Western Cape Government
Education

Directorate: Curriculum FET

TELEMATIC SCHOOLS PROJECT 2021

Physical Sciences
Grade 12
& 11

FOREWORD

The telematics program gives learners the opportunity to revise the curriculum content which was already covered by the teacher. The learners can also work through the exercises in this booklet. Learners are required to have their textbooks and notebooks at hand. The tutor will ask them to complete some of the exercises during the presentation. The rest of the exercises must be completed on their own. The presenter will make use of videos and slide shows to address misconceptions and to bring about a better understanding of the content. Learners are encouraged to do further reading on these topics to enhance their understanding. Learners are encouraged to use the venue at their schools to attend the telematics presentations under the supervision of a teacher.

This program endeavors to reach learners in rural areas and they are encouraged to live stream from their cell phones. The presenters will also receive your questions on the sections covered and they will respond to you via text messages. The covid-19 pandemic has made us more depended on the electronic media and we regard this as an opportunity to render a service to the Physical Sciences learners.

Organic chemistry isomers

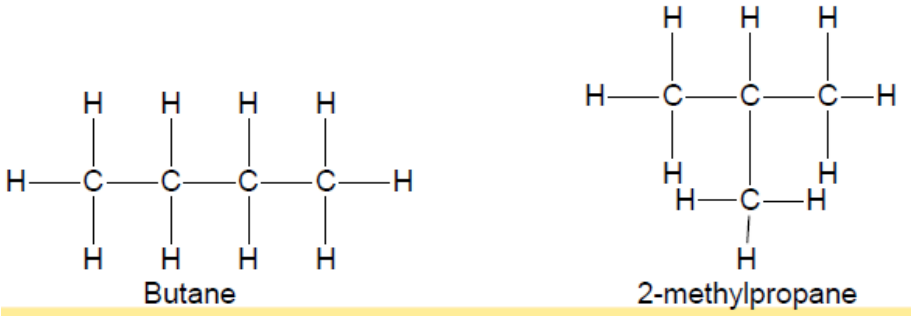
INTRODUCTION

Structural isomers: Organic molecules with the same molecular formula, but different structural formulae. The 3 types of structural isomers are:

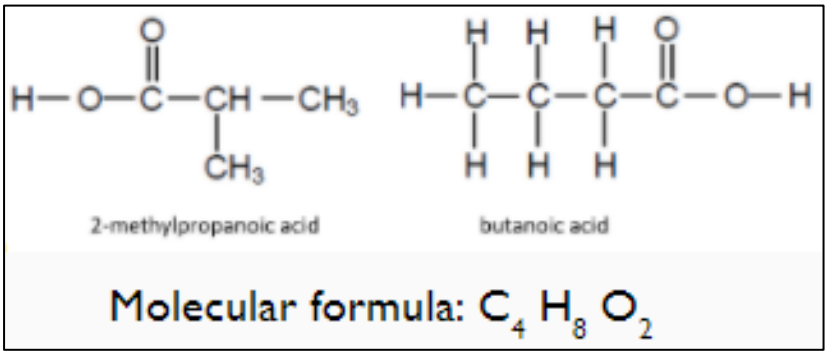
1. Positional isomers Chain isomers
2.
3. Functional isomers

Chain isomers:

Chain isomers: Same molecular formula, but different types of chains (branches).



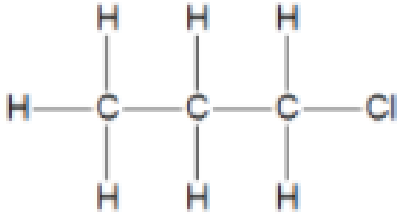
Molecular formula: $C_4 H_{10}$



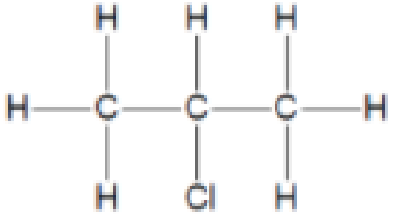
NOTE: The position of the functional group is never indicated in the IUPAC names of carboxylic acids or aldehydes. It is situated at C no.1.

Positional isomers

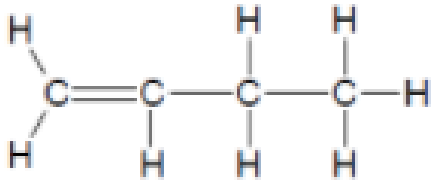
Positional isomers: Same molecular formula, but different positions of the SAME functional group.



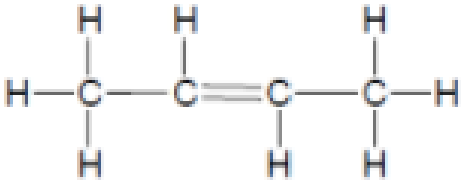
1-chloropropane



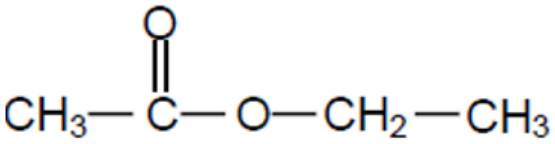
2-choropropane



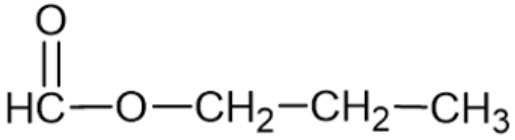
but-1-ene



but-2-ene



Ethyl ethanoate



Propyl methanoate

Functional isomers:

- Define *organic molecules* as molecules containing carbon atoms.

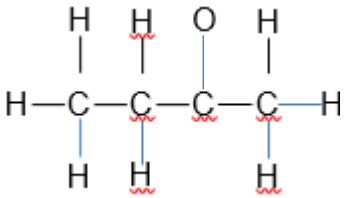
Organic molecular structures – functional groups, saturated and unsaturated structures, isomers

- Know the following definitions/terms:
  Molecular formula: A chemical formula that indicates the type of atoms and the correct number of each in a molecule.

  Example: C_4H_8O

  Structural formula: A structural formula of a compound shows which atoms are attached to which within the molecule. Atoms are represented by their chemical symbols and lines are used to represent ALL the bonds that hold the atoms together.

Example:



Condensed structural formula: This notation shows the way in which atoms are bonded together in the molecule but DOES NOT SHOW ALL bond lines.

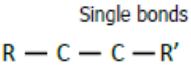
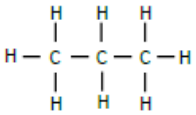
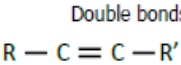
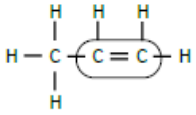
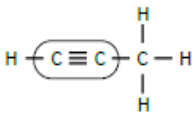
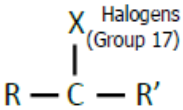
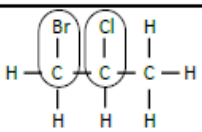
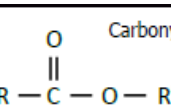
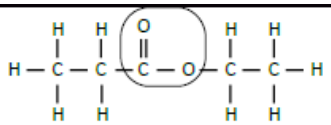
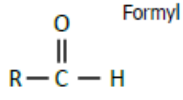
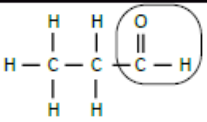
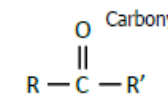
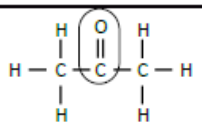
Example: $CH_3CH_2COCH_3$

Hydrocarbon: Organic compounds that consist of hydrogen and carbon only.
Homologous series: A series of organic compounds that can be described by the same general formula OR in which one member differs from the next with a CH_2 group.

Saturated compounds: Compounds in which there are no multiple bonds between C atoms in their hydrocarbon chains.

Unsaturated compounds: Compounds with one or more multiple bonds between C atoms in their hydrocarbon chains.

Functional group: A bond or an atom or a group of atoms that determine(s) the physical and chemical properties of a group of organic compounds

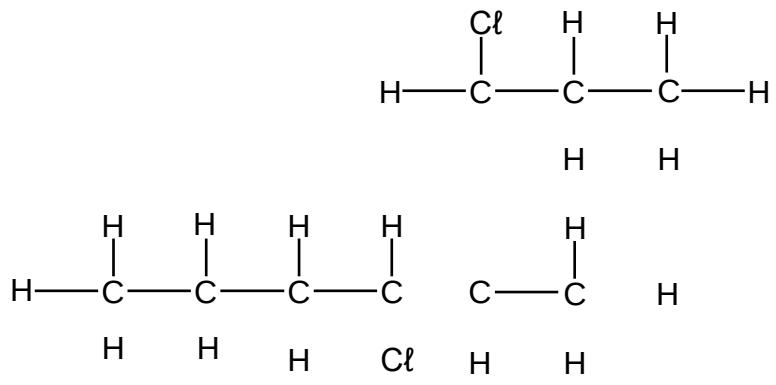
Homologous series and General formula	Functional group	Suffix	Examples		
			Structural formula	Condensed formula	Name
Alkanes C_nH_{2n+2}	Single bonds 	-ane		$CH_3CH_2CH_3$	propane
Alkenes C_nH_{2n}	Double bonds 	-ene		$CH_3CH{=}CH_2$	propene
Alkynes C_nH_{2n-2}	Triple bonds 	-yne		$CH{\equiv}CCH_3$	propyne
Haloalkane/ Haloalkene (Alkyl halide)	 Halogens (Group 17)	fluoro– chloro– bromo– iodo–		$CH_2BrCHClCH_3$	1–bromo–2–chloropropane
Esters R–COO–R′	 Carbonyl	-yl -oate (alch.) (carbox.)		$CH_3CH_2\mathbf{COO}CH_2CH_3$ (carbox.) (alch.)	ethyl propan**oate**
Aldehydes $C_nH_{2n+1}CHO$	 Formyl	-al		$CH_3CH_2\mathbf{CHO}$	pronan**al**
Ketone R–COC–R′	 Carbonyl	-one		$CH_3\mathbf{CO}CH_3$	propan–2–**one**

ORGANIC MOLECULES: BASIC CONCEPTS

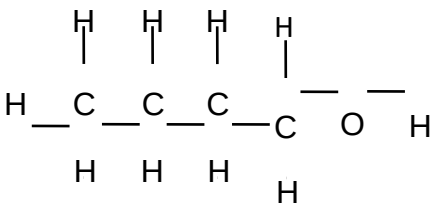
QUESTION 2

2.1 Consider the organic compounds represented by the letters **A** to **C** below.

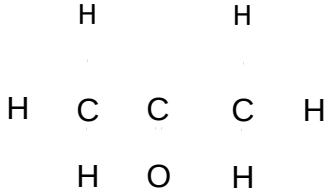
A



B



C



Write down the:

2.1.1 Name of the homologous series to which compound **C** belongs (1)

2.1.2 IUPAC name of compound **A** (3)

2.1.3 Structural formula of a tertiary alcohol that is a structural isomer of compound **B** (2)

2.2 An alcohol and methanoic acid are heated in the presence of concentrated sulphuric acid to form an ester.

2.2.1 What is the role of the concentrated sulphuric acid in this reaction? (1)

2.2.2 Write down the NAME or FORMULA of the inorganic product formed. (1)

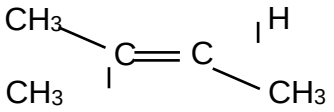
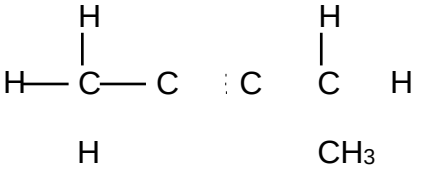
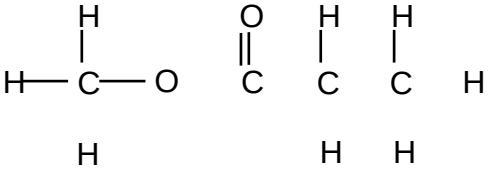
Write down the:

2.2.3 Structural formula of methanoic acid (1)

2.2.4 IUPAC name of the ester (2)

QUESTION 3

Consider the organic compounds **A** to **F**

A		**B**	
C	$CH_3CH_2CH_2CH_2OH$	**D**	2,2-dimethylpropane
E		**F**	$CH_3CHC(CH_3)_2$

3.1 Write down the LETTER that represents a compound that:

3.1.1 Has a carbonyl group (1)

3.1.2 Is an alcohol (1)

3.1.3 Is a CHAIN ISOMER of $CH_3(CH_2)_3CH_3$ (1)

3.2 Write down the:

3.2.1 IUPAC name of compound **B** (2)

3.2.2 Structural formula of compound **F** (2)

3.2.3 IUPAC name of a POSITIONAL isomer of compound **A** (3)

3.3 Compound **E** is formed when a carboxylic acid reacts with another organic compound.

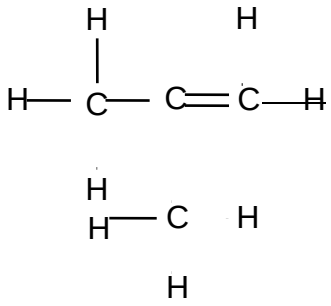
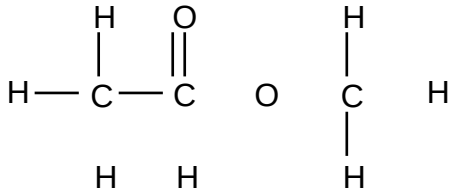
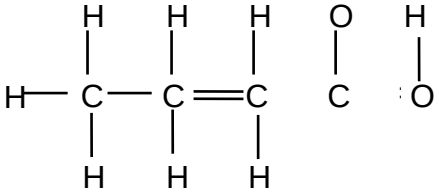
Write down the:

3.3.1 Homologous series to which compound **E** belongs (1)

3.3.2 NAME or FORMULA of the catalyst used for the preparation of compound **E** (1)

3.3.3 IUPAC name of compound **E** (2)

[14]

A		**B**	Ethyl ethanoate
C	2,3-dibromo-3-methylpentane	**D**	Polyethene
E		**F**	

4.1 Write down the LETTER that represents the following:

4.1.1 A hydrocarbon (1)

4.1.2 A functional isomer of compound **F** (1)

4.1.3 A compound which belongs to the same homologous series as compound **B** (1)

4.1.4 A plastic (1)

4.2 Write down the STRUCTURAL FORMULA of EACH of the following:

4.2.1 Compound **C** (3)

4.2.2 The acid used to prepare compound **B** (2)

4.2.3 The monomer used to make compound **D** (2)

4.3 Compound **A** reacts with an unknown reactant, **X**, to form 2-methylpropane.

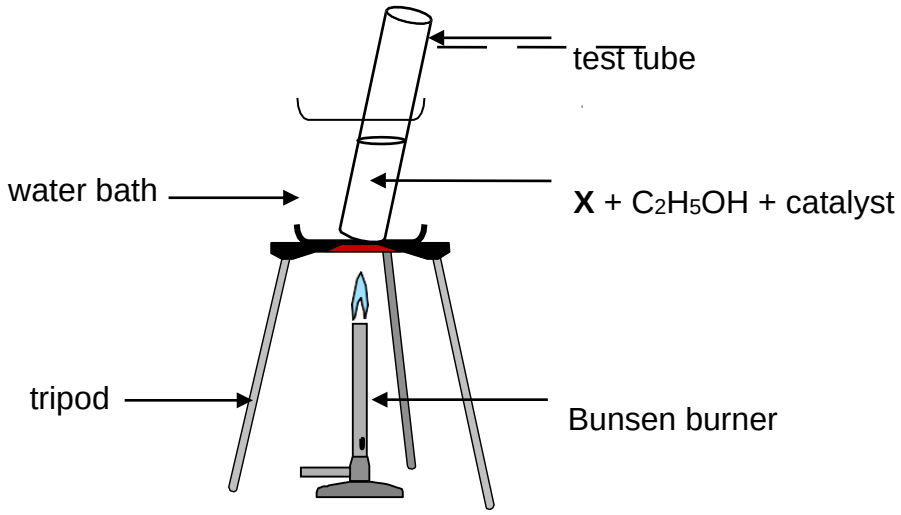
Write down the:

4.3.1 NAME of reactant **X** (1)

4.3.2 Type of reaction that takes place (1)

QUESTION 5

A test tube containing a straight chain organic acid **X**, ethanol and a catalyst is heated in a water bath, as illustrated below.



Organic compound **Y** is produced according to the following equation:

$$\mathbf{X} + C_2H_5OH \longrightarrow \mathbf{Y} + H_2O$$

5.1 Give a reason why the test tube is heated in a water bath instead of directly over the flame. (1)

5.2 Write down the:

5.2.1 Type of reaction that takes place here (1)

5.2.2 FORMULA of the catalyst needed (1)

5.2.3 Homologous series to which compound **Y** belongs (1)

The molecular mass of compound **Y** is 144 g·mol^{-1} and its empirical formula is C_4H_8O.

5.3 Determine the molecular formula of compound **Y**. (2)

5.4 Write down the IUPAC name of compound **Y**. (2)

5.5 Write down the structural formula of the organic acid **X**. (2)

[10]

Intermolecular Forces

Intermolecular forces and interatomic forces (chemical bonds)

- Name and explain the different intermolecular forces (Van der Waal's forces):
  - (i) Dipole-dipole forces:
    Forces between two polar molecules
  - (ii) Induced dipole forces or London forces:
    Forces between non-polar molecules
  - (iii) Hydrogen bonding:
    Forces between molecules in which hydrogen is covalently bonded to nitrogen, oxygen or fluorine – a special case of dipole-dipole forces
- Describe the difference between *intermolecular forces* and *interatomic forces*
  (intramolecular forces) using a diagram of a group of small molecules; and in words.

State the relationship between intermolecular forces and molecular size. For non-polar molecules, the strength of induced dipole forces increases with molecular size.

- Explain the effect of intermolecular forces on boiling point, melting point and vapour pressure.

Boiling point:

The temperature at which the vapour pressure of a substance equals atmospheric pressure. The stronger the intermolecular forces, the higher the boiling point.

Melting point:

The temperature at which the solid and liquid phases of a substance are at equilibrium. The stronger the intermolecular forces, the higher the melting point.

Vapour pressure:

The pressure exerted by a vapour at equilibrium with its liquid in a closed system. The stronger the intermolecular forces, the lower the vapour pressure.

ORGANIC MOLECULES: PHYSICAL PROPERTIES

QUESTION 6

6.1 Define the term *boiling point*. (2)

6.2 What is the relationship between strength of intermolecular forces and boiling point? (1)

The relationship between strength of intermolecular forces and boiling point is investigated using four organic compounds from different homologous series. The compounds and their boiling points are given in the table below.

COMPOUND		BOILING POINT (°C)
A	Propane	-42
B	Propan-2-one	56
C	Propan-1-ol	97
D	Propanoic acid	141

6.3 Refer to the TYPE and the STRENGTH of intermolecular forces to explain the difference in boiling points between:

11.3.1 Compounds **A** and **B** (3)

11.3.2 Compounds **C** and **D** (3)

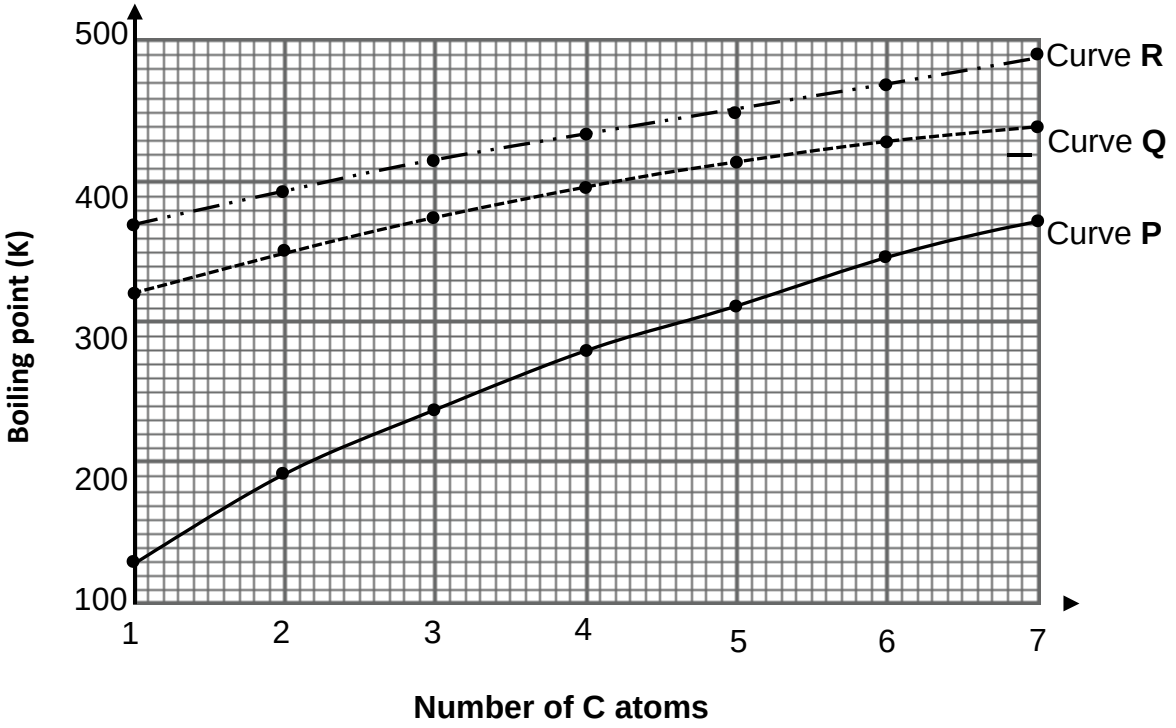
6.4 Is compound **B** a GAS or a LIQUID at room temperature? (1)

[10]

QUESTION 7

The relationship between boiling point and the number of carbon atoms in straight chain molecules of alkanes, carboxylic acids and alcohols is investigated. Curves **P**, **Q** and **R** are obtained.

GRAPH OF BOILING POINT VERSUS NUMBER OF C ATOMS



7.1 Define the term *boiling point*. (2)

7.2 For curve **P**, write down a conclusion that can be drawn from the above results. (2)

7.3 Identify the curve (**P**, **Q** or **R**) that represents each of the following:

7.3.1 Alkanes (1)

7.3.2 Carboxylic acids (1)

7.4 Explain the answer to QUESTION 7.3.2 by referring to the:

- Types of intermolecular forces present in alkanes, carboxylic acids and alcohols
- Relative strengths of these intermolecular forces
- Energy needed (5)

[11]

Question 8

The boiling points of straight-chain alkanes and straight chain alcohols are compared in the table below.

NUMBER OF CARBON ATOMS	BOILING POINTS OF ALKANES (°C)	BOILING POINTS OF ALCOHOLS (°C)
1	- 162	64
2	- 89	78
3	- 42	98
4	- 0,5	118

8.1 Explain the increase in boiling points of the alkanes, as indicated in the table. (3)

8.2 Explain the difference between the boiling points of an alkane and an alcohol, each having THREE carbon atoms per molecule, by referring to the TYPE of intermolecular forces. (4)

8.3 Does the vapour pressure of the alcohols INCREASE or DECREASE with an increase in the number of carbon atoms? (1)

8.4 How will the boiling point of 2-methylpropane compare to that of its chain isomer?

Write down HIGHER THAN, LOWER THAN or EQUAL TO. Give a reason for the answer by referring to the structural differences between the two compounds. (2)

[10]

QUESTION/*VRAAG* 8

8.1

- **Structure/*Struktuur*:**

  The chain length/molecular size /molecular structure/molecular mass/ surface area increases.
  Die *kettinglengte/molekulêregrootte/molekulêre struktuur/molekulêre massa/oppervlakte neem toe.*

- **Intermolecular forces/*Intermolekulêre kragte*:**
  Increase in strength of intermolecular forces/induced dipole /London/ dispersion /Van der Waals forces/momentary dipoles. ✓
  Toename in sterkte van intermolekulêre kragte/geïnduseerde dipoolkragte/Londonkragte/dispersiekragte/Van der Waalskragte / momentele dipool.

- **Energy/*Energie*:**
  More energy needed to overcome/break intermolecular forces. ✓
  Meer *energie benodig om intermolekulêre kragte te oorkom/breek.*

OR/*OF*

- **Structure/*Struktuur*:**
  From 4 C atoms to 1 C atom/bottom to top the chain length/molecular size/molecular structure/molecular mass/surface area decreases. ✓
  Van 4 C-atome na 1 C-atoom/onder na bo neem die kettinglengte/ molekulêre grootte/molekulêre struktuur/molekulêre massa/oppervlakte af.
- **Intermolecular forces/*Intermolekulêre kragte:***
  Decrease in strength of intermolecular forces/ induced dipole forces/ London forces/dispersion forces. ✓
  Afname in sterkte van intermolekulêre kragte/geïnduseerde dipoolkragte/ Londonkragte/dispersiekragte.
- **Energy/*Energie*:**
  Less energy needed to overcome/break intermolecular forces. ✓
  Minder energie benodig om intermolekulêre kragte te oorkom/breek. (3)

8.2

- Alkanes have London/dispersion/induced dipole forces. ✓
  Alkane het London-/dispersie-/geïnduseerde dipoolkragte.
- Alcohols have hydrogen bonding (in addition to London/dispersion/ induced dipole forces and dipole dipole forces). ✓
  Alkohole het waterstofbinding (in toevoeging tot London-/dispersie-/ geïnduseerde dipoolkragte en dipoolkragte).
- Hydrogen bonding are stronger intermolecular forces than London/ dispersion/ induced dipole forces. ✓
  Waterstofbindings is sterker intermolekulêre kragte as *London-/dispersie-/geïnduseerde dipoolkragte.*
  OR/*OF*
  More energy needed to overcome/break intermolecular forces in alcohols
  Meer energie benodig om intermolekulêre kragte te oorkom/breek in alkohole.
- Alcohols have higher boiling points than alkanes. ✓
  Alkohole het hoër kookpunte as die alkane. (4)

8.3 Decrease/*Neem af* ✓ (1)

8.4 Lower than/*Laer as* ✓

-

2-methylpropane/It is more branched/has a smaller surface area/has a shorter chain length (than butane/chain isomer) ✓
2-metielpropaan/Dit is vertak/het 'n kleiner oppervlakte/het 'n korter kettinglengte (as butaan/ketting-isomeer).

OR/*OF*

Butane/chain isomer is less branched /has larger surface area/longer chain length (than 2-methylpropane).
Butaan/ketting-isomeer is minder vertak/het 'n groter oppervlakte/het 'n langer kettinglengte (as 2-metielpropaan). (2)

[10]

Electricity and Internal resistance

OHM'S LAW

Current through a conductor is directly proportional to the potential difference across the conductor at constant temperature.

$$R = VI$$

Proof of Ohm's law:

The current in the circuit is changed using the rheostat, thus current is the independent variable and potential

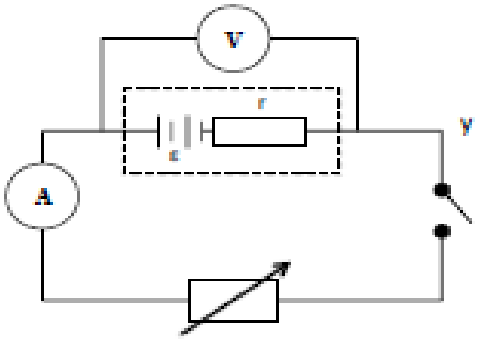
difference is the dependent variable. It is important that the temperature of the resistor is kept constant. The resultant graph of potential difference vs current indicates if the conductor is ohmic or non-ohmic.

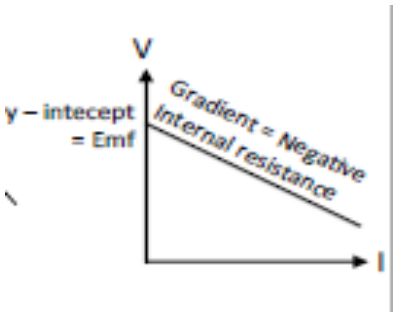
INTERNAL RESISTANCE

The potential difference across a battery not connected in a circuit is the emf of the battery. **Emf is the total energy supplied per coulomb of charge by the cell.** When connected in a circuit the potential difference drops due the internal resistance of the cells.

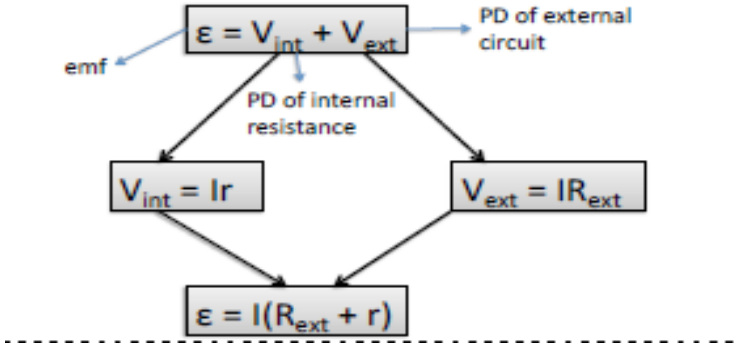
In reality all cells have internal resistance (r). Internal resistors are always considered to be connected in series with the rest of the circuit.

Determining the emf and internal resistance of a cell





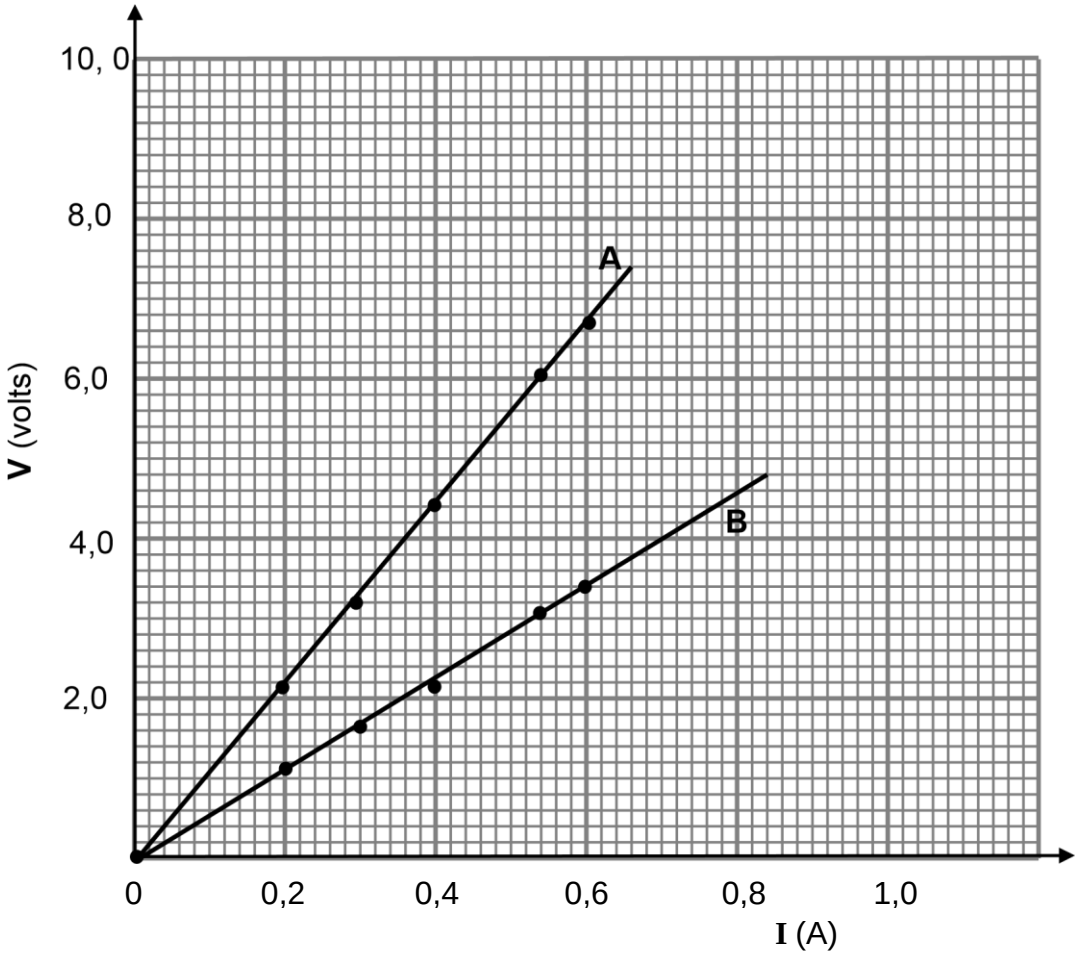
INDEPENDENT VARIABLE	**CURRENT (I)**
DEPENDENT VARIABLE	**POTENTIAL DIFFERENCE (V)**
CONTROLLED VARIABLE	**TEMPERATURE**



QUESTION 8

8.1 Learners want to construct an electric heater using one of two wires, **A** and **B**, of different resistances. They conduct experiments and draw the graphs as shown below.

Graph of V versus I for resistors A and B

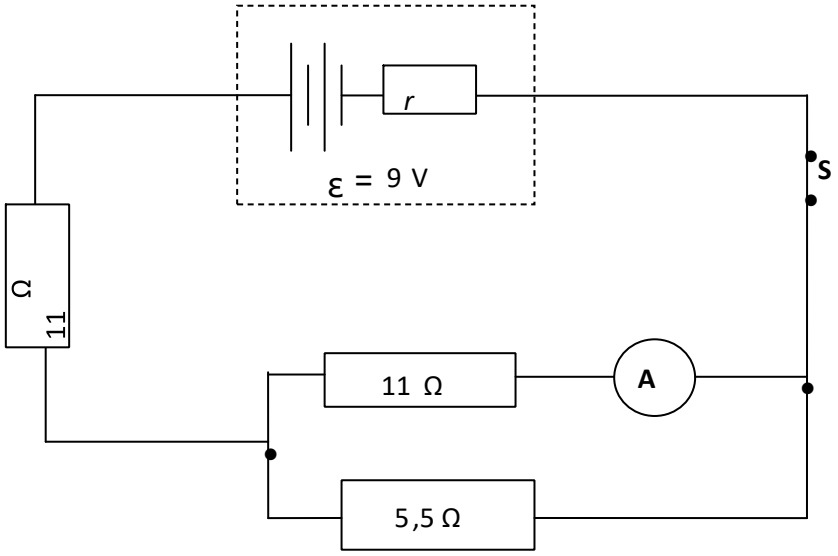


8.1.1 Apart from temperature, write down TWO other factors that the learners should consider to ensure a fair test when choosing which wire to use. (2)

8.1.2 Assuming all other factors are kept constant, state which ONE of the two wires will be the most suitable to use in the heater.

Use suitable calculations to show clearly how you arrive at the answer. (8)

8.2 In the circuit below the reading on ammeter **A** is 0,2 A. The battery has an emf of 9 V and internal resistance *r*.



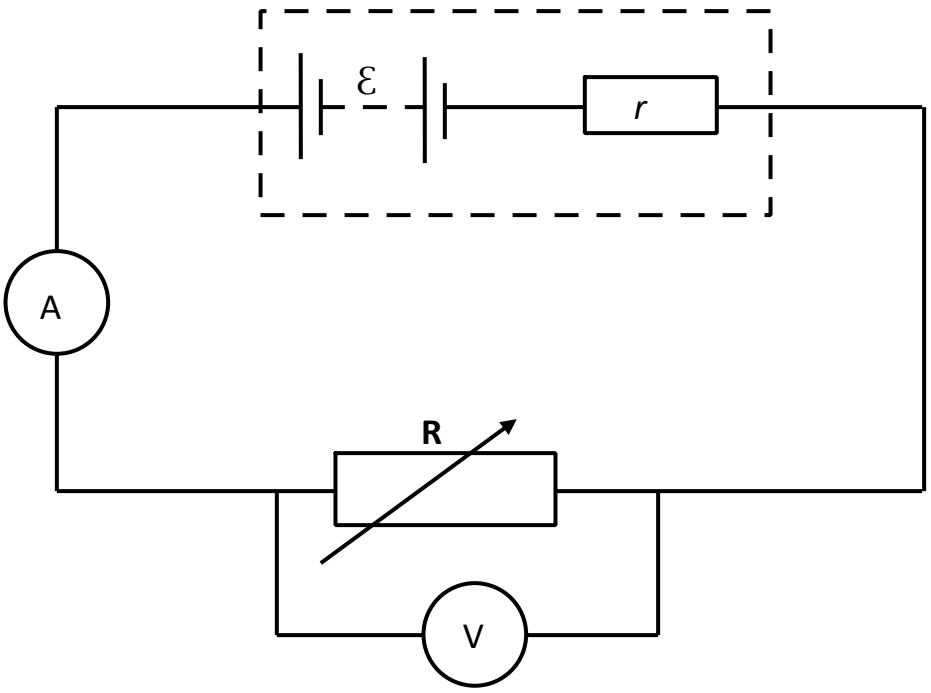
8.2.1 Calculate the current through the 5,5 Ω resistor. (3)

8.2.2 Calculate the internal resistance of the battery. (7)

8.2.3 Will the ammeter reading INCREASE, DECREASE or REMAIN THE SAME if the 5,5 Ω resistor is removed from the circuit? Give a reason for the answer. (2)

9.1 The emf and internal resistance of a certain battery were determined experimentally.

The circuit used for the experiment is shown in the diagram below.



9.1.1 State Ohm's law in words. (2)

The data obtained from the experiment is plotted on the attached graph sheet.

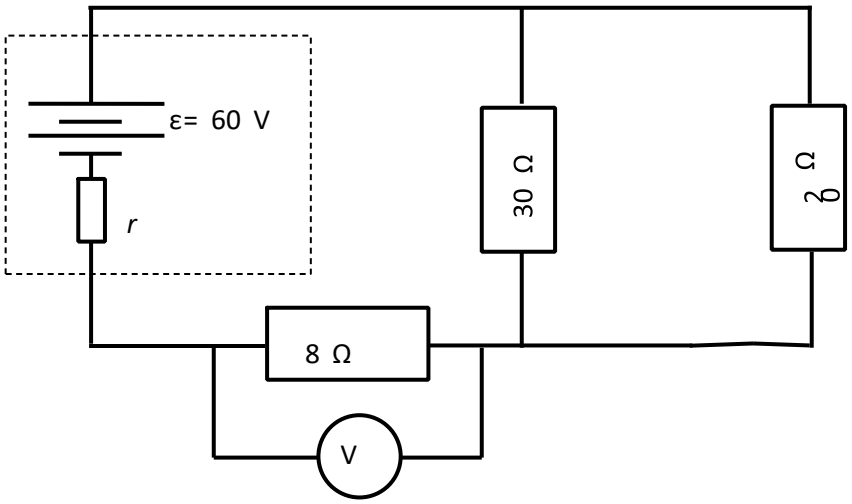
9.1.2 Draw the line of best fit through the plotted points. Ensure that the line cuts both axes. (2)

Use information in the graph to answer QUESTIONS 9.1.3 and 9.1.4.

9.1.3 Write down the value of the emf (ε) of the battery. (1)

9.1.4 Determine the internal resistance of the battery. (3)

9.2 The circuit diagram below shows a battery with an emf (ε) of 60 V and an unknown internal resistance *r,* connected to three resistors.



A voltmeter connected across the 8 Ω resistor reads 21,84 V.

Calculate the:

9.2.1 Current in the 8 Ω resistor (3)

9.2.2 Equivalent resistance of the resistors in parallel (2)

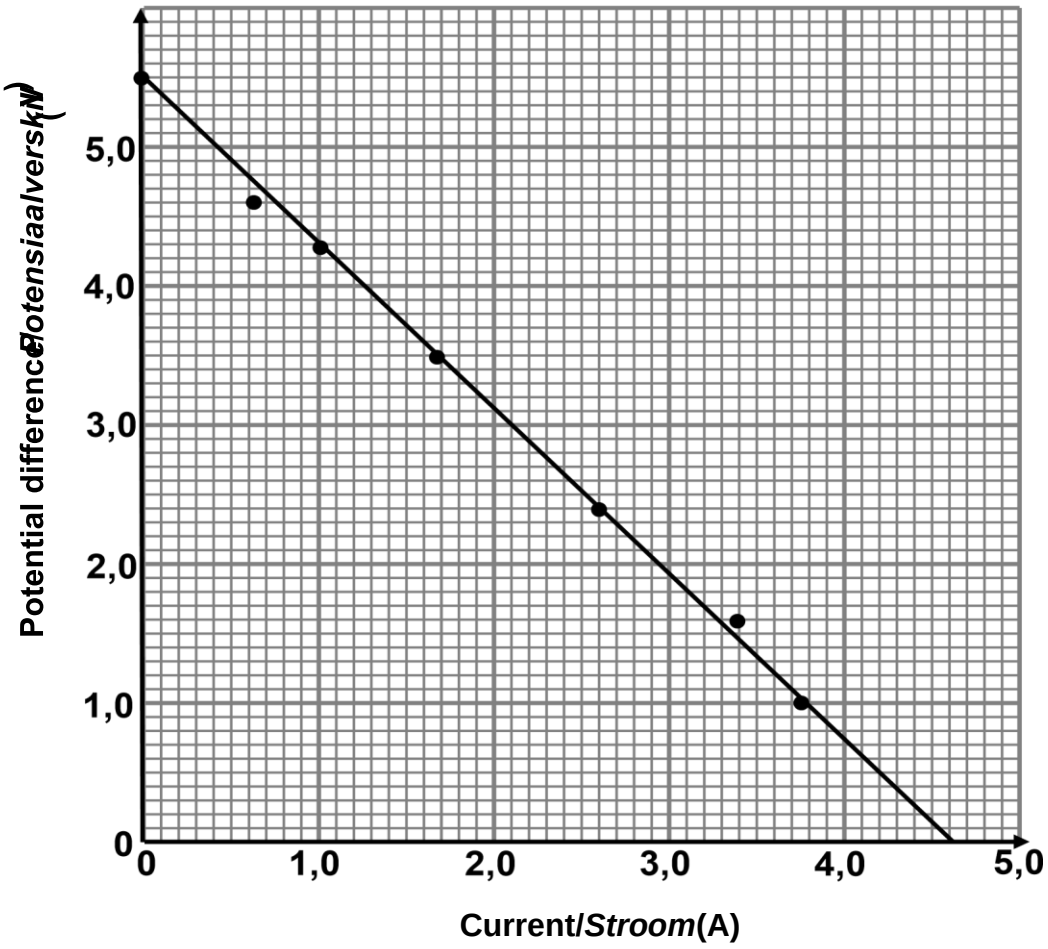
9.2.3 Internal resistance *r* of the battery (4)

9.2.4 Heat dissipated in the external circuit in 0,2 seconds (3)

9.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature □□
Die potensiaalverskil oor 'n geleier is direk eweredig aan die stroom deur die geleier by konstante temperatuur.

NOTE/LET WEL
If constant temperature is omitted -1 mark
Indien konstante temperatuur weggelaat word -1 punt (2)

9.1.2 **Graph of potential difference versus current**



Straight line passing through 4 or five points□.
Straight line with intercepts on both axes□.
Reguitlyn deur 4 of 5 punte
Reguitlyn met afsnitte op beide asse (2)

9.1.3 5,5 V (accept any value from /*aanvaar enige waarde vanaf* 5,4 V to/*tot* 5,6 V based on graph drawn/*op die grafiek gebaseer*.)

NOTE /*LET WEL* :

The value must be the y-intercept./ *Die waarde moet die y-afsnit wees.* (1)

9.1.4

Slope/*helling* = $\frac{\Delta V}{\Delta I}$ or/*of* $\frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{5,5-0}{0-4,6}$ ✓ ✓ $= -1,2$

Internal resistance/*Interne weerstand* (r) = 1,2 Ω✓

NOTE/*LET WEL*:

Any correct pair of coordinates chosen from the line drawn

Enige korrekte paar koördinate vanaf die getekende lyne gekies

For the equation $\varepsilon = I(R + r)$ or $\varepsilon = V_{ext} + Ir$ marks are awarded only if the correct I and V values are used from the graph

Vir die vergelyking $\varepsilon = I(R + r)$ of $\varepsilon = V_{ext} + Ir$ sal punte slegs toegeken word indien die korrekte waardes van I and V vanaf die grafiek gebruik is.

9.2.1

$R = \frac{V}{I}$

$I = \frac{V}{R}$

$V = IR$

✓any of these/*enige van hierdie*

$21,84 = I_{tot}$ (8) ✓

$I_{tot} = 2,73$ A✓

OPTION 1/*OPSIE 1*

$\frac{1}{R_{//}} = \frac{1}{R_{30}} + \frac{1}{R_{20}}$

$\frac{1}{R_{||}} = \frac{1}{30} + \frac{1}{20}$ ✓

$R_{||} = 12\ \Omega$✓

$R_{||} = \frac{R_{30} \times R_{20}}{R_{30} + R_{20}}$

$R_{||} = \frac{30 \times 20}{50}$ ✓

$= 12\ \Omega$✓

9.2.3

POSITIVE MARKING FROM QUESTION 9.2.1 AND 9.2.2
POSITIEWE NASIEN VANAF VRAAG 9.2.1 EN 9.2.2

OPTION 1/*OPSIE 1*

$R_{tot} = (8 + 12 + r)$ (for the addition/*vir optelling*)
$= (20 + r)$

$\varepsilon = I(R + r)$ ✓
60 ✓$= (2,73)(20 + r)$ ✓
$\therefore r = 1,98\ \Omega$✓

POSITIVE MARKING FROM QUESTION 9.2.1
POSITIEWE NASIEN VANAF VRAAG 9.2.1
OPTION 2/*OPSIE 2*

$V_{||} = I_{tot}R_{||}$
$= (2,73)(12)$ ✓
= 32,76 V

= (32,76 + 21,84) ✓ for addition/*vir optelling*

$\therefore V_{terminal}$
=
54,6 V

$\varepsilon = V_{lost} + V_{||} + V_8$
$60 = (V_{"lost"} + 32,76 + 21,84)$ ✓
$V_{"lost"} = 5,4$ V

$\frac{V}{I}$
$\frac{V}{R}$
$V = IR$

✓any of these/*enige van hierdie*

"V_{lost}" = 60 - 54,6 = 5,4 V

R =

I=

5,4 = 2,73 *r* *r*
= 1,98 Ω✓

NOTE/*LET WEL:*
No penalisation for omitted subscripts
Geen penalisering vir weggelate onderskrifte nie

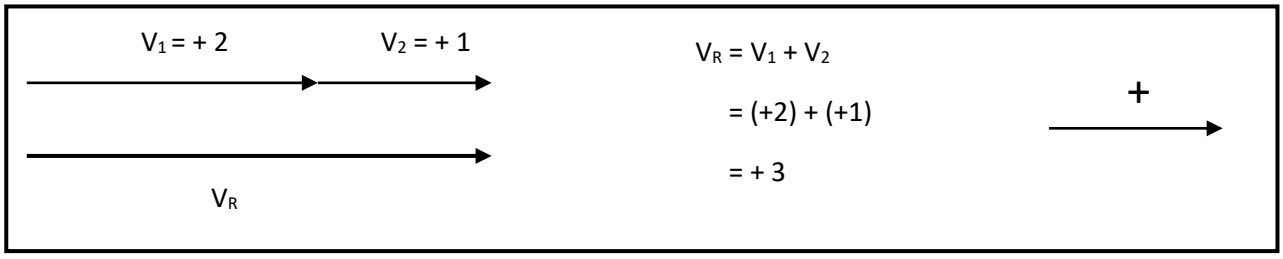
9.2.4

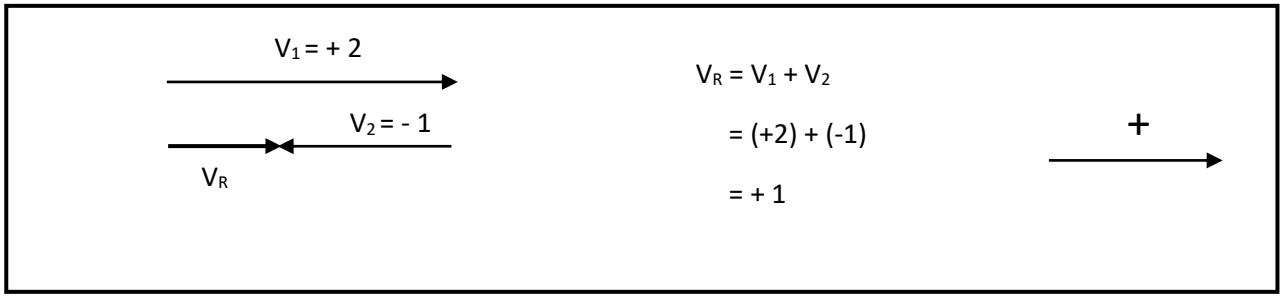
POSITIVE MARKING FROM 9.2 1 AND 9.2.2 ***POSITIEWE NASIEN VANAF VRAAG 9.2.1 EN 9.2.2***		
OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***	**OPTION 3/*OPSIE 3***
$W = \frac{V^2}{R}\Delta t$ ✓ $W = \frac{(54,6)^2}{20}(0,2)$ ✓ = 29,81 J ✓	$W = I^2R\Delta t$ ✓ = $(2,73)^2$ (20)(0,2) ✓ = 29,81 J ✓	$W = VI\Delta t$ ✓ = (54,6)(2,73)(0,2) ✓ = 29,81 J ✓

Mechanics: Newton's Laws

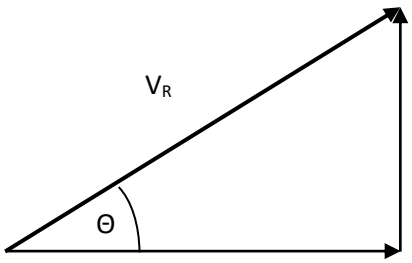
Resultant vector: A single vector that has the same effect as two or more vectors acting on an object.

Resultant vector in 1 dimension:





Resultant vector in 2 dimensions:



$V_R = \sqrt{V_x^2 + V_y^2}$

$= \sqrt{3^2 + 4^2}$

$= 5$

$\Theta = \tan^{-1}\frac{V_y}{V_x}$

$= \tan^{-1}\frac{4}{3}$

$= 53{,}13°$ anti-clockwise from the positive x-axis

∴ V_R = 5 units 53.13° anti-clockwise from the positive x-axis

Normal force: The force which a surface exerts on an object in contact with it which acts perpendicular to the surface. (F_N)

Frictional force: The force that opposes the motion of an object which act parallel to the surface. (F_f)

Static Frictional Force: The force that opposes the tendency of motion of a stationary object relative to the surface. (f_s)

$f_s^{max} = F_N\mu_s$
where:
f_s^{max} = maximum static frictional force (N)
F_N = Normal force (N)
μ_s = coefficient of static friction

Kinetic Frictional Force: The force that opposes the motion of a moving object relative to a surface. (f_k)

$f_k = F_N\mu_k$
where:
f_k = kinetic frictional force (N)

F_N = Normal force (N)
μ_k = coefficient of kinetic friction

$f_s > f_k$
$\mu_s > \mu_k$

$R_x = R\cos\Theta$ for the resultant x component if Θ is the angle between R and the x-axis
$R_y = R\sin\Theta$ for the resultant y component if Θ is the angle between R and the x-axis

Force and free-body diagrams:

Force diagram:

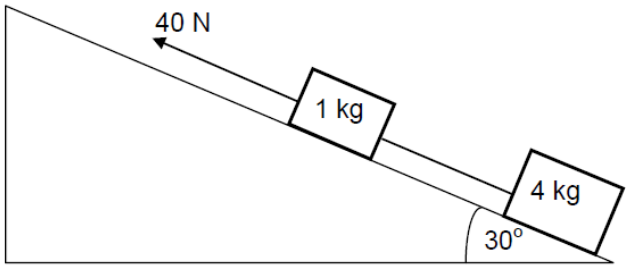
- Force is represented by an arrow.
- The direction of the force is represented by the direction of the arrow.
- The magnitude of the force is represented by the length of the arrow.

Free-body diagram:

- Diagram shows the relative magnitudes and directions of forces acting on an object that has been isolated from its surroundings.
- The object is drawn as a dot and all forces acting on it are drawn as arrows pointing away from the dot.
- The direction of the force is represented by the direction of the arrow.
- The magnitude of the force is represented by the length of the arrow.

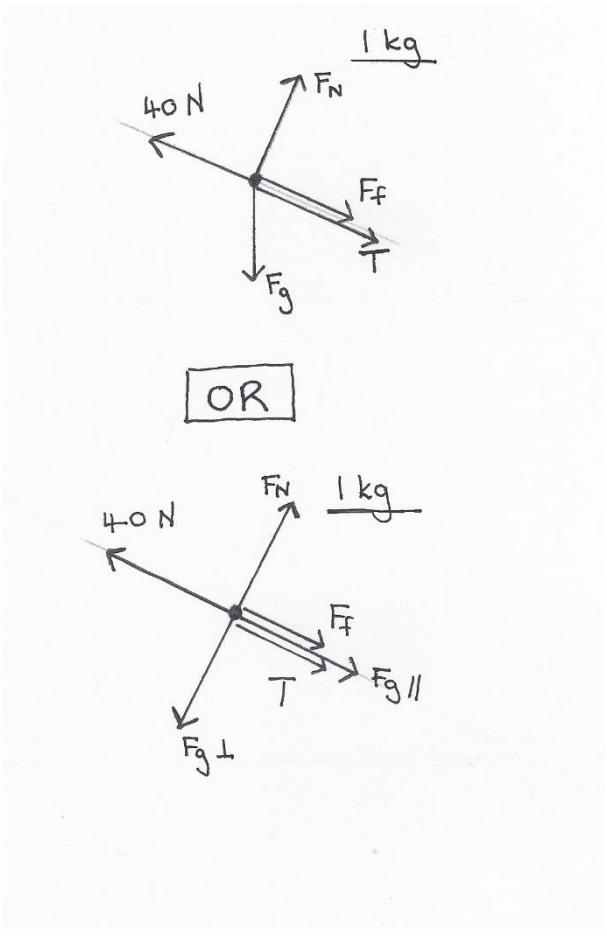
Example: (February/March 2015 NCS Grade 12 Paper 1, Question 2)

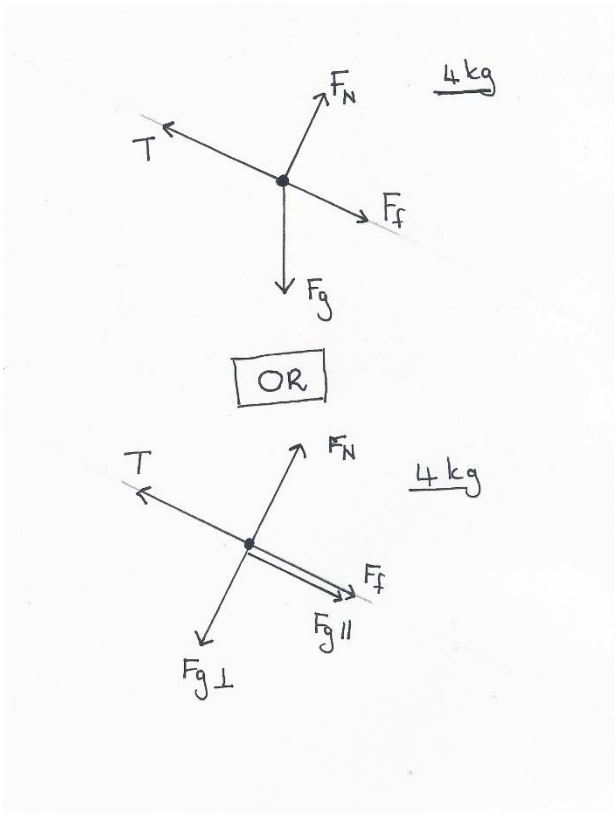
A block of mass 1 kg is connected to another block of mass 4 kg by a light, inextensible string. The system is pulled up a rough plane inclined at 30° to the horizontal, by means of a constant 40 N force parallel to the plane as shown in the diagram.



The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N. The coefficient of kinetic friction between the 1 kg block and the surface is 0,29.

Draw a fully labelled free-body diagram of all the forces acting on the 1 kg block and the 4 kg in two separate diagrams.





Newton's First Law of Motion: An object will remain in its state of rest or motion at constant velocity unless a non-zero resultant force acts on it.

Inertia: The resistance of an object to any change in its state of motion.

Newton's Second Law of Motion: When a non-zero resultant force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.

$F = ma$
where:
F = resultant force (N)
m = mass (kg)
a = acceleration ($m.s^{-2}$)

Newton's Third Law of Motion: When object A exerts a force on object B, object B simultaneously exerts a force on object A. The force will be equal in magnitude and opposite in direction.

Newton's Law of Universal Gravitation: Each particle in the universe attracts every other particle with a gravitational force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

$$F = \frac{Gm_1m_2}{r^2}$$
where:
F = force between two particles (N)
G = gravitational constant ($6,67 \times 10^{11}$ $N.m^2.kg^{-2}$)
m_1 = mass of object 1 (kg)
m_2 = mass of object 2 (kg)
r = distance between the centres of the objects (m)

M = Mass of Earth = $5,98 \times 10^{24}$ kg
R_E = Radius of Earth = $6,38 \times 10^6$ m

Weight: The gravitational force exerted by the Earth on an object on or near its surface.
Measured in Newton (N)

Mass: The amount of matter in a body.
Measured in kilogram (kg)

$w = mg$
where:
w = weight (N)
m = mass (kg)
g = gravitational acceleration ($9,8$ $m.s^{-2}$)

Weightlessness: The sensation experienced when all contact forces are removed.

November 2014 NSC Grade 12 Paper 1:

1.1 Which ONE of the following physical quantities is a measure of the inertia of a body?

A. Mass
B. Energy
C. Velocity
D. Acceleration

(2)

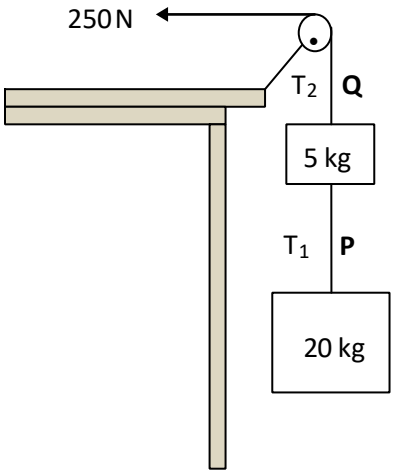
1.2 The magnitude of the gravitational force exerted by one body on another body is ***F***. When the distance between the centres of the two bodies is doubled, the magnitude of the gravitational force, in terms of ***F***, will now be …

A. $\frac{1}{4}F$
B. $\frac{1}{2}F$
C. $2F$
D. $4F$

(2)

QUESTION 2:

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.



2.1 State Newton's Second Law of Motion in words. (2)

2.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**.
(3)

2.3 Calculate the magnitude of the tension T_1 in string **P**. (6)

2.4 When the 250 N force is replaced by a sharp pull on the string, one of the two strings break.

Which ONE of the two strings, **P** or **Q**, will break? (1)

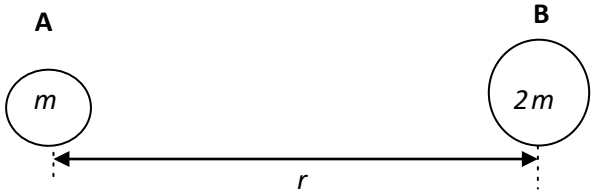
[12]

February/March 2015 NSC Grade 12 Paper 1:

1.1 Which ONE of the following forces always acts perpendicular to the surface on which a body is placed?

A. Normal force
B. Frictional force
C. Gravitational force
D. Tension force (2)

1.2 Two isolated bodies, **A** and **B**, having masses *m* and 2*m* respectively, are placed a distance *r* apart.



Consider the following statements regarding the gravitational force exerted by the bodies on each other.

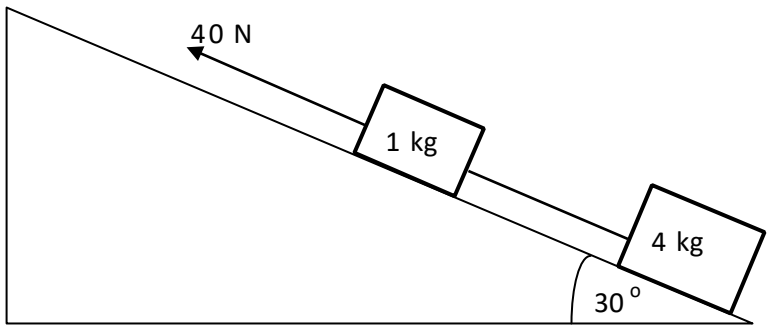
i. The force exerted by **B** on body **A** is half that exerted by **A** on body **B**.
ii. The force exerted on the bodies is independent of the masses of the bodies.
iii. The force exerted on body **A** by **B** is equal but opposite to that exerted on body **B** by **A**.
iv. The forces will always be attractive.

Which of the statements above is/are TRUE?

A. (i), (ii) and (iv) only
B. (ii), (iii) and (iv) only
C. (iii) and (iv) only
D. (iv) only (2)

QUESTION 2

A block of mass 1 kg is connected to another block of mass 4 kg by a light inextensible string. The system is pulled up a rough plane inclined at 30° to the horizontal, by means of a constant 40 N force parallel to the plane as shown in the diagram below.



The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N. The coefficient of kinetic friction between the 1 kg block and the surface is 0,29.

2.1 State Newton's third law in words. (2)

2.2 Draw a labelled free-body diagram showing ALL the forces acting on the **1 kg block** as it moves up the incline. (5)

2.3 Calculate the magnitude of the:

2.3.1 Kinetic frictional force between the 1 kg block and the surface (3)

2.3.2 Tension in the string connecting the two blocks (6)

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