SENIOR THREE
SELF STUDY MATERIALS
SCIENCE PACKAGE

THE REPUBLIC OF UGANDA
Ministry of Education and Sports

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE

CHEMISTRY

ATOMIC AND MOLECULAR STRUCTURES

Learning outcome

By the end of these lessons, you should be able to:

1. Define the term chemical bonding.
2. Explain how ionic, chemical and metallic bondings occur.
3. Demonstrate the role of valence electrons in bonding.

Lesson 1: Chemical bonding

Introduction:
Of your brother or sister and a friend at school, to whom would you tell your secret? Just like you have a stronger connection with one person than another, an atom, ion or molecule either is strongly or weakly attracted to another atom, ion or molecule. This lasting force of attraction between atoms, ions or molecules which results into the formation of chemical compounds is termed as **chemical bond**. When the force of attraction is strong, the type of bond is called **ionic bond**. When the force of attraction is weak, such a bond is called a **covalent bond**. Chemical bonds are formed by sharing or loss and gain of electrons.

a) Ionic bonding:
You earlier learnt that atoms use valence shell electrons to participate in chemical bonding. Metals have valence shells with 1, 2 or 3 electrons. Non-metals have valence shells with 5, 6 or 7 electrons. When atoms of metals combine with atoms of non-metals, metals completely lose electrons while non-metals completely gain electrons. The type of bonding is called **ionic bonding.**

Activity 1.1: Demonstrating bonding with beans
Materials needed:

- Six tins labelled A, B, C, X, Y and Z
- Six different types of beans
- Pen and paper

Procedure:

1. Put beans in tins as below:

A	B	C	X	Y	Z
1	2	3	5	6	7

2. Combine beans from two tins such that the total number is 8. Ensure that when combining beans, one tin remains empty when all the beans are transferred to another tin.
3. Write down the tin combinations that make eight, holding on to the rules in step 2. For example; **BY**. Duplicate the tins to have say 3 tins labelled A, repeat this for B and C. Develop more tin combinations for example A_3X, if contents of 3 tins labelled A are added to tin X to make eight beans.

	Combinations	
	beans picked from tin	beans picked from tin
Tin	A	X
Number of beans	1	5
Number of tins	3	1
Total beans	3	5
Combination formed	A_3Y	

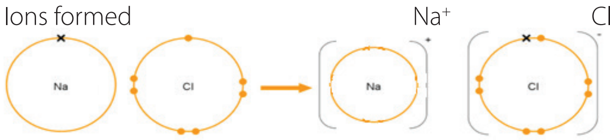
4. Redraw this table to form more 5 combinations.

Results and conclusion:

- Why should beans add up to 8 in each case?
- What do the beans in each tin represent?
- Which type of bonding has been demonstrated?

Summary:
We can now relate beans to atoms, the outermost electrons or valence electrons in atoms participate in bonding. During ionic bonding, atoms completely gain or lose electrons. An atom that loses electrons becomes positively charged while those that gain attain a negative charge. For example, the electron configuration of sodium is 2:8:1 and that of chlorine is 2:8:7, using the valence shell this can be demonstrated as:

Electron configuration of atoms 2:8:1 2:8:7
Electron configuration of ions 2:8 2:8:8
Ions formed Na^+ Cl^-



The valence shell electron in sodium is lost, leaving the shell empty while the lost electron is gained by the valence shell of chlorine to attain a maximum number of electrons on a shell.

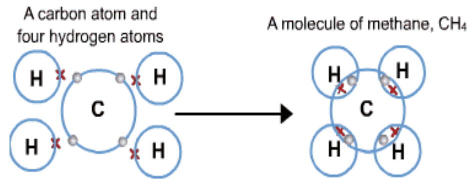
Follow-up exercise:
Aluminium has atomic number 13 while Chlorine has atomic number 17.

a) Write the electron configuration of the elements.
b) Using valence shell electrons show the formation of the compound formed.
c) Write the formula of the compound formed.
d) Which type of bond is this?

Lesson 2
b) Covalent bonding:

Sometimes atoms cannot donate or gain electrons but instead share them to attain stability. A chemical bond that involves the sharing of electron pairs between atoms is called a covalent bond, or molecular bond. The electron pairs shared between atoms are known as shared pairs or bonding pairs, and the stable balance of attractive and repulsive forces between atoms, when they share electrons, is known as **covalent bonding**. Carbon has 4 electrons in its valance shell, it neither loses nor gains electrons to maximally fill their shell but instead share their bonding electrons with other atoms.

Consider:

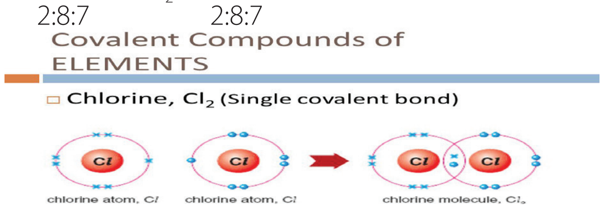


a)
b) Formation of methane (CH_4) from covalent bonding of carbon, $^{6}_{2}C$, and hydrogen, $^{1}_{1}H$.

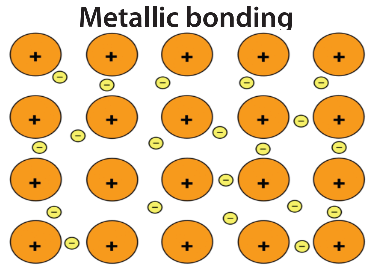
Carbon has 4 electrons in its outermost or valence shell while hydrogen has only 1. These two atoms share the valence shell electrons.

c) Formation of a chlorine molecule as two atoms of chlorine, $^{1}_{7}C$, bond with each other.

Cl + Cl $Cl_2(g)$
2:8:7 2:8:7



c) **Metallic bonding**

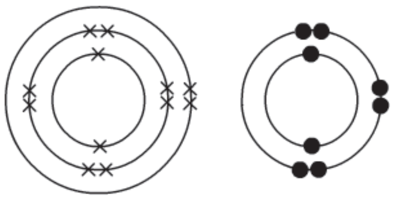


Metallic bonding is a type of chemical bonding that rises from the sharing of *free* electrons among a structure of positively charged ions (cations). For example, since sodium has one free electron on its outer most shell, eight sodium atoms share their free electrons creating a lump of sodium. Electrons in this structure are said to be delocalized. Metallic bonding accounts for many physical properties of metals, such as strength, ductility, heat and electrical conductivity, denseness, and shiny nature. Metal alloys are created through metallic bonding, for example, brass (zinc and copper) and steel (carbon and iron).

Follow –up activity

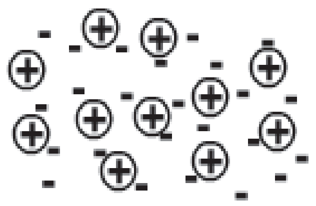
1. The diagram below shows the electron arrangements of magnesium and oxygen:

a) Draw a diagram showing how a bond is made between magnesium and oxygen.



b) What name is given to this type of chemical bond?

2. a) What type of chemical bond would you expect in hydrogen fluoride, HF?
b) Draw a diagram to show how this bond is formed.
3. Look at the diagram below**:**



a) Which type of structure is shown in the diagram?
b) Will a material with this structure be able to conduct electricity? Explain your answer.

Topic: Organic Chemistry

Lesson One:

Introduction

Organic Chemistry is a branch of chemistry dealing with compounds of carbons except oxides, carbonates, hydrogen carbonates and carbides.

Carbon has the ability to form bonds to itself. These bonds are very strong and can be single, double or triple bonds. Carbon forms four covalent bonds making it possible making it possible to have different groups attached to the chains of carbon atoms hence leading to a wide diversity of compounds being formed.

Important Terms:

1. Hydrocarbons

These are organic compounds containing hydrogen and carbon atoms only. They have a general molecular formula C_xH_y where x and y are the whole numbers. The main classes of hydrocarbons are alkanes, alkenes, and alkynes.

2. Homologous series

This is a group of organic compounds of similar structure which possess the same functional group and each member differs from the next by $–CH_2$ group.

Characteristics of a homologous series:

(i) members conform to the same general mol formula

(ii) each member differs in molecular formula from the next by a CH_2 group

(iii) members show similar chemical reactions but vary in vigour

(iv) The physical properties of members change gradually in the same direction along the series.

ALKANES

Alkanes are hydrocarbons with the general molecular formula, C_nH_{2n+2} where n≥1.Their names end with the suffix –ane.

Examples, Methane in which n=1, so its formula is $C_1H_{(2X1)+2}$ hence CH_4.

Ethane in which n=2, so its formula is $C_2H_{(2X2)+2}$ hence C_2H_6

Activity This table gives the first six members of alkanes. Fill in the gaps

Number of carbon atoms	Name of alkane	Molecular formula
1	Methane	
2	Ethane	
3	Propane	
4	Butane	
5	Pentane	
6	Hexane	

Structural formula

This shows the sequence and arrangement of atoms in a molecule.

For example, the molecular formula of propane is C_3H_8. The structural formula of Propane is; -C-C-C OR $CH_3CH_2CH_3$

Activity

Write the molecular and structural formula for each of the following alkanes;

a. Hexane
b. Butane
c. Pentane

Alkanes are saturated hydrocarbons i.e. all the atoms exert their usual combining power with other atoms and have only single covalent bonds.

Lesson two: General properties of Alkanes

Introduction

Physical properties

1. The first four members are gases, the next twelve members are liquids and the rest are waxy solids at room temperature.
2. They are insoluble in water but soluble in organic solvents.
3. They are less dense than water.

Chemical properties

1. Alkanes burn in oxygen forming carbon dioxide

e.g $CH_4(g) + 2O_2(g)$ $CO_2(g) + 2H_2O(g)$

In a limited supply of oxygen, carbon monoxide is formed.

$2CH_4(g) + 3O_2(g)$ $2CO_2(g) + 4H_2O(g)$

During combustion, a lot of heat is liberated hence alkanes are used as fuels for industrial and domestic purposes, for example:

- Butane is used in gas cigarette lighters
- Methane is found in natural gas and bio gas and is used in gas appliances.
- Butane found in petrol is used to run petrol engines.

ISOMERISM

This is the occurrence of two or more compounds with the same molecular formula but different structural formulae.
All alkanes with more than four carbon atoms have more than one structural for a given molecular formula i.e exhibit isomerism.
The easiest way of finding isomers is to draw the longest chain of carbon atoms first and then reduce it by one carbon atom at a time.

Activity 3

Write the structural formulae and names of possible isomers of compounds with the given molecular formulae

i) C_4H_{10}
ii) C_5H_{12}

Lesson four: Preparation of alkanes

There are mainly three ways of preparing alkanes i.e

a. Fractional distillation of crude oil or petroleum
Petroleum is a mixture of hydrocarbons with differing chain lengths. It was formed from the

remains of plants and animals which lived millions of years ago and decomposed.
Fractional distillation of petroleum gives various fractions or products.

Activity

1. Use the internet or chemistry text books to research and write the uses of the various fractions obtained after fractional distillation of petroleum. Present your work in a table.

Fraction	Uses
1.Gas (propane and butane)	
2.Petrol	
3.Paraffin	
4.Gas oil	
5.Diesel oil	
6.Lubricating oil	
7.Waxes and bitumen	

1. *Cracking*

Due to the increasing demand for petrol worldwide, it has become necessary to devise a new process of obtaining it i.e by cracking of gas oil.

Cracking is the process of breaking down the long chain hydrocarbons into shorter chain molecules by using heat or a catalyst.

2. Bio-gas

Under anaerobic conditions, bacteria feed on waste organic products for example animal wastes, human wastes and make them decompose. One of the products formed from this decay is methane gas which is a component of bio-gas.

Methane is an alkane and is used as a fuel for cooking and lighting purposes.

Activity

With reference to the internet and chemistry text books,

a. Describe how bio-gas can be obtained from cow dung
b. Mention any three advantages of bio-gas production
c. Give the disadvantages of bio-gas production

Lesson Five: ALKENES

These are members of a homologous series of a general molecular formula

C_nH_{2n} where n≥2.They have a carbon-carbon double bond as their functional group. They are unsaturated compounds-some atoms do not exert all their combining powers with other atoms.

Examples: Ethene, Propene, Butene

Task 5.1……Using the general molecular formula for alkenes, write the molecular formulae for the first three alkenes.

Alkenes are named by dropping the suffix –ane of the corresponding alkanes and replacing it with the suffix –ene.

Lesson six: Preparation of alkenes

Ethene gas can be prepared by the dehydration of ethanol by concentrated sulphuric acid at 180°C

CH_3CH_2OH (l)

conc.H_2SO_4

$CH_2{=}CH_2(g) + H_2O(g)$

Properties of Ethene

I. It is a colourless, sweet smelling and non-poisonous gas.
II. It is slightly less dense than air.
III. It is insoluble in water but soluble in organic solvents.
IV. Ethene burns in plenty of oxygen to give carbon dioxide and steam.

$C_2H_4(g) + 3O_2(g)$

$2CO_2(g) + 2H_2O(g)$

Because alkenes burn with a sooty flame, they are not suitable as fuels.

Activity 6

Linda carried out some tests on ethane gas and below are her results;

Test	Observation
-appearance	Colourless gas
-smell	No smell
-a lighted splint is applied to the neck of the gas jar of ethene	Gas burns with a sooty flame and condensation forms at the top of the gas jar.
-chlorine water is added to a gas jar of ethene gas	Chlorine water instantly changes from pale yellow to colourless.
-acidified potassium manganate (vii) is added to the gas jar of ethene.	The potassium manganate (vii) solution changes from purple to colourless.

i. What is the colour and smell of ethene gas?
ii. What kind of flame does ethene burn with?
iii. What forms at the neck of the gas jar?
iv. What is observed when chlorine water is shaken with ethene gas?
v. What is observed when ethene is shaken with acidified potassium manganate (vii) solution?

PHYSICS

Chapter: Motion

Lesson 1

Competence:

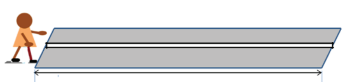
By the end of this lesson, you should be able to apply the relationship between speed, distance, and time

Introduction

Motion occurs in many aspects of life. When an object changes its position, it is said to have moved. When this happens, distance and time change. There are some natural phenomena which cause destruction as a result of motion, for example earthquakes and erupting volcanoes. These experiences help us understand motion. In this chapter, you will study the relationship between distance and time, and use it to calculate speed and acceleration and explain their implications.

Speed, distance and time.

Jane is to walk 500m in five minutes as shown in the illustration below. How many metres does she cover in one minute? Explain how you arrived at the answer. The answer you obtain is how fast Jane moves. Suggest also the units of your answer.



500m

How fast should she walk if she is to cover this distance in 10 minutes?

Suggest a term for your answer and state its SI unit.

Convert your answer to:

i. km/h

ii. m/s

Activity 1.0

Question: At what speed will you walk round the house?

What you need:

- Tape measure or meter rule or calibrated stick
- Watch/Stop watch/clock

In case you cannot get a tape measure or meter rule, ask an adult at home to count the number of paces round the house.

Did you know that the stride/pace of a normal adult is about 1 m

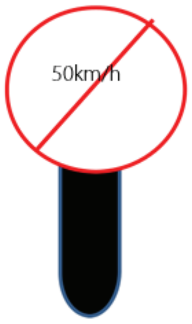
Procedure:

1. Measure the distance round the house.
2. Walk round the house and using a clock/watch to note the time it will take you to go round the house.
3. Determine your speed.
4. Repeat this activity while walking faster, and then running.
5. Compare the three results. What do you conclude?

Application

1. Cars and motorcycles are fitted with speedometers so that the driver/cyclist is able to know at what speed they are moving. Why is it necessary for the driver/cyclist to know their speed?

2. Have you seen such a road sign? What is its importance?



Summary:

- Jane's speed was the distance she moved every unit time
- The smaller the value of speed, the slower Jane was and vice versa.

Lesson 2

Competence:

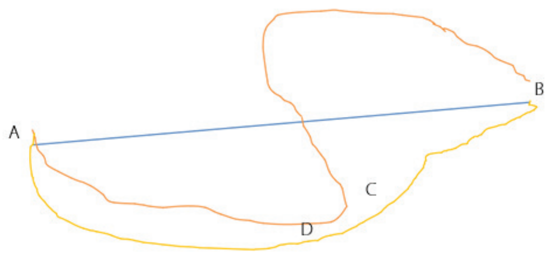
By the end of this lesson, you should be able to explain the terms displacement, velocity and acceleration.

Demonstrating displacement, velocity and acceleration

What is the difference between the following statements?

α. Jane moved 500m
β. Jane moved 500m in the southern direction

Activity 2.0



1. If Hope drives a car along the road from town A to B through C, which is 300 km away, the journey will take 5 hours.

At what rate does she cover this distance?

Suggest the term that represents the rate at which this journey is covered.

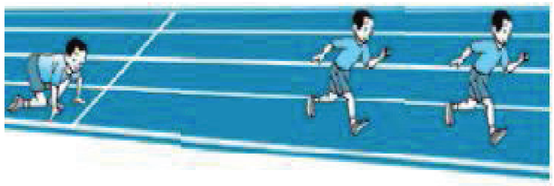
2. If she drives due east from town A to B it will be a distance of I00 km in half an hour. At what rate does she cover this distance?

Suggest the term that represents the rate at which this journey is covered.

Summary:

- **Displacement** is distance moved in a specified direction.
- The magnitudes of other paths, ACB and ADB, are known as the **distances** travelled from A to B because the direction is not specific.
- Rate of change of displacement is called **velocity**.
- Rate of change of distance is called **speed**.

Demonstrating acceleration

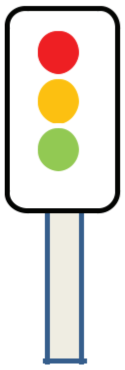


You are among a group of friends that are planning a competition in a relays game at the village football pitch. During the game, you realize that some are gaining distance ahead of the others.

- Explain why some are gaining distance ahead of the others.

- How did you arrive at the answer?

Exercise:



1. When traffic lights turn green, cars begin to move. What is happening to the velocity of the cars? Explain your answer.

2. When the light turns red, the cars gradually stop. What happens to the velocity of the cars? Explain your answer.

Summary:

When a driver steps on the accelerator, the car moves faster. In other words, its velocity increases with time. This is called **Acceleration**.

- When a driver steps on the brake, the car slows down. In other words, its velocity reduces over time. This is called **Deceleration**.

- Acceleration is defined as the change of velocity per unit time. Its unit is the meter per second per second (m/s^2).

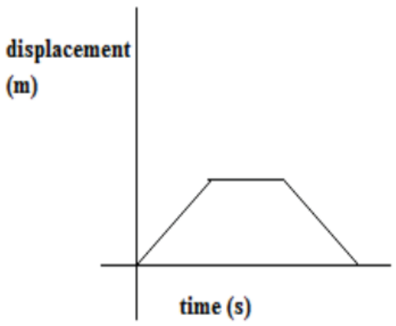
Acceleration = <u>Change of velocity</u>

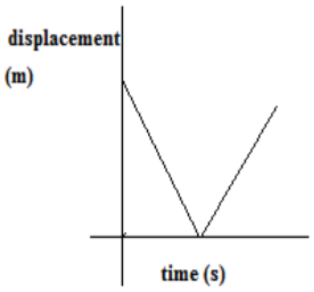
Time taken

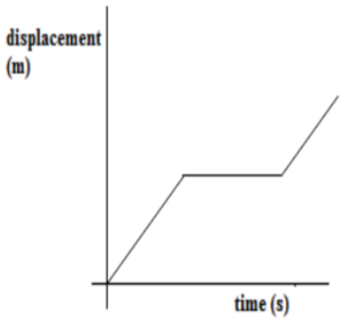
Interpreting motion graphs:

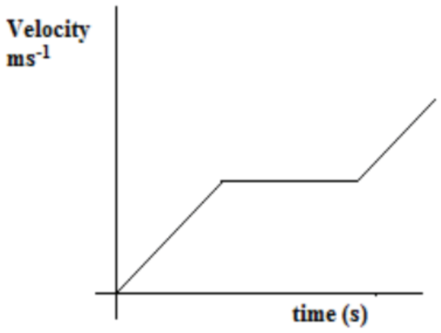
Activity

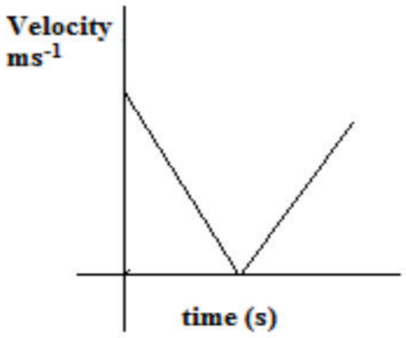
Apply your understanding of displacement and velocity to explain and demonstrate the motion indicated.







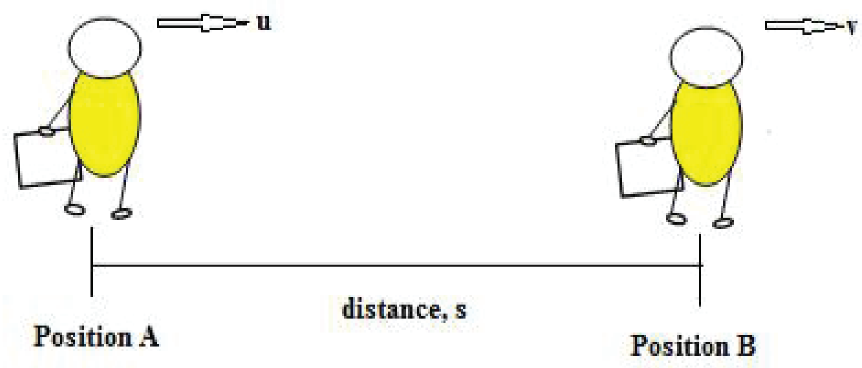




Lesson 3

Competence:

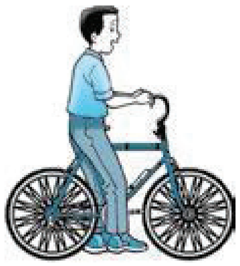
By the end of this lesson, you should be able to use equations of motion.



The illustration above shows John's initial velocity at position A as u, which increases steadily to a final velocity, v, at position B in a time t.

Activity 4:

1. Represent this information on a velocity-time graph and use it to get an expression for acceleration. This will give you the first equation of motion. Make v the subject of this formula.
2. From a constant velocity of 40 m s–1, the velocity of a bus increases to 90 m s–1 in 5 s. The acceleration of the bus is 10ms-1. Explain to your grandmother, what this value of acceleration means in terms of the movement of the bus.
3. Aziz cycles at a uniform speed of 20 m s–1. He then stops pedaling and his bicycle comes to a stop after 8 s. What is his average deceleration?



The second and third equations of motion:

Using the expression: average velocity =

$$= \frac{\text{displacement}}{\text{time taken}}$$

$$\frac{s}{t} = \frac{v+u}{2}$$

Using the 1st equation of motion you obtained earlier, substitute for v and make the subject of the formula. The expression you obtain is the second equation of motion.

Use the 1st and 2nd equations of motion you obtained to eliminate t. The expression you get is the 3rd equation of motion.

Exercise:

1. Starting from rest, Kiprotich reaches his maximum velocity in 3 seconds. He runs a distance of 24m in the 3 seconds. What is his acceleration?
2. By applying the brakes, a driver reduces the velocity of his car from 20m s^{-1} to 10m s^{-1} after a distance of 30m. Calculate the deceleration of the car.
3. Dan is riding his motorcycle at a velocity of 10m s^{-1} when he sees a cow ahead. He brakes the motorcycle and it stops.
4. If the deceleration of the motorcycle is 2m s^{-2}, what is the distance the motorcycle covers before it comes to rest?
5. If the cow was 30m ahead, did Dan miss it?
6. Briefly advise cyclists on how to avoid accidents.

Summary:

The equations of motion are:

v = u + at.................... 1st equation of motion

= ut + 1/2at2...............2st equation of motion

v2 =u2 + 2as.................. 3rd equation of motion where

u is the initial velocity, v is the final velocity, t is time, a is acceleration and S is the distance covered.

Lesson 4

Competence:

By the end of this lesson, you should be able to demonstrate, explain, and apply linear momentum.

Activity 1

You are training as a goalkeeper of your village football team. Your coach throws two balls for you to catch, one at a time.

Ball 1: Mass 0.5 kg at a velocity of 10 ms^{-1}

Ball 2: Mass 0.5 kg at a velocity of 30 ms^{-1}

If he threw the two balls with the same strength, which of the two balls would you prefer to catch and why?

Activity 2

The following day he throws two balls with the same strength as follows:

Ball 1: Mass 0.5 kg at a velocity of 10 ms^{-1}

Ball 2: Mass 1.0 kg at a velocity of 10 ms^{-1}

If he threw two balls with the same strength, which of them would you prefer to catch and why?

Summary:

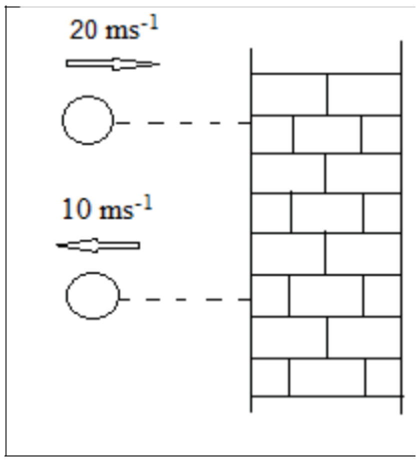
The moving balls produce an effect on your hands which are there to stop the motion of the ball. This effect is due to the **momentum** of the moving ball. Momentum depends on mass and velocity of an object.

Momentum = mass x velocity

Derive the unit of momentum.

Exercise:

1.



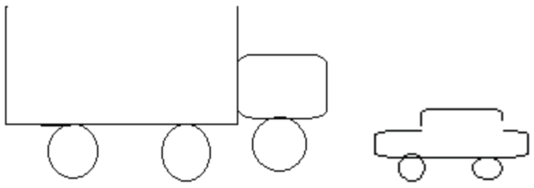
A ball of mass 1.0 kg strikes a wall at a velocity of 20m s^{-1} and rebounds at 10 m s^{-1}.

What is its momentum:

i. before it strikes the wall, and

ii. after the rebound?

2. A lorry loaded with matoke and a saloon car are moving at the same speed. The two have to stop at a police check point. Which of the two will be easier to stop? Explain your answer.



Conservation of linear momentum

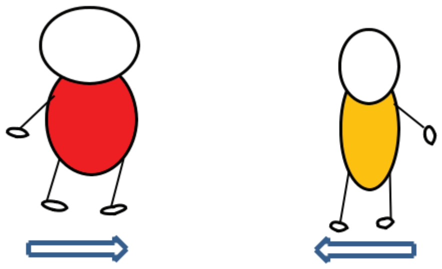
Activity

1. What does it mean to 'conserve'?

2. What is conservation of linear momentum?

Example

You see a friend you have not seen in a long time. The two of you run towards each other with open arms. When you meet, you hug each other for two minutes as you exchange greetings and slowly fall on the side of your friend because he is lighter than you are. If your mass is 60kg and your friend's mass is 45kg, find the velocity with which the two of you will gradually fall to the ground.



V = 5ms^{-1} V = 7 ms $^{-1}$

Conservation of linear momentum occurs when the total momentum of the objects **before a collision equals** that **after the collision.**

Your momentum before collision = 60 x 5

= 300ms^{-1}

Your friend's momentum before collision = 45 x -7

= -315 kgms^{-1}…….. (1)

What does the negative sign mean?

Total momentum before collision = 300 - 315

= -15 kgms^{-1}

Total momentum after collision = (60 + 45)v

=105v….. (2)

If momentum is conserved, (1) = (2)

-15 = 105v

v = -0.14 ms^{-1}; where v is your common velocity.

Question: Why is your common velocity negative?

Exercise

1. A trolley of mass 3kg moving at a velocity of 2m s^{-1} collides with another trolley of mass 0.5kg which is moving at a velocity of 1m s^{-1} in the same direction. If the 0.5kg trolley moves at a velocity of 2.5m s^{-1} in the same direction after the collision, what is the velocity of the 3kg trolley?
2. A butterfly rests on a leaf floating on the surface of a pond. The butterfly then starts moving to the tip of the leaf at a speed of 5cm s^{-1} while the leaf moves at 3cm s^{-1} in the opposite direction. If the mass of the leaf is 8g, determine the mass of the butterfly.
3. In the Bible, 1Kings 17: 49, David, a small man, was able to kill Goliath, a giant using a small stone! Discuss with a friend, how possible this could have been.

Lesson 5

Competence:

By the end of the lesson, you should be able to demonstrate and apply Newton's laws of motion.

Newton's 1st law of motion

Activity :Demonstrating Newton's 1st law of motion

What you need:

- A coin
- A beaker
- A smooth cardboard (you can also fold a piece of paper)

Procedure:

1. Place a coin on a smooth cardboard and place it over a cup.

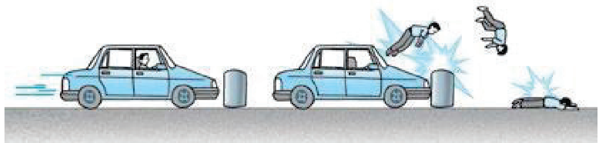
2. Push the card slowly and observe what happens to the coin.
3. Repeat the activity, but this time push the card away suddenly. Observe what happens to the coin.

4. Why does the coin behave differently in these steps?

Exercise:

Explain each of the following:

1. A passenger sways backwards when a car initially at rest suddenly starts moving forward.
2. When a bus is moving very fast and suddenly negotiates a corner in one direction, the passengers sway to the opposite direction.
3. If the brakes of the fast moving car are applied suddenly, the passengers jerk forward. This can result into a fatal accident as shown below.
4. Suggest how a passenger's safety in the above cases can be ensured.



Summary:

Newton's first law of motion-the law of inertia: A body continues in its state of rest or uniform motion in a straight line unless compelled by some external force to act otherwise.

Lesson 6

Newton's 2st law of motion

Activity1

Two cars, A and B are labeled at their rear as follow:

A: 1500 cc

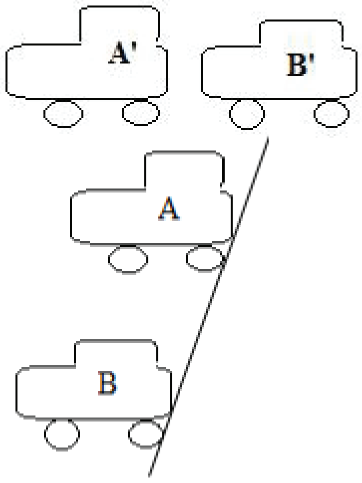
B: 3000 cc

What do these labels mean? You can ask someone who is knowledgeable about cars at home or in the neighborhood.

Activity 2

The figure below shows two cars: *A* and *B* of the same mass at the same starting line. The engine capacity of sports car A is much bigger than car B.

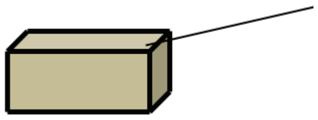
A' and B' shows their new positions after 3 seconds. Explain why this is possible.



You can also try out this activity by using an empty box, a few masses (e.g. books) and a string.

Procedure:

Tie the string to the box and put some masses in the box.



i. Hold the string and drag the box with a big effort in 1 minute. Note the distance the box covered.

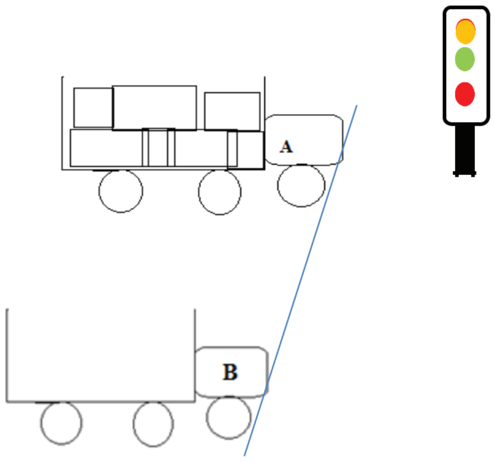
ii. Using a less effort, drag the box in 1 minute and note the distance the box covered. Try to move in a straight line in both cases.

Using activity 1 and 2, draw a conclusion on the relationship between the force applied to the mass and its acceleration.

Activity 3

The figure below shows two similar lorries, A (loaded) and B(not loaded) in front of a traffic light. When the light turns green, both drivers step on the accelerator at the same time with the same effort.

Three seconds later, Lorry B is ahead of A.



Explain why this is possible.

Using activity 3, draw a conclusion on the relationship between the mass and the acceleration on the mass.

Summary

The acceleration of an object is **directly proportional** to the force applied if the mass is constant (a ∝ F).

The acceleration of an object is **inversely proportional** to its mass when the force acting on it is constant (a∝ 1/F).

Task: Using the two relationships above, establish a relationship between force, mass and acceleration.

Summary

The net force F_{net} = *ma* is the mathematical expression of Newton's second law of motion.

Activity

Recall: The first equation of motion is: v = u + at

Using the 1st equation of motion, substitute for a in F = ma

Exercise

Okello pushes a 15kg box with a force of 60N. If the floor is frictionless, find the acceleration with which the box moves.

A car of mass 1200kg is moving at an acceleration of 2m s^{-2}. If the frictional force acting on the car is 750N, find

its engine thrust.

Lesson 7

Newton's third law of motion

Explain how a boat is able to move forward (or backwards) on water.

The picture shows a squid. Do some research and find out how it is able to propel itself in water.

Explain how your chair in your classroom, or at home is able to sustain your weight without collapsing.

Explain what happens when the air in an inflated balloon is released.

Summary:

When a body exerts a force on another body, the other body exerts an equal but opposite force on the first body.

This is sometimes stated as: to every action there is an equal and opposite reaction.

Exercise:

Discuss and make short notes on other real life situations where action and reaction apply.

Lesson 8

Competence:

By the end of this lesson, you should be able to differentiate between vector and scalar quantities.

Activity 1

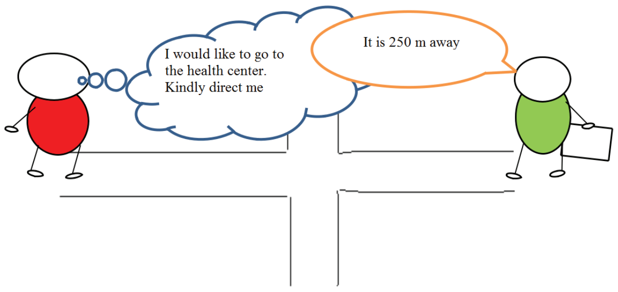
Consider the following statements:

i. Our home is 35km from the trading center.
ii. Our home is 35km east of the trading center.

What is the difference between these two statements?

Activity 2

Will Jose be able to reach the health center using Ali's help? Explain your answer.



Help Jose reach the health center!

Using the above two activities, define:

i. A scalar quantity

ii. A vector quantity

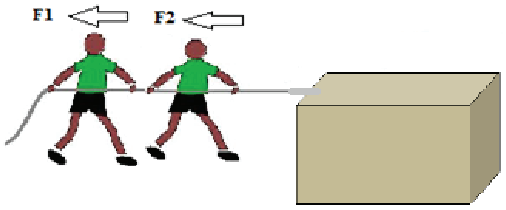
Give three examples of each.

Addition of scalar quantities

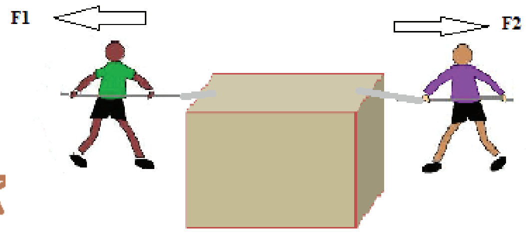
Town B is 50km is away town A while town C is 52km from town B. How far is town C from town A?

Addition of vector quantities:

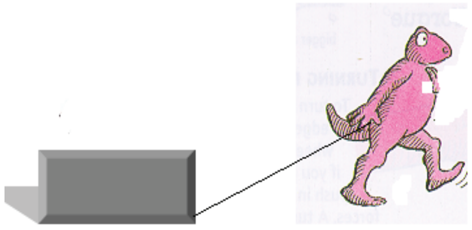
1. What is the total force F, with which the load is being pulled? In which direction does the load move?



2. Find the resultant force F, with which the box is being moved. Suggest the direction of its motion.



3. If Quinci pulls the concrete slab with a force of 85N at an angle of 45° to the horizontal, find the vertical and horizontal components of this force.



BIOLOGY

BIOLOGY SELF-STUDY MATERIALS

Senior Three

Topic: Gaseous Exchange

By the end of this topic, you should be able to demonstrate the mechanism of breathing.

Introduction

Breathing involves two actions; breathing in (inhalation) and breathing out (exhalation) of air.

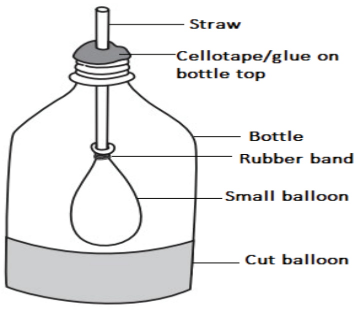
Activity: Demonstrating breathing

In the following activity, you are going to make a model and use it to demonstrate breathing in the human respiratory system.

Things you will need: 2 balloons (one small and one large), straw, empty plastic bottle, rubber band/ string.

Set up of the experiment

i) Measure 7 cm from the bottom of the water bottle and cut it off.
ii) Insert a straw of length 5 cm into the open end of the small balloon.
iii) Tie the balloon onto the straw using a rubber band. Make sure not to squeeze/ block the straw.
iv) Pierce a hole - the size of the straw - on the bottle top (cover of the bottle).
v) Insert the remaining open end of the straw through the hole at the bottle cap. Glue / cellotape the straw to make it firm on the cap.
vi) Cut the larger balloon in half. Keep the bottom half.
vii) Attach the bottom half of the larger balloon firmly around the cut end of the bottle.



Procedure

Part A

1. What do the following represent?
   i) Balloon in the bottle
   ii) Straw
   iii) Bottle
   iv) Piece of balloon at the bottom of the bottle
2. Pull the larger balloon at the bottom downwards.
   i) What does this action represent in the human respiratory system?
   ii) Why should the bottom of the balloon be pulled?
   iii) State what you have observed.
   iv) Explain your observation.
   v) What is the equivalent of this action in breathing process?
3. Now release the balloon to return to original position.
   i) What is this action equivalent to?
   ii) What do you notice?
   iii) Give reasons for your observation.
4. What is the scientific principle behind the breathing action?

Part B

1. Fill your mouth with water.
2. Push the water from your mouth into the small balloon through the straw.
3. Pull the larger balloon at the bottom downwards and then release it back to its position.
4. What do you observe?
5. Give reasons for your observation.

Follow-up activity

Corona virus causes accumulation of fluid in the human lungs. Patients suffering from Corona virus disease – 19 (COVID-19) have difficulty in breathing. How do you explain this?

MATHEMATICS

Class: SENIOR THREE

Mathematics

Topic: Position Vectors

Lesson 1

Learning outcome

By the end of this lesson, you should be able to describe two things:

i) A position vector as a column vector.

ii) To represent the position vector on a graph.

Materials needed:

Graph papers, a ruler and a pencil.

Introduction

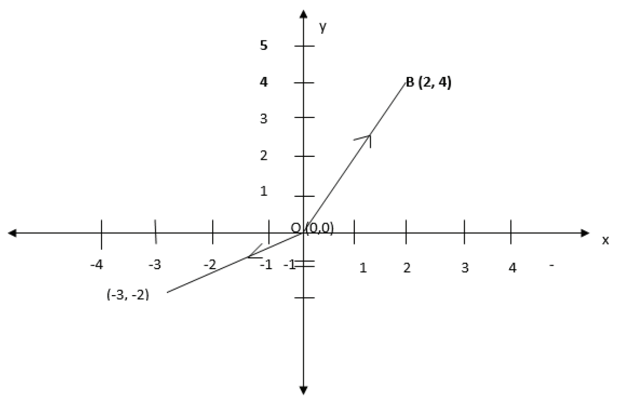
In S2, you looked at vectors and how they are represented as column vectors, with letters and also on a graph (geometrically). You also handled operations on vectors such as addition, subtraction and multiplying a vector with a scalar. The length or magnitude of vectors was also shown you.

Position vectors are also represented as column vectors, with letters and geometrically. A vector has both magnitude and direction. A position vector shows the position of a point from the origin. The position vectors are represented with letters such as ***OP, OA, OD*, *p, a, d*** or as column vectors such as

$$\begin{pmatrix}4\\3\end{pmatrix}\begin{pmatrix}4\\3\end{pmatrix}, \begin{pmatrix}7\\-2\end{pmatrix}\begin{pmatrix}7\\-2\end{pmatrix}, \begin{pmatrix}-8\\5\end{pmatrix}\begin{pmatrix}-8\\5\end{pmatrix}$$

Instructions

We are going to plot points on the x and y axes and write down their position vectors.



The coordinates of the origin O are (0, 0).

The position vector of point B (2, 4) is the column vector ***OB.***

X -coordinates: 2 strides to the right = +2

Y-coordinates: 4 strides upwards =+4

$$\boldsymbol{OB} = \begin{pmatrix}2\\4\end{pmatrix}\boldsymbol{OB} = \begin{pmatrix}2\\4\end{pmatrix}$$

The position vector of point *C* (-3, 1) is the column vector of ***OC.***

X-coordinate is 3 strides to the left = -3
Y-coordinate is 1 stride upwards = 1

$$\boldsymbol{OC} = \begin{pmatrix}-3\\1\end{pmatrix}\boldsymbol{OC} = \begin{pmatrix}-3\\1\end{pmatrix}$$

The position vector of any point *P*(x, y), is written

as ***OP*** with O as the origin (0, 0) and $\boldsymbol{OP} = \begin{pmatrix}x\\y\end{pmatrix}$

$$\boldsymbol{OP} = \begin{pmatrix}x\\y\end{pmatrix}$$

ACTIVITY

1. Using the x- and y-axes on a squared paper,
   a) Show the position vectors of the following points *D* (4, 6), *E* (-2, 5), *F* (1,-3).
   b) Write down the position vectors ***OD, OE, OF*** as column vectors, where O is the origin.

2. Write down the coordinates of the points whose position vectors are:

$$\boldsymbol{OM} = \begin{pmatrix}4\\-3\end{pmatrix}\boldsymbol{OM} = \begin{pmatrix}4\\-3\end{pmatrix}, \boldsymbol{ON} = \begin{pmatrix}-7\\-8\end{pmatrix}$$

$$\boldsymbol{ON} = \begin{pmatrix}-7\\-8\end{pmatrix}, \boldsymbol{OT} = \begin{pmatrix}-6\\11\end{pmatrix}\ \boldsymbol{OT} = \begin{pmatrix}-6\\11\end{pmatrix}$$

Lesson 2

Learning outcome

By the end of this lesson you, should be able to write a column vector of a vector when the position vectors of the end points of the vector are provided to you.

Materials you will need

- Graph paper or squared paper
- Ruler
- pencil

Introduction:

In the last lesson, we wrote position vectors of points as ***OP***, ***OA*** and in vector form

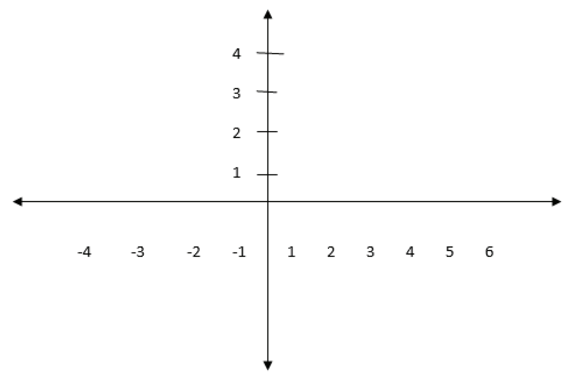
$$\begin{pmatrix}2\\-5\end{pmatrix}\begin{pmatrix}2\\-5\end{pmatrix}, \begin{pmatrix}7\\8\end{pmatrix}, \begin{pmatrix}7\\8\end{pmatrix}.$$

We also represented them on graphs.

We are now going to obtain column vectors of any given vectors using the position vectors of the end points of the vector. In senior two, you handled combination of vectors such as ***AB*** +***BC***= ***AC.*** This idea will also enable us to find the column vector.

Instructions

The graph below shows us the vector **ST** and the position vectors **OS** and **OT** of points **S** and **T** respectively.



Using addition (combination) of vectors

OT = ***OS*** + ***ST***
ST = ***OT***–***OS***
From the graph:

$$\boldsymbol{OT} = \begin{pmatrix}-4\\5\end{pmatrix}\boldsymbol{OT} = \begin{pmatrix}-4\\5\end{pmatrix}$$

And

$$\boldsymbol{OS} = \begin{pmatrix}4\\1\end{pmatrix}\boldsymbol{OS} = \begin{pmatrix}4\\1\end{pmatrix}$$

$$\boldsymbol{ST} = \begin{pmatrix}-4\\5\end{pmatrix} - \begin{pmatrix}4\\15\end{pmatrix}\boldsymbol{ST} = \begin{pmatrix}-4\\5\end{pmatrix} - \begin{pmatrix}4\\15\end{pmatrix}$$

$$\boldsymbol{ST} = \begin{pmatrix}-4-4\\5-1\end{pmatrix} = \begin{pmatrix}-8\\4\end{pmatrix}$$

$$\boldsymbol{ST} = \begin{pmatrix}-4-4\\5-1\end{pmatrix} = \begin{pmatrix}-8\\4\end{pmatrix}$$

Writing the vector ***ST*** directly from the graph

X-Coordinates- 8 strides to left = -8
Y – coordinates- 4 strides upward =4

$$\boldsymbol{ST} = \begin{pmatrix}-8\\4\end{pmatrix}\boldsymbol{ST} = \begin{pmatrix}-8\\4\end{pmatrix}.$$

This agrees with the method of using position vectors.

Therefore, the column vector of any vector is obtained by subtracting the position vector of the starting point form the position vector of the end point.

Also without using the axes, we obtain the column vector of a vector given the coordinates of the end points. Given two points A (-3, -2) and B (4, 2) to obtain the column vector ***AB.***

We first write the position vectors of the end points

A and *B* as $\boldsymbol{OA} = \begin{pmatrix}-3\\-2\end{pmatrix}\boldsymbol{OA} = \begin{pmatrix}-3\\-2\end{pmatrix}$, $\boldsymbol{OB} = \begin{pmatrix}4\\2\end{pmatrix}$

$$\boldsymbol{OB} = \begin{pmatrix}4\\2\end{pmatrix}$$

Also ***AB= OB – OA***

$$AB = \binom{4}{2} - \binom{-3}{-2}$$

$$AB = \binom{4}{2} - \binom{-3}{-2}$$

$$AB = \binom{4 - {}^{-}3}{2 - {}^{-}2} = \binom{7}{4}$$

$$AB = \binom{4 - {}^{-}3}{2 - {}^{-}2} = \binom{7}{4}$$

ACTIVITY

1) On a graph with x and y axes
   a) Plot the points V (3,-2) and W (-1, 4).
   b) Show the column vector of ***DE***
   c) Draw the combination of position vectors that make up the vector ***DE***
   d) Write the column vector for ***DE***.

2. Point R has position vector $\binom{5}{3}\binom{5}{3}$, vector **RQ**= $\binom{7}{4}\binom{7}{4}$

Write the position vector of Q.

Lesson 3

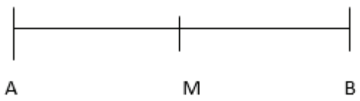
Learning outcome

By the end of this lesson, you should be able to write the position vector of the mid-point of a line segment.

Materials you will need:

1) Graph paper or squared paper
2) Ruler
3) Pencil
4) **Introduction**

A line segment has a mid-point. This is a point found halfway the line segment. A line segment AB, has two end points A and B.



M is the mid-point of the line segment AB.

The position vector of the mid-point M, is found by using the position vectors of end points A and B.

Instructions

On a graph with x and y axes, have **a drawn line segme**nt CD and you are going to find the position vector of M the mid-point of CD.

OM = OC + CM

But **CM = ½ CD**

CD = OD - OC (In the last lesson, we looked at this with end points)

OM = OC + ½ (OD – OC)

= OC + ½OD - ½ OC

OM = OC - ½ OC + ½ OD

OM = ½ OC + ½ OD

The position vector of a mid-point of a line segment is got by adding ½ of the position vectors of the end points of the line segment.

OC = $\binom{-2}{3}\binom{-2}{3}$, **OD**= $\binom{4}{-1}\binom{4}{-1}$,

OM = $\frac{1}{2}\binom{-2}{3}\binom{-2}{3} + \frac{1}{2}\binom{4}{-1}\binom{4}{-1}$

Multiplying a scalar by a vector

$$= \begin{pmatrix} \frac{1}{2} \times -2 \\ \frac{1}{2} \times 3 \end{pmatrix} + \begin{pmatrix} \frac{1}{2} \times 4 \\ \frac{1}{2} \times -1 \end{pmatrix}$$

$$= \begin{pmatrix} -1 \\ \frac{3}{5} \end{pmatrix} + \begin{pmatrix} 2 \\ -\frac{1}{2} \end{pmatrix}$$

$$= \begin{pmatrix} -1 + 2 \\ \frac{3}{2} + -\frac{1}{2} \end{pmatrix}$$

$$= \begin{pmatrix} 1 \\ \frac{2}{2} \end{pmatrix}, \quad = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

I can also use only the coordinates of C and D to obtain the position vector of M.

Start with getting the coordinates of the midpoint M. Using C (-2, 3) and D (4, -1).

x- Coordinators of M is = m -2+4 / 2 = 2/2 = 1

Y-coordinators of M is = 3+-1 /2 =2/2 = 1

M (1, 1).

Position vectors **OM** = $\binom{1}{1}\binom{1}{1}$,

ACTIVITY

1. On a graph paper draw the x and y axes between -6 and 6. Plot the points F (-4, -2) and G (4, 6) and join the line segments. Mark at point H as the mid-points of F and G.
   a) Use the position vectors of F and G, on the graph to obtain OH where O is the origin.
   b) Use the position vectors of F and G, without using the graph to obtain **OH.**
   c) Use only the coordinates of F and G, without using the graph to obtain **OH.**
2. The position vector of the midpoint of two points P (-5, -4) and Q (x, y) is (3, -2) obtain the values of x and y coordinates of point Q.

LESSON 4:

Learning outcome

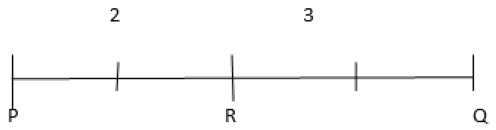
By the end of this lesson, you should be able to use the vectors to widen a line in a given ratio.

INTRODUCTION

A line segment is divided into a given proportion or ratio. Vectors are used to help in dividing any line in a given proportion or ratio.

INSTRUCTIONS

Draw a line segment **PQ.** Divide the line segment in a ratio 2:3.

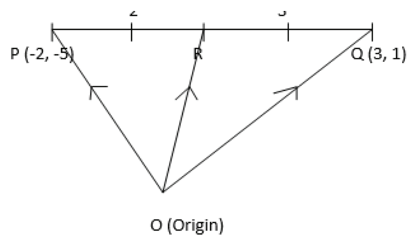


In the ratio 2:3, there is 2+3 portion, so 4 divide the line PQ into 5 equal proportions

Length **PR**= 2/5 **PQ** also **RQ**= 3/5 **PQ**

PQ= PR + RQ

Using position vectors



PR = $\frac{22}{55}$**PQ**

Also

RQ = $\frac{33}{55}$**PQ**

OR=**OP** +**PR**

But **PR** = $\frac{22}{55}$-**PQ**

And **PQ**=**OR**-**OP**

PR= $\frac{22}{55}$ (**OQ**-**OP**) = $\frac{22}{55}$**OQ**-$\frac{2}{5}\frac{2}{5}$**OP**

OR=**OP** + $\frac{22}{55}$**OQ** $\frac{22}{55}$**OQ**

OR= $\frac{33}{55}$**OP**+ $\frac{22}{55}$**OQ**

But OP = $\binom{-2}{1}\binom{-2}{1}$ and **OQ** = $\binom{3}{1}\binom{3}{1}$

OR = $\frac{3}{5}\binom{-2}{1}\frac{3}{5}\binom{-2}{1} + \frac{2}{5}\binom{3}{1}\frac{2}{5}\binom{3}{1}$

$$\textbf{OR} = \begin{pmatrix} \frac{3}{5} \times -2 \\ \frac{3}{5} \times 1 \end{pmatrix}\begin{pmatrix} \frac{3}{5} \times -2 \\ \frac{3}{5} \times 1 \end{pmatrix} + \begin{pmatrix} \frac{2}{5} \times 3 \\ \frac{2}{5} \times 1 \end{pmatrix}\begin{pmatrix} \frac{2}{5} \times 3 \\ \frac{2}{5} \times 1 \end{pmatrix}$$

$$\textbf{OR} = \begin{pmatrix} -\frac{6}{5} + \frac{6}{5} \\ \frac{2}{5} + \frac{2}{5} \end{pmatrix}\begin{pmatrix} -\frac{6}{5} + \frac{6}{5} \\ \frac{2}{5} + \frac{2}{5} \end{pmatrix} = \begin{pmatrix} \frac{0}{5} \\ \frac{5}{5} \end{pmatrix}\begin{pmatrix} \frac{0}{5} \\ \frac{5}{5} \end{pmatrix} = \binom{0}{1}\binom{0}{1}$$

Coordinates of R which divide point PQ in the ratio of 2:3 are (0, 1)

ACTIVITY

Point E divides the line segment KL in the ratio 1:3.

The coordinates of K are (4, 1) and L are (-5, 2). Use vectors to get the coordinates of E

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