as 10 m s^{-2}.

(i) find the atmospheric pressure in Pascals.
(ii) find the height of a water column that can be balanced by the atmospheric pressure. (Density of water is 1000 kg m^{-3}).

Answer

i. Atmospheric pressure $= h \times \rho \times g$

$$P = (76 / 100 \text{ m}) \times (13600 \text{ kg m}^{-3}) \times (10 \text{ m s}^{-2})$$
$$= 103\ 360 \text{ Pa}$$

ii. If the height of the water column is h,

$$h \rho g = 103360$$
$$h \times 1000 \times 10 = 103360$$
$$h = 103360 / 10000$$
$$h = 10.3360 \text{ m}$$

15.4 Floatation

We know that when we put a stone into a vessel containing water, it would sink while something like a piece of wood would float. Let us investigate what scientific principles lie behind the reasons for some objects to sink in water while some objects to float.

Upthrust

When we press an object that floats on water, such as a plank of wood on a water surface, we experience a force exerted by the water acting upwards. Even for an object that sinks in water, the weight that we feel when it is in water is less than its weight in air. This is becuase water exerts an upward force on objects that are immersed in water. This upward force is known as the upthrust. Not only water, any fluid exerts an upthrust on objects that are immersed or upthrust exerts on floating bodies too in that fluid.

Activity 15.3

- Suspend a piece of metal on a spring balance as shown in Figure 15.16 (a) and measure its weight.

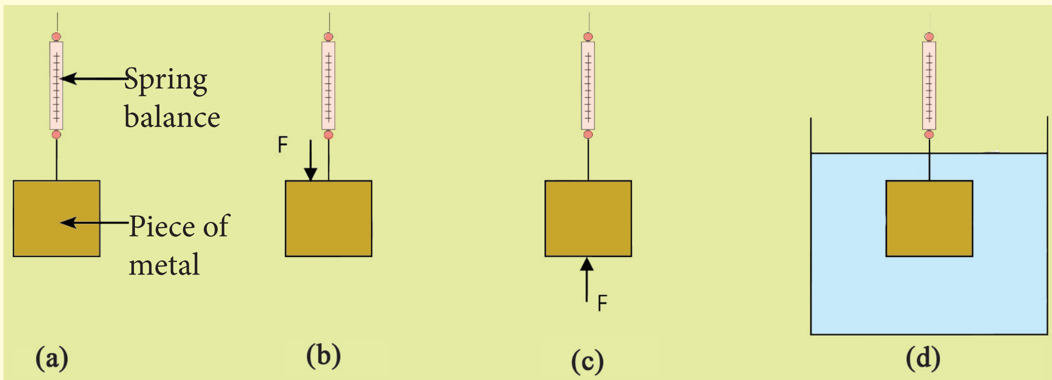


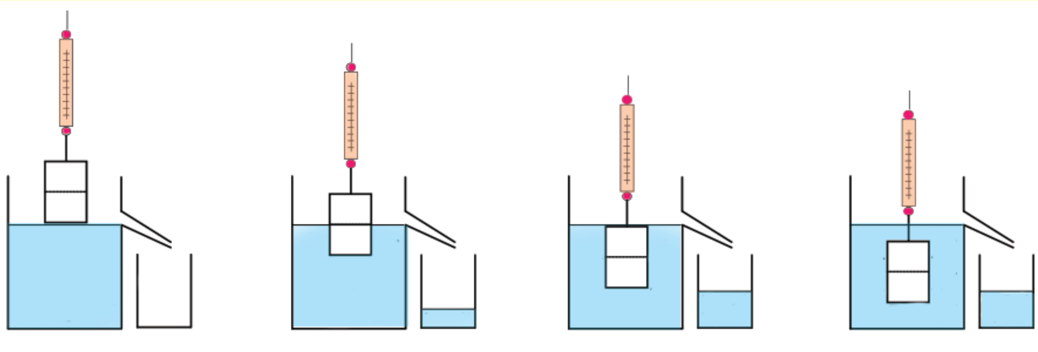
Figure 15.16 – Illustrating the upthrust

- Now exert a downward force on the piece of metal as shown in Figure 15.16 (b). Read the corresponding reading on the spring balance. It would be seen that the spring balance reading has increased as a downward force has acted. then, exert an upward force on the piece of metal as shown in Figure 15.16 (c) and read the spring balance reading. It is obvious that the spring balance reading would decrease as an additional force was exerted upwards. This shows clearly that a downward force acting on the object would increase the spring balance reading while an upward force would decrease the spring balance reading.

- Now immerse the object in water as shown in figure 15.16 (d) and read the spring balance reading. You will observe that the spring balance reading has decreased. According to the explanation given regarding the figure (c), the spring balance reading decreases when an upward force is acting on the object. Therefore, this confirms that an object immersed in a liquid (fluid) experiences an upward thrust exerted by the liquid.

Activity 15.4

- Get a cubic shaped piece of metal and mark by a line where its volume is divided into two equal parts.
- Now hang it on a spring balance and measure its weight in air.
- Get a beaker and measure its weight.
- Now submerge the metal cube in water to each of the levels indicated by the figures 15.17(a), (b), (c) and (d) and record the spring balance readings and the weight of the beaker together with the displaced water each time.



(a) (b) (c) (d)

Figure 15.17 – Set-up for measuring the upthrust

Complete the table given below using your measurements.

Stage	Spring balance reading (N)	Weight of beaker with displaced water (N)
(a) -Metal cube near the water surface		
(b) -Metal cube half submerged in water		
(c) -Metal cube fully immersed in water and near the water surface		
(d) -Cube fully immersed in water and far from the water surface		

What conclusions can you draw from the above activity?

Let us assume that thereadings taken by a pupil were as given below.

Stage	Spring balance reading (N)	Weight of beaker with displaced water (N)
(a) - Metal cube near the water surface	1.2	1.3
(b) - Metal cube half submerged in water	0.9	1.6
(c) - Metal cube fully immersed in water and near the water surface	0.6	1.9
(d)- Cube fully immersed in water and far from the water surface	0.6	1.9

The upward thrust and the weight of the displaced volume of water calculated from the readings above are tabulated below.

Stage	Upthrust (N)	Weight of dis-placed volume of water (N)
(a) - Metal cube near the water surface	0	0
(b) - Metal cube half submerged in water	0.3	0.3
(c) - Metal cube fully immersed in water and near the water surface	0.6	0.6
(d) - Cube fully immersed in water and far from the water surface	0.6	0.6

The conclusion that can be drawn from the results shown in the table above is that when the object is partially or fully submerged in water, the upward thrust acting on the object is equal to the weight of the water displaced by the object. This is known as the Archimedes' principle as it was first introduced by the scientist Archimedes.

Archimedes' Principle

When an object is partially or completely submerged in a fluid, the upthrust acting on it is equal to the weight of the fluid displaced by the object.

The figure 15.18 shows how three different objects A, B and C are submerged in water.

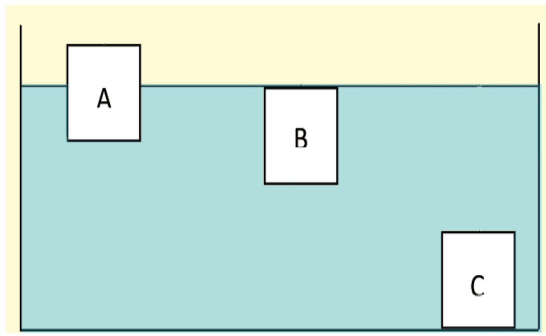


Figure 15.18 - Three different objects placed in water

Object *A* is partially submerged and floating while object *B* is fully submerged and floating. Object *C* is fully submerged and resting at the bottom of the container. Can you think of the reason for this difference? Engage in the following activity in order to understand it.

Activity 15.5

You will need three objects of different materials. One of them (*A*) should float in water, partially submerged. Another one (*B*) should float on water, fully submerged. Such an object could be obtained by filling an appropriate quantity of sand into a bottle that could be properly closed. The third object (*C*) should sink in water.

- Measure the weights of the three objects *A*, *B* and *C*.
- Now measure the apparent weights of the three objects while *A* is floating, partially submerged, *B* is floating, fully submerged and *C* is sunk.

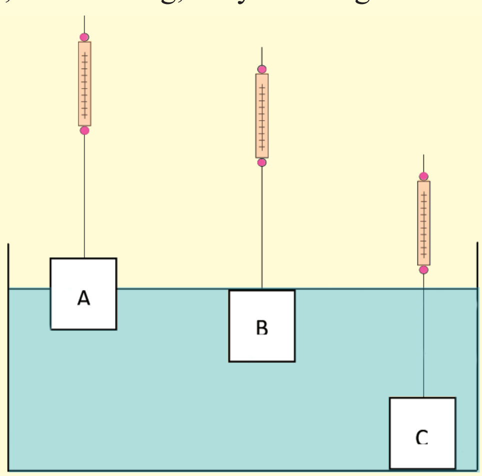


Figure 15.19 - Diagram for activity 15.5

Tabulate the observations and readings in the table given below. Try to fully submerge the floating object by applying an external force.

Object	Weight of the object (N)	Apparent weight of object in water (N)	Is the object partially submerged and floating? / fully submerged and floating? / sunk?
A			
B			
C			

Fill the following table with relevant calculations.

Object	How the object appeared in water	Weight of the object (N)	Upthrust on the object (N)
A			
B			
C			

What conclusion can you draw from your results?

The following table shows the readings and observations made by a student. Let us investigate the results he obtained.

Object	Weight of the object (N)	Apparent weight of object in water (N)	Is the object partially submerged and floating? /fully submerged and floating? / sunk?
A	1.1	0	Floating
B	1.8	0	Fully submerged and floating
C	2.4	0.5	Sunk

The corresponding calculations are shown in the table below.

Object	How the object appeared in water	Weight of the object (N)	Upthrust on the object (N)
A	Partially submerged and floating	1.1	1.1
B	Fully submerged and floating	1.8	1.8
C	Sunk	2.4	1.9

The results obtained from this activity are stated below.

The weight of the object that was partially submerged while floating and the weight of the object that was fully submerged while floating are equal to the upthrust exerted on the objects by water. The weight of the object that sank in water is greater than the upthrust exerted on the object by water.

When a force acting vertically downwards is applied on the object A that was partially submerged while floating, an additional force acting vertically upwards can be experienced. This is because the upthrust is greater than the weight of the object when the object is fully immersed in water giving rise to a resultant force acting upwards. Therefore, when the external force was removed. the object returns to the original position. That is, the object returns to the position where the upthrust is equal to the weight of the object.

The conclusion that could be drawn from this is, that the weight of an object that is partially or fully immersed in a fluid while floating is equal to the upthrust acting on the object and the weight of an object that is fully sunk in the fluid is greater than the upward thrust, the object sinks in the fluid.

That is,

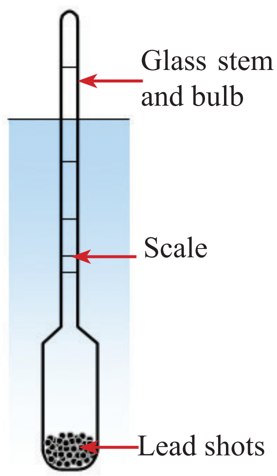
If the upthrust acting on an object fully immersed in a fluid,

(a) is less than the weight of the object, the object sinks in the fluid.

(b) is equal the weight of the object, the object floats in the fluid while being fully submerged in it.

(c) is greater than the weight of the object, the object floats while partially submerged in the fluid so that an upthrust equal to the weight of the object acts on it.

Hydrometer



Hydrometers are used to measure the density of liquids and solutions. It is made of glass. It has a cylindrical stem and a bulb as shown in the diagram. Mercury or lead shots are found inside the bulb to enable it to float vertically in the liquid .The liquid or the solution is taken to a vessel and the hydrometer is put in to it. Then the density of the liquid or the solution can be read directly by the scale given on the hydrometer.

Hydrometer has been made in accordance with the Archimedes' principle. The hydrometer immerses in the liquid to a height so as to displace a weight equal to the weight of the hydrometer. The volume of the liquid or the solution displaced is equal to the volume of the immersed part of the hydrometer. As a small volume of the liquid is displaced in a high density liquid, the hydrometer is immersed to only small depth. But when it is put in a low density liquid it immerses more because more liquid should displace, to produce the upthrust required to balance it.

Exercise 15.2

(1) (i) The depth of a reservoir is 1.2 m. Calculate the pressure at the bottom of the pond due to the water. ($g = 10 \text{ m s}^{-2}$, density of water $= 1000 \text{ kg m}^{-3}$)

(ii) Find the force exerted by the water on an area of 200 cm^2 at the bottom of the reservoir.

(2) (i) Describe a simple experiment to demonstrate that 'the pressure in a liquid increases with increasing depth'.

(ii) Write down a simple experiment to find out whether the pressure inside a balloon is less than or greater than the atmospheric pressure.

(3) (i) The atmospheric pressure at the sea level is 76 cm Hg. How much is this pressure in Pascals?

(ii) What is the height of a water column that exerts the same pressure as the above pressure?

(4) (i) Write down Archimedes' principle.

(ii) The weight of a piece of metal in air is 20 N. When it is completely immersed in water, its apparent weight is 5 N.

(a) What is the upward thrust exerted on the piece of metal by water?
(b) What is the weight of the water displaced by the piece of metal when it is completely immersed in water?

Summary

- Pressure is produced by liquids and gases as well as by solids.
- The pressure due to a liquid acts in every direction.
- The pressure due to a liquid increases as the depth (height of a column of liquid) increases.
- The formula $P = h \rho g$ is used to find the pressure due to a liquid column where
  h = height of the liquid column
  ρ = density of the liquid
  g = gravitational acceleration
- The space around the earth containing air is known as the atmosphere and the pressure produced by atmospheric air is known as the atmospheric pressure.
- The average value of the atmospheric pressure at the sea level is 76 cm Hg. That is, the atmospheric pressure at the sea level is equal to the pressure due to a mercury column of height 76 cm.
- In order to measure average value of the pressure, the mercury barometer and the aneroid barometer are used.
- When an object is partially or completely submerged in a liquid, an upthrust equal to the weight of the quantity of liquid displaced acts on the object by the liquid.
- When an object is floating on a liquid, the weight of the displaced liquid is equal to the weight of the object.

Technical Terms

Pressure	-	පීඩනය	-	அமுக்கம்
Hydraulic jack	-	ද්‍රව පීඩන ජැක්කුව	-	நீரியல் உயர்த்தி
Upthrust	-	උඩුකුරු තෙරපුම	-	மேலுதைப்பு
Atmosphere	-	වායුගෝලය	-	வாயுமண்டலம்
Mercury barometer	-	රසදිය වායුපීඩනමානය	-	இரச பாரமானி
Aneroid barometer	-	නිර්ද්‍රව වායුපීඩනමානය	-	அனிரொய்ட் பாரமானி