Chapter 8 Force and Motion

All daily activities involve force. We need force to produce motion. What is the meaning of force?

What is the effect of force on daily activities?

Let's understand:

- Force
- Effects of force

SCIENCE BLOG

Force is All Around Us

Force is an important part of our lives. When you walk or run, chew food or lift objects, you are applying force. You cannot see force but you can feel its effect.

Have you ever taken part in football matches or tug-of-war? All these activities require a pulling or pushing force. When playing football, you kick the ball using a pushing force while in tug-of-war, both teams pull hard on opposite ends of the rope to win.

Keywords

- Force
- Direction
- Gravitational force
- Elastic force
- Buoyant force
- Frictional force
- Weight
- Moment of force
- Pressure

8.1 Force

What is force?

Force is a **pull** or a **push** upon an object.

Almost all daily activities involve force such as opening a can of food, pressing a switch and opening a door.

Force may exist in various forms such as gravitational force, weight, normal force, frictional force, elastic force and buoyant force.

Let us carry out Activity 8.1 to show the presence of different types of forces.

Photograph 8.1 *Force is used to open a can of food and press a switch*

Activity 8.1

Aim: To investigate the presence of different types of forces.

Materials: Ball, wooden block, sandpaper and water

Apparatus: Spring, retort stand with clamp, 50 g weight, beaker and metre rule

A

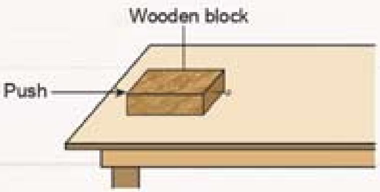
Instruction
1. Throw a ball up in the air (Figure 8.1).
2. Observe whether the ball keeps going up or falls down.

Figure 8.1

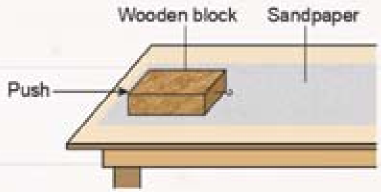
B

Instruction

1. Place a wooden block on a table. Why does the wooden block remain in its position?
2. Then, push the wooden block (Figure 8.2 (a)).
3. Repeat step 2 by pushing the same wooden block on a sandpaper (Figure 8.2 (b)).
4. Compare the difficulty of pushing the wooden block on the table and on the sandpaper.



(a) Push the wooden block on a table



(b) Push the wooden block on a sandpaper

Figure 8.2

C

Instruction

1. Hang a spring on a retort stand.
2. Hang a 50 g weight at the end of the spring (Figure 8.3).
3. Observe the change in the length of the spring.
4. Remove the weight and observe the change in the length of the spring.

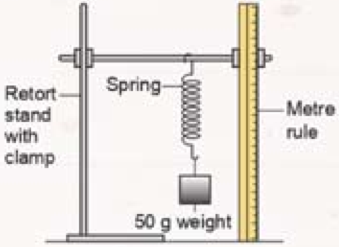


Figure 8.3

D

Instruction

1. Place a wooden block on the surface of the water in a beaker (Figure 8.4).
2. Press the wooden block to the bottom of the beaker and release it.
3. Observe what happens to the wooden block.

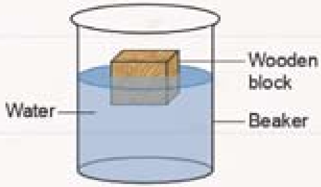


Figure 8.4

Questions

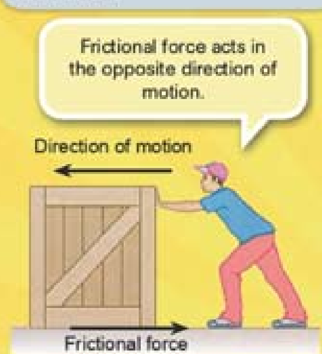
1. Identify the forces involved in Activities A, B, C and D.
2. What is the type of force acting on stationary objects?
3. What is the type of force that resists the motion of objects?

Types of Forces

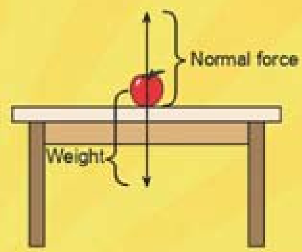
Gravitational force is the force that points towards the centre of the Earth. This force causes all objects that are thrown upwards to fall back to Earth.

Frictional force is the force that resists movement between two surfaces that are in contact with each other.

Normal force is the force produced when an object is in contact with a surface.



Types of forces



Buoyant force is the thrust force acting on an object that is floating on the surface of a fluid.

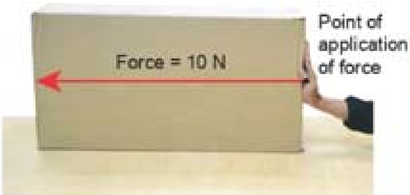
The **weight** of an object is defined as the gravitational force acting on it.

Elastic force exists when a material is stretched or compressed.

Figure 8.5 *Types of forces*

Characteristics of Force

Force is a vector quantity that has **magnitude** and **direction**. Magnitude is the quantity or value of a measurement.



Photograph 8.2 *Force acting on a box that is pushed*

Photograph 8.2 shows a pushing force with a magnitude of 10 N acting on a box. The direction of the force is as shown by the arrow and the **point of application** of the force is the hand that exerts the pushing force onto the box.

Figure 8.6 shows a hammer being used to remove a nail from the surface of a table. The force acting on the hammer has a magnitude of 15 N and its direction is as shown by the arrow. The **point of application** of force is at the head of the hammer, which is the area where the applied force is concentrated.

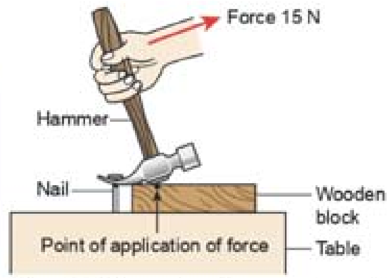
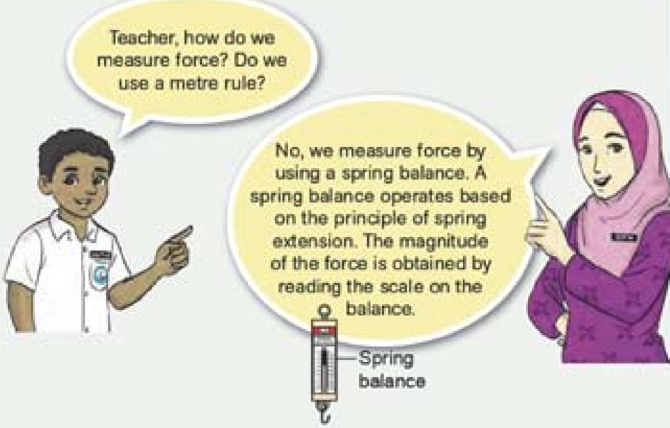


Figure 8.6 *Force acting when removing a nail using a hammer*

Measurement of Force



Today in History

Force is measured in newton (N), which is named after Sir Issac Newton, the scientist and mathematician who discovered gravitational force.

Unit of Force

The S.I. unit of force is **newton (N)**. The weight of an object is the gravitational force acting on the object. On Earth, an object with a mass of 100 g has a weight of 1 N. Therefore, an object with a mass of 1 kg has a weight of 10 N.

1 kg → 10 N

Activity 8.2

Aim: To measure force.

Materials: Weight (50 g), string, sandpaper and wooden block

Apparatus: Retort stand with clamp and spring balance

Instruction

A Weight of object

1. Hang a 50 g weight at the end of a spring balance (Photograph 8.3).
2. Record the reading of the spring balance.
3. Add up to five weights and record the reading of the spring balance.

Questions

1. What is the physical quantity measured by the spring balance?
2. What is the unit of the physical quantity for your answer in question **1**?
3. What happens to the reading of the spring balance when the number of weights is increased? Explain your answer.

Photograph 8.3

B Frictional force

1. Set up the apparatus as shown in Photograph 8.4.
2. Pull the spring balance until the wooden block starts to move and record the reading of the spring balance.
3. Repeat this activity by pulling the wooden block on a sandpaper.

Photograph 8.4

Questions

1. The wooden block moves only when enough pulling force acts on it. What type of force is resisting the movement of the wooden block?
2. State the difference in the reading of the spring balance when the wooden block is pulled on the table and when it is pulled on the sandpaper. What is the force involved that causes the difference between the readings of the two spring balances?

Action-Reaction Pair

Observe the objects in Photograph 8.5. Why do these objects remain stationary? What are the forces acting on these objects?

Photograph 8.5 *Car, book and apple in a stationary state*

There are three different situations that explain every action force has an equal magnitude (same magnitude) reaction force but in the opposite direction.

Situation 1 An object that remains on a table

A book that remains still on a table experiences gravitational force known as **weight**. At the same time, a reaction force called **normal force** will exist in the opposite direction. The book remains still on the table because the magnitude of the weight (**action force**) is the same as the normal force (**reaction force**) (Figure 8.7).

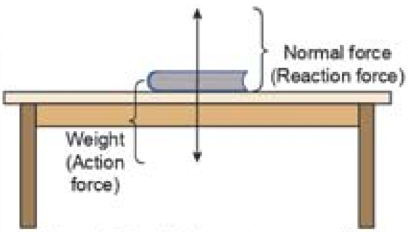


Figure 8.7 *Book that remains on a table*

Situation 2 An object that floats on water

A wooden block that floats on water experiences a gravitational force known as **weight**. At the same time, a reaction force called **buoyant force** will exist in the opposite direction. Objects can float on water because the magnitude of the weight (action force) is the same as the buoyant force (reaction force)(Figure 8.8).

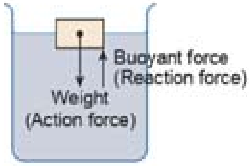


Figure 8.8 *Wooden block that floats on water*

Situation 3

Two trolleys in contact with each other and launched with a spring mechanism will move at same distance but in the opposite direction.

When two trolleys are pushed towards each other as in Figure 8.9 (a), the first trolley with the spring will exert an elastic force on the second trolley (action force) and at the same time, the second trolley will exert an elastic force of the same magnitude but in the opposite direction (reaction force).

When the two trolleys that were initially touching each other are launched as in Figure 8.9 (b), they will move at the same distance but in the opposite direction.

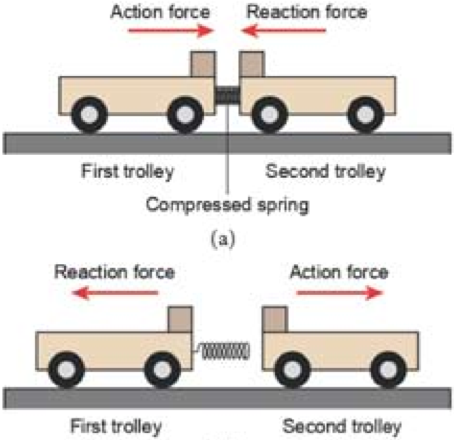


Figure 8.9 *Two trolleys pushed close together with compressed spring*

Formative Practice 8.1

1. Name the force acting in each of the following situations (Photograph 1).

(a) Bungee jumper jumping

(b) Bicycle moving on rough surface

(c) Hot air balloon floating in the air

Photograph 1

2. Photograph 2 shows a man pushing a car. Show the direction of the pushing force and point of application of force on the photograph.

Photograph 2

3. Photograph 3 shows a football being kicked by a player.
   (a) Name the forces involved in this situation.
   (b) Show the direction of the forces on the photograph.

Photograph 3

8.2 Effects of Force

Force cannot be seen but its effects can be felt. When a force acts on an object, the force can change the **shape**, **size** and **motion** of the object.

Let us carry out Activity 8.3 to study the effects of force on an object.

Activity 8.3

Aim: To study the effects of force.

Materials: Toy car and plasticine

Apparatus: Table

Instruction

1. Clear the table of your group.
2. (a) Place a toy car at one end of the table as shown in Figure 8.10.
   (b) Push the toy car using a force of small magnitude. Observe what happens to the stationary toy car.
   (c) Increase the pushing force and observe the change in the speed of the toy car.
   (d) Push the toy car again and ask another student to block the movement of the toy car using his hands. Observe what happens to the movement of the toy car.
   (e) Push the toy car again. Ask another student to push the toy car from the side. Observe what happens to the movement of the toy car.
3. Hold a piece of plasticine. Squeeze the plasticine and observe the shape and size of the plasticine.
4. Record all the observations obtained.
5. Make a conclusion about the effects of force observed.

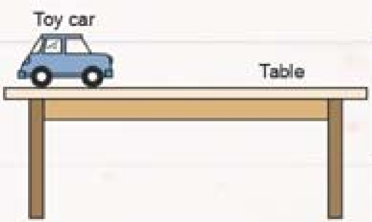


Figure 8.10

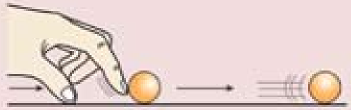
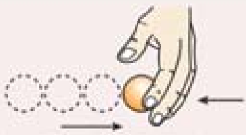
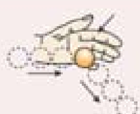
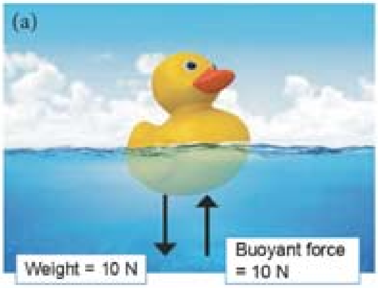
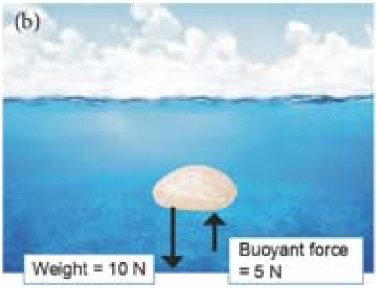
Effects of force	Situation 1 (Table tennis ball)	Situation 2 (Football)
Moving a stationary object	 • When a stationary object is pushed, the object moves	
Stopping a moving object	 • When force is applied in the opposite direction, the object will stop moving	
Changing the speed of an object that is in motion	• Force from the opposite direction slows down an object  • Force from the same direction speeds up an object 	
Changing the direction of motion of an object	 • Force from the side changes the direction of motion of an object	
Changing the shape and size of an object	 • Force can change the shape and size of an object	

Figure 8.11 *Effects of force*

Buoyant Force

An object will float if the buoyant force acting on it is enough to support its weight, that is buoyant force equals to the weight of the object. For example, the rubber duck below has a weight of 10 N. The reaction force, which is the buoyant force, acts with the same magnitude (10 N) but in the opposite direction (Photograph 8.6 (a)).





Photograph 8.6 *Condition of rubber duck and stone in water*

Conversely, an object will **submerge** if the buoyant force acting on it is not enough to support its weight, that is buoyant force is less than the weight of the object (Photograph 8.6 (b)).

> **Science Info**
>
> **Actual weight:** Weight of an object in the air.
>
> **Apparent weight:** Weight of an object immersed in fluid.

Buoyant force = Actual weight – apparent weight

Let us carry out Activity 8.4 to determine the buoyant force of an object in water.

Activity 8.4

Aim: To determine buoyant force.

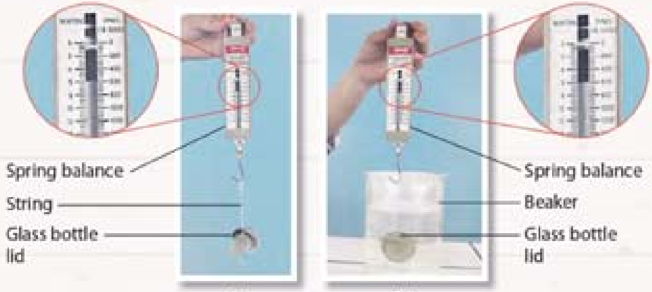
Materials: Glass bottle lid, rubber stopper, squash ball, plasticine and string

Apparatus: 250 ml beaker and spring balance

Instruction

1. Hang a glass bottle lid at the end of a spring balance as shown in Photograph 8.7 (a).
2. Record the actual weight of the glass bottle lid, W_1.
3. Fill 250 ml of water into a beaker.
4. Put the bottle lid into the water as in Photograph 8.7 (b).
5. Record the apparent weight of the bottle lid, W_2.
6. Calculate the buoyant force, F.
7. Repeat steps 1 to 6 using a rubber stopper, squash ball and plasticine.

8. Put the bottle lid, rubber stopper, squash ball and plasticine into the water. Observe whether they submerge or float.
9. Record your observation in the table below.



(a) (b)

Photograph 8.7

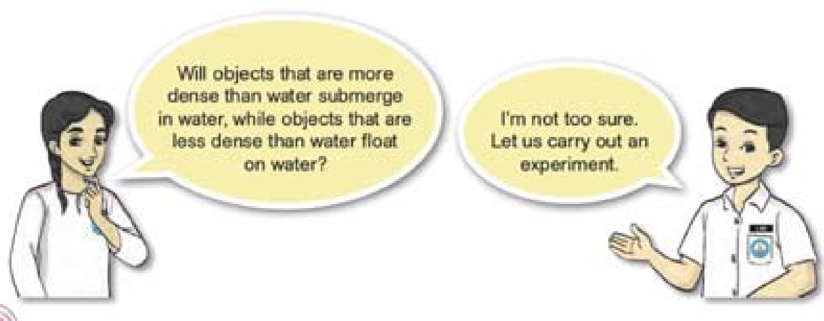
	Glass bottle lid	Rubber stopper	Squash ball	Plasticine
Actual weight, W_1 (N)				
Apparent weight, W_2 (N)				
Buoyant force, F (N)				
Submerge / float				

Question

1. What is the relationship between the buoyant force of an object and the condition of the object?

Density and Buoyant Effect

Different materials have different densities. The position of an object in a fluid depends on the density of the object, whether it is more or less than the density of the fluid.



Experiment 8.1

STEM

Aim: To study the effect of density on the position of an object in water.

Problem statement: Will an object that is more dense than water submerge or float in water?

Hypothesis: An object that is more dense than water will submerge, while an object that is less dense than water will float.

Variables:
(a) Constant variable: Volume of blocks
(b) Manipulated variable: Density of blocks
(c) Responding variable: Position of blocks in water

Materials: Copper block, aluminium block, cork block and wooden block of the same size

Apparatus: Weighing scale, glass basin and metre rule

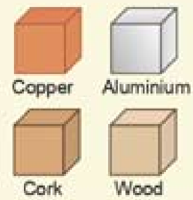


Figure 8.12 *Four blocks with the same size*

Procedure:
1. Weigh the mass of each block.
2. Calculate the volume of each block.
3. Calculate the density of each block using the following formula:

$$\text{Density (g/cm}^3) = \frac{\text{Mass (g)}}{\text{Volume (cm}^3)}$$

4. Record the mass, volume and density in the table below.

	Copper	Aluminium	Cork	Wood
Mass (g)				
Volume (cm^3)				
Density (g/cm^3)				

5. Put the four blocks into a glass basin filled with water. Observe the block that floats or submerges in water.

Conclusion:
Is the hypothesis accepted? Give your reasons.

Questions
1. Water has a density of 1.0 g cm^{-3}. Which block is more dense than water?
2. State whether the block that is more dense than water floats or submerges in water.

Figure 8.13 *Object floats*

When an object that is less dense than a liquid is pushed into the liquid, the buoyant force (upthrust force, *F*) is more than weight (*W*). It pushes the object up to the surface of the liquid. The object will **float** (Figure 8.13).

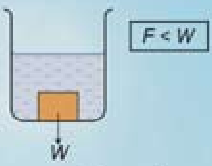


Figure 8.14 *Object submerges*

Conversely, when an object is more dense than the liquid, the buoyant force (upthrust force, *F*) is less than the weight of the object (*W*). It causes the object to submerge to the bottom of the liquid (Figure 8.14).

Table 8.1

Material	Density at 0 °C and 1 atmospheric pressure	
	$g\ cm^{-3}$	$kg\ m^{-3}$
Cork	0.24	240
Water	1.0	1 000
Glycerine	1.26	1 260
Iron	7.9	7 900
Lead	11.3	11 300
Mercury	13.6	13 600
Gold	19.3	19 300

Table 8.1 shows the densities of a few materials. Based on this table, cork floats on water because it is less dense than water. Glycerine, iron, lead, mercury and gold submerge in water because they are more dense than water.

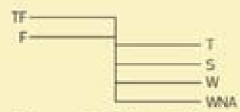


Figure 8.15 *Plimsoll line*

TF = Tropical freshwater
F = Freshwater
T = Tropical zone
S = Summer
W = Winter
WNA = Winter North Atlantic

Cargo ships are marked with Plimsoll lines for safety purposes. Due to the differences in temperature and concentration of salt, the density of sea water is different in different parts of the world. Plimsoll lines will help to determine the safe level for a ship to stay afloat.

Photograph 8.8 *Cargo ship*

Lever

We use various types of tools at home and in school every day. These tools help us perform tasks easily based on the lever principle. What is a lever? A **lever** is a bar that rotates on a fixed point. A lever is made up of three parts as shown in Figure 8.16.

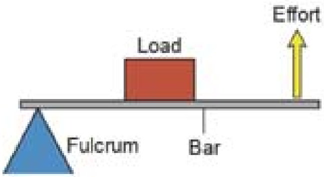


Figure 8.16 *Parts of a lever*

Effort : Force applied on the bar
Load : Object to be moved
Fulcrum : Fixed support point

A lever is a **simple machine**. What is the purpose of a lever?

A lever allows us to do work easily.

Opening a can lid with a spoon

Opening a bottle cap with a bottle opener

Photograph 8.9 *Examples of levers used to make work easier*

A lever allows us to use minimal force to do work.

Lifting a heavy load

Removing a nail

Photograph 8.10 *Examples of levers using minimal force*

Classification of Levers

Levers are classified into three types, first class, second class and third class, depending on the position of the effort, fulcrum and load.

First class lever

Fulcrum is between load and effort.

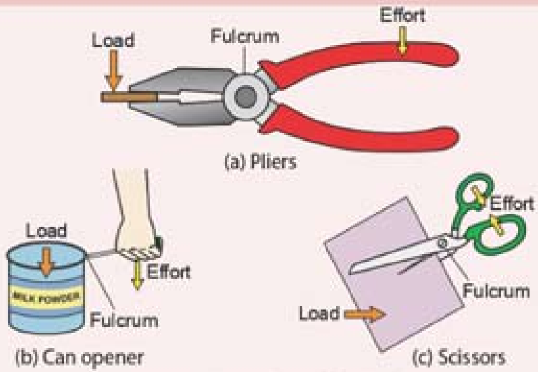
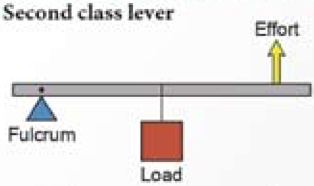


Figure 8.17 *Examples of first class lever*

Second class lever



Load is between fulcrum and effort.

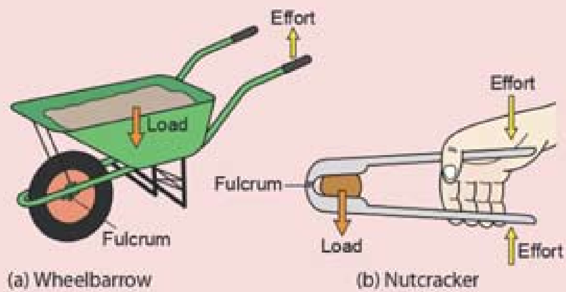
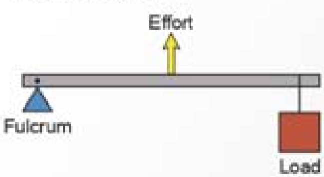


Figure 8.18 *Examples of second class lever*

Third class lever



Effort is between fulcrum and load.

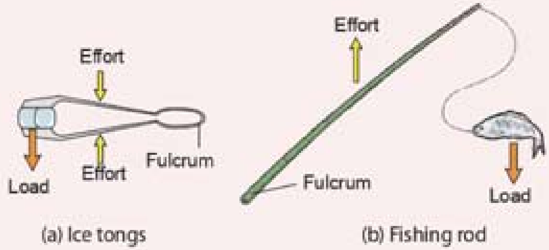


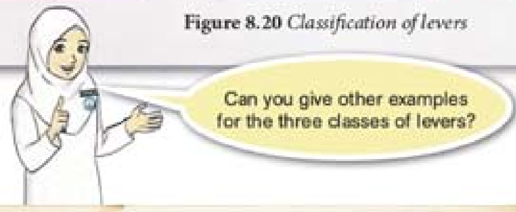
Figure 8.19 *Examples of third class lever*

The tree map below is a summary of the classification of levers.

Lever

- **First class lever**
  - Fulcrum is between load and effort
  - Example: Scissors
  - Can opener
- **Second class lever**
  - Load is between fulcrum and effort
  - Example: Nutcracker
  - Wheelbarrow
- **Third class lever**
  - Effort is between fulcrum and load
  - Example: Fishing rod
  - Forceps

Figure 8.20 *Classification of levers*



Activity 8.5

Aim: To discuss the various examples of levers in daily life according to their classes.

Instruction

1. Work in groups.
2. Every group has to find information regarding tools used in daily life and classify the tools into three classes of levers.
3. Label the position of load, effort and fulcrum on every tool.
4. Present your group discussion in class.

The Moment of Force

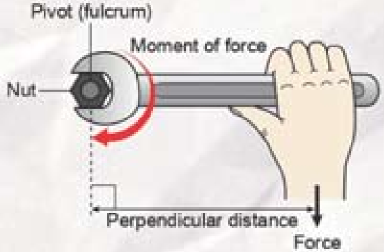
A force acting on an object can rotate the object at a fixed point (pivot or fulcrum). The turning effect produced is called the **moment of force**.

- The moment of force allows us to do work easily.
- The moment of force depends on the force applied and the **perpendicular distance** of the fulcrum to the force.

8.2.3
8.2.4

Examples of moment of force are like using a spanner to tighten a nut and the act of opening a door as shown in Figure 8.21.

(a)



(b)

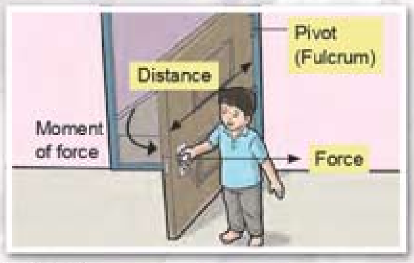


Figure 8.21 *Moment of force in daily life*

Method to calculate moment of force:

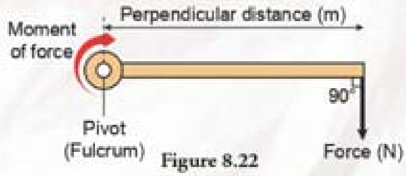


Figure 8.22

Moment of force = Force (N) × Perpendicular distance from the pivot to the force (m)

Unit for moment of force is **newton metre (N m)**.

Example 1:

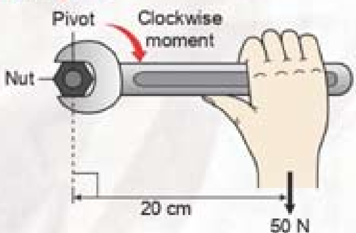


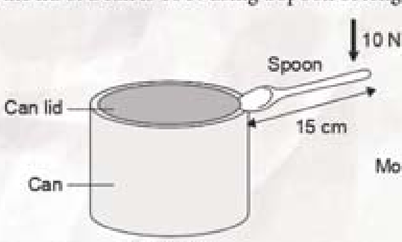
Figure 8.23

Moment of force = Force (N) x Perpendicular distance from the pivot to the force (m)
= 50 N x 0.2 m
= 10 N m

Moment of force has two directions, either clockwise or anticlockwise. It is found that the direction of moment of force to tighten the nut is clockwise. What is the direction of moment of force to loosen the nut?

Example 2:

The force used to open the lid of a can is 10 N using a spoon of length 15 cm. Calculate the moment of force



Moment of force = 10 N x 0.15 m
= 1.5 N m

Figure 8.24

Activity 8.6

Aim: To study the relationship between moment of force, effort and perpendicular distance from pivot to force.

Materials: Nut and screw

Apparatus: Spanner

Instruction

1. Prepare an item that is fitted with a nut and screw.
2. Hold a spanner in position *X* as shown in Figure 8.25 and tighten the nut. Then, hold the spanner in position *Y* as shown in Figure 8.26 and tighten the nut. Which position requires more effort? Which position results in greater moment of force?

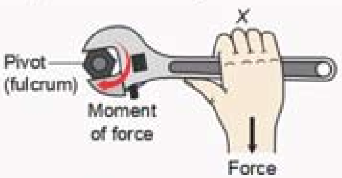


Figure 8.25 *Tightening nut from position X*

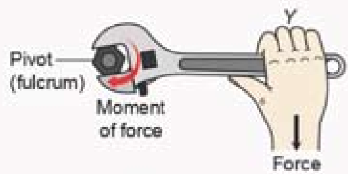


Figure 8.26 *Tightening nut from position Y*

Moment of force will increase if the:

- magnitude of force increases, by applying a greater force
- perpendicular distance from pivot to effort increases

Figure 8.27

Figure 8.27 shows a spanner used to tighten the nuts. Figure 8.27 (a) shows a 10 N force applied at a distance of 0.2 m from the turning point and in Figure 8.27 (b), force is applied at a distance of 0.1 m.

In Figure 8.27 (a), moment of force = 10 N× 0.2 m
= 2 N m

In Figure 8.27 (b), moment of force = 10 N× 0.1 m
= 1 N m

In conclusion, a greater moment of force is produced when force is applied at a greater distance from the turning point.

Observe Figure 8.28. The weight of the load produces a clockwise moment. The applied effort produces an anticlockwise moment to balance the lever horizontally. Therefore, the product of the magnitude of effort and the perpendicular distance from the pivot (fulcrum) is the same as the moment required to balance the lever.

Load (N) × Distance of load from fulcrum (m) = Effort (N) × Distance of effort from fulcrum (m)

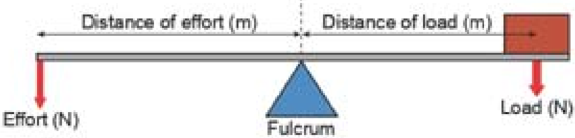


Figure 8.28 *Principle of moments of lever*

The formula above can be used to solve daily life problems involving levers as in the following.

Example 1

Figure 8.29 shows two children sitting on a see-saw. What is the distance of Jia Yin from the fulcrum so that the see-saw is balanced?

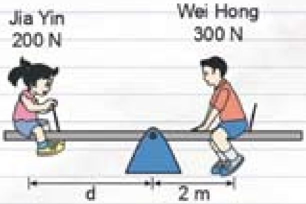


Figure 8.29

Solution:

Load × Distance of load from fulcrum = Effort × Distance of effort from fulcrum

$$200 \text{ N} \times d = 300 \text{ N} \times 2 \text{ m}$$

$$d = \frac{300 \text{ N} \times 2 \text{ m}}{200 \text{ N}}$$

$$d = 3 \text{ m}$$

Jia Yin has to sit 3 m away from the fulcrum.

Example 2

Figure 8.30 shows a man trying to move a boulder weighing 100 kg using a small stone as a fulcrum. The distance between the boulder and the small stone is 0.5 m and the distance between the man and the small stone is 2 m.

Calculate the effort required by the man to move the boulder.
(Gravitational force = 10 N kg^{-1})

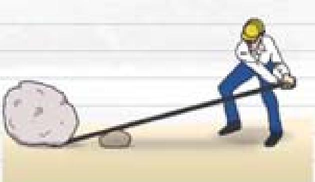


Figure 8.30

Solution:

$$\text{Load} = 100 \text{ kg} \times 10 = 1000 \text{ N}$$

Load × Distance of load from fulcrum = Effort × Distance of effort from fulcrum

$$1000 \text{ N} \times 0.5 \text{ m} = \text{Effort} \times 2 \text{ m}$$

$$\text{Effort} = \frac{1000 \text{ N} \times 0.5 \text{ m}}{2 \text{ m}} = 250 \text{ N}$$

Pressure

You have learned that force is a push or a pull applied on an object. But sometimes a large force cannot push or pull a small object. Why?

Observe Photograph 8.11 below.

(a) Press a thumbtack into a plank

(b) Press a coin into a plank

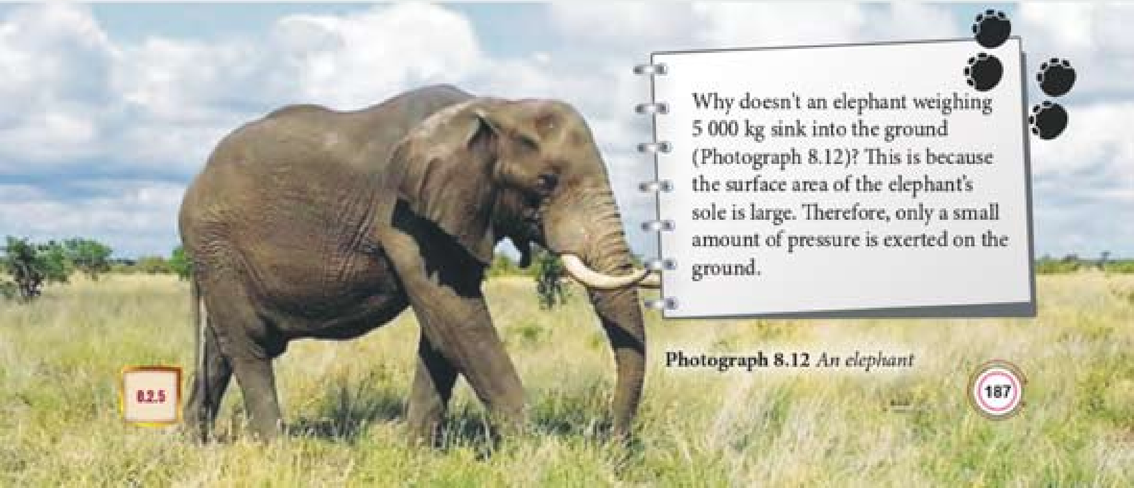
Photograph 8.11

You can press a thumbtack into a plank but you cannot press a coin into a plank even though the same force is applied. Do you know why?

The examples above show that the effects of force acting on a surface depend on the **surface area** on which the force is applied. Force applied on a smaller surface area will result in a larger pressure. Conversely, the same force applied on a larger surface area will result in a smaller pressure. **Pressure** is defined as force per unit area (direction of force is perpendicular to the surface area).

$$\text{Pressure} = \frac{\text{Force (N)}}{\text{Surface area (m}^2\text{)}}$$

The S.I. unit for pressure is pascal (Pa).
1 Pa equals 1 newton per square metre (N m^{-2}).



Why doesn't an elephant weighing 5 000 kg sink into the ground (Photograph 8.12)? This is because the surface area of the elephant's sole is large. Therefore, only a small amount of pressure is exerted on the ground.

Photograph 8.12 *An elephant*

8.2.5

Let us carry out Experiment 8.2 to study the effects of surface area on pressure produced by the same force.

Experiment 8.2

Aim: To study the relationship between surface area and pressure.

Problem statement: What is the effect of surface area on pressure produced by the same force?

Hypothesis: The larger the surface area, the lower the pressure exerted.

Variables:
(a) Constant variable: Metal blocks of the same mass
(b) Manipulated variable: Surface area
(c) Responding variable: Depth of dent

Materials: Metal block and plasticine

Apparatus: Retort stand with clamp, metre rule and thread

Procedure:
1. Prepare two metal blocks of the same mass.
2. Hang the two blocks as shown in Figure 8.31.
3. Place a piece of plasticine under the two metal blocks.
4. Release metal block *P* and measure the depth of the dent produced using a metre rule.
5. Repeat step 4 using metal block *Q*.

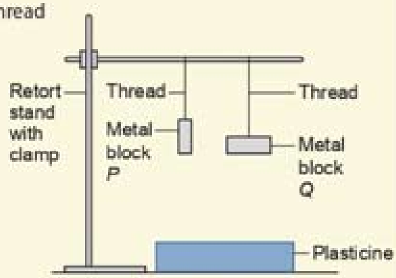


Figure 8.31

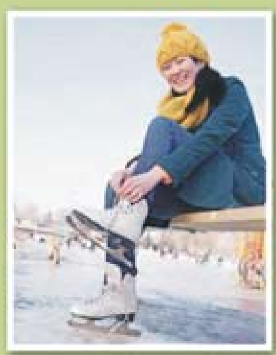
Result:

Metal block	*P*	*Q*
Depth of dent produced (cm)		

Conclusion:
Is the hypothesis accepted? Give your reasons.

Questions
1. What is the change in depth of the dent produced when the surface area upon which the force is applied increases?
2. What is the relationship between surface area and pressure?
3. State an inference based on the observation.
4. State the operational definition of pressure.

Application of Pressure in Daily Life



(a) Why are the metal blades of skating boots thin?

(b) Why is the blade of an axe thin?

(c) Why do tractors have big and wide wheels?

(d) What is the purpose of studs on the sole of football boots?

Photograph 8.13 *Examples of application of pressure in daily life*

Activity 8.7

21st Century

Aim: To discuss the application of pressure in daily life.

Instruction

1. Work in groups.
2. Discuss the application of pressure in daily life.
3. Present your group discussion using a multimedia presentation.

Gas Pressure

You would have surely played with balloons. Do you know why balloons expand when they are blown? Why do the balloons deflate when air is released from the balloons (Figure 8.32)?

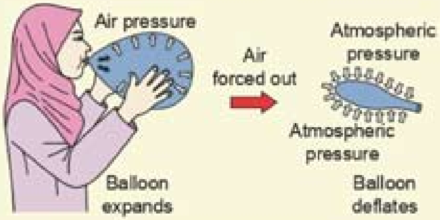


Figure 8.32 *Air pressure causes the balloon to expand and deflate*

The kinetic theory of gas states that air molecules always move about freely and collide with the walls of its container. The frequency of collision between the air molecules and the walls of the container will produce a force that pushes against the walls (Figure 8.33). This force is called **air pressure**.

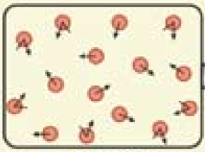


Figure 8.33

Let us carry out Activity 8.8 to show that air exerts pressure.

Activity 8.8

Aim: To show that air exerts pressure.

Instruction

1. Fill a glass with water until it is full.
2. Cover the mouth of the glass with a card.
3. Hold the card and turn the glass upside down quickly.
4. Remove your hand slowly. Observe if the water flows out (Figure 8.34).

Figure 8.34

Question

Why doesn't the water flow out when the hand that presses the card is removed?

Why do balloons burst when they are left under the Sun (Photograph 8.14)? Is it due to factors affecting air pressure? Let us carry out Activity 8.9 to study these factors.

Photograph 8.14 *Balloons left under the Sun*

Activity 8.9

Aim: To study the factors that affect gas pressure.

Material: Water

Apparatus: Bourdon gauge, 250 ml beaker, Bunsen burner, tripod stand, retort stand with clamp, wire gauze, wooden block, thermometer, rubber tube, stirrer, round-bottom flask and syringe

A Volume

Instruction

1. Set up the apparatus as shown in Figure 8.35.
2. Push the piston into the syringe. Observe the change in the reading of the Bourdon gauge.
3. Pull the piston out of the syringe. Observe the change in the reading of the Bourdon gauge.
4. Record your observations.

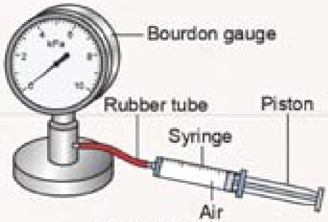


Figure 8.35

Question

What is the relationship between the volume of air and air pressure in the syringe?

B Temperature

Instruction

1. Set up the apparatus as shown in Figure 8.36.
2. Heat up the water in the beaker slowly. Observe the change in the reading of the thermometer and the Bourdon gauge.
3. Record your observations.

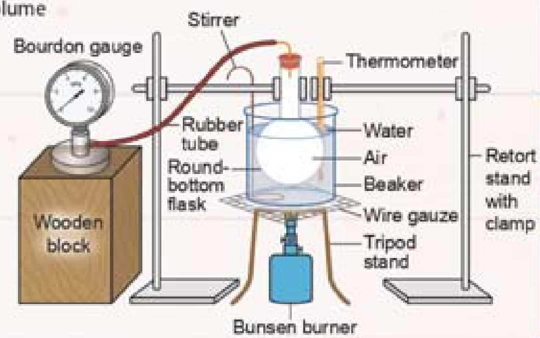


Figure 8.36

Question

What is the relationship between change in temperature and air pressure?

Factors that affect air pressure
- ☑ Volume
- ☑ Temperature

Volume

When a closed container is compressed, the volume in the container is reduced (Figure 8.37). This causes the air particles to **collide more frequently** with the walls of the container and air pressure in the container increases.

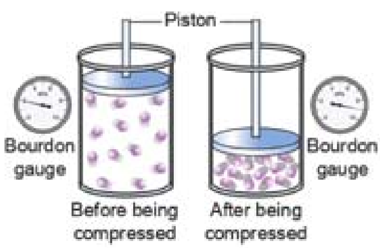


Figure 8.37 *Relationship between volume and air pressure*

Temperature

When the air temperature in a closed container increases, the air particles move faster. This causes the air particles to collide with the walls of the container more frequently and with a greater force (Figure 8.38). Therefore, the air pressure in the container increases.

Info
Relationship between Temperature and Air Pressure
http://www.passmyexams.co.uk/GCSE/physics/pressure-temperature-relationship-of-gas-pressure-law.html

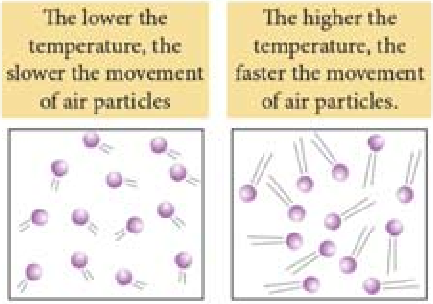


Figure 8.38 *Relationship between temperature and air pressure*

Atmospheric Pressure

When a drink is sucked out of its packet, the packet will compress (Photograph 8.15). What causes the packet to compress? When the drink is sucked out, the drink inside the packet becomes a partial vacuum and the air pressure inside decreases. Therefore, the higher air pressure outside will press onto the packet and compress it. The air pressure outside is called the **atmospheric pressure**. Atmospheric pressure is the pressure exerted by the atmosphere on the surface of the Earth and all objects on the Earth.

Photograph 8.15 *A packet of drink is compressed*

Application of the Concept of Air Pressure in Daily Life

The concept of air pressure allows us to use various tools to carry out daily activities easily. Let us study a few tools that function based on the concept of air pressure in Activity 8.10.

Activity 8.10

Aim: To show the existence of atmospheric pressure in daily life.

Materials: Water and shredded paper

Apparatus: Plunger, Magdeburg hemisphere, straw, syringe, vacuum cleaner, beaker, drinking glass, rubber tube, tiles and basin

Instruction

1. Wet the rim of a plunger with water. Press the plunger against a piece of tile so that air in the plunger is displaced (Figure 8.39). Try to pull the handle of the plunger. Can you detach the plunger from the tile? How is this situation related to atmospheric pressure?

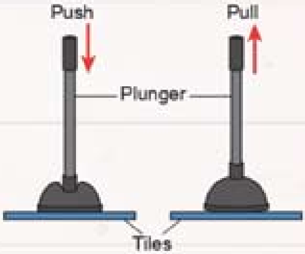


Figure 8.39

2. Attach two Magdeburg hemispheres together and turn the screws to remove the air inside. Try to pull and separate the two hemispheres (Figure 8.40). Can you do it? Explain this phenomenon.

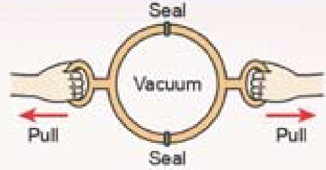


Figure 8.40

3. Fill a beaker with water and put in a drinking straw. Close the upper end of the straw (Figure 8.41). Lift up the straw. Observe what happens to the water in the straw. Explain your answer.

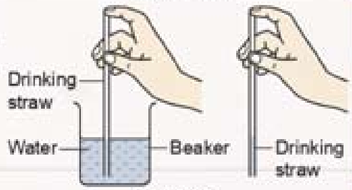


Figure 8.41

4. Arrange the apparatus as shown in Figure 8.42. Fill a rubber tube with water. Close both ends of the rubber tube. Then, place one end of the rubber tube in the water and the other end at a lower point outside the basin. Observe what happens to the water in the basin. What happens if both ends of the tube are at the same level?

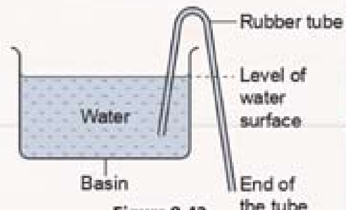


Figure 8.42

5. Insert a syringe into a glass of water (Figure 8.43). Pull the piston upwards. Observe what happens.

Figure 8.43

6. Scatter shredded papers on the floor. Then, use a vacuum cleaner to suck all the shredded papers (Figure 8.44). Observe what happens. How does the vacuum cleaner function?

Explain all the observations above using labelled figures to show the action of atmospheric pressure.

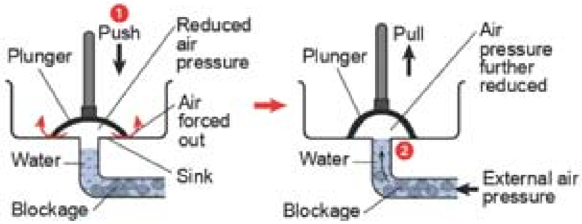

Figure 8.44

Note:
Students need to use the terms air pressure and atmospheric pressure correctly.

Application of the Concept of Air Pressure in Daily Life

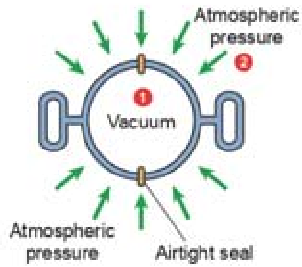
Plunger

1. When the plunger is pressed against the sink, the air inside it will be forced out and creates an area of low pressure.
2. The high pressure in the pipe pushes out the blockage stuck inside the sink when the plunger is pulled up.



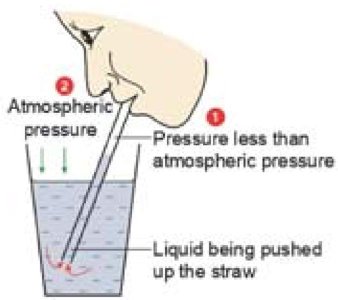
Magdeburg Hemisphere

1. When the air in the hemisphere is pumped out so that the space in the hemisphere becomes a vacuum, the pressure in the hemisphere is zero.
2. The two hemispheres cannot be separated because the atmospheric pressure outside will exert a very strong force on the hemispheres.



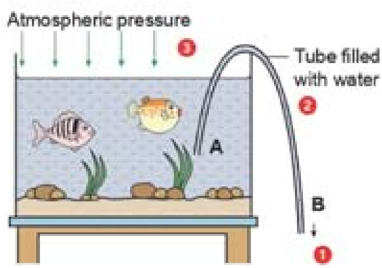
Straw

1. When air in the straw is sucked, the pressure inside the straw is reduced.
2. The higher air pressure outside (atmospheric pressure) will push the drink into the straw and finally into the mouth.



Syphon

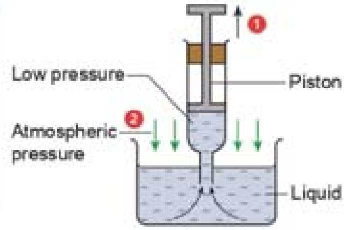
1. The end of tube B is placed lower than the end of tube A, causing water to flow out from it.
2. Water in the tube flows out and creates an area of low pressure in the tube.
3. Atmospheric pressure pushes the water into the tube, so the water flows out continuously.



Application of the Concept of Air Pressure in Daily Life

Syringe

1. When the piston is pulled up, the volume of air in the cylinder increases. This causes a low air pressure in the cylinder.
2. The higher air pressure outside (atmospheric pressure) will push the liquid into the syringe.



Vacuum cleaner

1. When the switch is turned on, the fan in the vacuum cleaner will push air out of the vacuum cleaner. This causes the air pressure in the vacuum cleaner to drop.
2. The higher atmospheric pressure outside will push the air and dust into the vacuum cleaner.

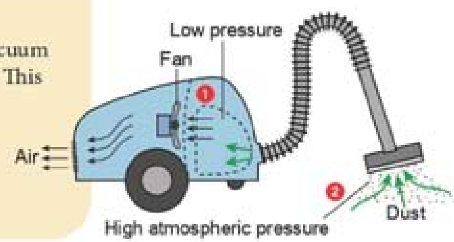
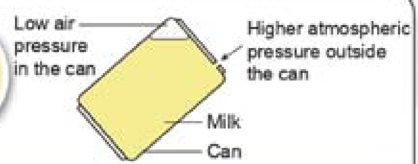
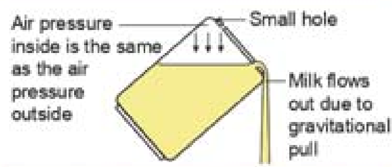


Figure 8.45 *Examples of application of air pressure in daily life*

My Science World



A can of condensed milk with one hole – milk does not flow out easily due to high pressure outside the can.



A can of condensed milk with two holes – milk flows out easily because air pressure inside and outside the can is equal.

Relationship between Altitude and Atmospheric Pressure

Do you know that atmospheric pressure depends on altitude? Atmospheric pressure decreases as altitude increases. This is due to gravitational attraction. Air molecules closer to the surface of the Earth are pulled together by the gravitational attraction causing a rise in pressure. At higher altitudes, air molecules are less affected by the gravitational attraction, so air becomes less heavy and expands easily. This causes a low atmospheric pressure at high altitude (Figure 8.46).

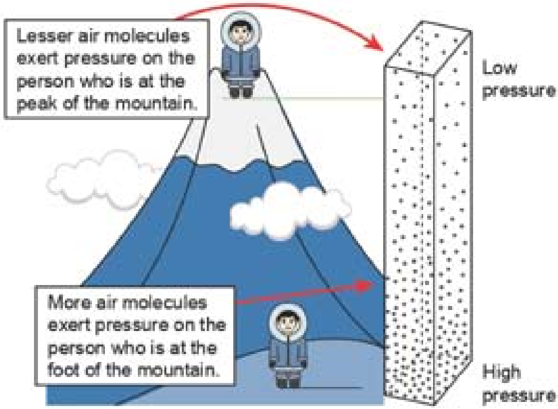


Figure 8.46 *Atmospheric pressure at different altitudes*

My Malaysia!

With the '*Malaysia Boleh*' spirit, two Malaysians, Datuk M. Magendran and Datuk N. Mohanadas became the first two Malaysians to conquer Mount Everest on 23rd May 1997. The peak of Mount Everest has an area of very low atmospheric pressure.

Scan the QR codes below for more information regarding the relationship between altitude and atmospheric pressure.

Info
Altitude Calculator, Atmospheric Pressure and Analysis
http://www.mide.com/pages/air-pressure-at-altitude-calculator

Info
Data Analysis Regarding Relationship between Altitude and Atmospheric Pressure
http://www.windows2universe.org/earth/Atmosphere/pressure_vs_altitude.html

Info
Interactive Lab – Interactive Activity and Quiz
http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atm_measure2.html

Effects of Depth on Liquid Pressure

When a diver is diving in the sea, his body will experience pressure (Photograph 8.16). The weight of the sea water acting on the body of the diver causes the pressure. What will the diver experience if he dives deeper into the sea? Let us carry out Activity 8.11 to find out the answer.

Photograph 8.16 *Diver at Sipadan Island*

Activity 8.11

Aim: To study the effect of depth on pressure in liquids.

Material: Water

Apparatus: 50 cm rubber tube, basin and 1 000 ml measuring cylinder

Instruction

1. Fill a measuring cylinder to the maximum volume and turn it upside down as shown in Figure 8.47.
2. Put one end of a rubber tube into the measuring cylinder.
3. Blow air into the other end of the rubber tube. Observe the change in size of the air bubbles rising from the bottom to the water surface.

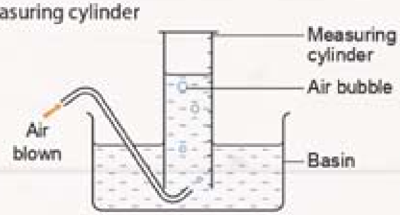


Figure 8.47

Questions

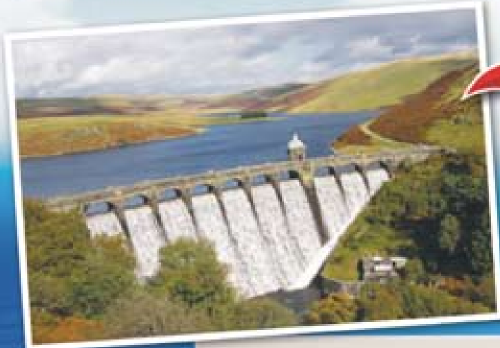
1. Compare the size of the air bubbles at the bottom of the basin and at the water surface.
2. State the relationship between volume of air bubbles and its depth in the water.
3. Explain this phenomenon in relation to pressure in liquids.

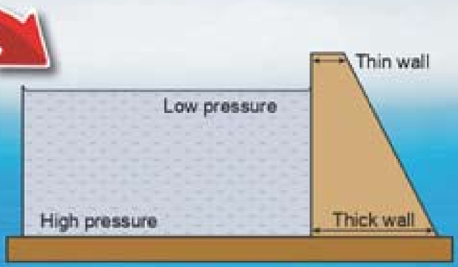
Based on the results of Activity 8.11, the size of the air bubbles becomes larger as the air bubbles rise to the surface. This is caused by the decreasing liquid pressure as depth of liquid decreases. Scan the QR code below for additional information regarding the effects of depth on liquid pressure.

Info

Effects of Depth on Liquid Pressure
http://oceanservice.noaa.gov/facts/pressure.html

Effects of Depth on Liquid Pressure in Daily Life





The walls of a dam are designed to be thicker at the base in order to withstand the high water pressure at the base of the dam.

A diver wears a special suit in order to withstand high water pressure.

The body of a submarine is made of strong material so that it will not be crushed by high water pressure.

Photograph 8.17 *Examples of effects of depth on liquid pressure*

Magical SCIENCE

STEM

It's fun to try!
Try carrying out the experiment shown in the video below to observe the effects of depth on liquid pressure.

Video of Pressure in Liquids
http://buluteksksm.my/Science/Video2.mp4

Video

Career in STEM

Mechanical engineers carry out research on dam designs, industrial plants, machines and many other things. They need knowledge of physics, such as the concept of water pressure when building dams.

Water from the bottom hole shoots out further than water from the upper hole due to pressure in liquid.

Formative Practice 8.2

1. Figure 1 shows a lever system in equilibrium. Calculate the weight of X.

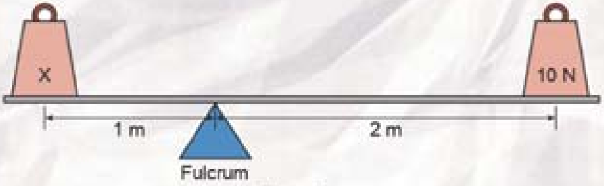


Figure 1

2. Figure 2 shows a cuboid with a weight of 5 N.
   (a) Which surface will exert the greatest pressure?
   (b) Calculate the pressure exerted by each surface.

Figure 2

3. A balloon filled with helium gas will rise upwards when released and float at a certain height.
   (a) Why does the balloon rise upwards?
   (b) Explain the change in the size of the balloon as it rises higher.
   (c) Show the forces acting on the balloon when it is floating with the help of a diagram.

Summary

Force and Motion

Force

- Types of forces
  - Gravitational force
  - Weight
  - Normal force
  - Elastic force
  - Buoyant force
  - Frictional force
- Characteristics of force
  - Force has magnitude
  - Force has direction
  - Force has point of application
- Measuring force in S.I. unit using spring balance
  - Weight of object
  - Frictional force
- For every force acting there is a reaction force of the same magnitude but in the opposite direction
  - Object that remains on the table
  - Object that floats on water
  - Two trolleys in contact with each other are released using spring mechanism

Effects of Force

- Effects of force
  - Moves stationary objects
  - Changes the velocity of objects
  - Stops moving objects
  - Changes direction of motion of objects
  - Changes shape and size of objects
- Difference in densities and effects of buoyancy on daily life
- Lever system
  - Effort
  - Fulcrum
  - Load
- Moment of force
- Pressure and its application in daily life
- Gas pressure and kinetic theory of gas
- Atmospheric pressure and the effects of altitude on atmospheric pressure
- Effects of depth on liquid pressure

Quiz

Interactive Quiz 8

SELF-REFLECTION

After learning this chapter, you are able to:

8.1 Force

- [ ] Describe and communicate about force.
- [ ] Explain that force has magnitude, direction and point of application.
- [ ] Measure force in S.I. unit.
- [ ] Explain with examples that every action force has an equal (same magnitude) reaction force but in the opposite direction.

8.2 Effects of Force

- [ ] Describe and communicate the effects of force.
- [ ] Explain and communicate the relationship between the differences in density and the effects of buoyancy in daily life.
- [ ] Classify and solve problems involving levers based on the position of fulcrum, load and effort.
- [ ] Explain and communicate about moment of force.
- [ ] Carry out experiment and communicate about pressure and its application in daily life.
- [ ] Elaborate and communicate about gas pressure based on the kinetic theory of gas.
- [ ] Explain and communicate the existence of atmospheric pressure and the effects of altitude on atmospheric pressure.
- [ ] Explain the effects of depth on liquid pressure.

Summative Practice 8

1. Identify the following types of forces.

(a)

____

(b)

____

Photograph 1

2. State the device used to measure force and the S.I. unit of force.

Measuring device: ______________________

S.I. unit: ______________________

3. Label the action force and the reaction force acting on the object in Photograph 2 below.

Photograph 2

4. Tick (✓) the activity that involves atmospheric pressure.

Inhaling air into lungs	☐
Opening a door	☐
Hanging a picture on the wall using a nail	☐
Drinking water from a straw	☐

Figure 1

5. Figure 1 shows a nail being removed from a plank using a hammer. If a force of 5 N is required to remove the nail, what is the moment of force required to pull the hammer in the direction shown in Figure 1?

6. Figure 2 shows a car that has a weight of 1 000 N. The area of contact of each tyre with the road is 0.1 m^2. Calculate

   (a) the total pressure exerted by the car on the road.

   (b) the pressure exerted by each tyre on the road.

Figure 2

7. A piece of stone has a weight of 20 N in the air and 15 N when fully submerged in water.

   (a) Determine the difference in the weight of the stone in the air and in water.

   (b) Determine the upthrust force on the stone.

   (c) Explain why the stone sinks in water.

8. Su Ling wants to use a straw to drink from a glass but she could not suck the water. She finds a small hole on the straw (Figure 3). Suggest a method to overcome the problem.

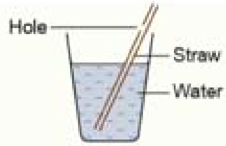


Figure 3

9. Mei Foong is invited to an event held at a field. The field has a soft ground. She has two pairs of shoes as shown in Figure 4. Suggest the most suitable pair of shoes to be worn by Mei Foong to attend the event. Give your reasons.

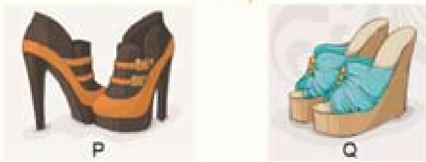


Figure 4

10. Azman wants to transfer liquid from beaker *B* to beaker *A* (Figure 5). He has tried a few times but failed. What is the problem? Modify the set up so that the liquid can be transferred from beaker *B* to beaker *A*.

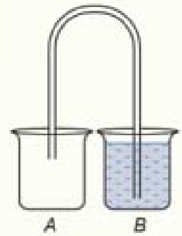


Figure 5

HOTS Mastery 8

11. Wan and Nurul sat on a see-saw (Figure 6). The see-saw is imbalanced because Wan's mass is 45 kg while Nurul's mass is only 30 kg. Suggest how Nurul can balance the see-saw.

Figure 6

12. Mr. Tan pushes a wheelbarrow on a muddy road (Figure 7). He finds it very difficult to push the wheelbarrow. Suggest one modification that can be made to reduce the pressure exerted on the road. Explain your answer.


Figure 7