Contents

Developed by Science Curriculum Working Group 24/12/03 to 28/12/03

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Chapter 1 Motion

A. Understanding Motion

Activity 1.1	
Brainstorming	**work as a class**
Write down some words that are related to motion. Write down your own definition of motion as you understand it.	

Motion – An object is in motion if it changes position relative to a reference point. A *reference point* is a place or object used as the comparison to determine if something is in motion. **It is very important to choose your reference point.**

If you are sitting in a room, you are not in motion if the reference points you used are on earth, because no position changes.

If you compare yourself with the sun, you are in motion, because there are position changes between you and the sun.

Exercises with Motion

(i). Decide whether these objects are in motion or not.

a. You are in a bus moving at the speed of 20km/hr. Compared to the driver, are you in motion?

b. Two runners are running at the same speed and direction. Is there any motion between them?

c. A train is moving at the speed of 50km/hr. Compared to the forest beside it, are the passengers in the train in motion?

d. You are sitting in your house. If your house is a reference point, can we say you are in motion?

(ii) Answer the following questions in your own language.

a. How can you know an object is in motion if its motion is too slow to see?

b. Why don't we notice the Earth beneath us is not in motion? Explain.

c. Identify three objects which are in constant motion.

Distance and displacement

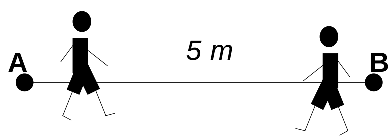
Distance is a measure of how far an object has traveled from a relative point.

Displacement is the change in position of an object from its relative point.

(Note: If an object has traveled and returned to its point of origin, its displacement is defined as 0, no matter how far its has traveled)

Comparing Distance and Displacement

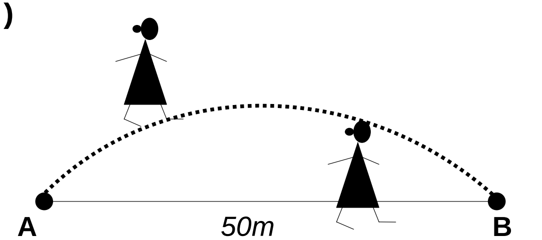
A boy moves from A to B.
His distance is 5 m.
His displacement is 5 m.



A second boy moves from A to B and returns back to A.
His distance is 5 + 5 = 10 m.
His displacement is 0 because no change in position.

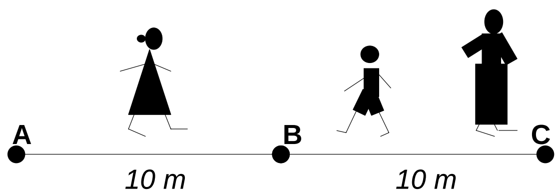
Exercises with distance and displacement

(i)



Two women travel from town A to town B. One woman travels from A to B along a straight line and another woman travels from A to B along a curved line. If the straight distance between A and B is 50m, whose displacement is greater?
Whose distance is greater?

(ii)



Person 1 moves from A through B to C without returning.

Person 2 moves from A through to C and returns back to B.

Person 3 moves from A to B and returns back to A.

a. Whose distance is the greatest?
b. Whose displacement is the greatest?
c. Order their distances from greatest to least.
d. Order their displacements from greatest to least.

(iii) A girl goes from her house to a nearby shop at the corner of the street and then returns home. Can you say that the distance she travels is equal to the magnitude of her displacement?

(iv) In one-round-about-town walking race the starting point is the same as the finishing point. Whose magnitude of displacement is greater? The person who completes the race or the person who gives up halfway?

B. Vector and Scalar quantities

Vector Quantity

A quantity that has both *magnitude* and *direction* is called vector quantity.

Magnitude = 50 cm
Direction = East

Scalar Quantity

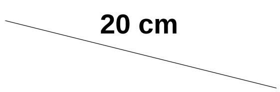
A quantity that has only *magnitude* is called scalar quantity.

Magnitude = 50 cm
Direction = no direction

Exercises with vector and scalar quantities

Which of these is a vector or a scalar?

(i)


(ii)


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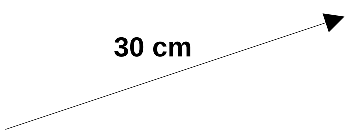

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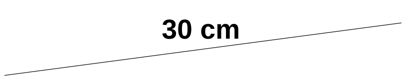


(v) weight of a body

(vi) displacement of a body

(vii) gravity of Earth

(viii) density of a body

(ix) distance of a journey

(x) mass of a body

(xi) volume of a body

(xii) force exerted on a body

C. Speed

Activity 1.1

How fast can you walk? **Work in groups**

Step 1 Choose one student from your group to demonstrate the activity.
Step 2 Each demonstrator walks about 20 meters.
Step 3 Record the time of each demonstrator takes.
Step 3 Which demonstrator walks fastest?
Did he/she take the longest time or shortest time?

Think it over

How can you describe that the student who walks fastest has the greatest speed?

The **speed** of a body tells how far it travels during every unit of time.
If you know the distance an object travels in a certain amount of time, you know the speed of the object. To calculate the speed of an object, divide the distance the object travels by the amount of time it takes to travel that distance.

$S = \frac{d}{t}$ where S is speed, d is distance, and t is the time taken.

Speed measurements consist of a unit of distance divided by a unit of time.
If a car travels at the speed of 90 kilometers/hour, that car travels 90 kilometers in one hour.
Speed is a scalar quantity.

Constant speed

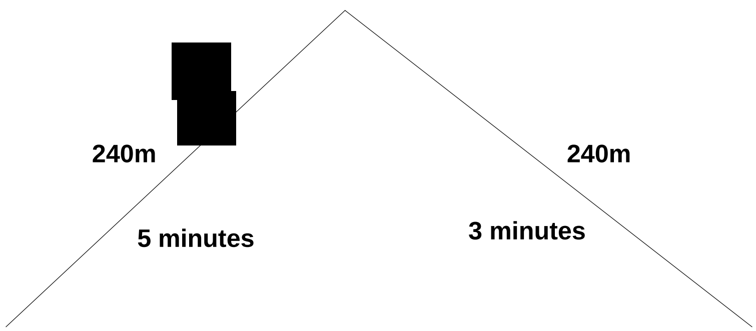
If an object moves at the same speed for several hours, the object is traveling at a constant speed.

e.g.:*A horse is moving at a constant speed. It moves 21 meters in 3 seconds.*
The speed of the horse = 21m / 3seconds
= 7 m/s

Note: The speed of Earth revolving around the sun is 30 m/s.

Average Speed

Most objects do not move at a constant speed.
For example, you may walk slowly to climb up the hill, and walk fast down the hill.



Average Speed = $\frac{\text{Total Distance}}{\text{Total Time}}$

$$\textit{Average Speed} = \frac{(240 + 240)\ m}{(5 + 3)\ min.} = \frac{480\ m}{480\ s} = 1\ ms^{-1}$$

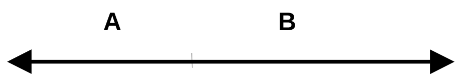
D. Velocity

When you know both the speed and direction of an object's motion, you know the velocity of the object. *Speed in a given direction is called velocity.* Velocity is vector quantity.

$$\text{Velocity} = \frac{\textit{distance}}{\textit{time}}$$

Exercises with velocity

(i)



Velocity of object A = 50 m/min. W.
Velocity of object B = 70 m/min. E.

A and **B** start their journey from the same point and at the same time. After moving for 1 minute, what is the distance between them?

(ii) Two cars are moving at the opposite directions and same speed of 50 m/s from town A and town B which are 1000m apart. In how many seconds will the two cars meet?

(iii) A car moves at speed of 20 km/hour, and another car moves at velocity of 20 km/hour. After 2 hours moving, which car's position can you know exactly?

(iv) Lu Reh comes to school every day. Which of the following measurements generally represents his motion?

(a) speed
(b) velocity
(c) constant speed

E. Acceleration

What do you know?

i. Can a speed of an object decrease or increase from one time interval to another time interval?

ii. If a car starts a journey from rest to get a certain speed, do you think that car speed must change or increase time by time?

iii. If you drop a ball from a certain height it takes 10 seconds. Do you think speed of the ball in the first second and speed of the ball in last second are the same? If not, which speed in faster?

Acceleration is the rate of change of velocity. In science, acceleration refers to increasing speed, decreasing speed, or changing direction.

$$\text{acceleration} = \frac{\textit{final velocity - initial velocity}}{\textit{time}}$$

Note:

If an object starts from rest, its initial velocity is 0. If an object stops, its final velocity is 0.

Exercises with acceleration

i. A cart rapidly picks up speed as it rolls down a slope. As it starts down the slope, its speed is $4ms^{-1}$. But 3 seconds later, at the bottom of the slope, its speed is $22ms^{-1}$. What is its acceleration?

ii. A particle with an initial velocity of $10ms^{-1}$ travels in a straight line and stops completely after 12 seconds. Find the acceleration of the particle.

Review Exercises

i. Choose the best answer to each item.

1. Which of the following is the vector quantity?
(a) speed
(b) mass
(c) acceleration
(d) distance

2. If the acceleration of the object is positive unit, we can say
(a) the initial velocity is greater
(b) the final velocity is greater
(c) the time taken is less
(d) the time taken is greater

3. A change in position with respect to the reference point is
(a) acceleration
(b) velocity
(c) direction
(d) motion

4. If you know a car travels 30 km in 20 minutes, you can find its
(a) acceleration
(b) average speed
(c) direction
(d) graph

5. A man traveled east for 20km and then continued traveling north for 10km. Based on the information above, which of the following is true?
(a) Distance is greater than displacement
(b) Displacement is greater than distance
(c) Distance and displacement are the same

6. A train traveled 135 miles at an average speed of 30 miles per hour. How long did the train take to make the trip?
(a) three and half hours
(b) four hours
(c) four and half hours
(d) five hours

ii. True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

1. ***Speed*** is the rate of change of velocity.
2. A quantity that has only ***direction*** is called scalar quantity.
3. ***Acceleration*** is the measure of increasing or decreasing of velocity in a given unit of time.
4. In a moving car, you are not moving from the reference point of the ***car***.
5. Distance is always ***greater than or equal to*** displacement.

iii. Check your understanding

1. Which has the greater speed, a hawk that travels 600 meters in 60 seconds or a tiny bird that travels 60 meters in 5 seconds? Explain.

2. You are studying the motion of the moon. What unit would you probably use to describe its speed? Explain why.

3. If the initial velocity of a particle is greater than the final velocity, is the particle accelerating or decellerating? Explain.

4. Draw the diagrams to show the differences of distance and displacement.

5. A bird accelerates from 18 ms^{-1} to 34 ms^{-1} in 8 seconds. What is the bird's average acceleration?

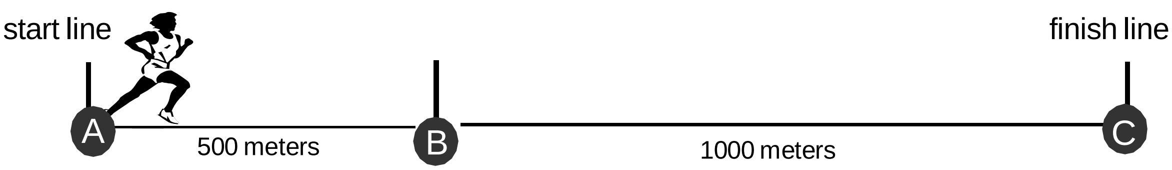
iv. Thinking skills

1. Suppose you have two measurements. One is the time that a car takes to travel a around a field. The other is the time the car takes to travel around another field. From these measurements, explain how you decide if the car is moving at a constant speed or if it is accelerating?

2. A family takes a car trip. They travel for an hour at 80 km/hr and then for 2 hours at 40 km/hr. Find the average speed.

3. A person travelled 20 km East and 10 km North. Are the distance and displacement the same? Give the reasons.

v. Application



1. Starting at rest, the runner accelerated to line B and then moved at constant speed until she reached the finish line. If she took 2.5 minutes to run from line B to the finish line, calculate her constant speed during that time.

2. The speed you calculated in question 1 is also speed the runner had at line B (at the end of her acceleration). If she took 2 seconds to accelerate from the start line to line B, what is her acceleration during that time?

3. In the second race, she took 1.5 minutes from the starting line to line B and 2.6 minutes from line B to the finish line. Is she accelerating or deaccerlerlating? Explain.

4. The average speed of the another runner from start line to finish line in the second race was 360 meters per minute. Compare to the above runner, who reached the finish line first? Explain.

Chapter Two: Force

A. Understanding forces

Force is a push or a pull. Like velocity and acceleration, forces are described not only by how strong they are, but also by the direction *in which they act.*

***F* = *ma* ; where *F* = force, *m* = mass, and *a* = acceleration**

Activity 2.1

How strong are you? **Work in pairs**

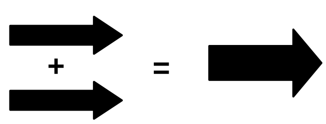
Step 1 Push the table with your partner in the same direction.
Step 2 Push the table with your partner in the opposite direction.
Step 3 Compare step 1 and step 2.

Think it over. In step 2, how would you describe:

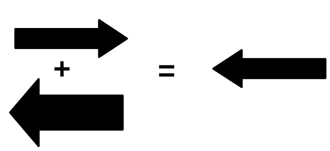
a) If the table is not moving?
b) If the table is moving toward you?
c) If the table in moving toward your partner?

Unbalanced forces

Unbalanced forces' action on an object will change the object's motion.
Unbalanced forces can cause an object to start moving, stop moving, or change direction.
When two forces act in the same direction they add together.

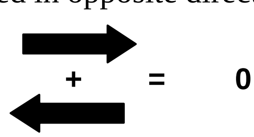


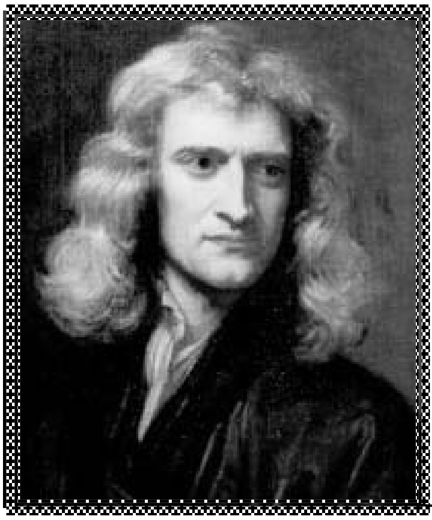
When two forces act in opposite directions they also add together. But the adding is the same as adding a positive and a negative number. If one force is greater than the other force, the overall force is in the direction of the greater force. In any situation, the overall force on an object after all the forces are added together is called the *net force.*



Balanced Forces

Two equal forces action on one object in opposite directions are called *balanced forces.*
Balanced forces acting on an object will not change the object's motion.
The net force of equal forces exerted in opposite direction is zero.





Newton's First Law of Motion

Inertia is the tendency of an object to resist change in motion. For example, if your are in a car that stops suddenly, inertia causes you to continue forward, Newton's First Law of motion states that an object at rest will remain at rest and an object is moving at constant velocity will continue moving at constant velocity unless acted upon by an unbalanced force. Newton's First Law is also called the ***Law of Inertia.***

Activity 2.2

Interpreting data **Work in groups of three**

Problem: How is the acceleration of a toy car related to the force that is pulling it?

Materials: *toy car, meter stick, spring scales, string, masking tape, stop watch, several bricks or other large masses*

Procedure:

Step 1 Attach a loop of string to a toy car. Place the bricks on the car.

Step 2 Using masking tape, mark off a one-meter distance on a level floor. Label one end *'Start'* and the other *'Finish'.*

Step 3 Attach a spring sale to the loop of string. Pull it so that you maintain a force of 2.0 N. Be sure to pull with the scale straight out in front. Practice applying a steady force to the car as it moves.

Step 4 Make a data table in your notebook like the one on the next page.

Step 5 Find the smallest force needed to pull the car at a slow, constant speed. Do not accelerate the car. Record this force on the first line of the table.

Step 6 Add 0.5 N to the force in **Step 5.** This will be enough to accelerate the car. Record the force on the second line of the table.

Step 7 Have one of your partners hold the front edge of the car at the starting line. Then pull on the spring scale with the force you found in **Step 6.**

Step 8 When your partner says "Go" and releases the car, maintain a constant force until the car reaches the finish line.

Step 9 A third partner should time how long it takes the car to go from start to finish. Record the time in the column labeled *Trial 1*.

Step 10 Repeat **Steps 7, 8,** and **9** twice more. Record your results in the columns labeled *Trial 2* and *Trial 3.*

Step 11 Repeat **7, 8, 9,** and **10**, using a force that is 1.0 N greater than the force you found in **Step 5.**

Step 12 Repeat **7, 8, 9,** and **10** twice more. Use forces that are 1.5 N and 2.0 N greater than the force you found in step 5.

Data Table

force (N)	trial 1 time (s)	trial 2 time (s)	trial 3 time (s)	average time (s)	average speed (m/s)	final speed (m/s)	acceleration (m/s^2)

Analyse and Conclude

1. For each force you used, find the average of the three times that you measured. Record the average in your data table.
2. Find the average speed of the car for each force. Use this formula:
   average speed = 1 m ÷ average time
3. To obtain the final speed of the car, multiply each average speed by 2. Record the result in your data table.
4. To obtain the acceleration, divide each final speed you found by the average time. Record the acceleration in your data table.
5. Make a line graph. Show the acceleration on the y-axis and the force on the x-axis. The y-axis scale should go from zero to about 1 m/s^2. The x-axis should go from zero to 3.0 N.
6. If your data points seem to form a straight line, draw a line through them.
7. Your first data point is the force required for an acceleration of zero. How do you know the force for an acceleration of zero?
8. According to your graph, how is the acceleration of the toy car related to the pulling force?

Think it over

Which variable is the manipulated variable? Which is the responding variable?

Activity 2.3

Design an experiment **Work in groups**

Design an experiment to test how the acceleration of the loaded toy car depends on its mass.

Think about

- How would you vary the mass of the toy car?
- What quantity would you need to measure that you did not measure in this experiment?
- Do you have the equipment to make that measurement? If not, what other equipment would you need?

B. Force, mass and acceleration

Activity 2.4

Observing - How do the rocks roll? **Work in groups**

Step 1 Place several small rocks in a toy truck. Hook a spring scale to the bumper of the truck.
Step 2 Practice pulling the truck with the spring scale so that the reading on the scale stays constant.
Step 3 Pull the truck with a constant force and observe its motion. Then remove a few rocks from the truck and pull it again with the same force.
Step 4 Remove a few more rocks and pull the truck again.
Step 5 Finally, empty the truck and observe how it moves with the same constant force.

Think It Over

How did changing the mass of the loaded truck affect its motion?

Newton's Second Law of Motion

The net force on an object is equal to the product of its acceleration and its mass.

$$\text{Force}_{net} = \text{mass x acceleration}$$

When mass is measured in kilograms and acceleration is measured in meter per second, force is measured in Newtons. (N) i.e. *1N = 1 kg x 1 m/s*

Activity 2.5

Problem solving **work in groups**

A woman is pulling a 52kg wagon (including two children). The force causes it to accelerate at 2 $m/5^2$. Calculate the net force that causes acceleration.

> ***Remember:*** $Force_{net}$ = mass x acceleration

Thinking it over

1. Is the force you calculated equal to the force the woman pulled?

2. A wagon including only one child is being pulled by the same force? What happens to the acceleration?

3. An object is being pulled by 80 N net force is acceleration at 4 m/s^2. How can you know the mass of the object?

C. Friction and gravity

Activity 2.6

Inferring **work in groups**

Problem: Can you move the book easily?

Step 1 Put your dictionary on the table
Step 2 Attach the spring scale to the book and pull. Record the force acted on it.
Step 3 Put 2 pens or pencils under the book and pull. Record the force acted on it.

What are the controlled variables?
What is the manipulated variable?
What is the responding variable?

Thinking it over

What causes the book to be more difficult to move?

Friction

Friction is the force that one surface exerts on another when they rub against each other. Every surface has very small bumps. Even surfaces that look smooth are really bumpy if you look through a microscope. As two surfaces slide across each other, their bumps rub against each other - that is they exert force agaonst each other. That force is the force of friction.

When solid surfaces slide over each other, we get s*liding friction.*
When an object rolls over a surface, we get *rolling friction.*
When an object moves through a liquid, we get *fluid friction.*

Resistance

Resistance is anything that slows down the motion.
The weight of the object and *friction* are examples of resistance.

Gravity

Gravity is the force that pulls objects toward Earth.

Activity 2.7

Observing **work in groups**
Which object drops faster?

Step 1 Make two clay balls. (About 50 g and 500 g)
Step 2 Drop the two clay balls at the same time from about 5m.
Which one hits the ground first?
What makes them to drop?

Thinking it over

What happens if you drop a small piece of paper and a big piece of paper in step 2?
What happens if you drop the two clay balls on the moon? And in space?

Free Fall

When the only force acts on an object is gravity, the object is said to be in *free fall.* An object in free fall accelerates as it falls.

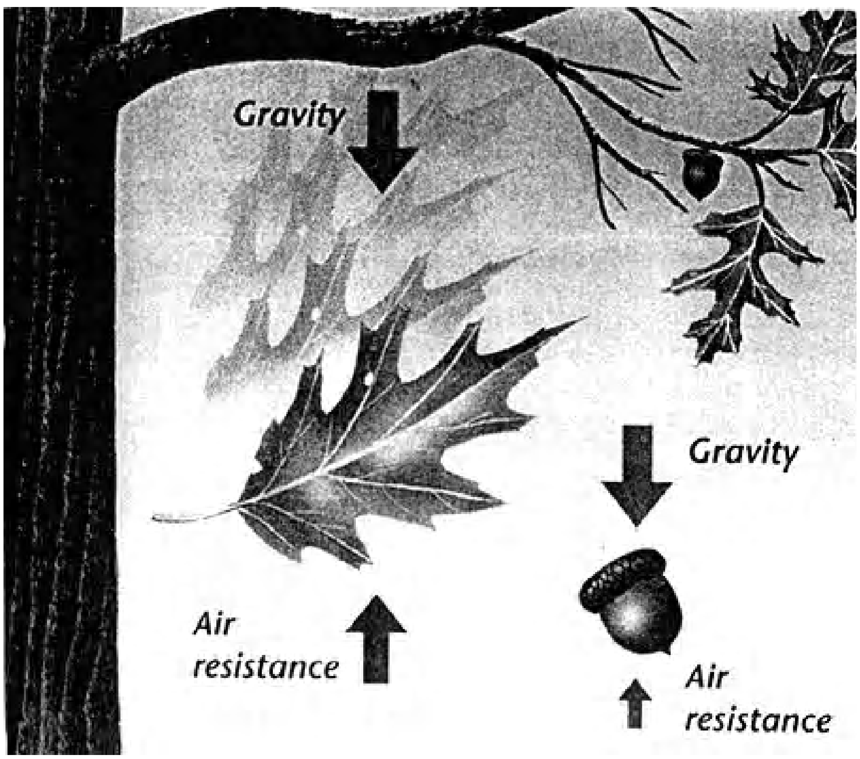
Suppose that an object is dropping from top of the building. Its starting velocity is 0 m/s.

- At the end of the first second its velocity is 9.8 m/s.
- After two seconds, its velocity is (9.8 + 9.8) = 9.6 m/s.
- After 3 seconds, the velocity is 29.4 ms^{-1}.

The velocity increases as long as it falls.

$V = V_0 + at$, where V is velocity, V_0 is initial velocity, a is acceleration, and t is time

Note: *All objects in free fall accelerate at the same rate regardless of mass.*



Air resistance

Objects falling through air experience a type of fluid friction. This is called *air resistance*. The greater surface area of an object the greater the air resistance.

Air resistance increases with velocity. So as a falling objects speeds up, the air resistance against it increases. Eventually, the resistance equals the force of gravity. When the forces are balanced, there is no acceleration, so although the object continues to fall, its velocity no longer increases. This velocity - the greatest velocity the object reaches - is called *terminal velocity.*

D. Weight, mass and volume Weight

Weight is a measure of the force of gravity on an object.The weight of an object is the product of its mass and acceleration due to gravity.

W = mg: **where *W* = weight, *m* = mass, and *g* = acceleration due to gravity**

A unit of weight is **kg ms^{-2}** or **N.**

For example:

*a 50-kilogram person weighs **50 kg x 9.8 m/s^2 = 490 newtons** on Earth's surface.*

Mass

Mass is the measure of the amount of matter in it. Mass is always a constant.
Wherever a body is, there is no changes in the value of the mass of the body.

Exercises calculating force, mass, weight and acceleration

i. Find the amount of a force that must act on a body of 10-kg mass to give it an acceleration of 5 ms^{-2}.

ii. Find the mass of a body weighing 75-kg ms^{-2} or N? (g = 9.8 ms^{-2})

iii. What is the acceleration of a body weighing 20N due to applied force of 20 N? Assume that there is no friction.

iv. A body is in free fall. Its starting velocity is 0m/s and its velocity increases by 9m/s. What is the velocity of the object after 9 seconds?

Gravitational Force

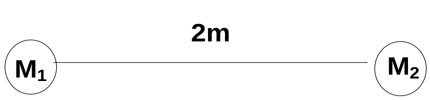
Every body attracts every other body in the universe. The gravitational force between the two bodies is directly proportional to the product of the masses, and inversely proportional to the square of the distance between.

$$G.F = G\frac{m_1 m_2}{r^2}$$

G = 6.67 x 10^{-11} m^3 kg^{-1} s^{-2} (G is constant)
G.F **= Gravitational Force**
M **= Mass of body**
r **= distance between two bodies.**

For example: Two bodies of mass 2 kg and 5 kg are at rest 2m apart.
To find the gravitational force interacting between them:

M_1 = 2 kg, M_1 = 5kg
G = 6.67 x 10^{-11} N m^2 kg^{-2}



Activity 2.7

Predicting

A steel ball robot weights 10kg and made of 10,000 small steel balls. On a space trip to the moon, a spaceship carries the steel ball robot to moon for observation.

Think it over

1. What will happen to the weight of steel ball and robot on the moon?
2. What will happen to the number of steel balls of robot on the moon?

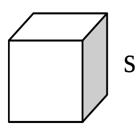
E. Volume

The volume of matter is the amount of space it takes.

Measuring the volume of a regular object

i. Cube

Example If one side of a cube is 4cm, the volume is:



$V = S^3$
$S = 4^3$
$V = 64$

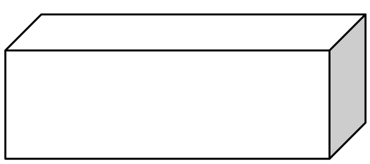
$V=S^3$

ii. Rectangular figure

Volume of rectangular figure = length x width x height

Example *If a length of rectangular figure is 5cm,the width is 2cm and the height is 3 cm, then its volume is :*

V = lwh
V = 5 x 2 x 3
V = 30 cubic centimeters (cm^3)

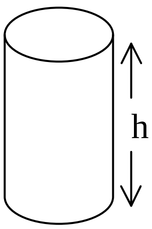


V=lwh

iii. Cylinder

Volume of a cylinder $\pi = 3.14$ r = *radius* h = *height*

$$V = \pi r^2 h$$

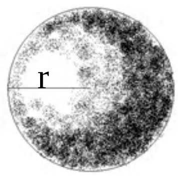


Example: *If a radius of the top or bottom surface of a cylinder is 10cm and its height is 25cm then its volume is:*

$V = \pi r^2 h$
$= 3.14 \times 10^2 \times 25$
$= 7760$ cubic centimeter (cm^3)

iv. Sphere

$$V = \frac{4}{3}\pi r^3$$

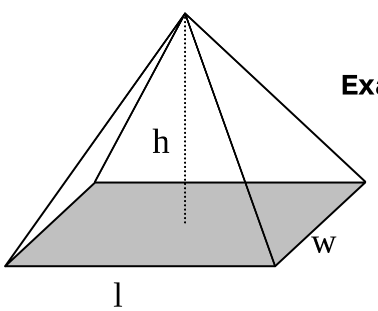


Example: *If a radius of a sphere is 10cm, then the volume is:*

$V = \frac{4}{3}\pi r^3$
$V = \frac{4}{3}\ 3.14 \times 10^3$
$V = 4186.67$ cubic centimeter (cm^3)

v. Pyramid

$$V = {}^1/_3\, l\, w\, h$$

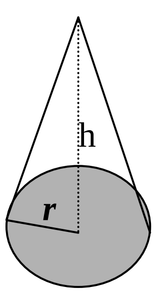


Example: *If the length of the base of pyramid is 5 cm and the width is 3 cm, and its height is 4 cm, the volume is:*

$V = {}^1/_3\, lwh$
$V = {}^1/_3 \times 5 \times 3 \times 4$
$V = 20\ cm^3$

vi. Cone

$$V = {}^1/_3 \pi r^2 h$$



Example: *If the radius of a cone is 4 cm and the height is 10 cm, the volume is:*

$V = {}^1/_3 \pi r^2 h$
$V = {}^1/_3 \times 3.14 \times 4^2 \times 10$
$V = 181.37\ cm^3$

Measuring the volume of an irregular object

Activity 2.8

Designing an expiriment: To measure the volume of a stone

Materials *Water, graduated cylinder, stone, notebook, pen, ruler*

Procedure

Step 1 Fill the graduated cylinder with water to the 50ml mark.

Step 2 Put the stone into the cylinder

Step 3 Read the water level, and record it in the table. Pour out the water.

Step 4 Repeat all 3 steps twice.

	volume of water	volume of water and stone	volume of stone
first	*50 ml*		
second	*50 ml*		
third	*50 ml*		

Problem solving

Calculate the average volume of water recorded in the table from your three experiments.

Why do you think it is useful to repeat this expiriment 3 times?

To measure liquids or powered solids, pour it into a measuring cylinder and read.

Units of volume

International system Unit (SI)

Cubic centimeter *(cm3)* for solids
Litre *(L)* for liquids and powdered solids

British System Unit

Cubic foot *(ft^3)* for solids
Gallon for liquids

Activity 2.9

Predicting **Work in groups**

Step 1 Your teacher will give you 5 objects: *cork, clay, stone, wood* and a *nail.*

Step 2 Which object is the most dense?
List the objects in order of density.

Density is the measurement of how much matter is contained in the a given volume.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \qquad D = \frac{m}{v}$$

The unit of density (SI unit) is gram per cubic centimeter: **g / cm^3 or gcm^{-3}**

Activity 2.10

Designing your own experiment: Making sense of density

Problem *Does the density of a subtance change when it is broken to pieces?*

In groups, you need to:

- Develop a hypothesis
- Design the expiriment

Procedure

Step 1 List the materials needed for the experiment.

Step 2 Identify controlled and manipulated variable.

Step 3 Write the procedures of the experiment.

Step 4 Create a data table and record the data from your experiment

Step 5 Analyze the densities recorded in the table.

Step 6 Write the conclusion of your experiment.

E. Action and reaction

Activity 2.11

Observation **work in groups**

Press a spring with your finger.
Can you feel that the spring is pushing back against your finger?
Can you say that every body will exert force against the object that is exerting on it?

Newton's Third Law of Motion

If one object exerts a force on another object, then the second object exerts a force of equal strength in the opposite direction on the first object.

Momentum

The momentum of an object is the product of its mass and its velocity.

Momentum = mass x velocity
M = mV

The unit of momentum is g*ms*$^{-1}$

Exercises with Momentum

i. Which has more momentum:
a. A 3 kg hammer swung at 1.5 m/s or
b. A 4 kg hammer swung at 0.9 m/s?

Momentum = mass x velocity

a. M = 3kg x 1.5m/s = 4.5kg m/s
b. M = 4kg x 0.9m/s = 3.6kg m/s

ii. A volleyball travels at 16 m/s, While a football moves at 7 m/s. The mass of the volleyball is 0.045 kg and the mass of the football is 0.14 kg. Which has more momentum?

Momentum = mass x velocity

a. M = 0.045 kg x 16 m/s = 0.72 kg m/s
b. M = 0.14 kg x 7 m/s = 0.98 kg m/s

The momentum of the football, which has smaller velocity, has more momentum than the volleyball. Why?

Law of conservation of momentum

Activity 2.12

Observing **work in groups**

Step 1 Put toy car A on the table. Put toy car B about 1 m behind car A.
Step 2 Push car B to hit car A.
What happened to car A and car B?
Which car's velocity is increasing or decreasing?

Thinking it over

In step 3, is the total momentum of the car A and B before colliding equal to the total momentum of car A and B after colliding?

Law of conservation of Momentum.

The total momentum of the objects that interact does not change. The total momentum of any groups of the objects remain the same unless outside forces act on the objects.

Activity 2.13 **work in pairs**

1. Calculating
Use the formula for momentum to find the momentum of each ball before and after the collision. Assume the mass of each ball is 0.4 kg.

2. Inferring
Find the total momentum before and after collision. Is the law of conservation of momentum satisfied in this collision? Explain.

3. Designing Experiments
Design an experiment in which you could show that momentum is not conserved between the balls when friction is strong.

F. Force and pressure

Pressure

Activity 2.14

Observing **work in pairs**

Materials *Bottles, straw pipes, clay, water, cups*

Step 1 Fill a bottle with about 10 ml water.
Step 2 Put two straw pipes into the bottle. Put pipe A about 10 cm into the bottle and pipe B just at the mouth of the bottle.
Step 3 Seal the bottle with clay.
Step 4 Fill a cup with about 200-ml water.
Step 5 Put the bottle upside down and dip pipe A into the cup.

Thinking it over
Observe what happen to the water in the cup?
What make the water in the cup pump up into the bottle?

Pressure is a force pushing on a surface. Pressure is equal to the force exerted on a surface, divided by total area over which the force is exerted.

$$P = F/A$$

Unit N/m^2 or Pascal (Pa)

Example: You have a closed bottle of soda. The force on the bottle cap due to the carbonation of soda is 14 N. If the area of the bottle cap is 7 cm^2, the pressure on the cap is:

$$F = 14\ N,\ A = 7\ cm^2,\ P = ?$$
$$P = F/A$$
$$P = 14N/7cm^2$$
$$P = 2\ N/cm^2$$

Activity 2.15

Think critically **work in pairs**

A woman wearing high-heeled shoes has a mass of 50 kg and an elephant has a mass of 500kg. Explain how the woman can exert pressure on a floor about three times the pressure exerted by the elephant.

Transmitting pressure in liquids

Activity 2.16

How does the pressure change? **work in groups**

Procedure

Step 1 Fill an empty two litre plastic bottle to the top with water. Screw on the lid tightly. There should be no bubbles in the bottle (or only very small bubbles).

Step 2 Lay the bottle on its side. Pick a spot on the bottle, and push in with your left thumb.

Step 3 With your right thumb, push in fairly hard on the spot at the other end of the bottle.What does your left thump feel?

Step 4 Pick another spot on the bottle for your left thump and repeat step 3.

Thinking it over

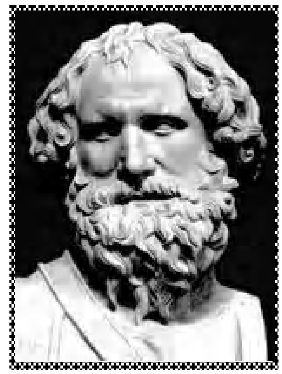
When you push in with your right thumb, does the water pressure in the bottle increase, decrease, or remain the same? How do you know?

Pascal's Principle

Pressure increases by the same amount throughtout an enclosed, or confirmed fluid. This fact was discovered in the 1960s by a French mathematician named Blaise Pascal.

When force is applied to a confirmed liquid, an increase in pressure is transmitted equally to all parts of the fluid.

Pascal's principle is applied in many devices especially in hydraulic devices such as hydraulic car lifts and hydraulic car brakes.



Buoyancy

Water exerts a force called the buoyant force that acts on a submerged object. The buoyant force acts in the upward direction, against the force of gravity, so it makes the object feels lighter.

Archimedes' Principle relates the amount of fluid a submerged object displaces to the buoyant force on the object. This relationship is named for the discoverer, the ancient Greek mathematician Archimedes.

The buoyant force on an object is equal to the weight of the fluid displaced by the object.

Bernoulli's Principle

Activity 2.17

Does water push or pull? **work in groups**

Procedure

Step 1 Hold the plastic spoon loosely by the edges of its handle so it is swinging freely between your fingers.

Step 2 Turn on a tap (or pour water from a cup) to produce a steady stream of water. Predict what will happen if you bring the curved back of the spoon into contact with the stream of water.

Step 3 Test your prediction. Repeat the test several times.

Step 4 Predict how your observations might change if you were to use a plastic fork instead of a spoon.

Step 5 Test your prediction.

Think it over

On the what side of the spoon is the pressure lower? How do you know? Does the fork behave any differently the spoon? If so, develop a hypothesis to explain why.

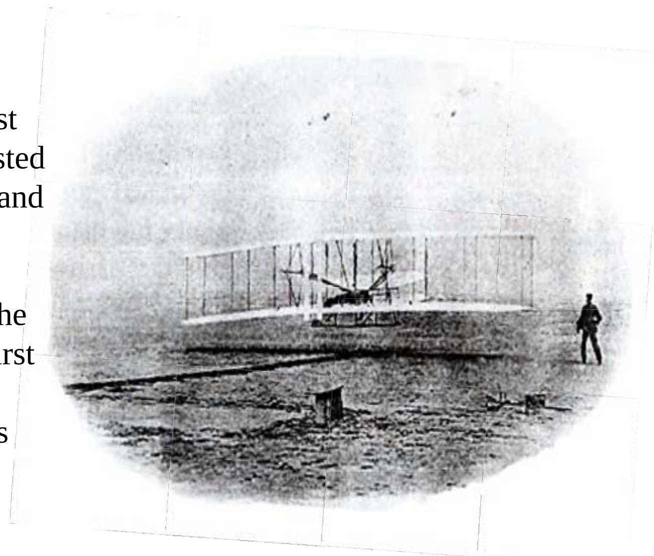
What happens when a fluid, such as air or water, moves? Consider what happens if when you hold a plastic spoon in a stream of running water? Surprisingly, the spoon is pushed toward the stream of water.

The pressure exerted by a moving stream of fluid is less than the pressure of the surrounding fluid.

The behavior of the spoon demonstrates *Bernoulli's principle.* The Swiss scientist Daniel Bernoulli found that the faster a fluid moves, the less pressure the fluid exerts.

In December of 1903, Wilbur and Orville Wright constructed the Kitty Hawk, the first airplane. Their first flight in Kitty Hawk lasted just 12 seconds. The plane flew 36 meters and made history.

What did the Wright brothers know about the flying that allowed them to construct the first airplane? And how can the principles they used explain how a jumbo jet can fly across the country?



Activity 2.17

Making your own automizer

Materials *plastic straw, scissors, glass of water*

Step 1 Cut a plastic straw part way through.

Step 2 Hold one end of a straw in a glass of water and bend the other half of the straw at a right angle at the cut.

Step 3 Blow hard through the straw. Making sure that no one is in the way!

Step 4 Show your device to your partner.
Do they know what it is and why it works?
Explain the device to them in terms of Bernoulli's principle.

Review Exercises

i. Choose the best answer to each item.

1. When two equal forces act in opposite direction on an object, they are called
(a) friction forces
(b) balanced forces
(c) centripetal forces
(d) gravitational forces

2. If the masses of two objects are the same and the velocity of object A is greater than object B, which of the following is true?
(a) the momentum of object A is greater
(b) the acceleration of object A is greater
(c) the force exerted on object is greater
(d) the pressure on object A is greater

3. Which of the following is an example of Newton's Third law of motion?
(a) A boy is cycling down hill.
(b) The moon is revolving round the Earth.
(c) A rocket is launched to space.
(d) A football hits the net.

4. Which of the following has the greater weight?
(a) A man has a mass of 60 kg.
(b) A stone weighing 120N.
. **(c)** An object moving at an average speed of 2 m/s that has 200 kgm/s of momentum.
(d) A log with the surface area of 1.5 m^2 that has 50 Pascal(Nm^{-2}) of pressure

5. Pressure can be measured in units of
(a) N.
(b) N/cm^2.
(c) N/cm.
(d) N/cm^3

6. If the buoyant force on an object in water is greater than the object's weight, the object will
(a) sink.
(b) hover beneath the surface of the water.
(c) be crushed by the water pressure.
(d) rise to the surface and float.

7. Much of the lift that enables an airplane to fly can be explained using
(a) Pascal's principle
(b) Bernoulli's principle
(c) Archemedes' principle
(d) Newton's first law

8. The density of an object can be determined by its
(a) weight and volume
(b) its mass and volume
(c) its mass and pressure
(d) its weight and force

ii. True or False

If the statement is true, write true. If the statement is false, change the underlined word or words to make the statement true.

1. If an object is in free fall, the velocity of first second is **greater** than the last second.
2. **Pressure** is the measure of the force of gravity exerted on an object.
3. *"A truck needs more fuel than a motorbike to travel the same distance."*
This statement applies to Newton's **second** law of motion.
4. Newton's second law of motion states that the force of an object is **inversely** proportional to its mass and velocity.
5.The **pressure** of an object can be determined by its mass and velocity.
6. Mass is the measure of the amount of **gravity** in it.
7. Air resistance is a kind of **fluid** friction.
8. The breaking system of a car is an example of a **hydraulic device**.
9. If the density of an object is less than that of water, it will **sink**.

iii. Checking Understanding

1. Explain how force, mass, and acceleration are related.

2. Explain why a flat sheet of paper dropped from a height of 2 meters will not accelerate at the same rate as a sheet of paper crumpled into a ball.

3. If you drop a football to the floor, it bounces up. Is a force needed to make it to bounce up? Explain.

4. You have a closed bottle of soda. The force on the bottle cap due to the carbonation of the soda is 20 N. If the area of bottle cap is 8 cm^2, what is the pressure on the cap?

5. Explain how Bernoulli's principle can keep a bird in the air.

6. How can you use the density of an object to predict whether it will float or sink?

7. What is the difference between weight and mass?

8. Two children who are fighting over a toy pull on it from opposite sides. The result is a standoff. Explain this in term of the net force.

Thinking Skills

1. Your kite rises into the air as you run quickly on a windy day. Is the air pressure greater above the kite or below it? Explain your answer.

2. You are riding fast on a bicycle when your bike suddenly hits a tree. Using the term *inertia*, explain what happens.

3. The momentum of an object moving at a constant velocity of 10m/s is 0.2 kgm/s. If the volume of the object is 50 cm^3, find the density of the object.

4. A sphere made of steel is put put in water and, surprisingly, it floats. Develop a hypothesis to explain this observation.

5. You have a gold coin. Suggest an experiment to determine if it is pure gold or not.

6. Draw a diagram in which two forces acting on an object are unbalanced and a diagram in which two balanced forces act on an object. Use an arrow to show the forces.