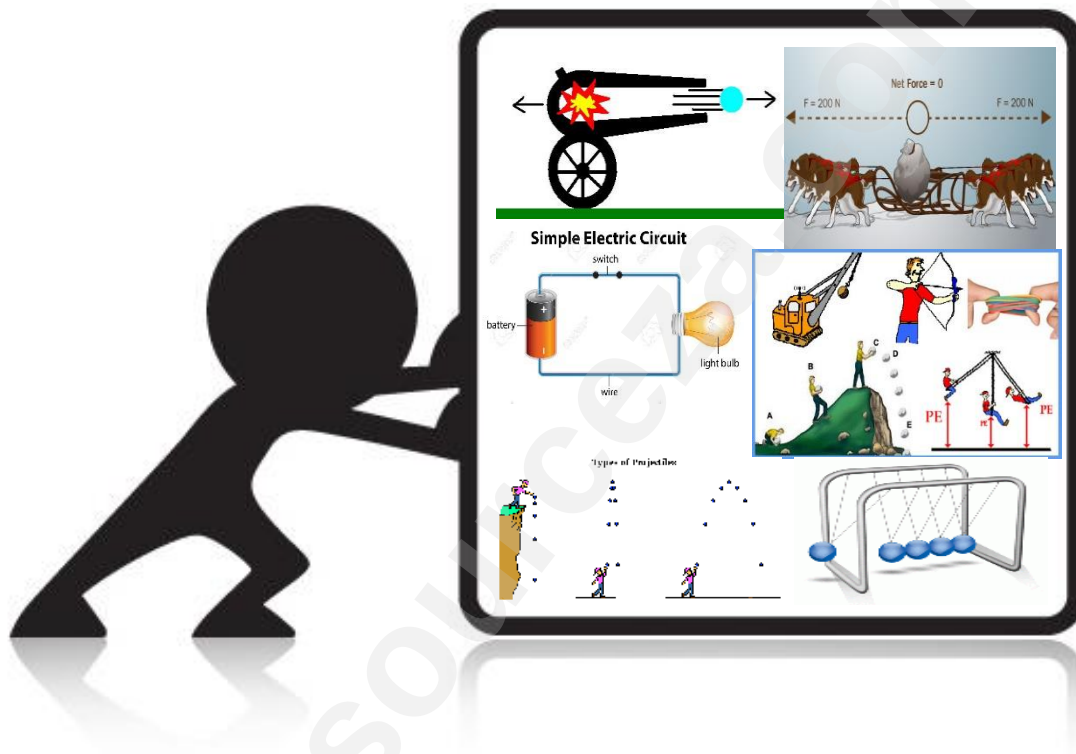




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THE LAST PUSH



PHYSICAL SCIENCES

PAPER 1 GRADE 12

Week 1: 12 & 13 October 2018 (5Hours)

Week 2: 19 & 20 October 2018 (5 Hours)

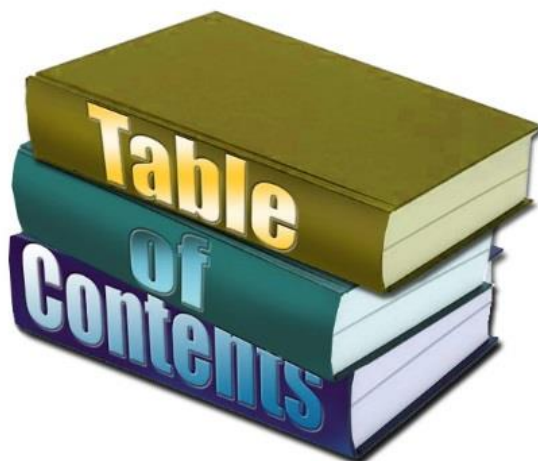
Week 3: 26 & 27 October 2018 (5 Hours)

Week 4 PAPER 2: 2 - 04 Nov 2018 (11 Hours)

NB: Go Back to LAST PUSH PAPER 2)

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1. GENERAL EXAM GUIDELINES

The Physical Sciences subject area has been divided into six knowledge areas consisting of physics and chemistry components — one of these is an integrated knowledge area spanning both components.

When doing revision with learners, teachers should familiarize themselves with the following documents:

- The Physical Sciences Grade 12 examination guidelines (2017).

The Physical Sciences Grade 12 examination guidelines (2017) give specific details regarding the themes to be tested in each of the knowledge areas.

It outlines the format of the question papers in Chemistry and Physics, knowledge that is required from content in Grades 10 and 11 and the core content that will be assessed in the final examination.

- The National Senior Certificate (NSC) Diagnostic Reports (2014 -2017)

The National Diagnostic Reports give specific details on Common errors and misconceptions that were identified in previous examinations, as well Suggestions for improvement in relation to teaching and learning.

Format of Question Papers

PAPER 1: PHYSICS 3 HOURS	MARKS	PAPER 2: CHEMISTRY 3HOURS	MARKS
SECTION A MULTIPLE – CHOICE QUESTIONS (10)	10 X 2 = 20	SECTION A MULTIPLE CHOICE QUESTIONS (10)	10 X 20 = 20
SECTION B LONGER QUESTIONS ASSESING ALL THEMES (i.e. MECHANICS; WAVES, SOUND & LIGHT; ELECTRICITY & MAGNETISM)	130	ASSESING ALL THEMES (i.e. CHEMICAL CHANGE; MATTER & MATERIAL ; CHEMICAL SYSTEMS	130
TOTAL	150	TOTAL	150

NB: The examination does not necessarily include all the themes, but all the knowledge areas are covered.

Weighting of Cognitive Levels

Papers 1 and 2 will include questions across all four cognitive levels. The distribution of cognitive levels in Physics and Chemistry papers is given below.

Cognitive level	Description	Paper 1 (Physics)	Paper 2 (Chemistry)
1	Remembering/ Recall	15%	15%
2	Understanding/ Comprehension	35%	40%
3	Applying and analysing	40%	35%
4	Evaluating and creating (synthesis)	10%	10%

Weighting of Prescribed Content

Paper 1: Physics Focus							
Content	Marks	Total	Duration	Weighting of cognitive levels			
Mechanics	63	150 marks	3 hours	15	35	40	10
Waves, sound and light	17						
Electricity and magnetism	55						
Matter and materials	15						

Paper 2: Chemistry Focus							
Content	Marks	Total	Duration	Weighting of cognitive levels			
Chemical change	84	150 marks	3 hours	15	40	35	10
Chemical systems	18						
Matter and materials	48						

Data Sheet (Information Sheet)

Remind learners that the separate data sheets for paper 1 and paper 2 are included in the question papers.

PAPER1	PAPER 2
TABLE 1: Physical constants	TABLE 1: Physical constants
TABLE 2: Formulae sheet	TABLE 2: Formulae sheet
	TABLE 3: Periodic table
	TABLE 4: Standard reduction potentials

Prior Knowledge from Grades 10 & 11

All skills and application of knowledge learnt in Grade 10 and 11 are transferred and applicable to assessment in Grade 12. i.e.

PAPER 1

- The use of equations of motion in solving problem dealing with momentum, work and power.
- The use of Newton's laws of motion
- Sound waves and properties of sound, and Electromagnetism

NB: PRACTICAL FOCUSED QUESTIONS

In both paper 1 and paper 2, there will always be questions on practical investigations and the following definitions and concepts must be studied carefully:

- **Dependent variable:** This is the variable that is being measured in an experiment. It forms the vertical axis (y-axis) of a graph.
- **Independent variable:** This is the variable that is manipulated or changed in an experiment. It forms the horizontal axis (x-axis) of a graph.
- **Control variable:** This is the variable that is kept constant so that the relationship between the independent and dependent variables can be found.
- **Investigative question:** It is a relationship between independent and dependent variables (the order is not fixed). It is phrased as a question with a question mark.
- **Hypothesis:** It is an assumption prediction about the actual relationship between the independent and dependent variables are/is and this can be proved right or wrong by doing an investigation. It is a statement but not a question.
- **Fair test:** This is an experiment (or investigation) in which there is only one independent variable.

PAPER 1(PHYSICS FOCUS)

- Learners must learn theory. There are obvious definitions statement/theories/laws/ principles/ processes that must be learnt [as stated in the Examination Guidelines].
- Learners must learn the laws, definitions and principles. These are ‘easy marks’ for learners to get.

N.B: Two marks are awarded for a correct definition/ law/ principle. No marks are available for an incorrect or partially correct definition.

❖ CALCULATIONS:

- Learners must always start with the formula/equation exactly as shown on the formulae sheet.
- Marks will be awarded for: Correct formula, correct substitution and correct answer with unit.
- Learners must not manipulate the formula before the substitution.
- No marks will be awarded if an incorrect or inappropriate formula is used, even though there may be relevant symbols and applicable substitutions.

❖ EXPLANATIONS AND INTERPRETATIONS:

- Learners must learn theory in order to correctly answer questions requiring interpretation or explanation.
- In the question, any explanation **MUST** always start with what stays constant, e.g. *“For a constant velocity of sound / speed if the frequency increases, λ decreases”*.
- Learners must learn the symbols so they can know their meanings and can therefore use the correct equation. Make sure learners know which symbols are **vectors** – these symbols will therefore also have a direction
- Learners must read questions slowly and thoroughly. Be sure what information has been given and what it is they have to calculate.
- Make sketches to make things easier and fill in as much information as possible on their sketches.
- If objects move in opposite directions, e.g. up and down or left and right, learners must allocate symbols for the directions before they do any calculations. Then stick to their decision (choices of directions).
- Learners must make sure whether friction can be ignored or if it is present.
 - Learners must know appropriate graphs: make a summary of all the graphs and advise learners to study them.
 - Graphs must be labelled / named.

N.B. Learners must make use of *subscripts* in equations to make things easier, e.g.

$$V_{tot} = I_{tot} x R_{tot} \text{ or } W_{net} = f_{net} \Delta x \cos \theta$$

But they must first write down the formula as written on the formula sheet.

❖ **MULTIPLE CHOICE QUESTIONS:**

- **MULTIPLE CHOICE QUESTIONS can be a powerful tool to assess learners' understanding of concepts (if used properly).**
- Use MULTIPLE CHOICE QUESTIONS to address ALL key aspects and concepts in Physics, as outlined in the Examination Guidelines.
- Do NOT focus on the correct answers ONLY. For example, Question 1.3 below can be used to address ALL aspects on VERTICAL PROJECTILE MOTION including GRAPHS.

1.3 A learner is standing on the roof of a 25m high building. She leans over the edge and throws a stone vertically upwards at $8\text{m}\cdot\text{s}^{-1}$. *Ignore the effects of air resistance.*

She wants to calculate the time it will take the stone from the moment she throws the stone until it hits the ground. She uses the equation

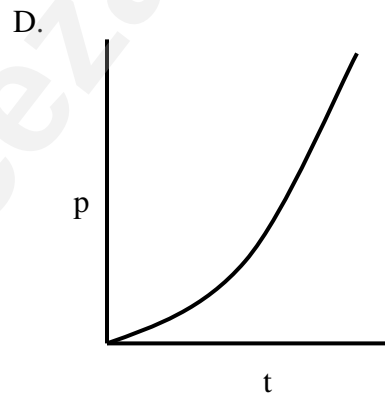
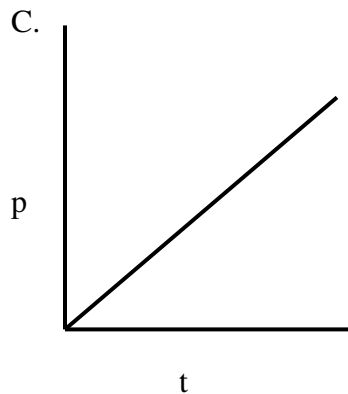
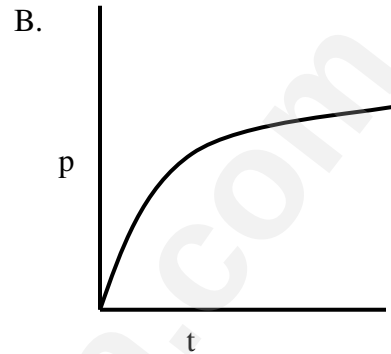
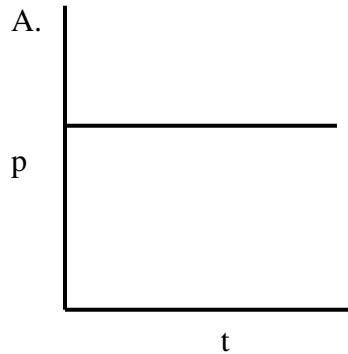
$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ for the calculation. Which of the following shows the correct substitutions for the calculation?

- A $25 = 8\Delta t + \frac{1}{2}(9,8)\Delta t^2$
 - B $-25 = 8\Delta t + \frac{1}{2}(9,8)\Delta t^2$
 - C $-25 = 8\Delta t + \frac{1}{2}(-9,8)\Delta t^2$
 - D $-25 = -8\Delta t + \frac{1}{2}(-9,8)\Delta t^2$
- Make sure to develop learners' skills in the answering of multiple choice questions. In cases where the answer is not immediately obvious, learners should go through steps of eliminating obviously incorrect answers.

NB: Please note that there will always be TWO statements or items that are obviously wrong. Eliminate them first.

Example 1: Multiple Choice Questions

A trolley starts from rest and is driven along a horizontal track by a motor which exerts a constant driving force. The effects of friction and air resistance can be neglected. Which one of the following graphs best represents the momentum of the trolley versus time?

**Approach**

Because of the *constant force* B and D are automatically out. The choice is now limited to A and C. C will be the correct answer because the trolley starts from rest (zero).

NB: Where calculations are involved, it is advisable to do the arithmetic before looking at possible solutions.

Example 2

Object A has kinetic energy E , object B of twice the mass is moving at twice the velocity of A. The kinetic energy of B is

A. E B. $2E$ C. 4 D. $8E$ **Approach**

$$E_k = \frac{1}{2}mv^2 = 2 \times 2^2 = 8$$

Therefore the correct answer is **D**

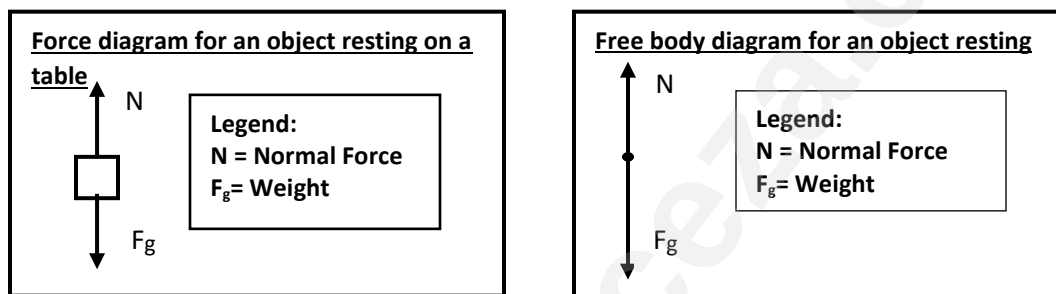
2. NEWTON'S LAWS AND APPLICATIONS

- The drawing of **free-body diagrams** is central to solving problems involving forces acting on objects and as such, teachers should emphasise this during their teaching/revision.

NB: Force diagrams and free body diagrams:

- In a force diagram we represent the object with a small block or circle and the forces that act on it with vector arrows.
- In a free body diagram the object is represented by a dot.

The force diagram and free body diagram for an object that rests on a table are as follows:



- The vector nature of forces is important (direction in which a force is exerted). The direction of a force determines the direction of the change in motion.
- Balanced forces cause a body to maintain its present state of motion (at a constant/uniform speed in a straight line or remaining at rest/stationary), and not a change in motion.
- In the absence of **net forces** or if the **net force** on an object is zero, a moving object tends to move along a straight line path indefinitely.

NB: Objects will undergo changes in motion only in the presence of net force or only if the net force is nonzero.

Note:

- Distinguish between forces acting ON the body and forces exerted BY the body. Only the forces acting ON the body affects its motion.
- Forces are represented by arrows.
- In the description of forces the **direction** must also be stated.
- “Gravity” is not a force, it should be “**gravitational force of earth on the body**”.

NB: Exam questions will require learners to apply Newton's Laws of motion to a variety of equilibrium and non-equilibrium problems including:

- ❖ A single object:
 - Moving on a horizontal plane with or without friction
 - Moving on an inclined plane with or without friction
 - Moving in the vertical plane (lifts, rockets, etc.)
- ❖ Two-body systems (joined by a light inextensible string):
 - Both on a flat horizontal plane with or without friction
 - One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley
 - Both on an inclined plane with or without friction
 - Both hanging vertically from a string over a frictionless pulley

When solving problems,

Newton's First TWO Laws of Motion (Newton I and II) form a whole and as such it is difficult to isolate them in a problem.

- If the body tends to **maintain its existing motion** (moves at a constant/uniform velocity), Newton's First Law applies.
- If an **accelerating body** is mentioned, or a (net) resultant force on a body, Newton's Second Law

Note: In the solving of typical Newton's Second Law problems, we distinguish between two situations:

- i. If only one force is acting on the body, use the formula, $F_{\text{net}} = ma$.
- ii. When TWO or more forces in opposite directions (horizontally or vertically) are acting on the body, firstly obtain an equation for the resultant/net force in terms of the two (or more) opposing forces [the net/resultant is always the bigger force minus the smaller force].
 - ❖ Try to consider systems involving pulleys(as well as masses horizontal and incline planes) where learners have to identify all the forces acting on different masses and use simultaneous equations to arrive at the answer.
 - ❖ Teachers need to explain to learners the purpose of pulleys in a system.
 - ❖ Emphasize the drawing of the free body diagrams, especially the skill to *isolate* the bodies and then identify the forces acting on each body.

LAW III: NEWTON'S THIRD LAW OF MOTION (the law of action-reaction)

Whenever one object exerts a force on a second object, the second object *simultaneously* exerts a force of equal magnitude but in the opposite direction on the first object.

- Newton's Third Law has no connection with the other two laws of motion.
- All forces in nature occur in pairs. Therefore an interaction exists between TWO bodies; this interaction is known as an **action-reaction pair**.
 - The action can be regarded as the force exerted by the first body on the second body,
 - The reaction would be the force exerted by the second body on the first body.
- The forces are of the same magnitude but act in opposite directions.
- The forces act simultaneously on **TWO different bodies** and therefore cannot be regarded as balanced forces.

NB: Application of Newton's Third Law is often integrated in **momentum** and **impulse** problems.

Newton's Universal Law of Gravitation

Every body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

NOTE: This law is more likely to be asked in Multiple Choice Questions to test learners understanding of variables (proportionalities):

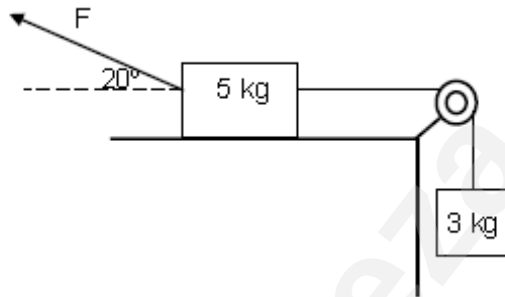
- Show how the gravitational force is directly proportional to the mass of both interacting objects (i.e. as the mass of either object increases, the force of gravitational attraction between them also increases).
- If the mass of one of the objects is doubled, then the force of gravity between them is doubled.
- If the mass of one of the objects is tripled, then the force of gravity between them is tripled.
- If the mass of both of the objects is doubled, then the force of gravity between them is quadrupled; and so on.
- Show how the gravitational force is inversely proportional to the square of the separation distance between the two interacting objects (i.e. as two objects are separated from each other, the force of gravitational attraction between them also decreases).
- If the separation distance between two objects is doubled (increased by a factor of 2), then the force of gravitational attraction is decreased by a factor of 4 (2 raised to the second power).
- If the separation distance between any two objects is tripled (increased by a factor of 3), then the force of gravitational attraction is decreased by a factor of 9 (3 raised to the second power).

QUESTION 2 (FREE STATE) NEWTON'S LAWS AND APPLICATIONS

A 5 kg block, resting on a rough horizontal surface, is connected by a light inextensible string passing over a light frictionless pulley to a second block of mass 3 kg hanging vertically.

An applied force F is acting on the 5 kg block as shown in the diagram below and the coefficient of kinetic friction between the 5 kg block and the surface is 0,2.

The 5 kg block accelerates to the left.



- 2.1 Define the term frictional force
- 2.2 Calculate the magnitude of the:
 - 2.3.1 Vertical component of F if the magnitude of the horizontal component of F equals 38 N
 - 2.3.2 Normal force acting on the 5 kg block
- 2.3 State Newton's Second Law of motion
- 2.4 Draw a labelled free-body diagram to indicate all the forces acting on the 3 kg block
- 2.5 Calculate the magnitude of the tension in the string connecting the two blocks

QUESTION 2 (NORTH WEST 2016) NEWTON'S LAWS AND APPLICATIONS

Two wooden blocks of masses 2 kg and 3 kg respectively are placed on a rough horizontal surface. They are connected by a string. A constant horizontal force of 10 N is applied to the second string attached to the 3 kg mass as shown in the diagram below. Assume that both strings are light and inextensible.



The system moves towards the right with a constant velocity

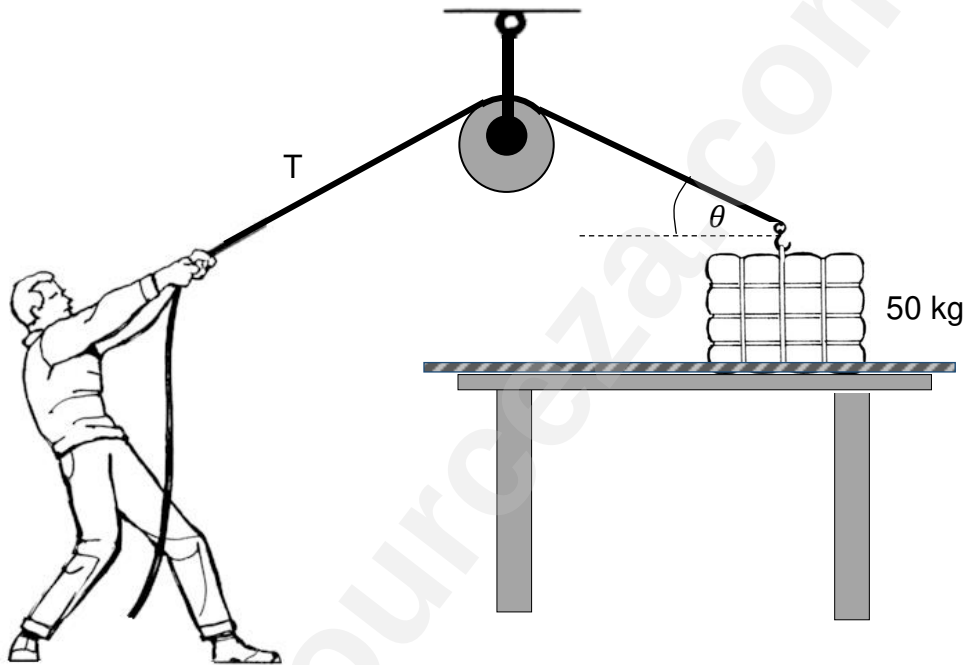
- 2.1 Define the term kinetic frictionless force
- 2.2 What is the magnitude of the net force acting on the system?
- 2.3 Draw a labelled free-body diagram showing ALL the forces acting on the 3 kg block as it moves towards the right
- 2.4 Calculate the coefficient of kinetic friction between the surface of the table and the two wooden blocks

The 10 N is increased to 30 N so that the system now accelerates

- 2.5 Calculate the acceleration of system

QUESTION 2 (WESTERN CAPE 2016) NEWTON'S LAWS AND APPLICATIONS

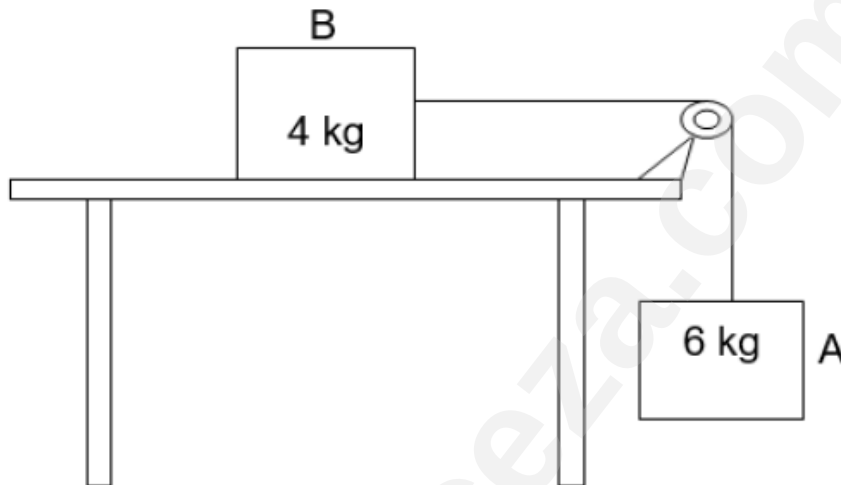
A man applies a constant pulling force on a heavy parcel of mass 50 kg using a light inextensible rope which passes over a light frictionless pulley as shown in the diagram below. The coefficient of static friction between the parcel and the rough table surface is 0,34. The magnitude of the maximum static frictional force is 120 N. Ignore the mass of the rope.



- 2.1 Draw a free-body diagram showing all forces exerted on the parcel
- 2.2 State, in words, *Newton's Second Law of Motion*.
- 2.3 Show that the magnitude of the vertical component of the tension force in the rope is 137,06 N.
- 2.4 Hence, determine the magnitude of the tension force in the rope (T) as well as the angle (θ) that the rope forms with the horizontal.
- 2.5 The man now increases the magnitude of his pulling force. Under the action of this new constant force, the parcel begins to slide horizontally along the table.
 - 2.5.1 How will the magnitude of the normal force change as the parcel slides across the table surface? State only INCREASES, DECREASES or REMAINS THE SAME.
 - 2.5.2 Give a reason for your answer to QUESTION 2.5.1.

QUESTION 2 (EASTERN CAPE 2016) NEWTON'S LAWS AND APPLICATIONS

A 4 kg block B, resting on a flat, rough horizontal table, is connected by a light inextensible string to a 6 kg block A. The string is passed over a light frictionless pulley in such a way that A hangs vertically downwards as shown in the diagram below.



- 2.1 Write down Newton's Second Law of motion in words.
- 2.2 Draw a free-body diagram of all forces acting on block B.
- 2.3 The kinetic frictional force experienced by block B is 32, 53 N to the left. Calculate the magnitude of the acceleration.
- 2.4 Calculate the coefficient of kinetic friction between the surface of the table and block B.
- 2.5 How will the frictional force on the block be affected if the 4 kg block is pulled at an angle of 30° to the horizontal?

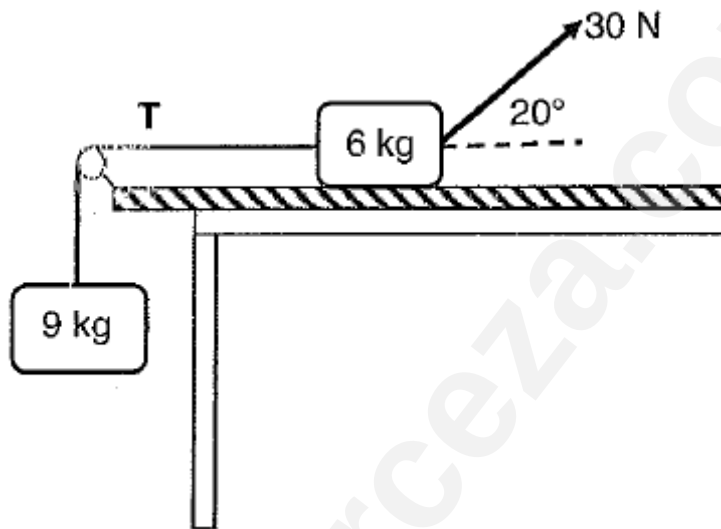
Write down INCREASE; DECREASE or REMAIN THE SAME.

Explain your answer.

QUESTION 2 (MPUMALANGA 2016) NEWTON'S LAWS AND APPLICATIONS

A block of mass 6 kg rests on a rough horizontal table. It is connected by a light inextensible string **T** which passes over a light frictionless pulley to another block of mass 9 kg hanging vertically as shown below.

When a 30 N force is applied to the 6 kg block at an angle of 20° to the horizontal, the 6 kg block accelerates at $3,35 \text{ m}\cdot\text{s}^{-2}$ TO THE LEFT.

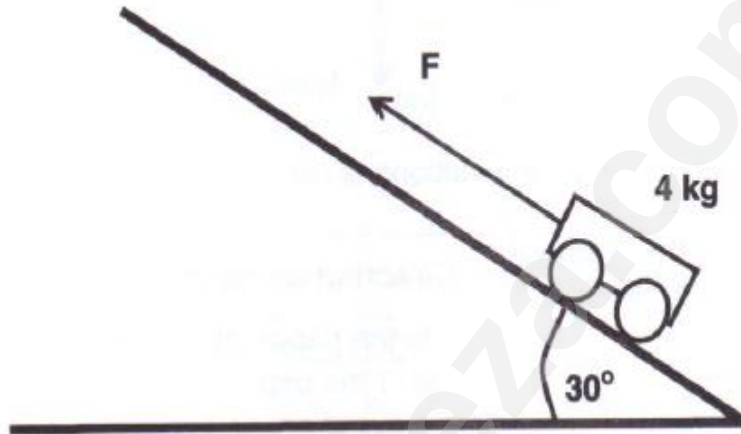


The coefficient of kinetic friction between the 6 kg block and the surface of the table is μ_k . Ignore the effects of air friction.

- 2.1 Draw a labelled free-body diagram that shows ALL the forces acting **on 6 kg block**.
- 2.2 Write down Newton's SECOND law in words.
Calculate the:
- 2.3 Normal force on the 6 kg block.
- 2.4 Tension in string **T**.
- 2.5 Coefficient of kinetic friction (μ_k) between the 6 kg block and the table.

QUESTION 2 (LIMPOPO 2016) NEWTON'S LAWS AND APPLICATIONS

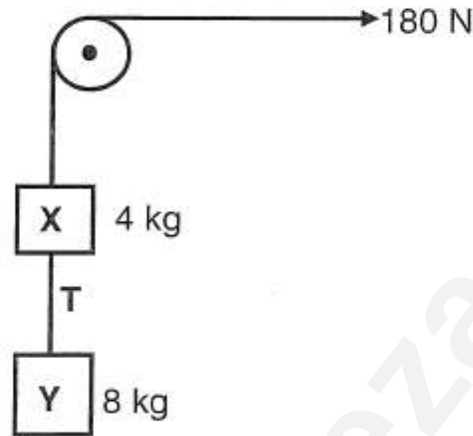
- 2.1 A 4 kg trolley is at rest on a rough inclined surface, which makes an angle of 30° with the horizontal. A constant force F is applied, causing the trolley to accelerate up the incline for 2m at $0,43 \text{ m}\cdot\text{s}^{-2}$. (Ignore the rotation effects of the wheels and air friction.)



- 2.1.1 State, in words, Newton's Second Law of Motion.
- 2.1.2 Draw a labelled free body diagram showing ALL the forces acting on the trolley as it moves up the slope.
- 2.1.3 If the coefficient of kinetic friction, μ_k , along the incline is 0,2, calculate the magnitude of the:
- Frictional force on the trolley as it moves up the slope
 - Applied force F .
- 2.2 A spaceship, mass 2 000 kg, is moving towards Earth. Calculate the magnitude of the gravitational force that the spaceship will experience when it is 100 km above the Earth's surface.

QUESTION 2 (GAUTENG 2016) NEWTON'S LAWS AND APPLICATIONS

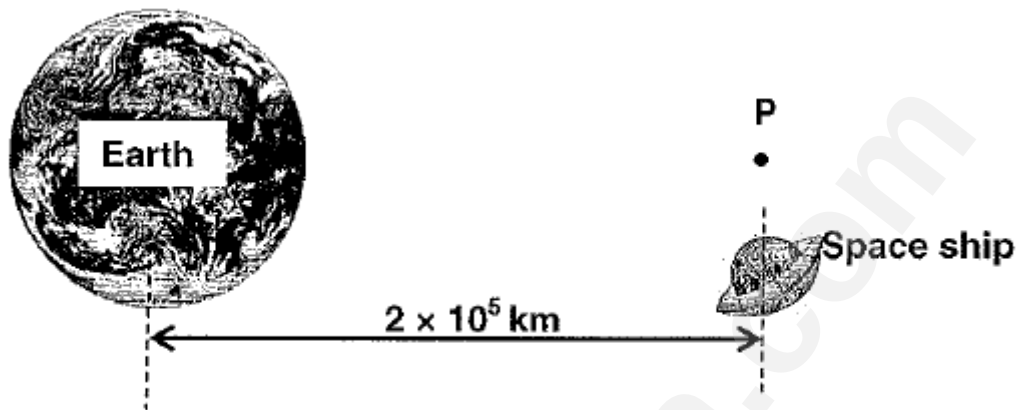
Block **X** mass of 4 kg is connected to block **Y** of mass 8 kg by a light, inextensible string. Another light, inextensible string attached to block **X** runs over a frictionless pulley. The system is pulled by means of a constant force of 180 N as shown in the diagram below. Ignore the effects of air resistance.



- 2.1 State *Newton's second law of motion* in words
- 2.2 Draw a labelled free body diagram showing ALL the forces acting on object X
- 2.3 Calculate the:
 - 2.3.1 tension T in the string connecting the two blocks
 - 2.3.2 magnitude of the acceleration of block X

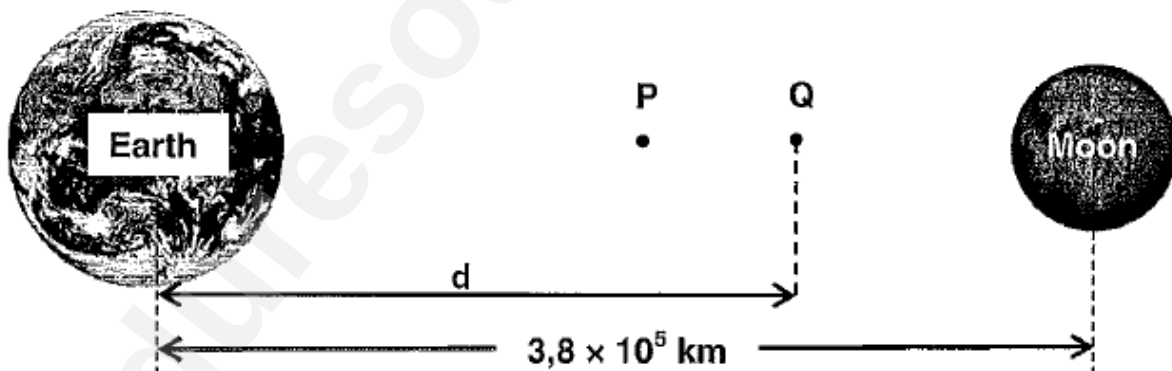
QUESTION 3 (MPULANGA 2016) NEWTON'S LAWS AND APPLICATIONS

A space ship, mass 3 500 kg, is at rest at point P, 2×10^5 km from the centre of the earth.



- 3.1 State *Newton's Law of Universal Gravitation* in words.
- 3.2 Calculate the magnitude of the gravitational force that the space ship experiences at point P.

Point Q is a point on a straight line between the moon and the earth. Point Q is a distance d from the centre of the earth. The space ship experiences a ZERO net force when it is at rest at point Q.



The mass of the moon is $7,35 \times 10^{22}$ kg and it is at average $3,8 \times 10^5$ km from the earth.

- 3.3 Calculate the distance between points P and Q.

3. VERTICAL PROJECTILE MOTION IN ONE DIMENSION (1D)

For vertical projectile motion (near the surface of the Earth if air friction is ignored)

It is important to note the following about free-falling bodies:

- In the absence of air friction, a body thrown upwards, downwards or released from rest is in **free fall**.
- The only force acting on the body is the **gravitational force of attraction (of earth)**.
- The acceleration of the body (g) remains constant throughout its fall.
- At or near the surface of Earth, the acceleration due to gravity is equal to approximately $9,8 \text{ m.s}^{-2}$ downwards.
- In the absence of air friction, any two bodies (regardless of their masses) will hit the ground at the same time if they are dropped from the same height simultaneously.
- For a free-falling body that is thrown upwards and return to the thrower's hand, the time taken for the upward motion is equal to the time taken for the downward motion.
- For a free-falling body that is thrown upwards and returns to the thrower's hand, the magnitude of the velocity at which the object leaves the thrower's hand (v_i) is equal to the magnitude of the velocity at which the object returns to the thrower's hand (v_f), although v_i and v_f are in opposite directions.
- Projectiles have **zero velocity** at their greatest height (maximum height).
- Projectiles can have their motion described by a single **set of equations** for the upward and downward motion.
- Emphasize the use of equations of motion, for e.g. to determine:
 - The greatest height reached given the velocity with which the projectile is launched upward (initial velocity)
 - The time at which a projectile is at a particular height given its initial velocity.
 - The height relative to the ground of the position of a projectile shot vertically upward at launch, given the time for the projectile to reach the ground.

NB: Exam questions will require learners to solve problems and sketch and interpret position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:

- A free-falling object
- An object thrown vertically upwards
- An object thrown vertically downwards
- Bouncing objects (restricted to balls)

Hints at Solving Problem Solving on Vertical Projectile Motion

1. Draw a diagram (showing the trajectory of a projectile).
2. Learners should be advised to determine and show the frame of reference of motion before they start with the question e.g. upward motion as positive / downward motion as negative.[Choose the direction of displacement (velocity or acceleration) that is to be positive]

If downward motion is taken as positive	If upward motion is taken as positive
$g = +9,8\text{m.s}^{-2}$	$g = -9,8\text{m.s}^{-2}$
For an object moving upwards: $v < 0$ For an object moving downwards: $v > 0$ For an object at its highest position: $v = 0$	For an object moving upwards: $v > 0$ For an object moving downwards: $v < 0$ For an object at its highest position: $v = 0$
For an object at any position above its starting point: $\Delta y < 0$ For an object at any position below its starting point: $\Delta y > 0$ For an object at its starting point: $\Delta y = 0$	For an object at any position above its starting point: $\Delta y > 0$ For an object at any position below its starting point: $\Delta y < 0$ For an object at its starting point: $\Delta y = 0$

1. Write down what you are given (in symbols, remember the sign).
2. Write down what you want to find.
3. Write down the appropriate kinematic equation.
4. Always write the complete equation first and show all substitutions, even zero values.
5. Place a unit after every final answer.
6. The acceleration due to gravity is **always constant and downwards** and may be +ve or -ve depending upon choice of sign convention.
7. The use of a velocity-time (v-t) graph often simplifies the calculation.

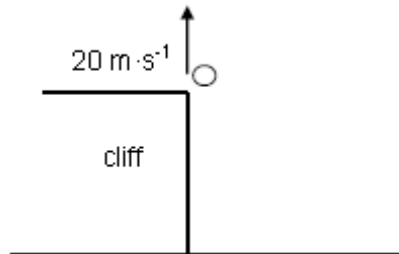
Represented on the graph are all of the **five** variables i.e. v and t , the intercept on the v axis is $v_i(t=0)$, the slope is a and the area under the graph is $\Delta x/\Delta y$.

- At the **maximum or highest point**, the **velocity** of the object is zero.
- The **y intercept** of a velocity time graph is the **initial velocity** of the object
- The **x intercept** of a velocity time graph gives the **time taken** to reach the maximum height.
- The **gradient or slope** of a velocity time graph is the **acceleration** of the object.
- The **area** under a velocity time graph is a measure of **displacement**.

8. Do not confuse instant velocity, and acceleration.

QUESTION 3 (FREE STATE 2016) VERTICAL PROJECTILE MOTION

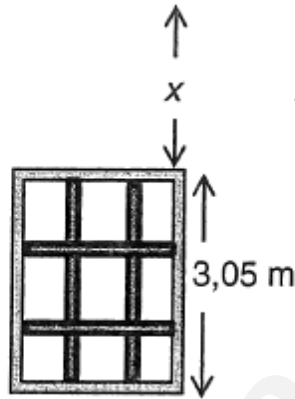
A boy, standing on the edge of a cliff, projects a ball vertically at a speed of $20\text{m}\cdot\text{s}^{-1}$. On its return the ball passes the boy and reaches the ground at the bottom of the cliff 6 s after it was projected. Ignore all effects of air friction.



- 3.1 Define the term *free fall*
- 3.2 Give the magnitude and direction of the acceleration of the ball the moment it reaches its maximum height
- 3.3 Calculate the time taken by the ball to pass the boy on its way downward
- 3.4 Calculate the height of the ball above the ground 2, 8 s after it is released
On reaching the ground, the ball bounces inelastically from the ground.
- 3.5 Sketch a position-time graph for the motion of the ball from the time it is projected till it reaches its maximum height after the first bounce. Use the top of the cliff as zero position. Clearly indicate the time of 6 s on the graph

QUESTION 3 (NORTH WEST 2016) VERTICAL PROJECTILE MOTION

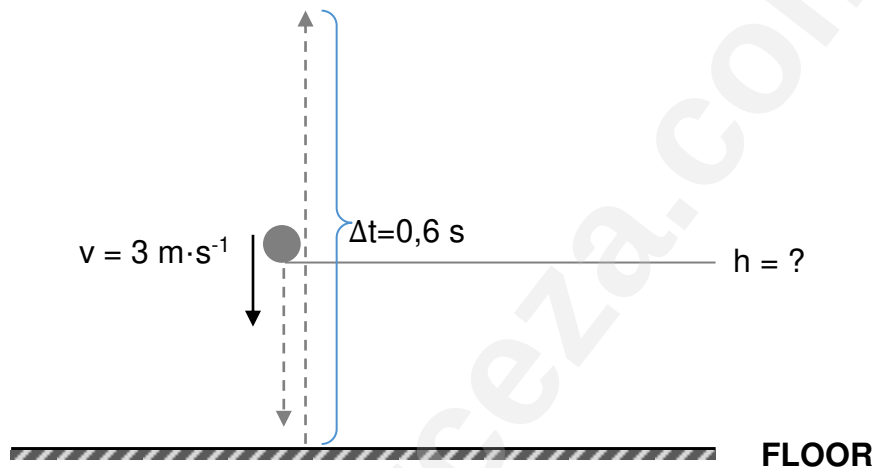
A stone is dropped from the roof of a tall building. After it has fallen a distance of x metres, it passes a window which is 3,05 m high in 0,1 s. Refer to the diagram below.



- 3.1 Define the term *free fall*
- 3.2 In which direction is the stone accelerating as it passes the window? Write down only UPWARDS, DOWNWARDS
- 3.3 Prove that the distance of x metres, between the roof and the top of the window is 45,95 m
- 3.4 Sketch a velocity-time graph from the instant the stone is dropped to the time it reaches the top of the window. Indicate the velocity when it reaches the top of the window.

QUESTION 3 (WESTERN CAPE 2016) VERTICAL PROJECTILE MOTION

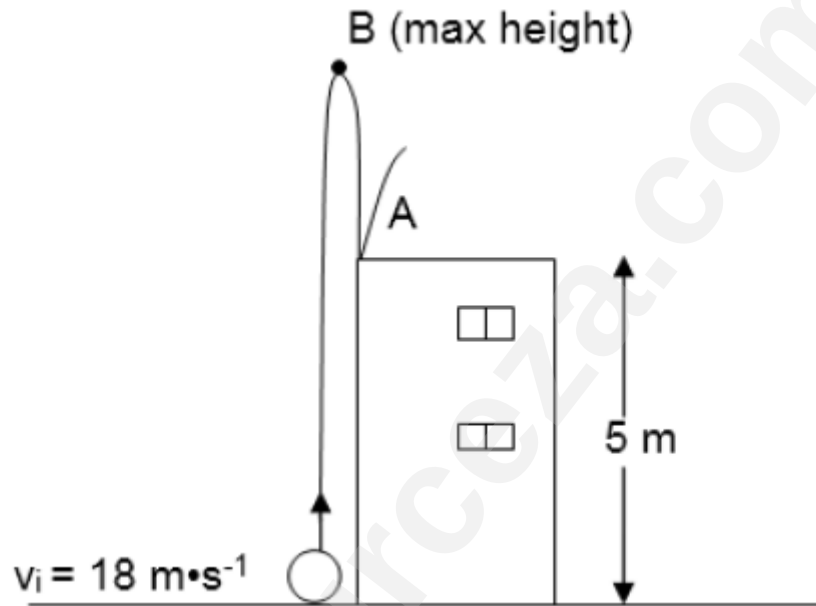
A girl is playing in her bedroom with a super bouncy ball which has a mass of 50 g. The girl throws the super bouncy ball straight down towards the ground from an unknown height(h) with a speed of $3 \text{ m}\cdot\text{s}^{-1}$. It hits the ground and bounces straight up past her and it reaches its maximum height 0,6 s after bouncing. Ignore the effects of air friction.



- 3.1 Calculate the speed with which the ball leaves the floor after bouncing.
- 3.2 If the ball loses 5% of its kinetic energy during each bounce, calculate the kinetic energy of the ball just before its first bounce.
- 3.3 Using energy principles, determine the height from which the girl threw the ball.
- 3.4 Using the ground as reference, sketch a position vs time graph showing the motion of the bouncy ball from the moment the ball is thrown until it reaches its maximum height after the first bounce.

QUESTION 3 (EASTERN CAPE 2016) VERTICAL PROJECTILE MOTION

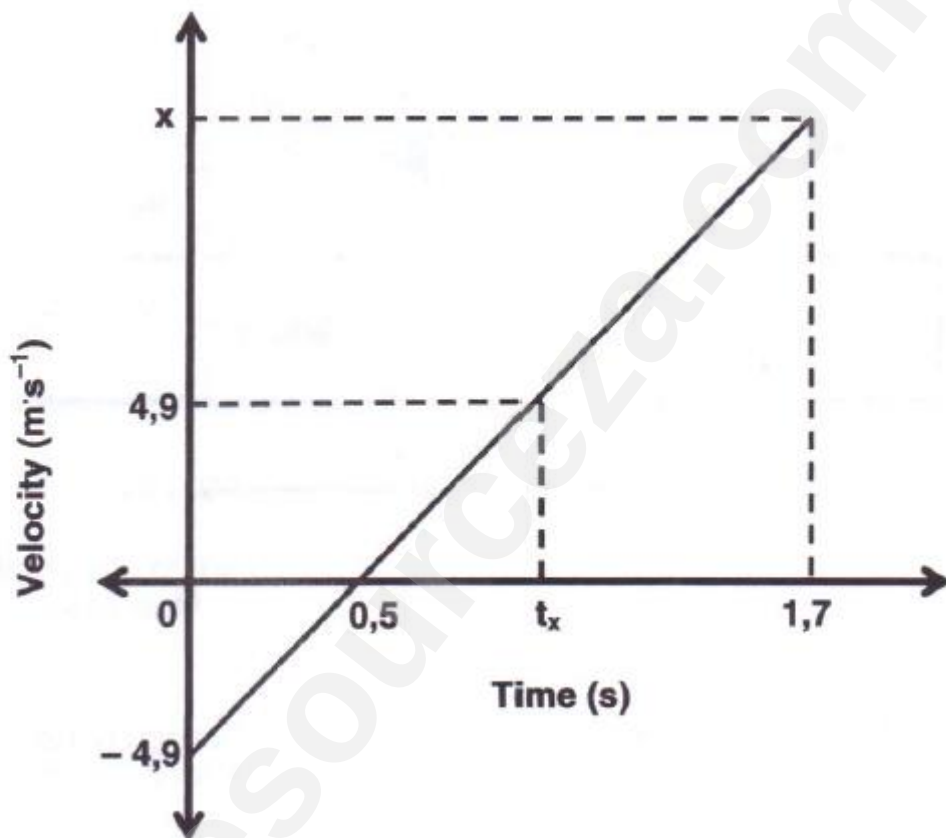
A ball is projected vertically upwards from the ground with a speed of $18\text{ m}\cdot\text{s}^{-1}$. It passes the roof of a 5 m tall building on its way up and reaches its maximum height at **B**. On its way down, the ball strikes the roof of the building at point **A** as shown in the diagram below. Ignore the effects of air friction.



- 3.1 Write down the magnitude of the velocity of the ball at point **B** the maximum height above the ground.
- 3.2 Write down the magnitude and direction of the acceleration of the ball at point **B**.
- 3.3 Calculate the following regarding the ball:
 - 3.3.1 The time it takes to reach point **B** above the ground
 - 3.3.2 The velocity at the instant it strikes the roof at point **A**
 - 3.3.3 The total time it takes, from the instant it is projected to the time it strikes the roof at point **A**
- 3.4 Sketch the velocity-time graph for the motion of the ball from the ground up until it hits the roof of the building.
Indicate the following on your graph:
 - i. initial velocity
 - ii. time at point **B** (the maximum height)
 - iii. final velocity

QUESTION 3 (LIMPOPO 2016) VERTICAL PROJECTILE MOTION

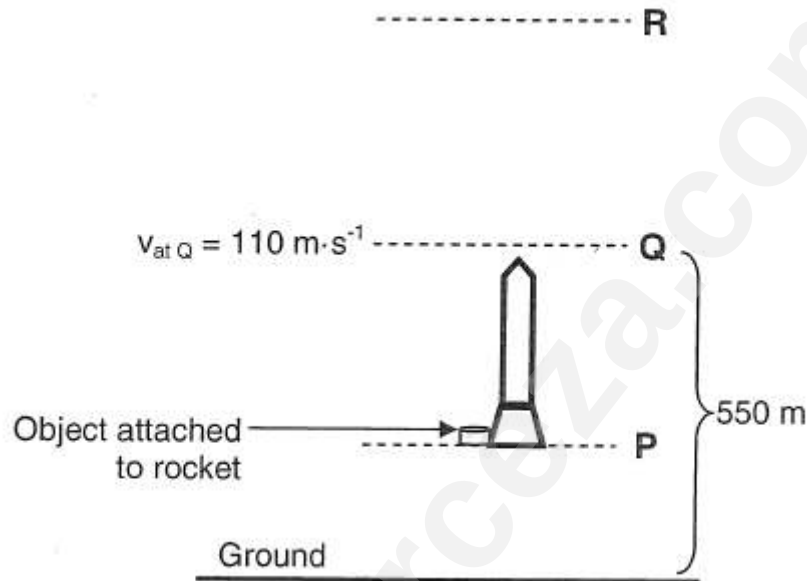
The velocity – time graph below shows the motion of a ball that is thrown vertically upwards from the balcony of a building. It takes 0,5 for the ball to reach the highest point above the balcony, after which it falls past the balcony and strikes the ground. Ignore the effects of friction.



- 3.1 State the numerical value of:
 - 3.1.1 The gradient of the above velocity – time graph.
Provide a reason for your answer.
 - 3.1.2 Time, T_x , as shown on the graph.
- 3.2 Use ONLY the graph (and NOT equations of motion) to determine the maximum height the ball reaches above the balcony.
- 3.3 Calculate, using equations of motions and data from the graph, the:
 - 3.3.1 Velocity, x , with which the ball strikes the ground
 - 3.3.2 Height of the balcony above the ground
- 3.4 Sketch an acceleration versus time graph for the motion of the ball.

QUESTION 3 (GAUTENG 2016) VERTICAL PROJECTILE MOTION

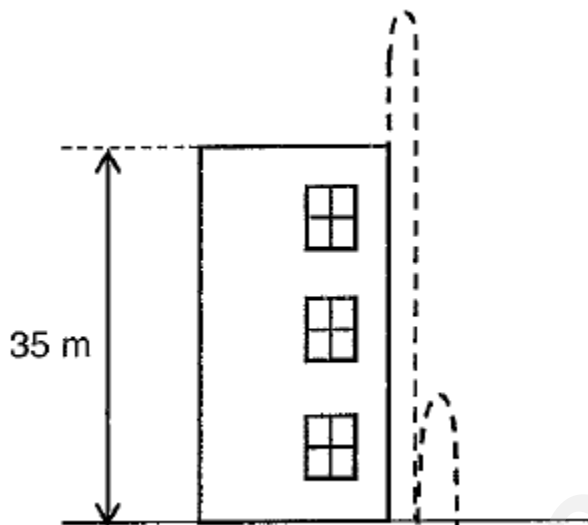
A stationary rocket on the ground is launched vertically upwards. When it is 550 m above the ground (point Q) an object is released from the rocket. At this instant the velocity of the rocket is $110 \text{ m}\cdot\text{s}^{-1}$. The object reaches its MAXIMUM height ABOVE ground at point R. Ignore the effects of air friction



- 3.1 Give a reason why the object keeps moving upwards after it is released from the rocket
- 3.2 What is the direction of the acceleration of the object at:
 - 3.2.1 Point P
 - 3.2.2 Point R
- 3.3 ONLY use EQUATIONS OF MOTION to calculate the time taken by the OBJECT to...
 - 3.3.1 reach its maximum height after being released from the rocket at point Q
 - 3.3.2 reach the ground after being released from the rocket at point Q
- 3.4 Sketch the velocity versus time graph for the complete motion of the object. On the graph indicate the following:
 - Initial velocity
 - Time to reach its maximum height
 - Time when it reaches the ground

QUESTION 3 (MPUMALANGA 2014) VERTICAL PROJECTILE MOTION

A ball is projected vertically upwards from the roof of a 35 m high building at a velocity of $15 \text{ m}\cdot\text{s}^{-1}$. The ball reaches the ground and bounces back.



- 3.1 Define the term projectile.
- 3.2 Calculate the:
 - 3.2.1 Maximum height the ball reaches above the ground.
 - 3.2.2 Time taken by the ball to reach the ground for the first time.
- 3.3 Sketch a velocity-time graph for the motion of the ball, from the time it was projected until it reaches the ground after the bounce.

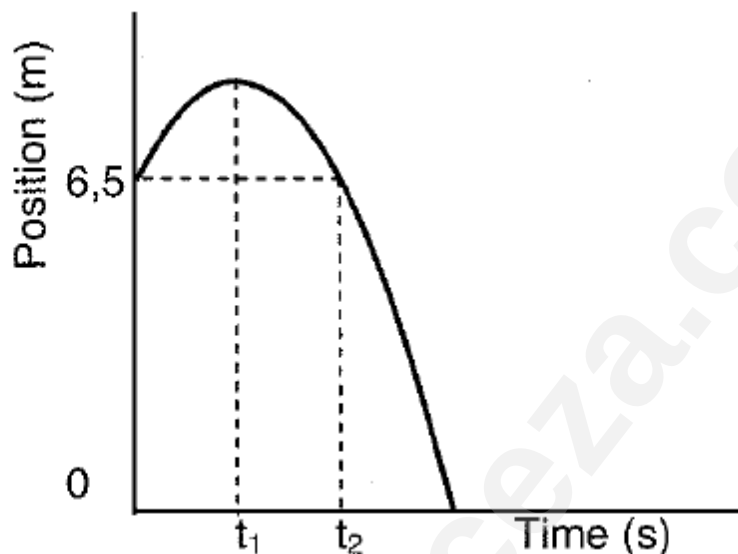
Show the following clearly on the graph:

 - (a) The initial velocity of the ball.
 - (b) The time taken to reach the ground for the first time.

QUESTION 3 (GAUTENG 2014) VERTICAL PROJECTILE MOTION

The position-time graph for a tennis ball thrown vertically upwards from the second floor of a school building is shown below.

Ignore all effects of air friction.

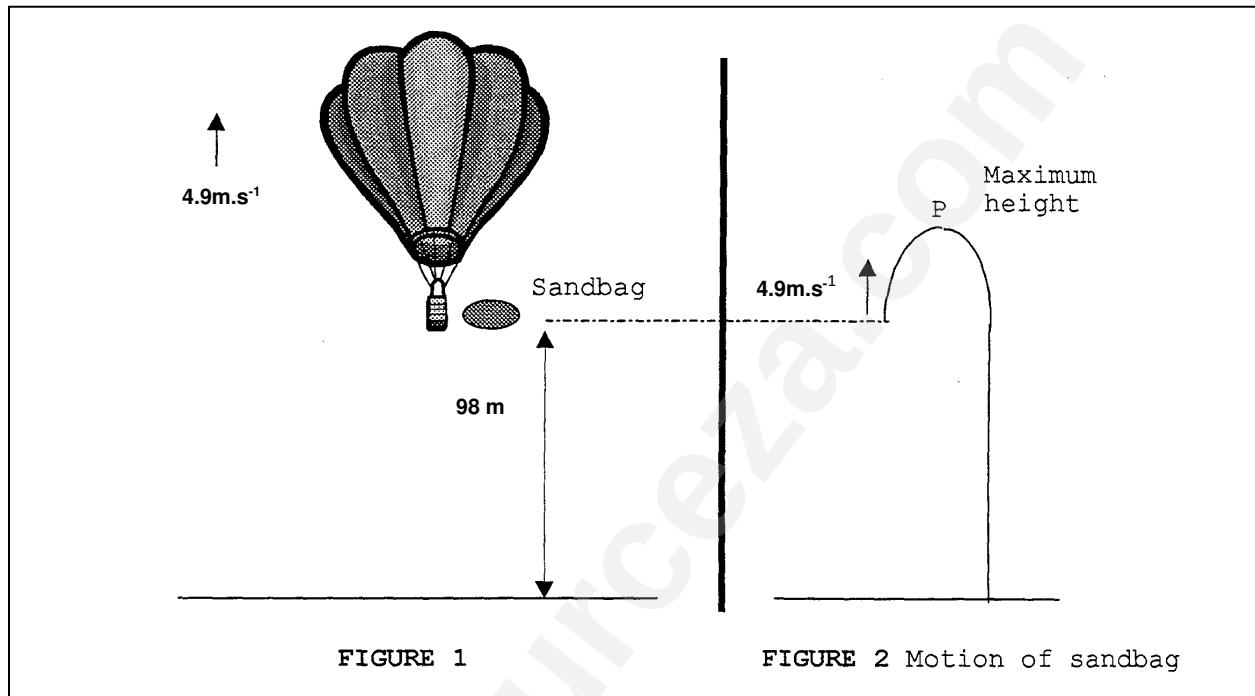


The height of the second floor is 6,5 m. The ball rises 0,9 m from the point projection before it starts to fall to the ground.

- 3.1 Write down the magnitude and direction of the acceleration of the ball while it is moving upwards.
- 3.2 Calculate the time t_1 it takes the ball to reach its maximum height.
- 3.3 Calculate the initial velocity of the tennis ball the instant it is released.
- 3.4 Sketch a velocity-time graph for the motion of the ball from the moment it is thrown vertically upwards till it reaches the ground. Label the axes and show all the relevant values on the graph.

QUESTION 3 Hot Air Balloon

A hot-air balloon is rising upwards at a constant velocity of 4.9 m.s^{-1} . When the balloon is 98 m above the ground, a sandbag is dropped from it (see **FIGURE 1**). **FIGURE 2** shows the path of the sandbag as it falls to the ground. Ignore air resistance.



- 3.1 At the instant the sandbag is dropped, it moves upwards with reference to the ground. Give a reason for this observation
- 3.2 What is the magnitude of the acceleration of:
 - 3.2.1 The hot-air balloon while the sandbag is in it
 - 3.2.2 The sandbag the moment it is dropped from the hot-air balloon
- 3.3 Will the velocity of the hot-air balloon **INCREASE**, **DECREASE** or **REMAIN THE SAME** immediately after the sandbag has been released? Explain fully.
- 3.4 Determine the maximum height **P**, above the ground, reached by the sandbag after it is released from the hot-air balloon.
- 3.5 Calculate the time taken for the sandbag to reach this maximum height after it has been released.
- 3.6 Calculate the total time taken for the sandbag to reach the ground after it has been released.

4. MOMENTUM AND IMPULSE

- Define linear momentum as the product of an object's mass and its velocity.
- Linear momentum is a vector quantity has the same direction as the velocity of the object.
- Calculate the linear momentum from a moving object using $p = mv$.
- State Newton's Second Law in terms of momentum: The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.
- Express Newton's Second law in terms of momentum in symbols: $F_{\text{net}} = \frac{\Delta p}{\Delta t}$
- Explain the relationship between net force and change in momentum for a variety of motions.
- Calculate the change in momentum when a resultant force acts on an object and its velocity:
 - Increases in the direction of motion (e.g. 2nd stage rocket engine fires)
 - Decreases (e.g. brakes are applied).
 - Reverses its direction of motion e.g. a soccer ball kicked back in the direction it came from.
- Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum in each of the above cases.

Impulse

- Define the impulse of a force as *the product of the average net force and the time interval during which the resultant/net force acts on the object.*
- Deduce the impulse-momentum theorem : $F_{\text{net}} \Delta t = \Delta p$
- Solve problems involving impulse and change in momentum when the applied force is in the **horizontal** or **vertical direction**.
- Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.

Note:

$$\begin{aligned}\Delta p &= \Delta(mv) \\ &= p_{\text{after}} - p_{\text{before}} \\ &= mv_f - mv_i \\ &= m(v_f - v_i)\end{aligned}$$

- Apply the concept of impulse to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.

NB: For all safety futures use the formula: $F_{\text{net}} = \frac{\Delta p}{\Delta t}$

And note that the purpose of airbags, seatbelts and arrestor bedsits to **increase the time during which momentum changes** and according to the equation $F_{\text{net}} = \frac{\Delta p}{\Delta t}$ the **force during impact will decrease**.

Conservation of Linear Momentum

- Explain what is meant by a **closed/an isolated system** (in Physics), i.e. *a system on which the resultant/net external force is zero*.
- A closed/an isolated system excludes **external forces** that originate outside the colliding bodies, e.g. friction. Only **internal forces**, e.g. contact forces between the colliding objects, are considered.
- State the principle of conservation of linear momentum:

The law of conservation of linear momentum: *The total linear momentum of an isolated system remains constant (is conserved).*

In problems where the Law Conservation of momentum is used, always start with:

Total momentum before collision/explosion = Total momentum after collision/explosion

OR $p_{\text{before}} = p_{\text{after}}$
 $m_1 v_i + m_2 v_i = m_1 v_f + m_2 v_f$

Elastic and Inelastic Collisions

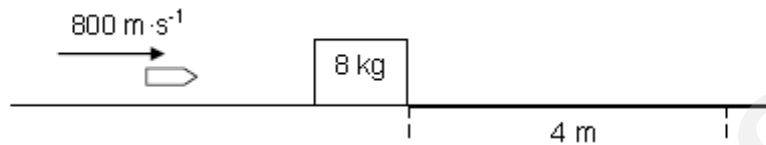
- During an elastic collision, both momentum and kinetic energy are conserved.
- During an inelastic collision, only momentum is conserved.

NB: In order to prove that a collision is elastic or not, the TOTAL kinetic energy of the bodies are calculated before the collision and after the collision SEPARATELY.

If the TOTAL kinetic energy of the bodies before the collision equals the TOTAL kinetic energy of the bodies after the collision, then the collision is **elastic**. If not, the collision is **inelastic**.

QUESTION 4 (FREE STATE 2016) MOMENTUM & IMPULSE

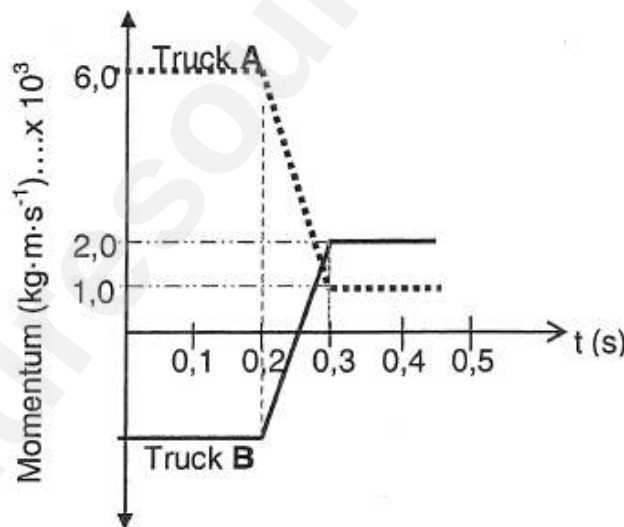
The diagram below shows a bullet, of mass 40 g, that is travelling horizontally at a speed of $800 \text{ m}\cdot\text{s}^{-1}$. The bullet strikes a stationary block of mass 8 kg and becomes embedded in it. The bullet and the block together travel on a rough horizontal surface for 4 m before coming to a stop.



- 4.1 Define in words the term *impulse*
- 4.2 Calculate the change in momentum of the block caused by the impact of the bullet
- 4.3 Use energy principles to calculate the magnitude of the frictional force acting on the block after impact with the bullet.

QUESTION 4 (NORTH WEST 2016) MOMENTUM & IMPULSE

Truck A of mass 2 000 kg moving eastwards collides with truck B of mass 1 500 kg. The graph (Not drawn to scale) shows how the momentum of each of the trucks varies with time.



- 4.1 Write down the principle of conservation of linear momentum
- 4.2 Write down the initial momentum of truck A
- 4.3 Determine the magnitude and direction of the velocity of truck B before the collision
- 4.4 Is the collision between the trucks ELASTIC or INELASTIC? Show how you arrived at the answer by means of calculations

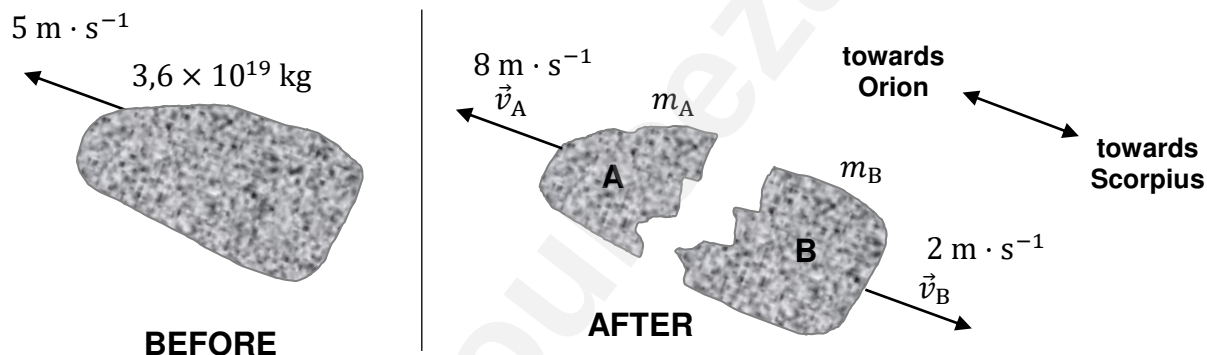
QUESTION 4 (WESTERN CAPE 2016) MOMENTUM & IMPULSE

Scientists are investigating the possibility of making use of a subsurface nuclear explosive in order to deflect asteroids from possible collision with the Earth.

Such a nuclear explosive was buried beneath the surface of an asteroid of mass $3,6 \times 10^{19} \text{ kg}$. Before detonation, a stationary astronaut on a nearby spacecraft measured the velocity of the asteroid to be $5 \text{ m} \cdot \text{s}^{-1}$ towards the constellation of Orion. When the explosive was detonated the asteroid split into two fragments, **A** and **B**.

The explosion projected the two fragments **A** and **B** in opposite directions towards the constellations Orion and Scorpius with speeds of $v_A = 8 \text{ m} \cdot \text{s}^{-1}$ and $v_B = 2 \text{ m} \cdot \text{s}^{-1}$ respectively.

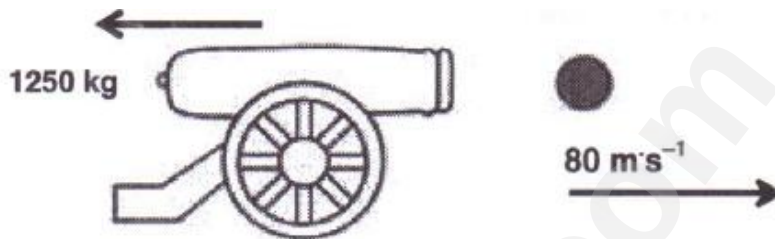
NB. All speeds are measured relative to the spaceship.



- 4.1 State, in words, the *principle of conservation of linear momentum*.
- 4.2 Show that fragment A has a mass of $2,52 \times 10^{19} \text{ kg}$.
- 4.3 Hence determine the impulse experienced by asteroid fragment A.
- 4.4 The two fragments move apart from each other and after some time their centres of mass are 150 km apart. Calculate the magnitude of the gravitational force that the two asteroid fragments exert on each other.

QUESTION 4 (LIMPOPO 2016) MOMENTUM & IMPULSE

A cannon has a mass of 1 250 kg and is 1 000 times heavier than the cannon ball that it fires during a routine training exercise. The cannon ball leaves the barrel at a horizontal velocity of $80\text{m}\cdot\text{s}^{-1}$



The cannon **comes to rest** 1 second after being fired.

- 4.1 Define, in words, the term *impulse*.
- 4.2 Calculate the:
 - 4.2.1 Maximum velocity with which the cannon moves backwards
 - 4.2.2 Magnitude of the average net force that causes the cannon to come to rest

QUESTION 4 (EASTERN CAPE 2016) MOMENTUM & IMPULSE

A man and a woman each wearing roller skates, stand facing each other on a flat frictionless horizontal surface. The man pushes the woman and the woman moves to the right at $4\text{m}\cdot\text{s}^{-1}$



- 4.1 State the *principle of conservation of linear momentum* in words.
- 4.2 The masses of the man and the woman are 80 kg and 50 kg respectively.

How does the impulse on the woman compare to that on the man?

Write **only** GREATER THAN, SMALLER THAN or EQUEAL TO.
- 4.3 Calculate the man's velocity immediately after pushing the woman away from him.
- 4.4 Calculate the impulse on the woman.

5. WORK ENERGY AND POWER

- The drawing of **free-body diagrams and Applications of Newton's Laws Motion** is central to solving problems involving Work, Energy and Power and as such, teachers should emphasise this during their teaching/revision.
- The Conservation of linear momentum is often intergraded with Work, Energy and Power in the examination.

Key Concepts:

- What is Work ?
- Work done on an object by a constant force
- Work done on an object by conservative forces
- Work done on an object by non-conservative forces
- Work-energy theorem
- Conservation of Mechanical Energy
- Power

Prerequisites:

Some familiarity with the following concepts would be helpful in understanding the information in this module.

- Vectors
- Different kinds of forces
- Newton's Laws of Motion
- Energy and Conservation of Energy

PART A: THE WORK-ENERGY THEOREM

- Exam questions that require to application of the Work-Energy Theorem may be asked on the following cases/contexts:
 - In the horizontal plane [with and without friction]
 - In the vertical plane [with and without friction]
 - On the inclined plane [with and without friction]
- It is very important to draw a **Force Diagram** or a **Free Body Diagram** before trying to solve the problem. (**Grade 11 work – different kinds of forces**).
- The formula $W = F \Delta x \cos \theta$ is applicable for any force. For example, if the work done by the frictional has to be calculated then the formula will be adapted to

$$W_{\text{friction}} = F_{\text{friction}} \Delta x \cos \theta$$

- Equation $W_{\text{net}} = \Delta E_k$ (i), state the Work-Energy Theorem as an equation.
- In words the **Work-Energy Theorem** states that: *“The work done on an object by a net force is equal to the change in kinetic energy of the object”*.

From the work energy theorem, $W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = \Delta E_k$(ii)

For purposes of calculations, equation (ii) can be used for calculations involving horizontal and vertical motion of objects, as well as motion on inclined planes.

- The starting point for applying this theorem is to identify whether the object is **accelerating or not**.
 - If the acceleration is zero (velocity is constant or zero) then **W_{net} is zero** as well as (**F_{net} and ΔK is zero**).
 - If the acceleration is not zero then there is a resultant force in the direction of the acceleration. (**Newton’s Second Law of Motion**)
Determine this resultant force and then solve the equation.
 - Remember that the resultant/net force is in the direction of the acceleration. This is not necessarily in the direction of the motion (negative acceleration) so the value of θ may either be 0° or 180° .

Note that:

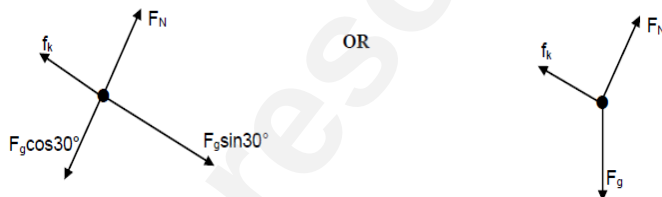
- If an object moves at **CONTANT VELOCITY**, the work done by the net force is zero because there is no change in kinetic energy. Individual forces can however do individual works.
- If the kinetic energy of an object decreases, the work done on it by the net force is negative.
- If the kinetic energy of an object increases, the work done on it by the net force is positive.

- If you are not restricted to use the Work-Energy Theorem, then in addition to the above formulae, apply the relevant formula from the list below to solve the problem:
 - $V_f^2 = V_i^2 + 2a \Delta x$ (When acceleration is uniform)
 - $0 = \Delta U + \Delta K$ (When mechanical energy is conserved)
 - $(U + K)_i = (U + K)_f$ (When mechanical energy is conserved)
 - $W_{nc} = \Delta U + \Delta K$ (When mechanical energy is not conserved i.e. when non-conservative forces act on the object)

- **Motion on Inclined Plane**

- Before we attempt to apply the work-energy theorem to problems involving inclined planes we must first familiarize learners with the **components of weight (F_g)** on the incline plane.
- Therefore, the trigonometry of the inclined plane as it relates to F_g and N and their components must be sharpened.
- Learners should know that the normal force for the same object differs in magnitude when it is on an inclined surface and when it is on a horizontal surface.
- We use axes perpendicular and parallel to the inclined plane to resolve the weight into its components.
- The reason for this is that the component of the weight parallel to the surface of the inclined plane influences motion on the plane and must be taken into account when dealing with motion on the inclined plane.

NB: In case of an incline plane, do not put the weight as well as the components on the same diagram, this will mean that the weight is applicable twice. (Use either the weight or the components of the weight).



- As already mentioned, the formula $W = F \Delta x \cos \theta$ is applicable for any force. For example, if the work done by the frictional has to be calculated then the formula will be adapted to

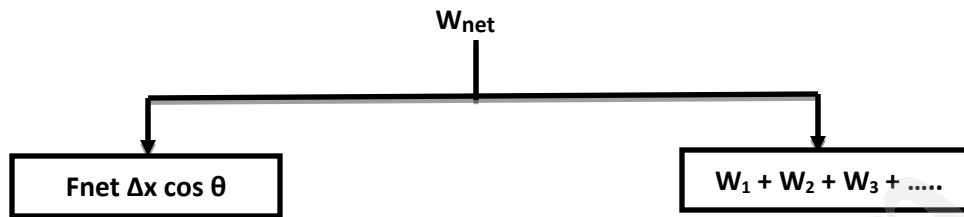
$$W_{f_k} = F_{f_k} \Delta x \cos \theta$$

- Remember to determine the value of θ (**the angle between the force doing work and the displacement**) and substituting this value.

NB: $\sin \theta$ comes in when motion is on an inclined plane.

$F_{g\parallel} = mg \sin \theta$ on the surface of the **inclined plane**, where θ is the angle between the inclined plane and horizontal in this case.

STRATEGY FOR SOVING PROBLEMS USING THE WORK-ENERGY THEOREM



1. Draw a force or free body diagram showing **all** forces acting on the object.
2. Write down the equation: $W_{\text{net}} = \Delta E_k$
3. If the equation in 1 cannot solve the problem, write the following:

$$W_{\text{net}} = \Delta E_k$$

$$F_{\text{net}} \Delta x \cos \theta = \Delta E_k$$

4. If the equation in 2 cannot solve the problem, write the following:

$$W_{\text{net}} = \Delta E_k$$

$$W_1 + W_2 + \dots = \Delta E_k$$

To use equations in 3 or 4 you will need the following information:

5. Find F_{net} i.e. the resultant force acting on the object. Use a free body diagram to help you.
OR identify the individual forces for which F_{net} is the SUM.
6. Find the angle θ between F_{net} (OR each force acting on the object) and Δx . It can ONLY be 0° OR 180°

Note: $\theta = 0^\circ$: $\mathbf{F}$ and $\Delta \mathbf{x}$ have the same direction. $\mathbf{F}$ does positive work

$\theta = 90^\circ$: $\mathbf{F}$ is perpendicular to $\Delta \mathbf{x}$. $\mathbf{F}$ does no work on the object.

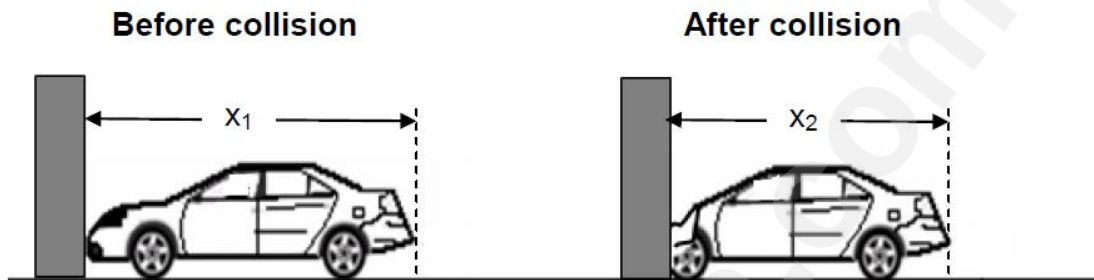
$\theta = 180^\circ$: $\mathbf{F}$ and $\Delta \mathbf{x}$ have opposite direction. $\mathbf{F}$ does negative work

7. You will need the mass of the object and its velocities, initial and final, wherever applicable.
8. Calculate the work done by each of the forces.
9. If an object moves at a **constant velocity**, the net work done (W_{net}) on an object is *zero* ($W_{\text{net}}=0$).

NB. Find the **Sum of All the Work Done** on the object and equate them to zero and then find the unknown. Always check your answer for correctness.

QUESTION 5A: [NOV. 2012] HORIZONTAL PLANE

In order to measure the net force involved during a collision, a car is allowed to collide head-on with a flat, rigid barrier. The resulting crumple distance is measured. The crumple distance is the length by which the car becomes shorter in coming to rest.

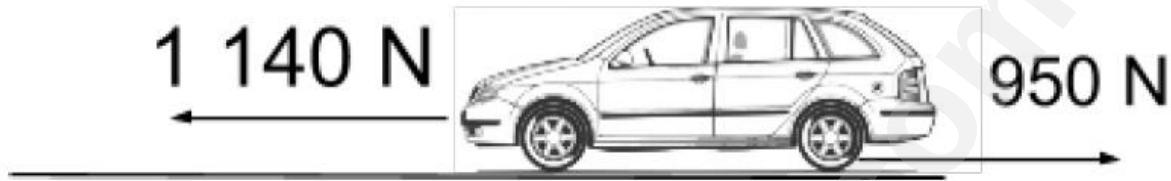


In one of the tests, a car of mass 1 200 kg strikes the barrier at a speed of 20 m s^{-1} . The crumple distance, $(x_1 - x_2)$, is measured as 1,02 m. (Ignore the effects of frictional forces during crumpling.)

- 5.1 Draw a labelled free-body diagram showing ALL the forces acting on the car during the collision. (3)
 - 5.2 State the *work-energy theorem* in words. (2)
 - 5.3 Assume that the net force is constant during crumpling.
 - 5.3.1 USE THE WORK-ENERGY THEOREM to calculate the magnitude of the net force exerted on the car as it is brought to rest during crumpling. (4)
 - 5.3.2 Calculate the time it takes the car to come to rest during crumpling. (4)
- [14]**

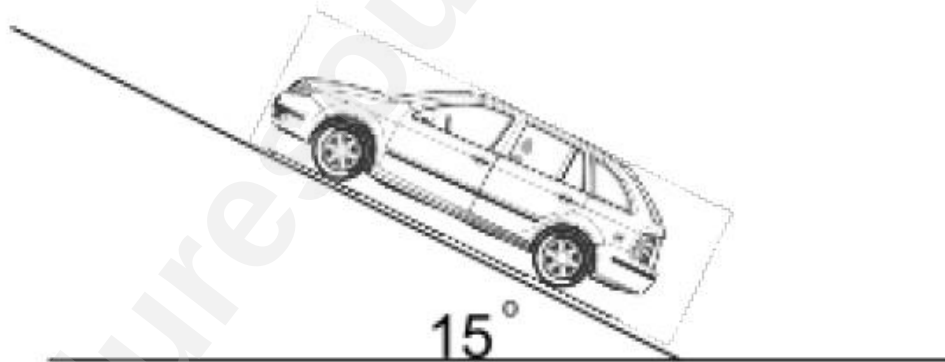
QUESTION 5A: [MSED PRELIM 2013] HORIZONTAL AND INCLINE PLANE

A car with a mass of 2 000 kg accelerates from rest on a straight horizontal road. The engine produces a force of 1 140 N on the car, while a friction force of 950 N also acts on the car.



- 5.1 Write down the work-energy theorem in words. (2)
- 5.2 Use the work-energy theorem to determine how far this car must travel in order to reach a velocity of $2 \text{ m}\cdot\text{s}^{-1}$. (5)

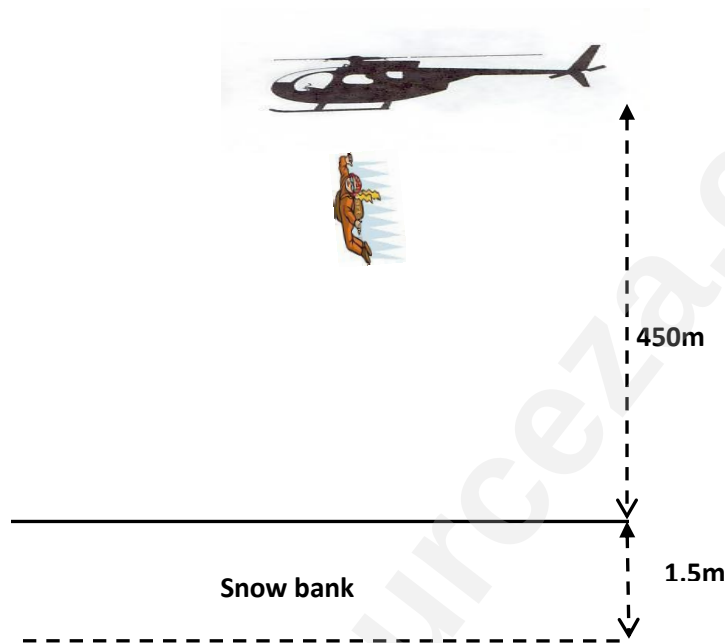
When the car reaches the velocity of $2 \text{ m}\cdot\text{s}^{-1}$, it starts to move up a slope that makes an angle of 15° with the horizontal. The force provided by the engine as well as the friction force remains the same.



- 5.3 Draw a free body diagram to show ALL the forces acting on the car as it moves up the slope. (4)
- 5.4 Using the work-energy theorem, calculate the speed of the car after it travelled 0,5 m up the slope. (4)
- [15]**

QUESTION 5A [KUTLWANONG JUNE EXAM 2014] VERTICAL PLANE

A paratrooper in full kit, total mass 120 kg, jumps at a height of 450 m from a stationary helicopter. The paratrooper's parachute does not open and he reaches a **terminal velocity** of 30 m.s^{-1} before luckily landing on a snow bank. The snow bank gives way, creating a crater of 1,5 m deep. The paratrooper comes to rest at the bottom of the crater with minor injuries.

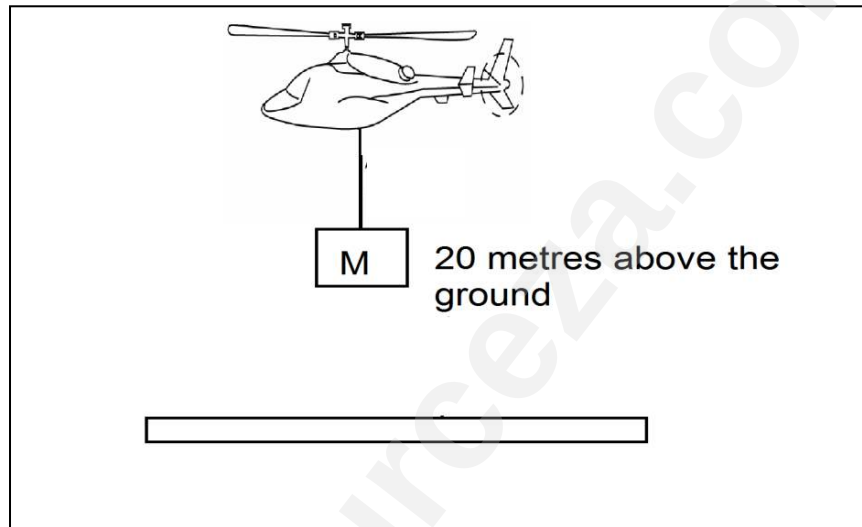


- 5.1 Under what conditions will a falling body reach **terminal velocity**? (2)
- 5.2 Draw a free-body diagram indicating all the forces acting on the parachutist, falling at terminal velocity. (2)
- 5.3 Will the mechanical energy of the parachutist stay constant throughout the fall?
Give a reason for your answer. (2)
- 5.4 Calculate the initial gravitational potential energy of the paratrooper, relative to the ground. (4)
- 5.5 Calculate the paratrooper's kinetic energy just before he lands on the snow. (3)
- 5.6 State the work–energy theorem in words. (2)
- 5.7 Use the work–energy theorem to calculate the total work done by air resistance on the paratrooper while he falls. (4)
- 5.8 Calculate the average force exerted by the snow in stopping him. (5)

[24]

QUESTION 5A [MSED PRELIM 2014] VERTICAL PLANE

A rescue helicopter is stationary (hovers) above the ground. It lowers a crate containing medical supplies with a mass 50 kg onto the ground below. When the crate is at a height of 20 m above the ground it has a velocity of 2 m.s^{-1} . The crate is lowered at a constant acceleration onto the ground with a cable, where it eventually comes to rest. Assume there is no sideways motion during the descent. Air friction is NOT to be ignored.



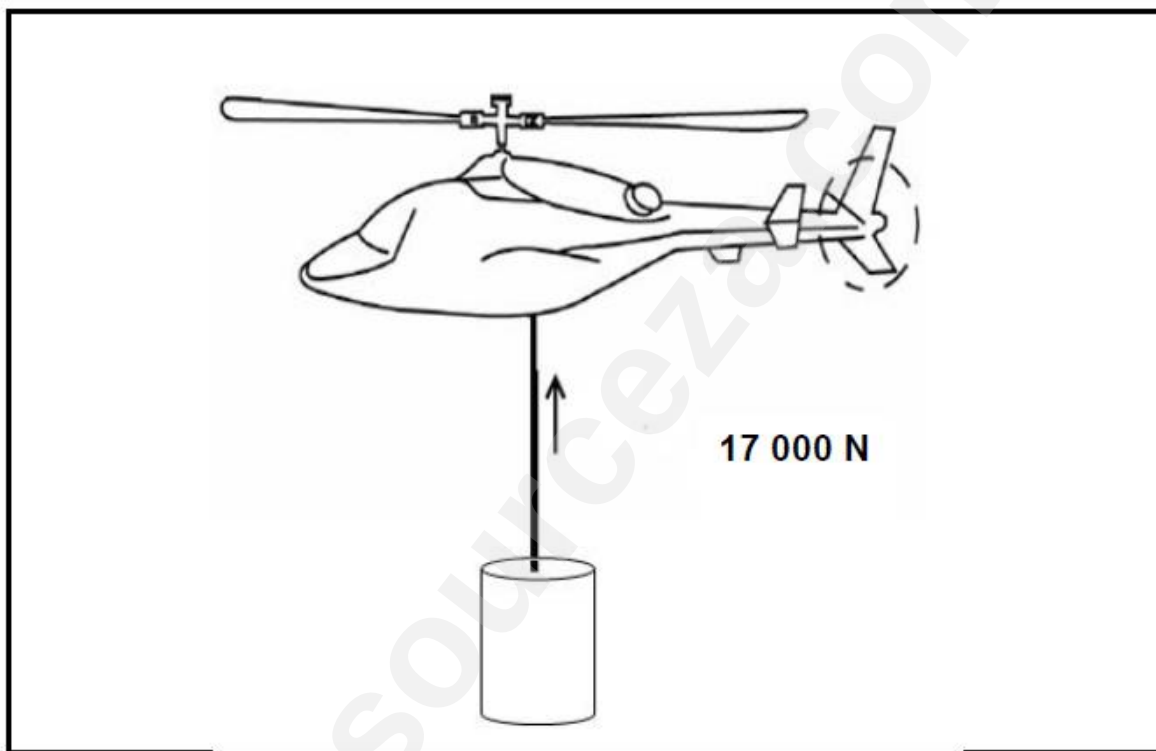
- 5.1 Define a *non-conservative force*. (2)
- 5.2 Identify TWO *non-conservative forces* acting on the crate during its downward descent (motion). (2)
- 5.3 Draw a free-body diagram showing ALL the forces acting on the crate while it is being lowered to the ground. (3)
- 5.4 Write down the work-energy theorem in words. (2)
- 5.5 Use the work-energy theorem to calculate the acceleration of the crate as it is lowered to the ground. (6)

[15]

QUESTION 5A [EASTERN CAPE SEP.2015] VERTICAL PLANE

During a fire extinguishing operation, a helicopter remains stationary (hovers) above a dam while filling a bucket with water. The bucket, of mass 80 kg, is filled with 1 600 kg of water. It is lifted vertically upwards through a height of 20 m by a cable at a **CONSTANT SPEED** of $2\text{m}\cdot\text{s}^{-1}$. The tension in the cable is 17 000 N.

Assume there is no sideways motion during the lift. *Air friction is NOT ignored.*

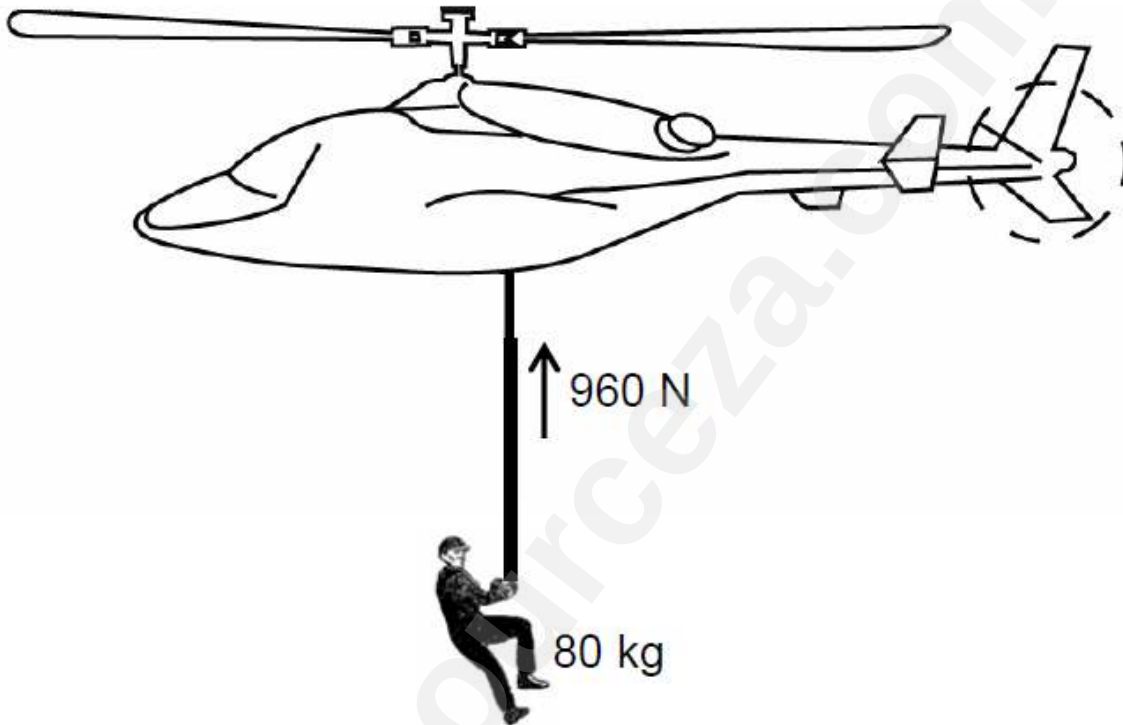


- 5.1 State the *work-energy theorem* in words. (2)
- 5.2 Draw a labelled free body diagram showing ALL the forces acting on the bucket of water, while being lifted upwards. (3)
- 5.3 Use the **WORK ENERGY THEOREM** to calculate the work done by air friction on the bucket of water after moving through the height of 20 m. (5)

[10]

QUESTION 5A [DoE NOV. 2011]VERTICAL PLANE]

A rescue helicopter is stationary (hovers) above a soldier. The soldier of mass 80 kg is lifted vertically upwards through a height of 20 m by a cable at a **CONSTANT SPEED** of $4\text{ m}\cdot\text{s}^{-1}$. The tension in the cable is 960 N . Assume that there is no sideways motion during the lift. Air friction is **NOT** to be ignored.



- 5.1 State the work-energy theorem in words. (2)
- 5.2 Draw a labelled free-body diagram showing **ALL** the forces acting on the soldier while being lifted upwards. (3)
- 5.3 Write down the name of a non-contact force that acts on the soldier during the upward lift. (1)
- 5.4 Use the **WORK-ENERGY THEOREM** to calculate the work done on the soldier by friction after moving through the height of 20 m . (5)

[11]

QUESTION 5A [KUTLWANONG PRELIM 2014] VERTICAL PLANE

A 4549,6 N applied upward force (up-thrust) enables a 102 kg rocket to accelerate upwards from rest for 200 m, subject to a constant average resistance from air friction of 1 000 N.. Assume the mass of the rocket remains constant.



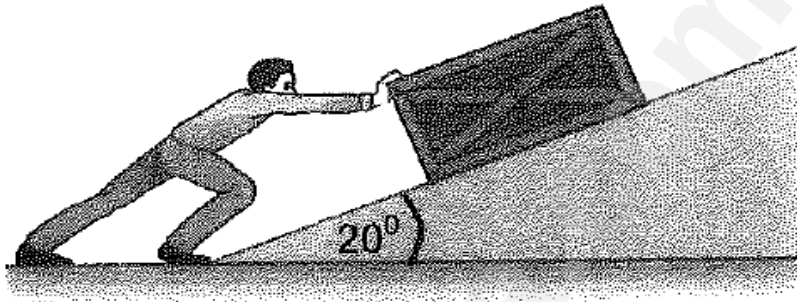
4549,6 N

- 5.1 Draw a free-body diagram indicating all the forces acting on the rocket as it accelerates upwards. (3)
- 5.2 Calculate the net work done on the rocket as it accelerates upwards. (6)
- 5.3 State the work–energy theorem in words. (2)
- 5.4 Use the WORK-ENERGY THEOREM to calculate the final speed reached by the rocket. (4)

[15]

QUESTION 5A [LIMPOPO PRELIM 2014]: INCLINE PLANE – UP THE SLOPE

A man pushes a crate, of mass 10 kg, up a rough surface inclined at 20° to the horizontal, with a 100 N force parallel to the surface.



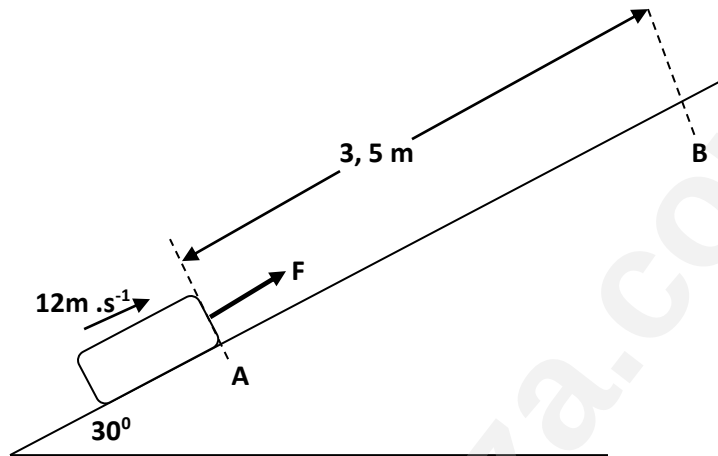
The crate is pushed 5 m up the surface with an initial speed of $1,5 \text{ m}\cdot\text{s}^{-1}$. The coefficient of kinetic friction between the crate and surface is 0,4.

- 5.1 Draw a labelled free body diagram to show all the forces acting on the crate. (4)
- 5.2 Calculate the work done by gravity. (3)
- 5.3 Calculate the:
 - 5.3.1 energy lost due to friction (6)
 - 5.3.2 work done by the man in pushing the crate up the surface (1)
- 5.4 State the Work - Energy Theorem in words (2)
- 5.5 Use the WORK- ENERGY THEOREM to calculate the final velocity of the crate after it has been pushed 5 m. (4)

[20]

QUESTION 5A [MPUMALANGA PRELIM 2014]: INCLINE PLANE-UP THE SLOPE

A constant force F is applied to a crate of mass 25 kg to move it upwards along a frictionless inclined plane. When it reaches point A, its speed is 12 m.s^{-1} and $10,8\text{ m.s}^{-1}$ when it reaches point B which is $3,5\text{ m}$ further up the incline.

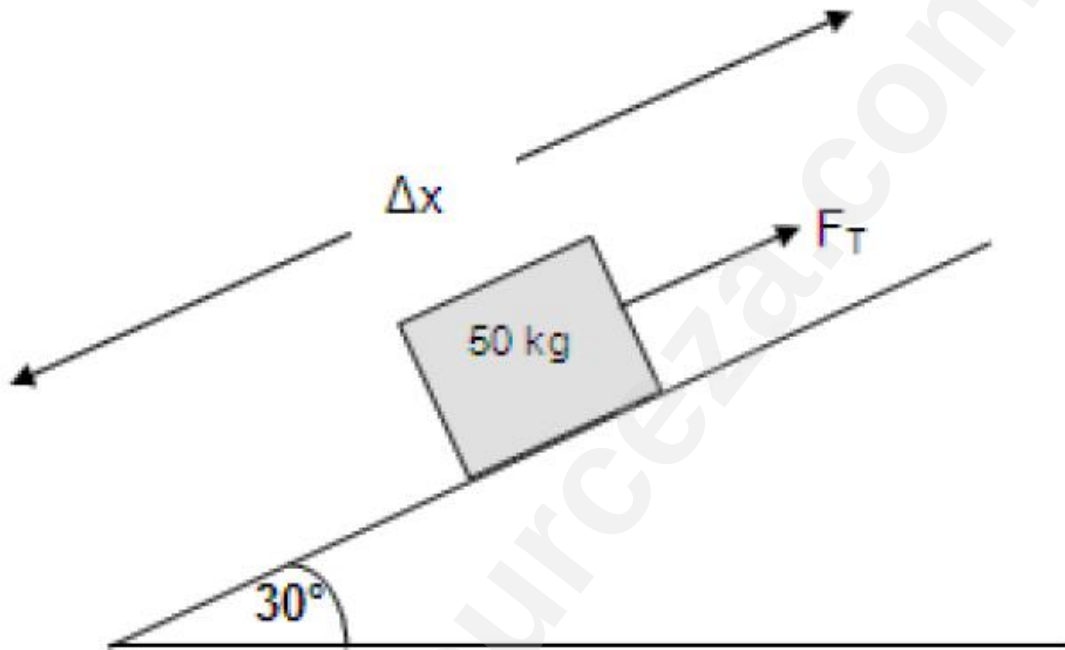


- 5.1 Draw a free force diagram showing ALL the forces acting on the crate while it is moving up the incline. (3)
- 5.2 Is mechanical energy conserved during this motion? Write down YES or NO and briefly explain the answer. (2)
- 5.3 Write down the NAME of the conservative force that acts on the crate (1)
- 5.4 Give a reason why the normal force does no work on the crate during its motion up the incline. (1)
- 5.5 In which direction does the net force act on the crate as it moves up the incline? Write only **FROM A TO B** or **FROM B TO A**. (1)
- 5.6 Use **ENERGY PRINCIPLES** to calculate the magnitude of the force F . (6)

[14]

QUESTION 5A [EASTERN CAPE PRELIM: 2014] INCLINE - DOWN THE SLOPE

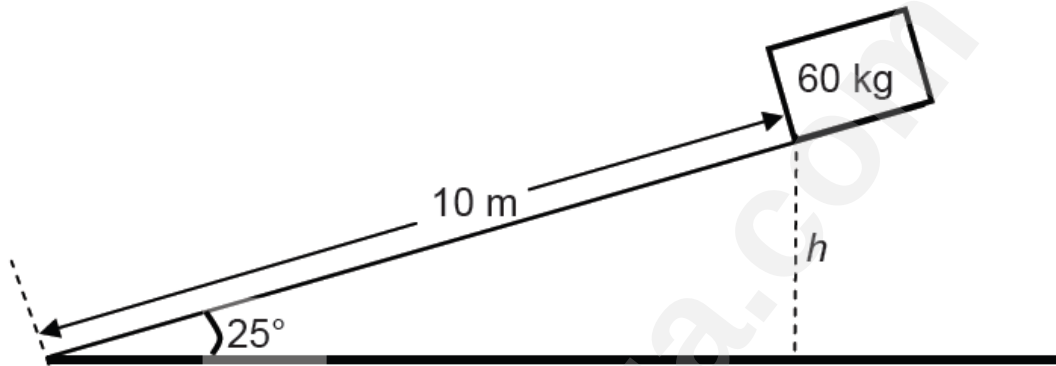
The diagram below shows a crate of mass 50 kg sliding down a steep slope. The slope makes an angle of 30° with the horizontal. The motion of the crate as it moves down the slope is controlled by a worker using a rope attached to the crate. The rope is held parallel to the slope. The tension in the rope, F_T , is 300 N and a constant frictional force of 50 N acts on the crate as it slides down the slope.



- 5.1 Draw a **labelled free-body diagram** showing the forces parallel to the slope acting on the crate as it moves down the slope. (3)
- 5.2 State the **WORK-ENERGY THEOREM** in words. (2)
- 5.3 The change in kinetic energy of the crate is 450 J as it slides from the top to the bottom of the slope.
- Use the **work-energy theorem** to calculate the length of the slope, Δx . (5)
- 5.4 Calculate the coefficient of kinetic friction on the crate as it moves down the slope. (4)
- [14]**

QUESTION 5A [DoE SUPPLEMENTARY 2010] INCLINE PLANE- DOWN A SLOPE

A box of mass 60 kg starts from rest at height h and slides down a rough slope of length 10 m, which makes an angle of 25° with the horizontal. It undergoes a constant acceleration of magnitude $2 \text{ m} \cdot \text{s}^{-2}$ while sliding down the slope.



5.1 State the work-energy theorem in words. (2)

5.2 Draw a free-body diagram to show ALL the forces acting on the cardboard box while it slides down the slope. (3)

5.3 The box reaches the bottom of the slope.

Calculate the following:

5.3.1 The kinetic energy of the box, using the equations of motion (5)

5.3.2 The work done on the box by the gravitational force (4)

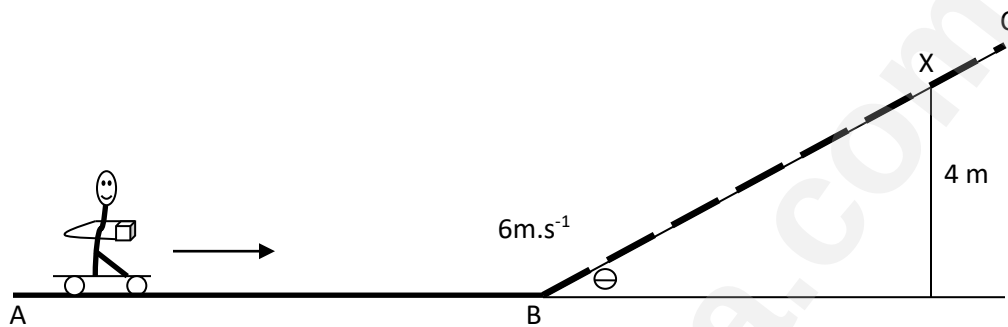
5.3.3 The work done on the box by the frictional force, using the WORK-ENERGY THEOREM (4)

5.3.4 The magnitude of the frictional force acting on the box (3)

[21]

QUESTION 5A [FREE STATE SEP. 2015] INCLINE UP-THE SLOPE

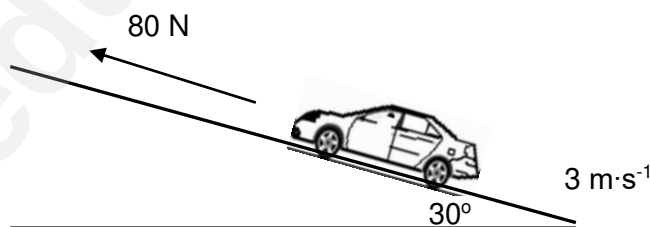
- 5.1 A boy on roller-skates moves at a constant velocity in an easterly direction along a frictionless horizontal part **AB** of a track carrying a parcel. He decides to increase his velocity by throwing the parcel horizontally away from him.



- 5.1.1 In which direction must the parcel be thrown to cause a maximum increase in the velocity of the boy? (1)
- 5.1.2 Name and define in words the law in physics that you have applied in QUESTION 5.1.1. (3)

On reaching point **B** at a velocity of $6\text{ m}\cdot\text{s}^{-1}$, the boy on the roller-skates, with total mass 57 kg , continues to move up a rough section **BC** of the track and comes to rest at position **X**, height 4 m . The magnitude of the frictional force acting on the roller-skates, is 40 N .

- 5.1.3 Calculate value Θ of the inclined plane. (6)
- 5.2 A remote controlled car is driven up an inclined plane at 30° to the horizontal as shown below. The car of mass 4 kg , experiences an average forward force of 80 N . A frictional force of 15 N is acting on the car as it moves up the plane. The speed of the car at the bottom of the inclined plane is $3\text{ m}\cdot\text{s}^{-1}$.



Use energy principles to calculate the speed of the car after it has travelled 5 m up the inclined plane.

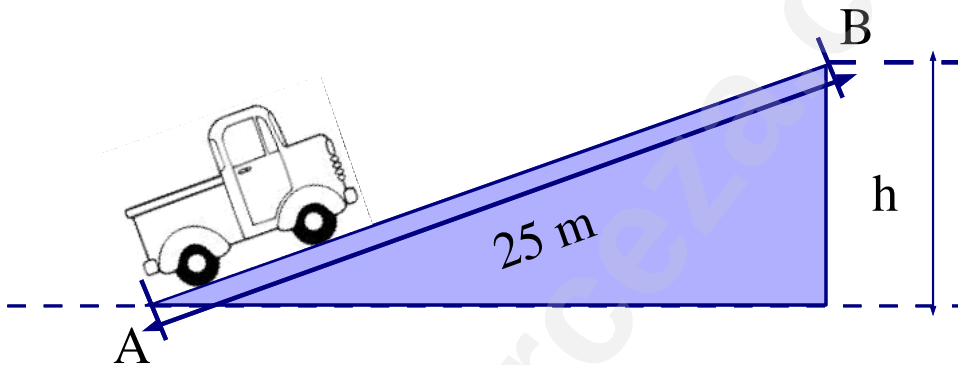
(7)
[17]

QUESTION 5A [KWA-ZULU NATAL SEP. 2015] INCLINE UP-THE SLOPE

The diagram below shows a truck of mass, 12 000 kg free-wheeling (with the engine switched off) , up a straight inclined road of length 25 m.

On entering the incline at the bottom, point **A**, the truck is moving at 25 m.s^{-1} and on reaching the top, **B**, of the incline the truck is moving at 20 m.s^{-1} .

The truck experiences a constant frictional force of magnitude 3 400 N as it moves up the incline.



- 5.1 State the **work-energy theorem** in words. (2)
- 5.2 Calculate the:
 - 5.2.1 net work done on the truck on moving from the bottom of the incline to the top of the incline. (4)
 - 5.2.2 work done by the frictional force. (3)
- 5.3 Is the frictional force a conservative or non-conservative force? (1)
- 5.4 Calculate the height, **h**, reached by the truck at the top of the incline, **B**. (5)

[15]

QUESTION 5A (WESTERN CAPE) CURVE AND INCLINE PLANE

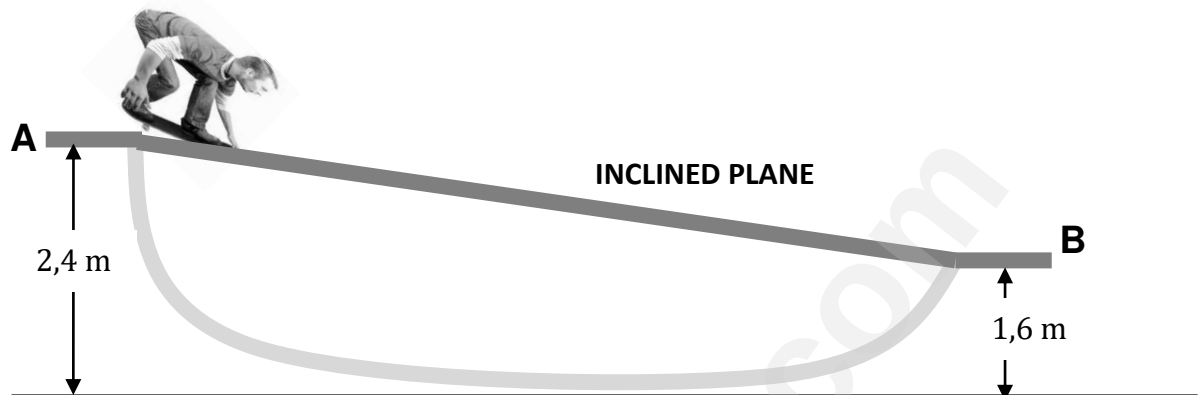
A skateboarder of mass 75 kg is practicing a sequence of tricks at the local skate park on a half-pipe. The skater leaves point A, 2,4 m above the ground. He skates down the ramp towards point B. He reaches Point B, 1,6 m above the ground, with a speed of $3,75 \text{ m}\cdot\text{s}^{-1}$ just by rolling along and without using his feet to push himself along the half-pipe.

The skateboarder has not oiled the wheels of his skateboard for some time, so there is significant friction between the axles and the wheels of the skateboard.



- 5.1 State in words, the *work-energy theorem*. (2)
- 5.2 Calculate the work done by the gravitational force on the skateboarder as he moves from Point A to Point B. (4)
- 5.3 Using the work energy theorem, determine the work done by the frictional force exerted on the skateboard. (6)

- 5.4 The skateboarder thinks about constructing an inclined plane to join Points A and B to provide an alternative route between these two points.



- 5.4.1 How would the work done by the gravitational force change if he were to roll from Point A to Point B along the inclined plane instead of following the curved track?

Answer only INCREASES, DECREASES or REMAINS THE SAME. (1)

- 5.4.2 Explain your answer to QUESTION 5.4.1. (2)

[15]

PART B: ENERGY AND POWER

Learners are required to apply the **Conservation of Mechanical Energy** to the following cases (in accordance with CAPS):

- ❖ Objects dropped or thrown vertically upwards;
- ❖ “Roller Coasters”-Type Problems;
- ❖ The motion of a Pendulum bob (swinging motion);
- ❖ Inclined plane (frictionless surface)

HINTS ON SOLVING PROBLEMS USING CONSERVATION OF MECHANICAL ENERGY

1. The MECHANICAL ENERGY is only conserved in a closed/an isolated system. ENERGY IS ALWAYS CONSERVED.
2. If it is a closed system the mechanical energy at a specific point is equal to the mechanical energy at another point. Do not water this down to $E_p = E_k$ if the top and the bottom points are being used. This is wrong and learners will not get credit for their work.
3. If mechanical energy is conserved, you can write the total initial energy at some point

$$E_i = E_{p_i} + E_{k_i}$$

Then, write an expression for the total final energy at the final point that is of interest

$$E_f = E_{p_f} + E_{k_f}$$

Because mechanical energy is conserved, you can equate the two total energies and solve for the quantity that is unknown.

$$\therefore (E_p + E_k)_i = (E_p + E_k)_f$$

$$\therefore (mgh + \frac{1}{2}mv^2)_i = (mgh + \frac{1}{2}mv^2)_f$$

4. Remember to substitute all the **zero values** since the learners get credit for knowing the values in question are zero. They have therefore to show the values.
5. Pendulum problems can be started with the equation,

$$E_{\text{Lowest}} = E_{\text{Highest}}$$

$$\therefore E_{pL} + E_{kL} = E_{pH} + E_{kH}$$

$$\therefore (mgh + \frac{1}{2}mv^2)_L = (mgh + \frac{1}{2}mv^2)_H$$

Note: equations of motion cannot be used, because this is not motion in a straight line.

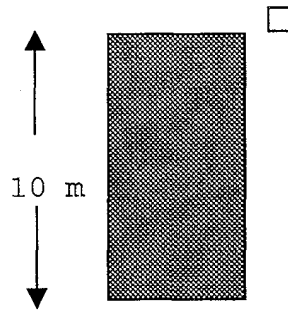
- ❖ If it is not a closed system, calculate the Mechanical Energy at the different points separately and use the difference in energy as **WORK DONE BY FRICTION**. OR Use the **WORK-ENERGY THEOREM** to calculate the necessary values.

$$\Delta E = E_f - E_i = (E_p + E_k)_f - (E_p + E_k)_i = \text{Work done on the object by the frictional force, OR}$$

$$\therefore W_{nc} = \Delta U + \Delta K = \Delta E_{ME}, \quad \text{Where } W_{nc} \text{ is work done by the non-conservative forces.}$$

QUESTION 5B: VERTICAL PLANE [DBE HG 2003]

A 50 kg cement block is lifted to the roof of a 10 m high building.

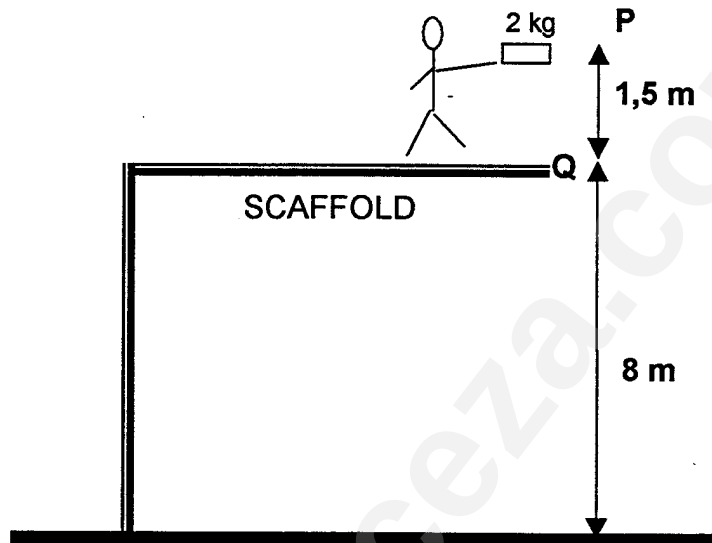


- 5.1 Calculate the increase in the gravitational energy of the block as it is lifted from the ground to the top of the building. (4)
- 5.2 The block is now dropped from the roof of the building. While the block is falling, mechanical energy is conserved. Explain briefly what this means. (2)
- 5.3 Use the *law of conservation of mechanical energy* to calculate:
- 5.3.1 The kinetic energy of the block at a height of 5 m (2)
- 5.3.2 The speed of the block the instant before it hits the ground (3)

[11]

QUESTION 5B: VERTICAL PLANE [DBE HG 2006]

A bricklayer stands on a scaffold 8 m above the ground. An assistant throws a brick, mass 2 kg, which the bricklayer catches at point P, 1,5 m above the scaffold. *Ignore the effect of air resistance.*



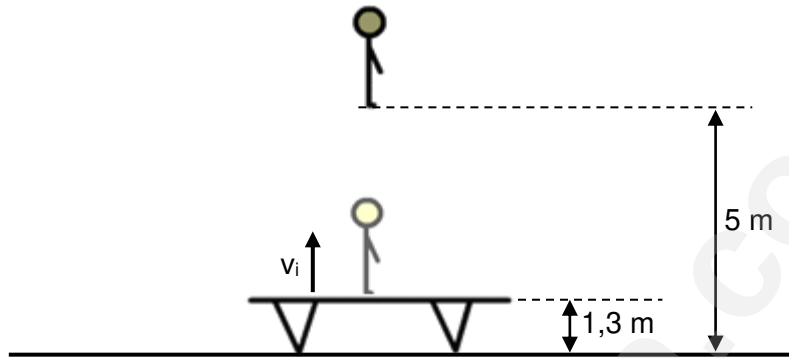
The brick slips out of his hand and falls to point Q on top of the scaffold.

- 5.1 Calculate the gravitational potential energy of the brick at P relative to the ground. (4)
- 5.2 Calculate the velocity with which the brick strikes the scaffold. (4)
- 5.3 Calculate the kinetic energy of the brick just before it strikes the scaffold at point Q. (4)

[12]

QUESTION 5B: VERTICAL PLANE (ADDITIONAL EXEMPLER 2008)

A gymnast (of mass 25 kg) jumps vertically upward from a trampoline as illustrated below.



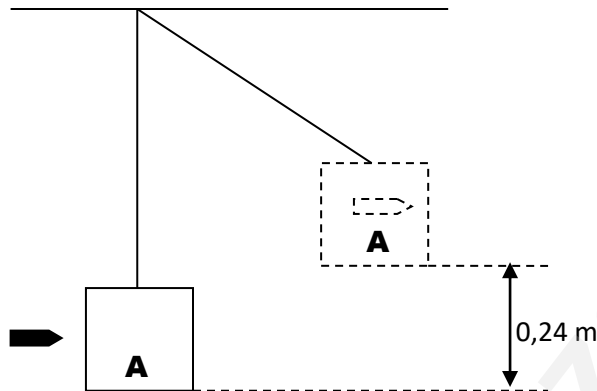
The gymnast leaves the trampoline at a height of 1,3 m and reaches a maximum height of 5 m. Ignore the effects of friction.

- 5.1 Write down the law of *conservation of mechanical energy* in words. (2)
- 5.2 Using the law of conservation of mechanical energy, calculate the initial speed v_i with which the gymnast leaves the trampoline. (5)
- 5.3 Will the mechanical energy of the gymnast stay constant throughout the jump (fall)?
Give a reason for your answer. (2)
- 5.4 Draw a free body diagram of *All forces* acting on the gymnast while she jumps vertically upward from a trampoline. (1)
- 5.5 Write down the *work-energy theorem*. (2)
- 5.6 Use the WORK- ENERGY THEOREM to calculate the speed with which the gymnast returns to the trampoline. (5)

[17]

QUESTION 5B: PENDULUM PROBLEM [DBE HG]

A bullet (mass 0,02 kg) is fired at a wooden block A (mass 3,40 kg) and remains embedded in it. The bullet-block system swings through a vertical height of 0,24m. The effects of air resistance are negligible.

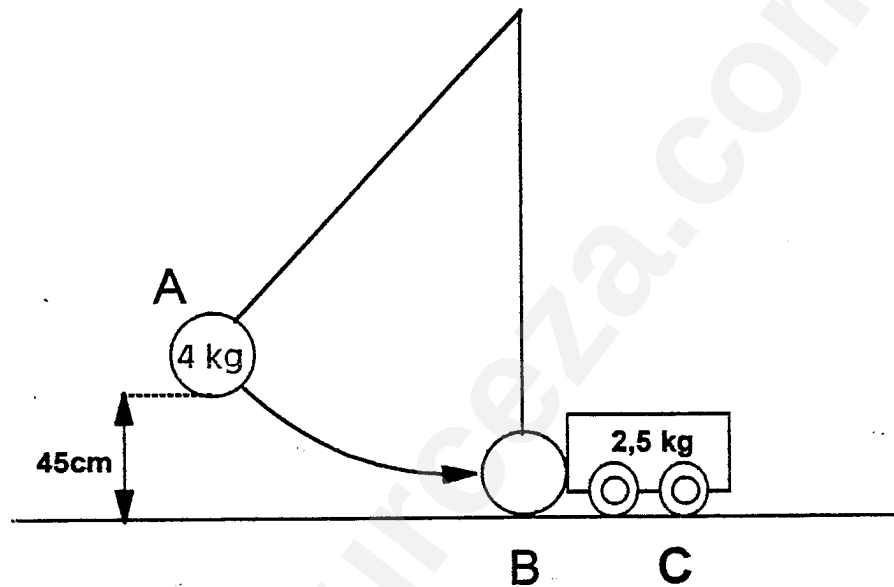


- 5.1 Calculate the change in gravitational potential energy of the bullet-block system when it swings to maximum height. (4)
- 5.2 **Name** the law (or principle) of physics, which can be applied to determine the velocity of the bullet-block system before it swings up to its maximum height. (1)
- 5.3 Determine the speed of the bullet-block system immediately before it swings to its maximum height. (4)
- 5.4 **Name** the (or principle) of physics, which can be applied to determine the velocity of the bullet before it strikes the block. (1)
- 5.5 With what speed does the bullet strike the block? (5)
- 5.6 What fraction of the original kinetic energy of the bullet is transferred to the bullet-block system? (5)

[20]

QUESTION 5B: PENDULUM PROBLEM[DBE HG]

An iron ball with a mass of 4 kg is held by a strong, light, inelastic rope. It is pulled sideways by a horizontal force and held at position A, 45 cm above its lowest position. *The effects of air resistance are negligible.*

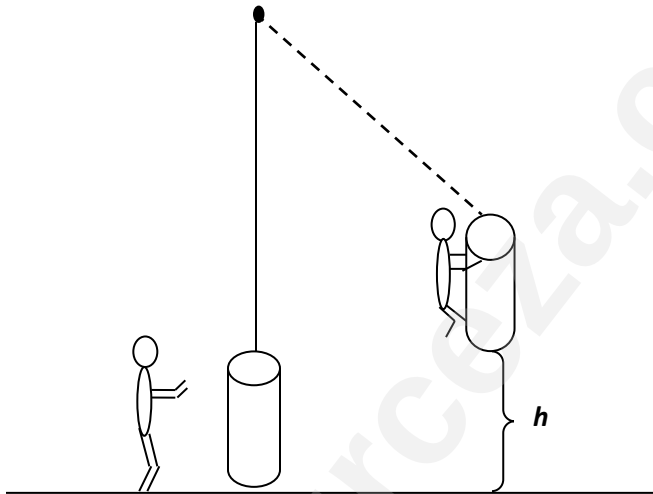


- 5.1 Distinguish between *potential energy* and *kinetic energy* (4)
- 5.2 Calculate the potential energy of the iron ball while it is held at position A. (3)
- 5.3 The iron ball is now released. Ignore friction and, by using ONLY energy relationships, show that the magnitude of the velocity with which the iron ball passes its lowest position (i.e. position B) is $3 \text{ m} \cdot \text{s}^{-1}$. (5)
- 5.4 At its lowest position, the iron ball strikes a stationary trolley, C with a mass of 2,5 kg.
 - 5.4.1 Calculate the momentum of the iron ball the moment before it collides with the trolley. (3)
 - 5.4.2 Calculate the speed with which the trolley C moves off, if the iron ball loses half its momentum. (7)

[22]

QUESTION 5B: PENDULUM PROBLEM

A large padded bag of mass 40 kg is suspended at rest just above the ground by a long Light nylon rope hanging from a tall tree. Sandile of mass 85 kg runs horizontally and collides with the bag with a speed of 8 m.s^{-1} . On colliding with the bag, he grabs on to the bag in such a way that he and the bag swing away upwards as shown. *The effects of air resistance are negligible.*



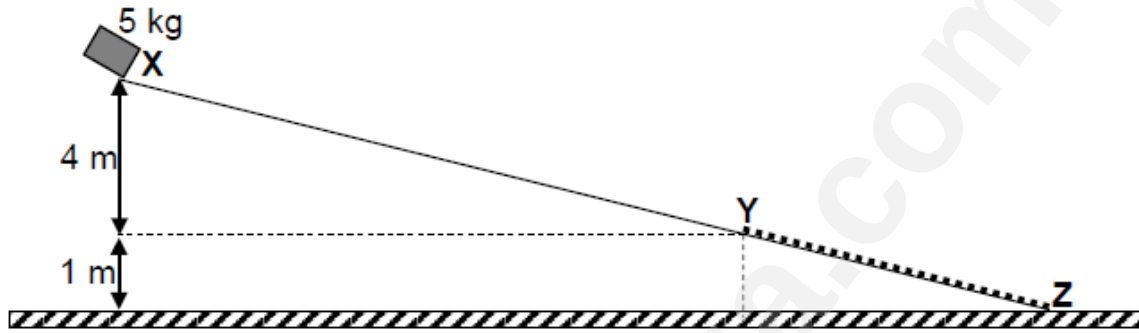
- 5.1 State, in words, the *Law of Conservation of Linear Momentum*. (2)
- 5.2 Calculate the combined speed of Sandile and the bag, immediately after he collides with the bag. (5)
- 5.3 Calculate the maximum height, h , to which Sandile and the bag will swing. (6)

[13]

QUESTION 5B: (INCLINE PLANE)

(DBE NOV. 2013)

A 5 kg rigid crate moves from rest down path **XYZ** as shown below (diagram not drawn to scale). Section **XY** of the path is frictionless. Assume that the crate moves in a straight line down the path.



5.1 State, in words, the *principle of the conservation of mechanical energy*. (2)

5.2 Use the principle of the conservation of mechanical energy to calculate the speed of the crate when it reaches point **Y**. (4)

On reaching point **Y**, the crate continues to move down section **YZ** of the path. It experiences an average frictional force of 10 N and reaches point **Z** at a speed of $4 \text{ m}\cdot\text{s}^{-1}$.

5.3 APART FROM FRICTION, write down the names of TWO other forces that act on the crate while it moves down section **YZ**. (2)

5.4 In which direction does the net force act on the crate as it moves down section **YZ**? Write down only from '**Y** to **Z**' or from '**Z** to **Y**'. (1)

5.5 Use the WORK-ENERGY THEOREM to calculate the length of section **YZ**. (5)

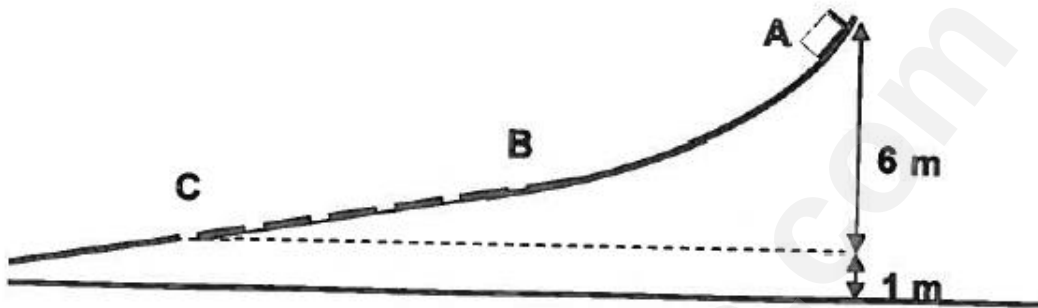
Another crate of mass 10 kg now moves from point **X** down path **XYZ**.

5.6 How will the velocity of this 10 kg crate at point **Y** compare to that of the 5 kg crate at **Y**? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

[15]

QUESTION 5B: INCLINE PLANE**(FREE STATE PREPARATORY EXAM: 2014)**

A 3 kg metal block moves from rest at point **A** down an incline as shown in the diagram below and reaches a speed of $6 \text{ m}\cdot\text{s}^{-1}$ at **B**. Section **AB** of the path is frictionless.



- 5.1 Would you describe the movement of the block on section **AB** of the path as free fall? Give a reason for your answer. (2)
- 5.2 Draw a labelled free body diagram to show all the forces acting on the Block as it moves down section **AB**. (1)
- 5.3 Calculate the net work done on the block as it moves down section **AB** of the path. (3)
- 5.4 Use ENERGY PRINCIPLES to calculate the height of the block at position **B**. (4)
- 5.5 On reaching point **B**, the block continues to move down section **BC** of the path which is 5m in length. The block now experiences a frictional force and reaches point **C** at a speed of $2 \text{ m}\cdot\text{s}^{-1}$.

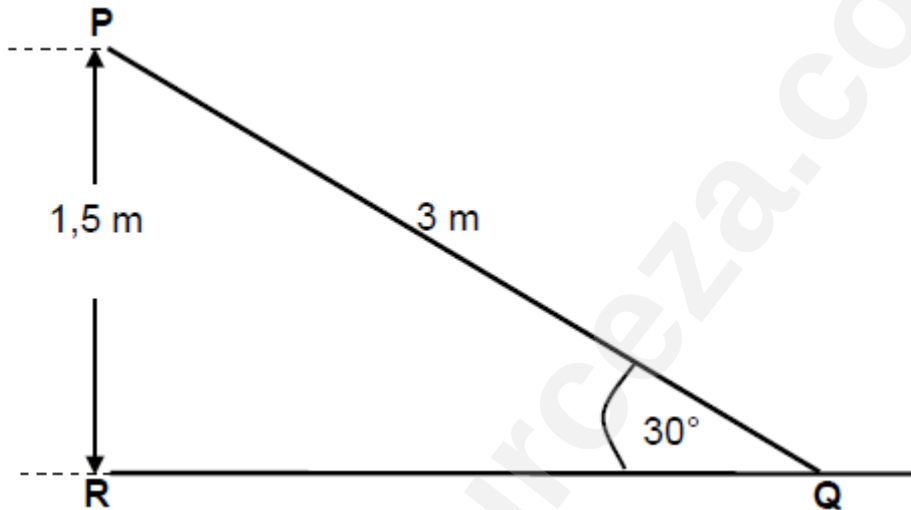
Use ENERGY PRINCIPLES to calculate the magnitude of the average frictional force acting on the block as it moves down section **BC** of the path. (5)

[15]

QUESTION 5B: INCLINE PLANE**(DBE March 2013)**

The simplified diagram below shows a slide **PQ** at a playground. The slide is 3 m long and 1,5 m high. TWO boys, Sibusiso (of mass 40 kg) and a Thabo (of mass 22 kg), stand at the top of the slide at **P**.

Thabo accelerates uniformly from rest down the slide. He experiences a constant frictional force of 1,9 N. Sibusiso falls vertically down from the top of the slide through the height **PR** of 1,5 m. (Ignore the effects of air friction).



- 5.1. Write down the *work-energy theorem* in words. (2)
- 5.2. Draw a labelled free-body diagram to show ALL the forces acting on:
 - 5.2.1. Sibusiso while falling vertically downwards (1)
 - 5.2.2. Thabo as he slides down the slide (3)
- 5.3. Use the principle of CONSERVATION OF MECHANICAL ENERGY to calculate the speed of Sibusiso when he reaches the ground at **R**. (4)
- 5.4. Use the WORK-ENERGY THEOREM to calculate the speed of Thabo when he reaches the end of the slide at **Q**. (5)
- 5.5. How would the velocity of Thabo at **Q** compare to that of Sibusiso at **R** if the slide exerts no frictional force on the girl?
Write down only GREATER THAN, LESS THAN or EQUAL TO. (1)
- 5.6. When Thabo reaches the end of the slide he starts running, but his speed remains constant (i.e. same speed as he reached the end of the slide at **Q**). Calculate the power at which he is running. Assume that the average frictional force acting on him remains constant. (3)

[19]

QUESTION 5B: ROLLER COASTER

A roller coaster operates on the principle of conservation of mechanical energy. Thus there is a continuous conversion of gravitational potential energy to kinetic energy and vice versa. If it can be assumed that no external forces are doing work on the car as it travels from the initial summit to the end of the track (where finally an external braking system is employed), then the total mechanical energy of the roller coaster car is conserved.

The diagram below illustrates a roller coaster car with a **mass of 1 000 kg**. The car is initially lifted through a **height of 40 m** and then released on the track. Assume that no external forces act on the car and answer the following questions:

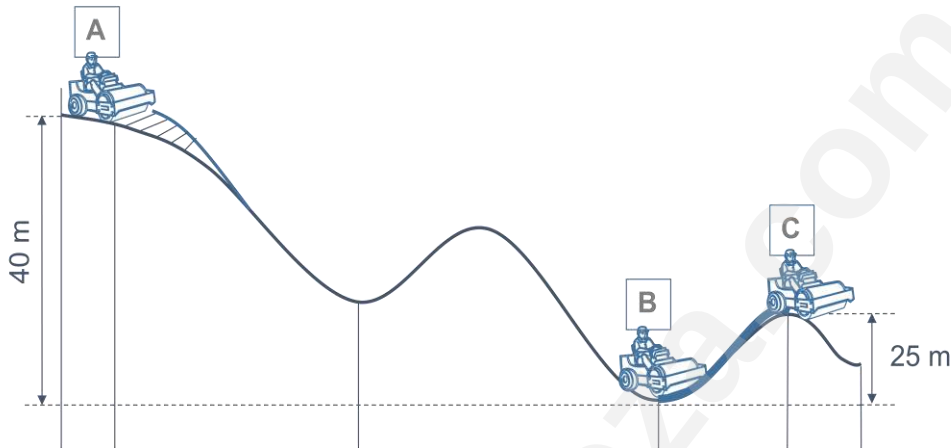


- 5.1 Where does the original energy (at A) from the roller coaster car come from? (2)
- 5.2 What is the total mechanical energy of the roller coaster car? (3)
- 5.3 At what speed will the roller coaster car move at point C? (5)
A crane is being designed to lift a load of 1 000 kg vertically upwards at $0,8 \text{ m.s}^{-1}$.
- 5.4 What power output is required to do this? (4)

[14]

QUESTION 5B: ROLLER COASTER PROBLEM

The diagram below shows a roller coaster car starting from rest at point A. The route from A to B is frictionless, while the route from B to C has a rough surface. The combined mass of the car and its passenger is 1 000 kg.

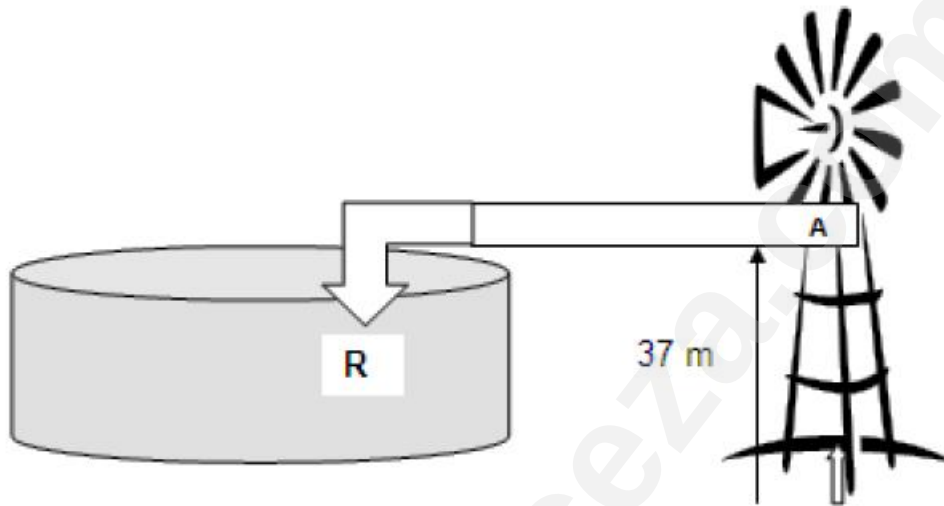


- 5.1 State, in words, the *principle of the conservation of mechanical energy*. (2)
- 5.2 Use the law of conservation of mechanical energy to determine the speed of the car at B. (5)
- 5.3 Use your answer to (5.2) in order to calculate the **MAGNITUDE** of the work done by the frictional force while the car is moving from B to C. (5)

[12]

QUESTION 5C: POWER (EASTERN CAPE PREPARATORY EXAM: 2014)

A windmill is used on a farm to pump water out of a well that is 37 m deep. The water flows past point A, 37 m above the well to the dam with a constant velocity of $2 \text{ m} \cdot \text{s}^{-1}$.



- 5.1 Calculate how much energy is necessary to pump 90 kg of water out of the well to point A. (4)
- 5.2 It is necessary to pump 90 kg of water per minute. What is the maximum power that the windmill must produce? (3)
- 5.3 The farmer wants to modernize the farm. The farmer decides to buy a 0,5kW petrol water pump.
 - 5.3.1 Will the petrol water pump be able to produce the required power? (YES or NO) (1)
 - 5.3.2 Why would you advise the farmer to rather use a windmill instead of a petrol water pump? (1)

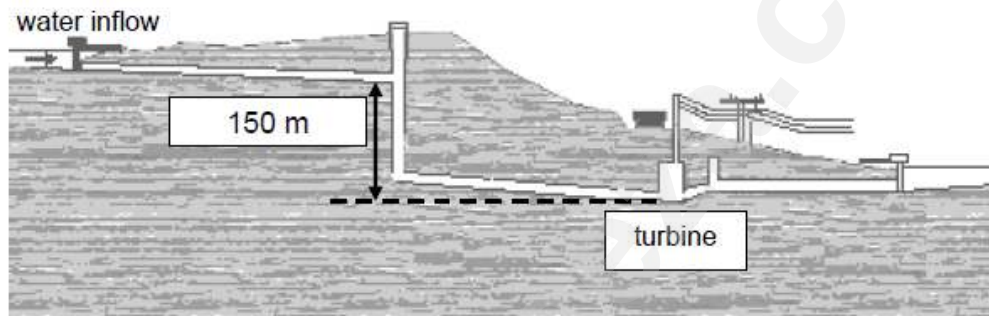
[11]

QUESTION 5C: POWER (DBE NOV. 2008)

The diagram below represents how water is funneled into a pipe and directed to a turbine at a hydro-electric power plant. The force of the falling water rotates the turbine.

Each second, 200 m^3 of water is funnelled down a vertical shaft to the turbine below. The vertical height through which the water falls upon reaching the turbine is 150 m . Ignore the effects of friction.

NOTE: One m^3 of water has a mass of $1\,000 \text{ kg}$.

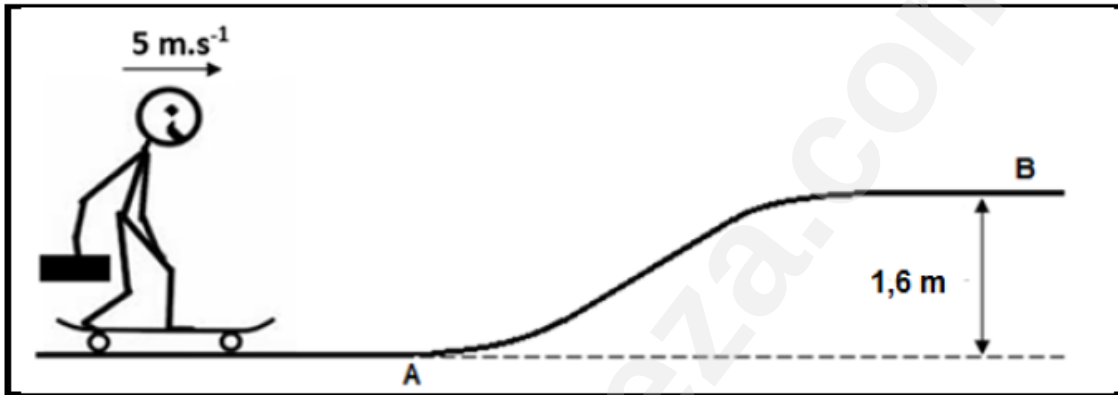


- 5.1 Calculate the mass of water that enters the turbine each second. (1)
- 5.2 Calculate the kinetic energy of this mass of water when entering the turbine. Use energy principles. (4)
- 5.3 Calculate the maximum speed at which this mass of water enters the turbine. (3)
- 5.4 Assume that a generator converts 85% of this maximum kinetic energy gained by the water into hydro-electricity. Calculate the electrical power output of the generator. (2)
- 5.5 Explain what happens to the 15% of the kinetic energy that is NOT converted into electrical energy. (1)

[11]

QUESTION 5D: MOMENTUM AND ENERGY [EASTERN CAPE SEP. 2015]

A boy on a skateboard moves at $5\text{ m}\cdot\text{s}^{-1}$ to the right towards point A at the bottom of a slope which is 1,6 m high. He is carrying a 4 kg parcel. The total mass of the boy, his skateboard and the parcel is 70 kg. He needs to increase his speed, in order to reach point B at the top of the slope. He decides that if he throws the parcel horizontally, it will increase his forward velocity. IGNORE ALL FRICTION.

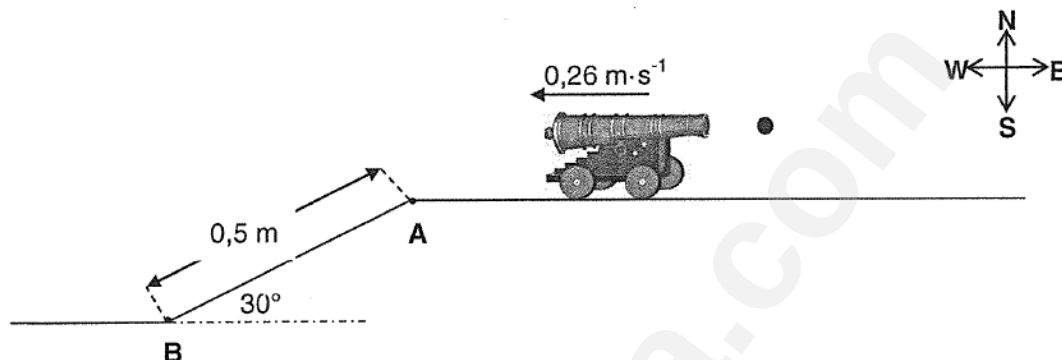


- 5.1 In which direction must the boy throw the parcel in order to increase his forward velocity? (**TO THE LEFT** or **TO THE RIGHT**) (1)
- 5.2 Give the name of Newton's law of Motion that you used to obtain your answer in QUESTION 5.1 (1)
- 5.3 State the *Principle of conservation of mechanical energy*. (2)
- 5.4 Calculate the velocity of the boy immediately after the parcel leaves his hand in order for him to reach the top of the slope at point B. (4)
- 5.5 Calculate the minimum velocity with which he must throw the parcel in order for him to reach the top of the slope at point B. (4)
- 5.6 How will the answer in QUESTION 5.4 be affected, if the boy throws the same parcel with higher velocity in the same direction as indicated in QUESTION 5.1?
Write down INCREASES, DECREASES or REMAIN THE SAME.
Explain your answer. (3)

[15]

QUESTION 5D: MOMENTUM AND ENERGY [MPUMALANGA SEP. 2015]

A toy canon, mass $1,6 \text{ kg}$, is at rest on a rough horizontal surface as shown in the diagram. A steel marble, mass $0,8 \text{ kg}$ is fired horizontally to the east from the canon. Immediately after the marble, the canon moves at $0,26 \text{ m}\cdot\text{s}^{-1}$ to the west.



5.1 Calculate the speed of the steel marble immediately after firing the marble. (4)

5.2 The steel marble experiences a force $\mathbf{F}$ during the firing. Explain in terms of $\mathbf{F}$ how the force experienced by the CANON compares with that experienced by the steel marble. (3)

The canon reaches point **A** with a speed of $0,2 \text{ m}\cdot\text{s}^{-1}$ and then moves down a rough $0,5 \text{ m}$ long slope **AB**.

5.3 Explain why this is NOT a closed system. (1)

5.4 Calculate the kinetic frictional force experienced by the canon as it moves from **A** to **B** if the coefficient of kinetic friction (μ_k) is $0,12$. (3)

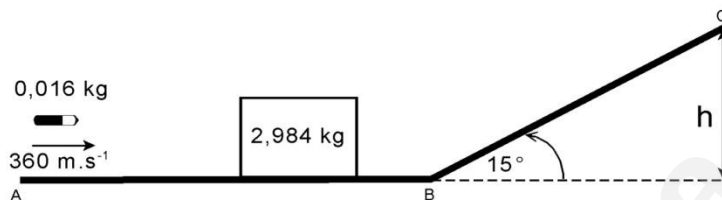
5.5 Using ENERGY PRINCIPLES only, calculate the velocity of the canon at point **B**. (5)

[16]

QUESTION 5D: MOMENTUM AND ENERGY [KWA-ZULU NATAL SEP. 2015]

The block is at rest on a frictionless surface **AB**. The distance **BC** makes an angle of 15° to the horizontal.

A bullet of mass $0,016 \text{ kg}$ moving at a velocity of 360 m.s^{-1} collides with and enters a stationary block of mass $2,984 \text{ kg}$. The bullet does not exit the block.



5.1 State the *Law of Conservation of Linear Momentum*. (2)

5.2 Show by calculation that the bullet- block combination has a velocity of $1,92 \text{ m.s}^{-1}$. (4)

At point **B** the kinetic energy of the bullet- block combination is $5,5296 \text{ J}$ and its potential energy at **C** is $4,6746 \text{ J}$. When slope **BC** has a frictional force the bullet block combination reaches **BC** = $0,614 \text{ m}$.

5.3 Calculate the coefficient of kinetic friction for the block- bullet combination for it to reach a height, **h**, of $0,159 \text{ m}$. (8)

[14]

6. DOPPLER EFFECT

- Use the general Doppler equation $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ for any calculation (i.e. when EITHER the source or the listener is moving).

Note: Only the general Doppler equation, as shown above, or the equation for the specific situation are accepted as correct formulae for a calculation.

- Teachers need to explain the Doppler equation to learners so that they can understand when and why to add or subtract the velocities of the source or listener to that of sound. **For**

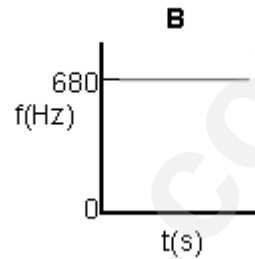
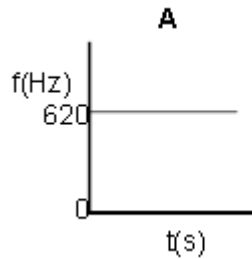
example, if the source moves towards a stationary observer, only $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ or

$f_L = \frac{v}{v - v_S} f_S$ are accepted as correct formulae.

- This equation is a combination of **FOUR** scenarios:
 - A moving source approaching a stationary listener,
 - A moving source moving away from a stationary listener,
 - A moving listener approaching a stationary source and
 - A moving listener moving away from a stationary source.
- When using the general Doppler equation the following approach can be helpful:
 - If a source of sound waves moves towards a stationary listener, f_L will be higher than f_S , thus $v_L = 0$ and a **negative sign** is used for v_S in the **denominator** in order to obtain a higher observed frequency value. $\therefore f_L = f_S \frac{v}{v - v_S}$
 - If a source of sound waves moves away from a stationary listener, f_L will be lower than f_S , thus $v_L = 0$ and a **positive sign** is used for v_S in the **denominator** in order to obtain a lower observed frequency value. $\therefore f_L = f_S \frac{v}{v + v_S}$
 - If a listener moves towards a stationary source of sound waves, f_L will be higher than f_S , thus $v_S = 0$ and a **positive sign** is used for v_L in the **numerator** in order to obtain a higher observed frequency value. $\therefore f_L = f_S \frac{v + v_L}{v}$
 - If a listener moves away from a stationary source of sound waves, f_L will be lower than f_S , thus $v_S = 0$ and a negative sign is used for v_L in the numerator in order to obtain a lower observed frequency value. $\therefore f_L = f_S \frac{v - v_L}{v}$
- Describe applications of the Doppler Effect with ultrasound waves in medicine, e.g. to measure the rate of blood flow or the heart of a foetus in the womb.

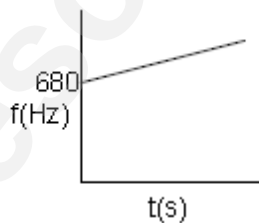
QUESTION 6 (FREE STATE 2016) DOPPLER EFFECT

- 6.1 The siren of a stationary police car emits sound at a frequency of 650 Hz. An observer travelling in a car at constant velocity measures the frequency of the detected sound from the siren for two different situations. The results obtained are presented in graphs A and B below.



- 6.1.1 Define the *Doppler effect*
- 6.1.2 Which graph demonstrates the results obtained when the observer was travelling towards the siren. Give a reason for your answer.
- 6.1.3 Calculate the speed of the observer using the data from graph A. (Take the speed of sound in air as 340 m.s^{-1})

The observer now conducts a new investigation and from the results obtained the graph shown below.



- 6.1.4 Explain the change in the shape of the graph when compared to graphs B
- 6.2 State ONE use of the Doppler effect in medicine

QUESTION 6 (NORTH WEST 2016) DOPPLER EFFECT

A sound source, moving at constant speed, approaches and then passes a stationary detector. The minimum and maximum frequencies detected are 749 Hz and 751 Hz. The speed of sound in air is $340 \text{ m}\cdot\text{s}^{-1}$.

- 6.1 Write down the *Doppler effect* in words
- 6.2 At what stage was the frequency of sound recorded equal to 749 Hz? While the sound source was moving ... (Write MOVING or MOVING AWAY FROM the detector)
- 6.3 Is the wave length detected at a frequency of 751 Hz, GREATER THAN, LESSER THAN or EQUAL TO the wave length of the sound produced by the source?
- 6.4 Determine the speed of the sound source

QUESTION 6 (WESTERN CAPE 2016) DOPPLER EFFECT

- 6.1 A police car moves away from an accident scene at a constant speed with its siren on. A paramedic at the accident observes a 7% drop in the frequency of the sound of the siren in comparison to when the car was standing still. Speed of sound in air on that day is $335 \text{ m}\cdot\text{s}^{-1}$.
 - 6.1.1 State in words, the *Doppler effect*.
 - 6.1.2 Calculate the speed of the car.
- 6.2 An astronomer on Earth observes the missing frequencies in a line spectrum from a distant galaxy. The frequencies associated with specific elements are all lower than expected.
 - 6.2.1 With what kind of line spectrum is the astronomer working?
Answer only ABSORPTION or EMISSION.
 - 6.2.2 Identify the type of shift seen by the astronomer.
 - 6.2.3 Is the distant galaxy moving towards or away from our Solar System.

QUESTION 6 (EASTERN CAPE 2016) DOPPLER EFFECT

A police car is moving down along on a flat road at a constant speed and emits from its siren sound waves with frequency 346 Hz. A woman sitting next to the road detects sound waves at a frequency that is 50 Hz more than the frequency of sound waves emitted by the siren as the police car is moving towards her.

- 6.1 State the *Doppler effect* in words.
- 6.2 Explain, in terms of wave motion, why the frequency heard by the woman is higher than the frequency of the source.

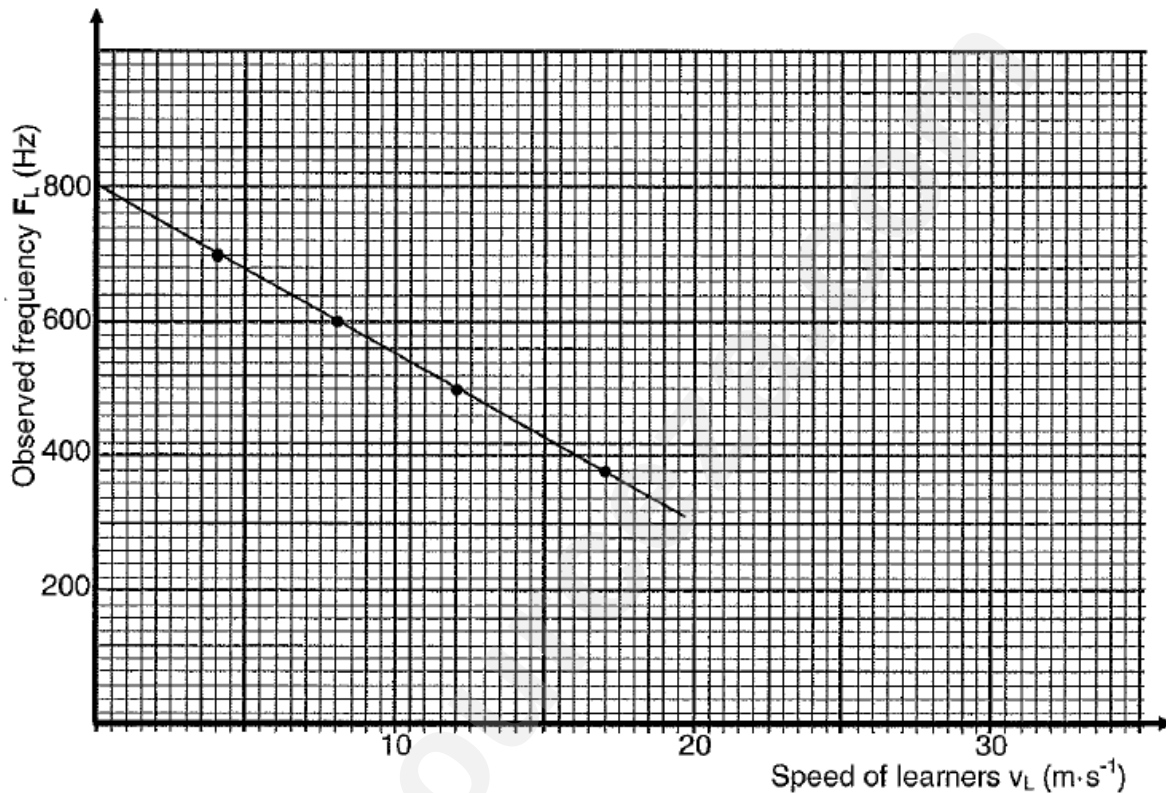
Assume that the speed of sound in air is $340 \text{ m}\cdot\text{s}^{-1}$

- 6.3 Calculate the speed of the car.
- 6.4 State ONE application of the Doppler effect in medicine
- 6.5 A line in a hydrogen spectrum has a frequency of $7,55 \times 10^{14} \text{ Hz}$ when measured in laboratory. The same line in the spectrum of a distant star has a frequency of $17,23 \times 10^{11} \text{ Hz}$.

State whether the distant star is moving TOWARDS or AWAY from the earth.
Give reason for the answer.

QUESTION 6 (MPUMALANGA 2016) DOPPLER EFFECT

During an experiment learners move at different velocities away from a stationary sound source. The learners write down the observed frequency F_L for each of the different velocities and obtain the following graph. Ignore the effect of wind.



- 6.1 Write down an investigative question for this experiment.
- 6.2 State the *Doppler effect* in words.
- 6.3 Use the graph and write down the value of the frequency of the sound source.
Give a reason for the answer.
- 6.4 Calculate the gradient of the graph.
- 6.5 Use the gradient of the graph as calculated in Question 6.4 to calculate the speed of sound in air.

QUESTION 6 (LIMPOPO 2016) DOPPLER EFFECT

- 6.1 A bird, flying at a constant velocity, emits sounds with a frequency of 90 Hz. A stationary observer hears the sounds from the bird at 88 Hz.
- 6.1.1 State the *Doppler Effect* in words.
- 6.1.2 Is the bird moving TOWARDS or AWAY from the observer?
- 6.1.3 Calculate the magnitude of the velocity with which the bird is flying.
- 6.2 The velocities of galaxies relative to the earth can be determined by studying the red shift observed in their spectrums. The table below shows the velocities of three galaxies, **D**, **E** and **F**, relative to the earth.

Galaxies	D	E	F
Speed ($\times 10^7$) $\text{m}\cdot\text{s}^{-1}$	0,15	1,52	2,44

- 6.2.1 What is meant by the term '*red shift*'?
- 6.2.2 State the type of spectrum observed for the different galaxies.
- 6.2.3 Which galaxy **D**, **E** or **F** shows the greatest red shift?
Give a reason for your answer.

QUESTION 6 (GAUTENG 2016) DOPPLER EFFECT

- 6.1 A flying bat emits sound waves at a frequency of 75 Hz. A stationary observer detects the frequency of the sound waves emitted as 73 Hz. The speed of sound in air is $340 \text{ m}\cdot\text{s}^{-1}$.
- 6.1.1 State the *Doppler Effect* in words
- 6.1.2 Is the bat flying TOWARDS or AWA from the observer?
- 6.1.3 Calculate the speed at which the bat is flying
- 6.2 Briefly explain the observations that enable scientists to tell the universe is expanding
- 6.3 State TWO applications of the Doppler Effect in medicine

7. ELECTROSTATICS

- Objects can be **positively**, **negatively** charged or **neutral**.
- Coulomb's law describes the electrostatic force between two point charges and can be stated as: the magnitude of the electrostatic force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

In symbols: $F = k \frac{Q_1 Q_2}{r^2}$

Note: As with Newton's Universal Gravitational Law, Coulombs law describes TWO proportionalities:

1. The force is **directly proportional** to the **product of the charges** ($F \propto Q_1 Q_2$).
2. The force is **inversely proportional** to the **square of the distance** between the centres of the two charges ($F = \frac{1}{r^2}$).

Hints at solving problems using Coulomb's Law.

- Draw a picture of the situation.
- List all the given information and convert to SI units if necessary.
- In the formula $F = k \frac{Q_1 Q_2}{r^2}$,
 - The charge is measured in Coulombs (C).
 - The **distance** (**r**) between the centres of the two charges is measured in metres(m).
 - G (Gravitational constant) and k (Coulomb's constant: $9 \times 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^{-2}$) must not be confused.
 - Remember to square the distance (r^2).
- When you use Coulomb's Law, substitute only the magnitude of the charges into the equation, and not the signs.
- You then determine the direction of the force by deciding whether one charge exerts an electrostatic force of attraction or repulsion on the other charge.

NB: The electrostatic force is **attractive** for **unlike charges** and **repulsive** for **like charges**.

- When there are more than two charges, every charge exerts a force on every other charge.
 - Choose a positive direction.
 - Decide whether each force points in the positive or negative direction.
 - Use Coulomb's law to calculate the magnitude of each force.
 - Add ALL the forces to determine the net force
 - Check that the answer make sense (in relation to the direction chosen as positive).

Electric field

- Describe an *electric field* as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
- Draw electric field patterns for the following configurations:
 - A single point charge
 - Two point charges (one negative, one positive OR both positive OR both negative)
 - A charged sphere
- We can represent the electric field using field lines. By convention electric field lines point away from positive charges (like charges repel) and towards negative charges (unlike charges attract).

We use the following conventions when drawing electric field lines:

- Arrows on the field lines indicate the direction of the field, i.e. the direction in which a positive test charge would move if placed in the field.
- Electric field lines point away from positive charges (like charges repel) and towards negative charges (unlike charges attract).
- Field lines are drawn closer together where the field is stronger.
- Field lines do not touch or cross each other.
- Field lines are drawn perpendicular to a charge or charged surface.
- The greater the magnitude of the charge, the stronger its electric field. We represent this by drawing more field lines around the greater charge than for charges with smaller magnitudes.

Some important points to remember about electric fields:

- There is an electric field at **every point** in space surrounding a charge.
- Field lines are merely a **representation** – they are not real. When we draw them, we just pick convenient places to indicate the field in space.
- Define the *electric field at a point*: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point.
- Calculate the electric field at a point due to a number of point charges, using the equation to determine the contribution to the field due to each charge. (Restrict to three charges in a straight line).
- There are THREE formulae used to calculate electric field intensity:
 - In the formula, $E = \frac{F}{q}$, q is a charge which **experiences** a force in an existing field.
 - In the formula, $E = k \frac{Q}{r^2}$ however, Q is the charge which **causes** the field of we want to determine the field intensity at any point. (In many questions, “due to” is commonly used).
 - ***In the formula, $E = \frac{V}{d}$, E is the electric field intensity between parallel plates, where, V , is the potential difference between two parallel charged plates at a distance, d .
- When there is more than one charge, the electric fields to each charge add up, or superpose, to produce a net electric field.

Note: Apply the same procedure used to determine the net force when there are several forces:

- Choose a positive direction.
- Decide whether each electric field due to each charge points in the positive or negative direction.
- Use the formula, $E = k \frac{Q}{r^2}$, to calculate the magnitude and direction of the electric field due to each charge..
- Add ALL the electric fields to determine the net or resultant electric field.
- Check that the answer make sense (in relation to the direction chosen as positive).

QUESTION 7 (FREE STATE) ELECTROSTATICS

The diagram below shows two identical spheres R and S carrying charges of $-6\mu\text{C}$ and $+2\mu\text{C}$ respectively placed a distance apart in vacuum.

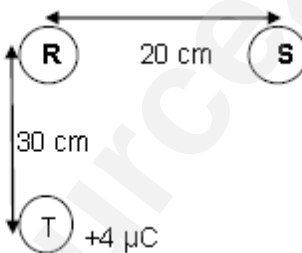


7.1 State *Coulomb's Law* in words

Spheres R and S are brought into contact for a while and then separated by a distance of 20 cm

7.2 Calculate the charge on each sphere

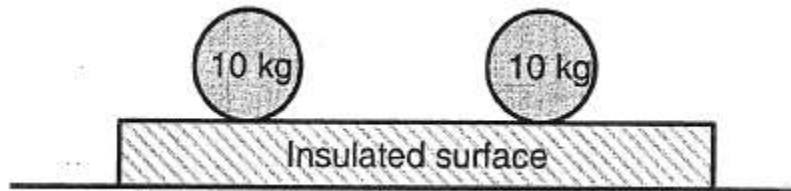
After R and S has touched, a third sphere T, of charge $+4\mu\text{C}$, is placed at a position as shown in the diagram below.



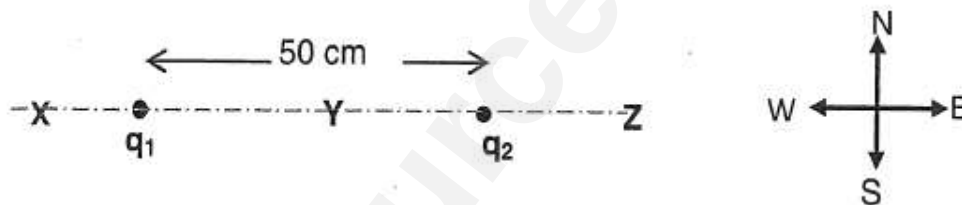
7.3 Calculate the net electrostatic force acting on R due to the presence of spheres S and T

QUESTION 7 (NORTH WEST) ELECTROSTATICS

Two identical metal spheres each of mass 10 kg are placed on an insulated surface as shown



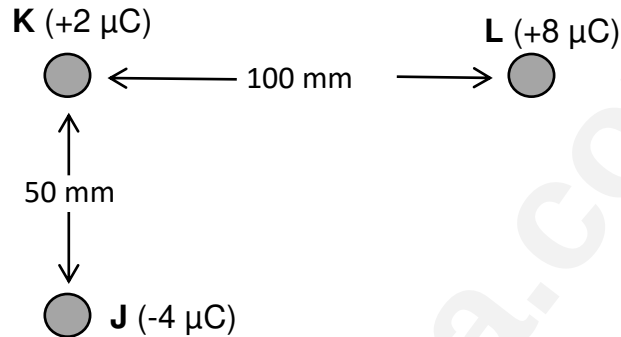
- 7.1 Write down *Coulomb's law* in words
- 7.2 Calculate how much charge of equal magnitude each sphere must have if the electrostatic force must be exactly equal to the gravitational force exerted by one sphere on the other?
- 7.3 Two point charges q_1 and q_2 are placed 50 cm apart. Charge q_1 carries +20nC and q_2 carries -80 nC. Point X, Y and Z along a straight line are positions in the electric field surrounding the charges. Refer to the diagram below



- 7.3.1 In which position (X, Y or Z) can the electric field be zero?
- 7.3.2 Point Z is 70 cm from point charge q_1 . Calculate the net electric field at Z

QUESTION 7 (WESTERN CAPE) ELECTROSTATICS

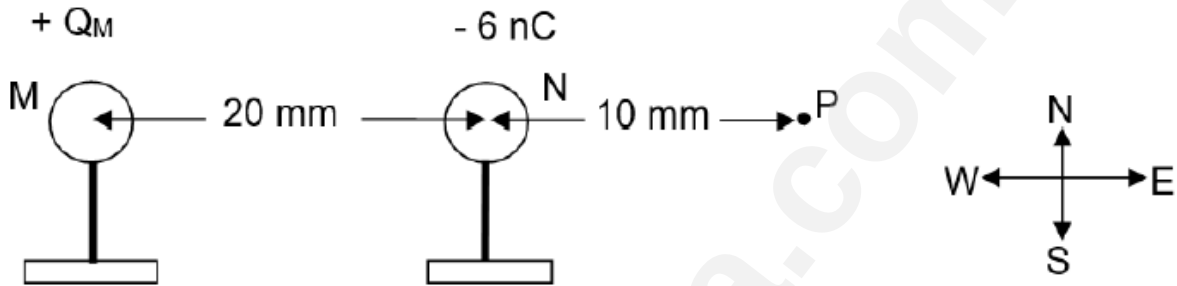
Three charges J, K and L are arranged on a horizontal plane so that angle JKL is a 90° angle. The charges are $-4\ \mu\text{C}$, $+2\ \mu\text{C}$ and $+8\ \mu\text{C}$ respectively. J and K are 50 mm apart and K and L are 100 mm apart. J and L are fixed in position while K is free to move.



- 7.1 State in words, *Coulomb's Law*.
- 7.2 Calculate the magnitude of the electrostatic force between charges J and K.
- 7.3 Draw a free-body diagram showing the electrostatic forces exerted on K due to charges J and L. Also show on the vector diagram how the net force can be determined
- 7.4 Calculate the magnitude and direction of the net electrostatic force exerted on K due to charges J and L.
- 7.5 Define, in words, *electric field at a point*.
- 7.6 Calculate the magnitude of the net electric field at K. Give your answer in scientific notation.

QUESTION 7 (EASTERN CAPE) ELECTROSTATICS

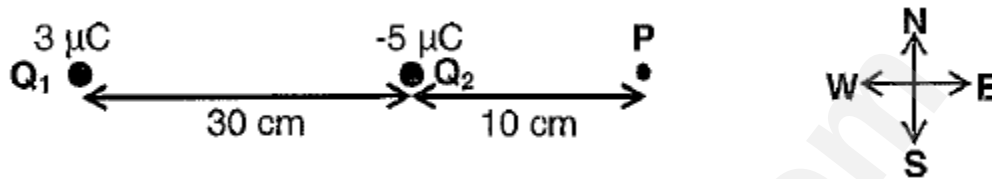
Two metal spheres, **M** and **N**, on insulated stands carry charges $+Q_M$ and -6 nC respectively. The distance between the two charges is 20 mm and **P** is a point at 10 mm from sphere **N** as shown below. The NET ELECTRIC FIELD at point **P** due to presence of **M** and **N** is $5,2 \times 10^5\text{ N}\cdot\text{C}^{-1}$ westwards.



- 7.1 Define the term *ELECTRIC FIELD* at a point.
- 7.2 Calculate the magnitude of charge Q_M on sphere **M**.
- 7.3 The two spheres were allowed to make contact and moved back to their original positions.
 - 7.3.1 Draw the electric field pattern due to the two charges
 - 7.3.2 Calculate the...
 - (a) Number of electrons transferred from one sphere to another sphere after separation.
 - (b) Magnitude and the direction of the force that sphere **M** exerts on sphere **N** **after contact**.

QUESTION 7 (MPUMALANGA) ELECTROSTATICS

Two charged particles Q_1 and Q_2 are placed 30 cm apart as shown in the diagram below. Point P is 10 cm east of charge Q_2



7.1 Define the term *electric field at a point*.

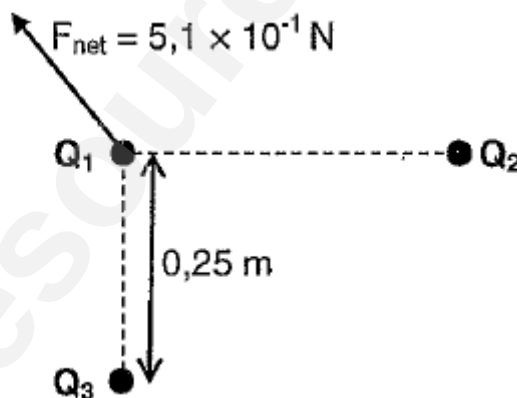
7.2 Calculate the magnitude and direction of the net electric field at point P.

The two charges are brought into contact with each other and placed at their original positions.

7.3 Calculate the charge on each of the particles after contact.

After Q_1 and Q_2 were brought into contact, a charge Q_3 is placed 0,25 m due south of Q_1 .

Charge Q_1 experiences a net force of magnitude $5,1 \times 10^{-1}$ N due to other two charges as shown in the diagram.



7.4 What is the nature of the charge on Q_3 ? Choose from POSITIVE or NEGATIVE.

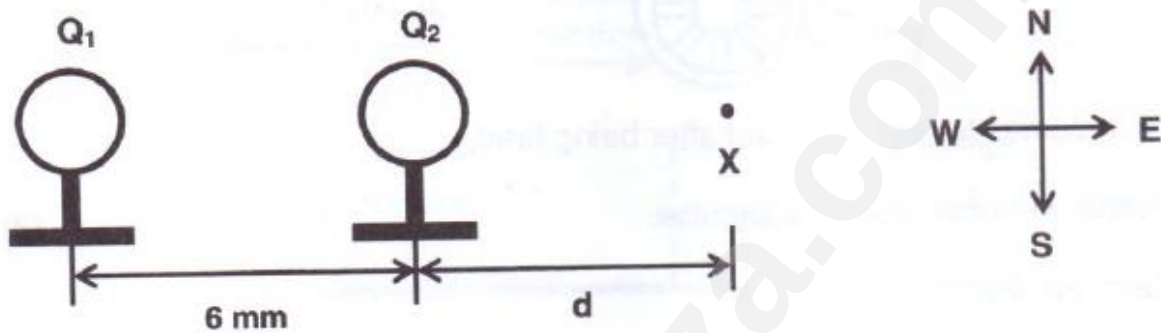
7.5 Calculate the magnitude of the charge on Q_3 .

7.4 What is the nature of the charge on Q_3 ? Choose from POSITIVE or NEGATIVE.

7.5 Calculate the magnitude of the charge on Q_3 .

QUESTION 7 (LIMPOPO) ELECTROSTATICS

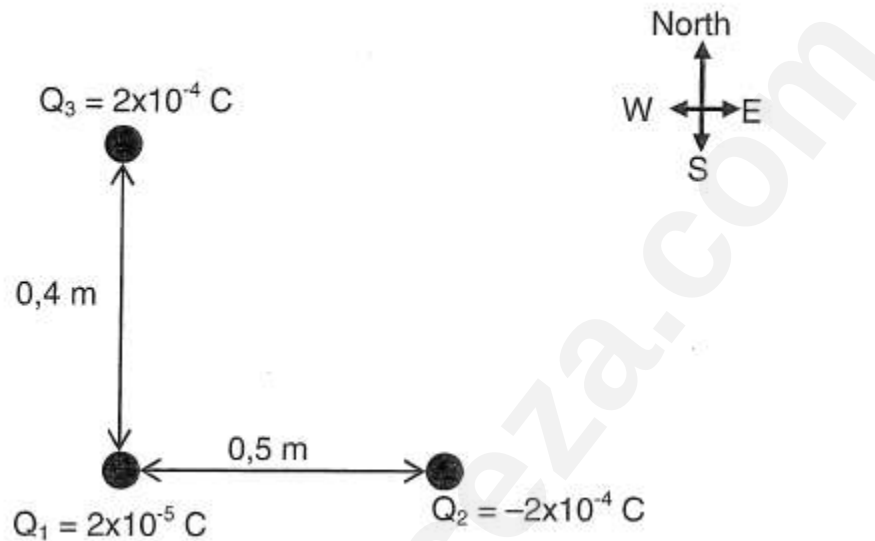
Two very small, identical spheres, Q_1 and Q_2 , with the SAME NEGATIVE charge, are placed on insulating stands with their centres 6 mm apart. The magnitude of the electrostatic force that Q_1 exerts on Q_2 is 4×10^{-3} N. Point X is distance d east of Q_2 , as shown below.



- 7.1 Draw the resultant electric field pattern due to charges Q_1 and Q_2 .
- 7.2 State, in words, *Coulomb's Law of Electrostatics*.
- 7.3 Calculate the magnitude of the charge on Q_1
- 7.4 The electric field at point X, due to Q_1 ONLY, is $4,44 \times 10^{-15} \text{ N}\cdot\text{C}^{-1}$ west. Calculate distance d .

QUESTION 7 (GAUTENG) ELECTROSTATICS

Three charges Q_1 , Q_2 and Q_3 carrying charges of $+2 \times 10^{-5} \text{ C}$, $-2 \times 10^{-4} \text{ C}$ and $+2 \times 10^{-4} \text{ C}$ respectively are positioned as shown in the diagram below.



- 7.1 State *Coulomb's Law* in words
- 7.2 Draw a diagram that shows the electrostatic forces exerted on Q_1 by Q_2 and Q_3
- 7.3 Calculate the net electrostatic force on Q_1 by Q_2 and Q_3

8. ELECTRIC CIRCUITS

1. Ohm's Law governs the relationship between current and potential difference for a circuit element at constant temperature. Mathematically we write $R = \frac{V}{I}$.
2. Conductors that obey Ohm's Law are called ohmic conductors; those that do not are called non-ohmic conductors.
3. Ohm's Law can be applied to a single circuit element or the circuit as a whole (if the components are ohmic).
4. The equivalent resistance of resistors in series (R_s) can be calculated as follows:

$$R_s = R_1 + R_2 + R_3 + \dots + R_n$$
5. The equivalent resistance of resistors in parallel (R_p) can be calculated as follows:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$
6. Real batteries have an internal resistance.
7. The potential difference (V) of the battery is related to its emf (ε) and internal resistance (r) by:

$$\varepsilon = V_{\text{load}} + V_{\text{internal resistance}} \text{ or } \varepsilon = IR_{\text{ext}} + Ir.$$
8. The external resistance in the circuit is referred to as the load.
9. Define *power* as the rate at which work is done. Mathematically we write $P = W/\Delta t$.
10. When Solving circuit problems involving the concepts of power and electrical energy, we use the following: $P = VI$, $P = I^2 R$ or $P = V^2/R$
11. Deduce that the kilowatt hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.
12. Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

Hints on solving Electric Circuits

When analyzing combination circuits, it is critically important to have a solid understanding of the concepts that pertain to both series circuits and parallel circuits. Since both types of connections are used in combination circuits, the concepts associated with both types of circuits apply to the respective parts of the circuit.

The main concepts associated with series and parallel circuits are organized in the table below:

Series Circuits	Parallel Circuits
- The current is the same in every resistor; this current is equal to that in the battery. - The sum of the voltage drops across the individual resistors is equal to the voltage rating of the battery. - The overall resistance of the collection of resistors is equal to the sum of the individual resistance values,	- The voltage drop is the same across each parallel branch. - The sum of the current in each individual branch is equal to the current outside the branches. - The equivalent or overall resistance of the collection of resistors is given by the equation
$R_{\text{tot}} = R_1 + R_2 + R_3 + \dots$	$1/R_{\text{eq}} = 1/R_1 + 1/R_2 + 1/R_3 \dots$

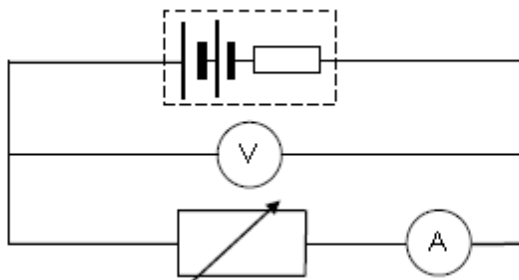
Each of the above concepts has a mathematical expression. Combining the mathematical expressions of the above concepts with the Ohm's law equation ($\Delta V = IR$) allows one to conduct a complete analysis of a combination circuit.

The following suggestions for approaching combination circuit problems are very important:

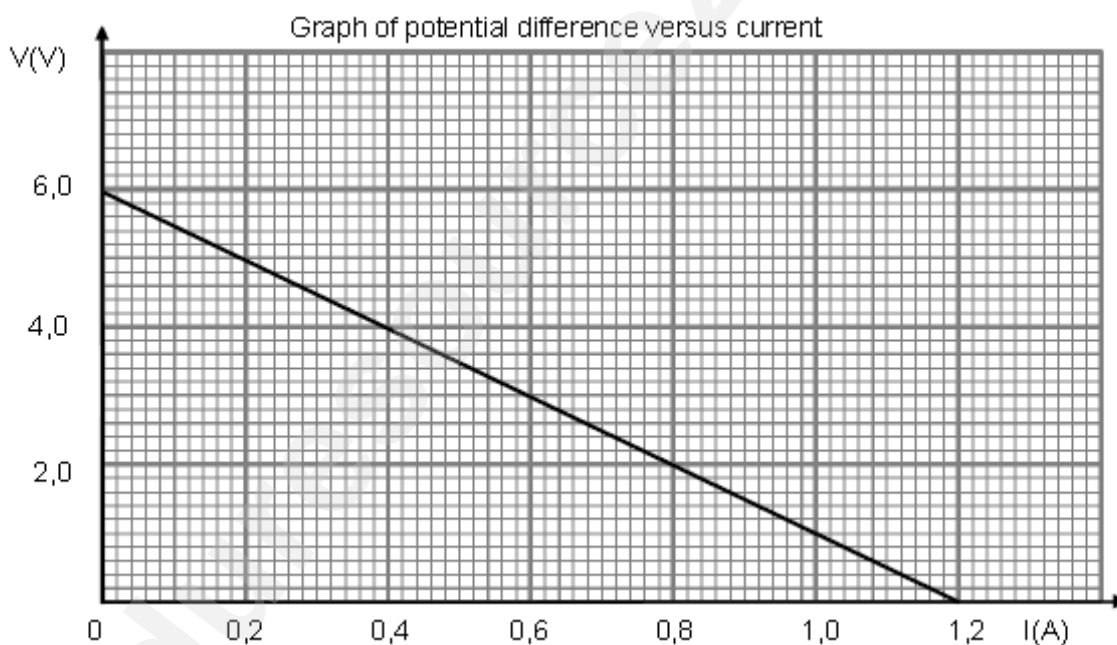
- If a schematic diagram is not provided, take the time to construct one.
- When approaching a problem involving a combination circuit, take the time to organize yourself, writing down known values and equating them with a symbol such as I_{tot} , I_1 , R_3 , ΔV_2 , etc.
- Know and use the appropriate formulae for the equivalent resistance of series-connected and parallel-connected resistors. Use of the wrong formulae will guarantee failure.
- Transform a combination circuit into a strictly series circuit by replacing (in your mind) the parallel section with a single resistor having a resistance value equal to the equivalent resistance of the parallel section.
- If solving Series-Parallel circuits, solve the Parallel parts first, then you are left with only a much-easier Series circuit.
- Use the Ohm's law equation ($\Delta V = IR$) often and appropriately. Most answers will be determined using this equation. When using it, it is important to substitute the appropriate values into the equation. For instance, if calculating I_2 , it is important to substitute the ΔV_2 and the R_2 values into the equation.

QUESTION 8 (FREE STATE) ELECTRIC CIRCUITS

- 8.1 A group of learners conducts an experiment to determine the internal resistance of a battery. They connect the battery to a rheostat, an ammeter and a voltmeter as shown in the diagram below.

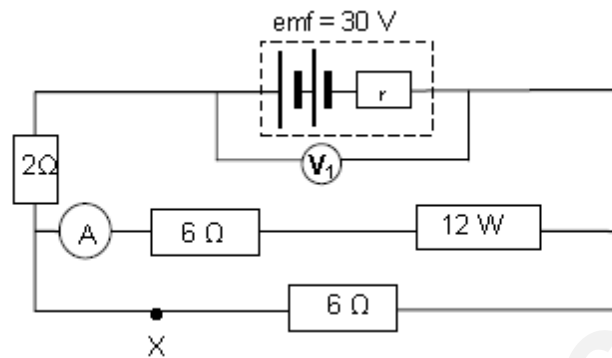


The data obtained are shown in the graph below.



- 8.1.1 Explain the purpose of the rheostat
- 8.1.2 Name the independent variable in the experiment
- 8.1.3 What is the value of the emf of the battery
- 8.1.4 Calculate V_{internal} if the current in the circuit is equal to 0,8 A

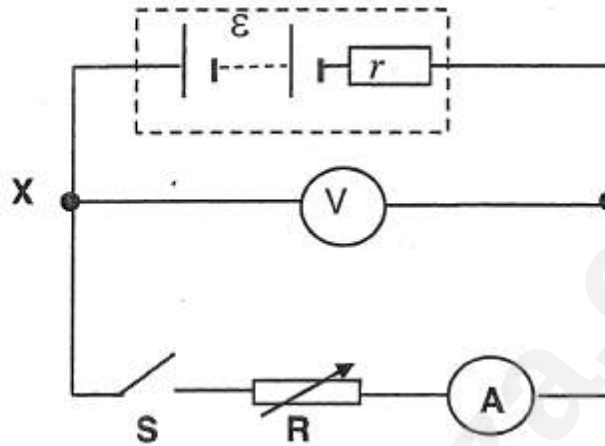
- 8.2 Three resistors and an electrical device are connected to a 30 V battery with internal resistance r as shown in the circuit diagram below. The ammeter has a reading of 2 A.



- 8.2.1 Define the term emf of a battery
- 8.2.2 Calculate voltmeter reading V_1
- 8.2.3 Calculate the internal resistance of the battery
- 8.2.4 An additional resistor is connected at position X as indicated in the diagram. How will voltmeter reading V_1 be affected? Write down only INCREASE, DECREASE or STAYS THE SAME. Give an explanation for your answer.

QUESTION 8 (NORTH WEST) ELECTRIC CIRCUITS

Learners perform an experiment to determine the internal resistance of a battery using the circuit diagram below.



The readings obtained from the experiment are shown in the table below.

$R (\Omega)$	0	2	4	6	8
$\frac{1}{I} (A^{-1})$	0,14	0,26	0,38	0,5	0,62

8.1 The equation used by the learners is:

$$R = \frac{\mathcal{E}}{I} - r$$

Use the data from the table to draw a graph of R verses $\frac{1}{I}$ ON THE GRAPH SHEET

8.2 What is the physical quantity represented by the slope of the graph?

8.3 Use information from the graph to determine the value of the:

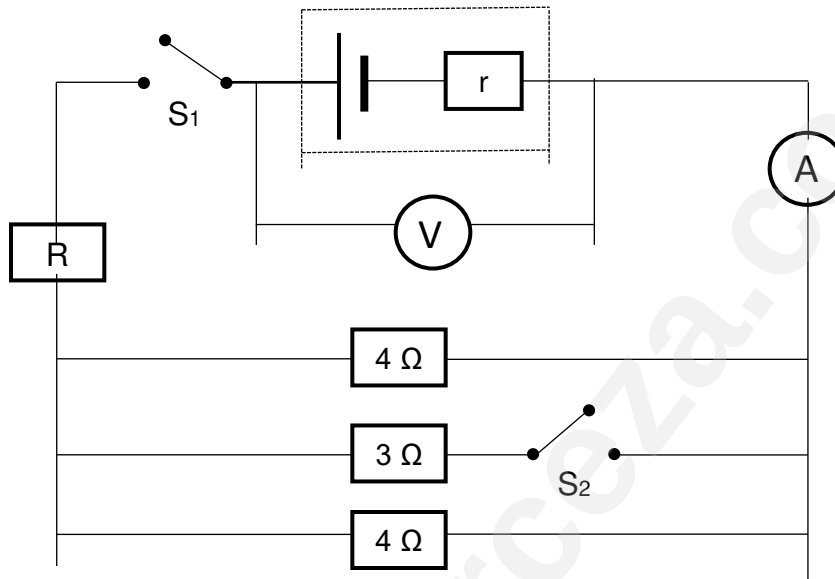
8.3.1 emf of the battery

8.3.2 internal resistance of the battery

8.4 The voltmeter across XY is replaced by a connecting wire of negligible resistance. Determine the current in the battery.

QUESTION 8 (WESTERN CAPE) ELECTRIC CIRCUITS

A battery is connected to a circuit with four resistors and two switches as shown in the diagram below. When switch S_1 is open and no current flows, the voltmeter reading across the terminals of the battery is 18 V.



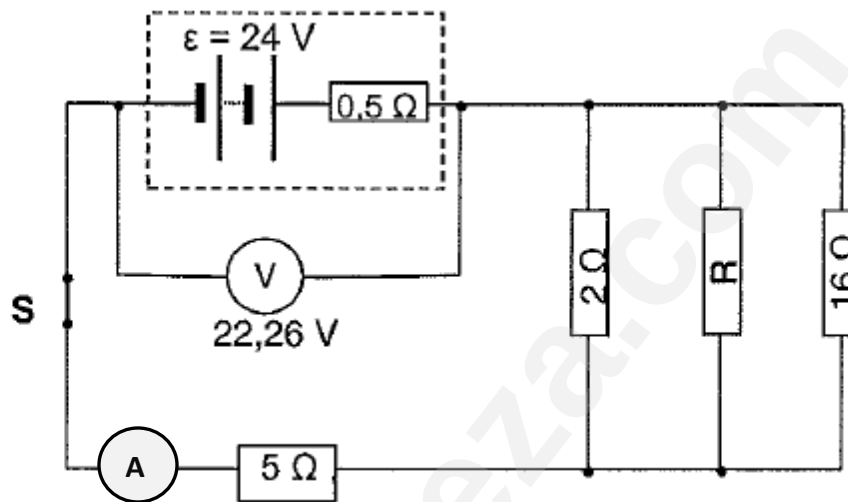
- 8.1 Write down the term that describes the voltmeter reading when switch S_1 is open.

When both switches are closed, the voltmeter reading decreases by 0,9 V and the ammeter reads 4,5 A.

- 8.2 Write down the term that describes the voltmeter reading when both the switches are closed.
- 8.3 Calculate the internal resistance of the battery.
- 8.4 Which of the resistors in parallel carries the largest current?
Write down 4 Ω or 3 Ω . Explain your answer.
- 8.5 Calculate the resistance of resistor R.
- 8.6 Name the one environmental factor that could cause the resistance of R to change.
- 8.7 Switch S_2 is now opened.
Will the voltmeter reading INCREASE, DECREASE or STAY THE SAME?
Explain your answer without doing any calculation.

QUESTION 8 (MPUMALANGA) ELECTRIC CIRCUITS

A battery with an internal resistance of $0,5\ \Omega$ and an emf ($\mathcal{E}$) of 24 V is connected in a circuit, as shown below. With switch **S** closed, the high-resistance voltmeter (**V**) has a reading of $22,26\text{ V}$.



8.1 Explain the concept *emf* of 24 V in terms of work done.

Calculate the:

8.2 Ammeter reading

8.3 Power dissipated in the $16\ \Omega$ resistor.

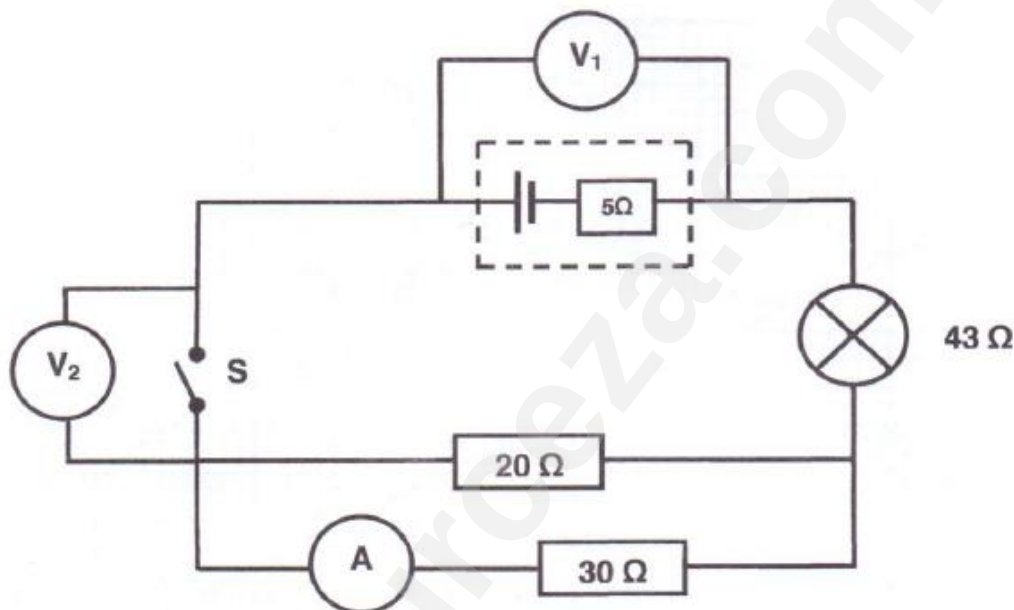
8.4 Current passing through resistor **R**.

Resistor R is removed from the circuit.

8.5 Will the power dissipated in the $16\ \Omega$ resistor INCREASE, DECREASE or REMAIN CONSTANT? Explain the answer without doing any calculations.

QUESTION 8 (LIMPOPO) ELECTRIC CIRCUITS

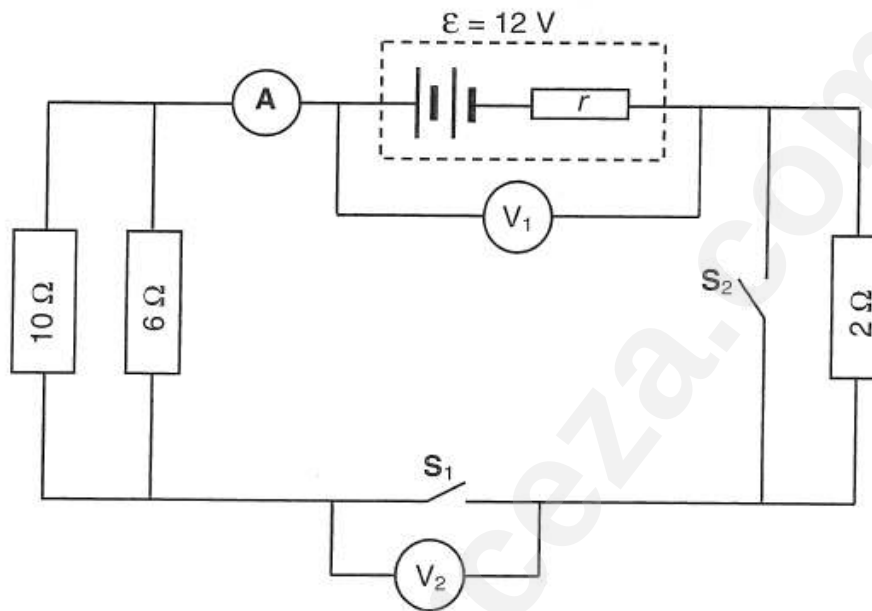
A battery with an unknown emf and internal resistance of $5\ \Omega$ is connected to a $43\ \Omega$ bulb and other resistors as shown in the circuit below. Voltmeter V_1 is connected across the battery and voltmeter V_2 is connected across the open switch S . Ignore the resistance of the ammeter and connecting wires.



- 8.1 Define, in words, the term *emf*.
- 8.2 The reading on V_1 **decreases** by $4,5\ \text{V}$ when switch S is closed.
 - 8.2.1 What causes the decreases in the reading on voltmeter V_1 ?
 - 8.2.2 What is the reading on V_2 when switch S is closed?
 - 8.2.3 Calculate the emf of the battery.
 - 8.2.4 Calculate the reading on the ammeter.
- 8.3 Will the power of the bulb **INCREASE**, **DECREASE** or **REMAINTHE SAME** when the $20\ \Omega$ resistor is removed?
Explain your answer.

QUESTION 8 (GAUTENG) ELECTRIC CIRCUITS

The battery in the circuit represented below has an emf of 12 V and an internal resistance r . Voltmeter V_1 is connected across the battery. The resistance of the connecting wires is negligible.



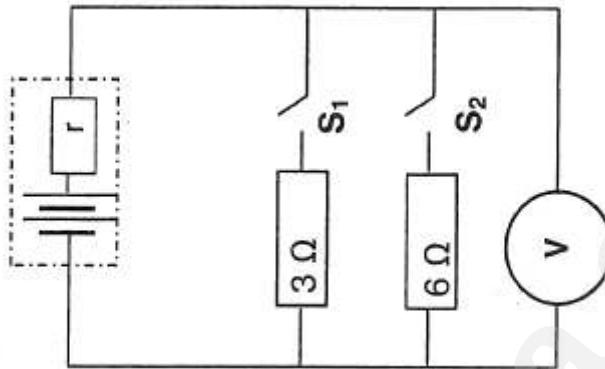
Switches S_1 and S_2 are both open.

- 8.1 Write down the reading on voltmeter V_2
- 8.2 Switch S_1 is now closed. Switch S_2 remains open. The reading on V_1 is now 10 V
Calculate the:
 - 8.2.1 Total external resistance of the circuit
 - 8.2.2 Internal resistance of the battery
- 8.3 Both switches S_1 and S_2 are now closed

How will the reading on the ammeter be affected? Choose from INCREASES, DECREASES or REMAIN THE SAME. Explain the answer.

QUESTION 8 (NORTH WEST) ELECTRIC CIRCUITS

In the circuit below, two resistors are connected in parallel, to a battery with an internal resistance r and a high resistance voltmeter



When S_2 is open and S_1 closed, the voltmeter reading is 12 V

When S_2 is closed and S_1 open, the voltmeter reading is 16 V

8.1 Write down Ohm's law in words

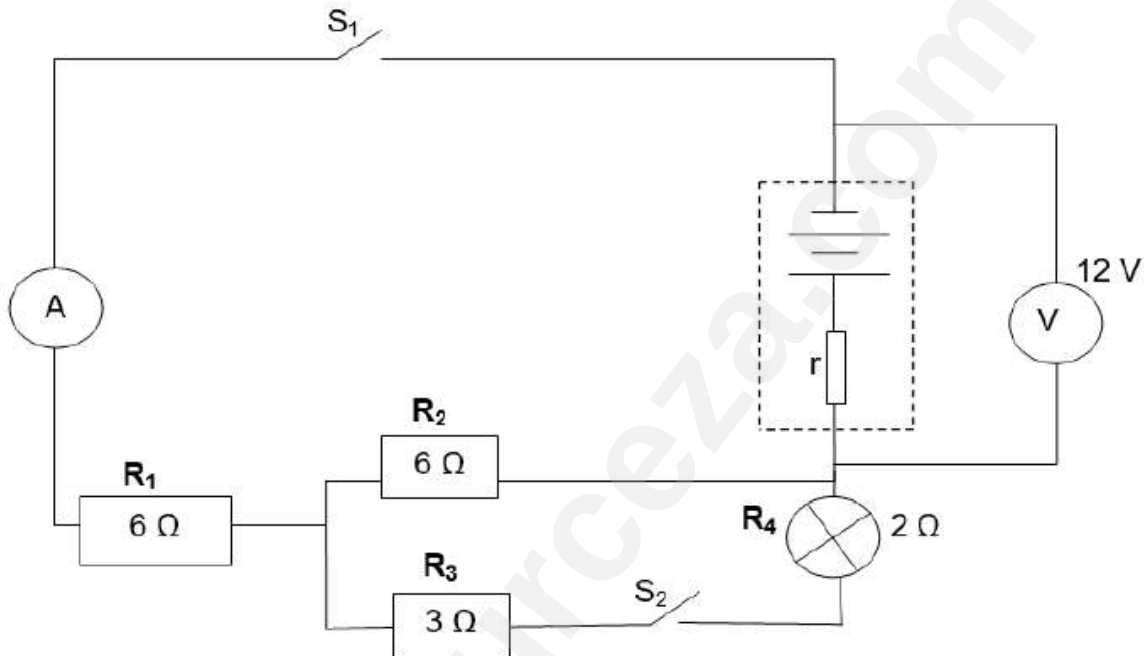
8.3 Calculate the voltmeter reading when both switches:

8.3.1 S_1 and S_2 are open

8.3.2 S_1 and S_2 are closed

QUESTION 8 (EASTERN CAPE) ELECTRIC CIRCUITS

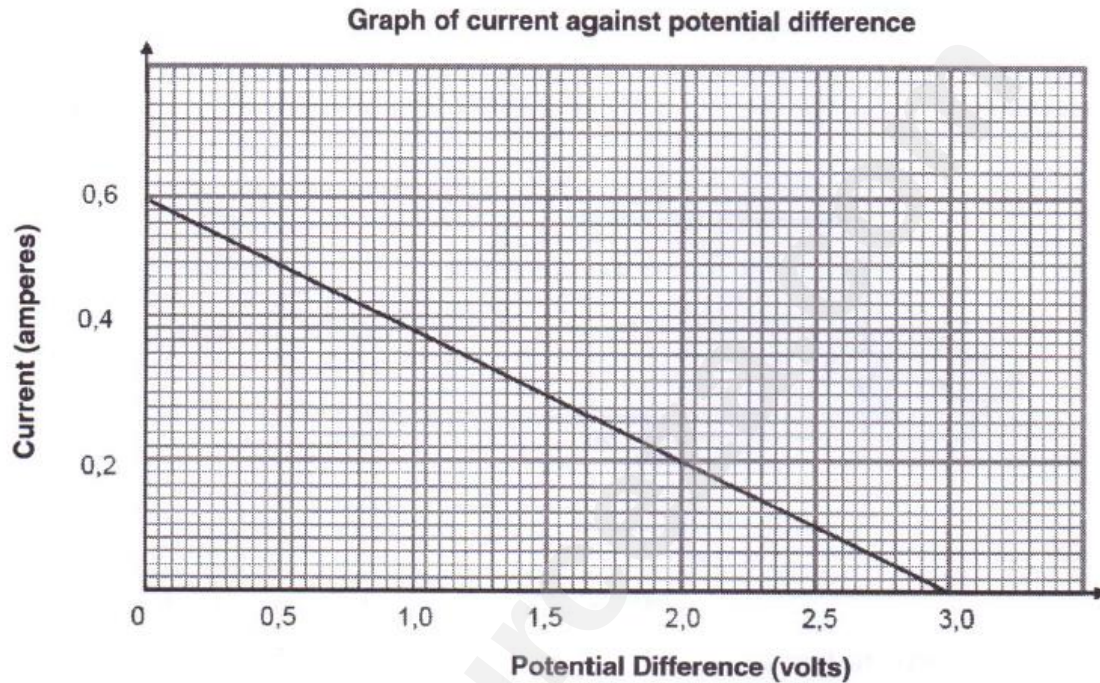
In the circuit below, the battery has an emf of 12 V and internal resistance r . The three resistors and the bulb are connected as shown in the diagram. The resistance of the bulb is $2\ \Omega$. Initially both switches S_1 and S_2 are open. Assume that all the connecting wires and an ammeter A have negligible resistances.



- 8.1 With only switch S_1 closed, the reading on the voltmeter drops to 10,8 V. Calculate the ...
- 8.1.1 reading on ammeter A .
- 8.1.2 internal resistance, r of the battery.
- 8.2 With both switches, S_1 and S_2 , closed, the ammeter reads 1,5 A.
- 8.2.1 Calculate the power dissipated by the bulb.
- 8.2.2 What effect will the closing of both switches have on the “lost volts”?
- Write only INCREASE, REMAINS THE SAME OR DECREASE.
- Fully explain your answer.

QUESTION 8 (LIMPOPO) ELECTRIC CIRCUITS

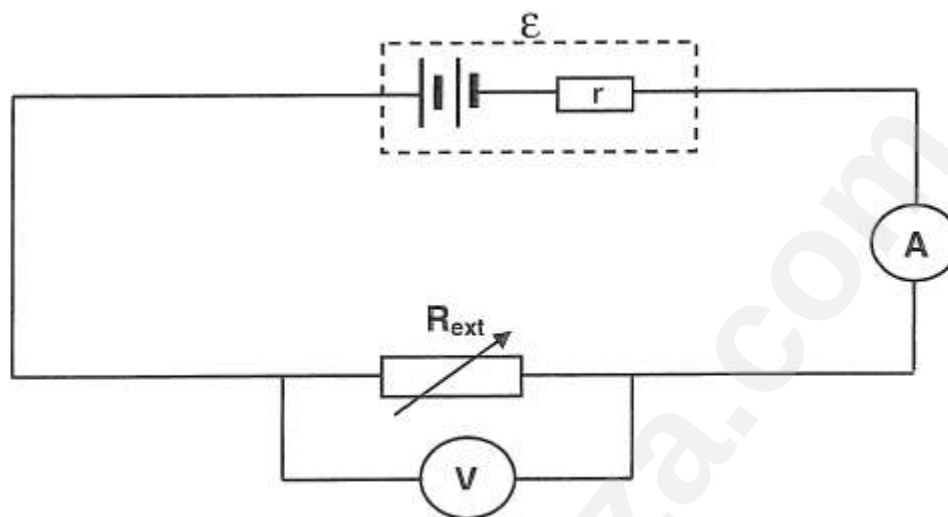
A learner sets up a circuit to determine the emf ($\mathcal{E}$) and internal resistance (r) of a battery. The learner obtained the following graph from the data of the investigation.



- 8.1 Define, in words, the term *internal resistance*.
- 8.2 Using the **graph ONLY** determine the value of the following:
- 8.2.1 Emf ($\mathcal{E}$) of the battery
 - 8.2.2 'Lost' volts when the current in the circuit is 0, 2 A
 - 8.2.3 Internal resistance of the battery.

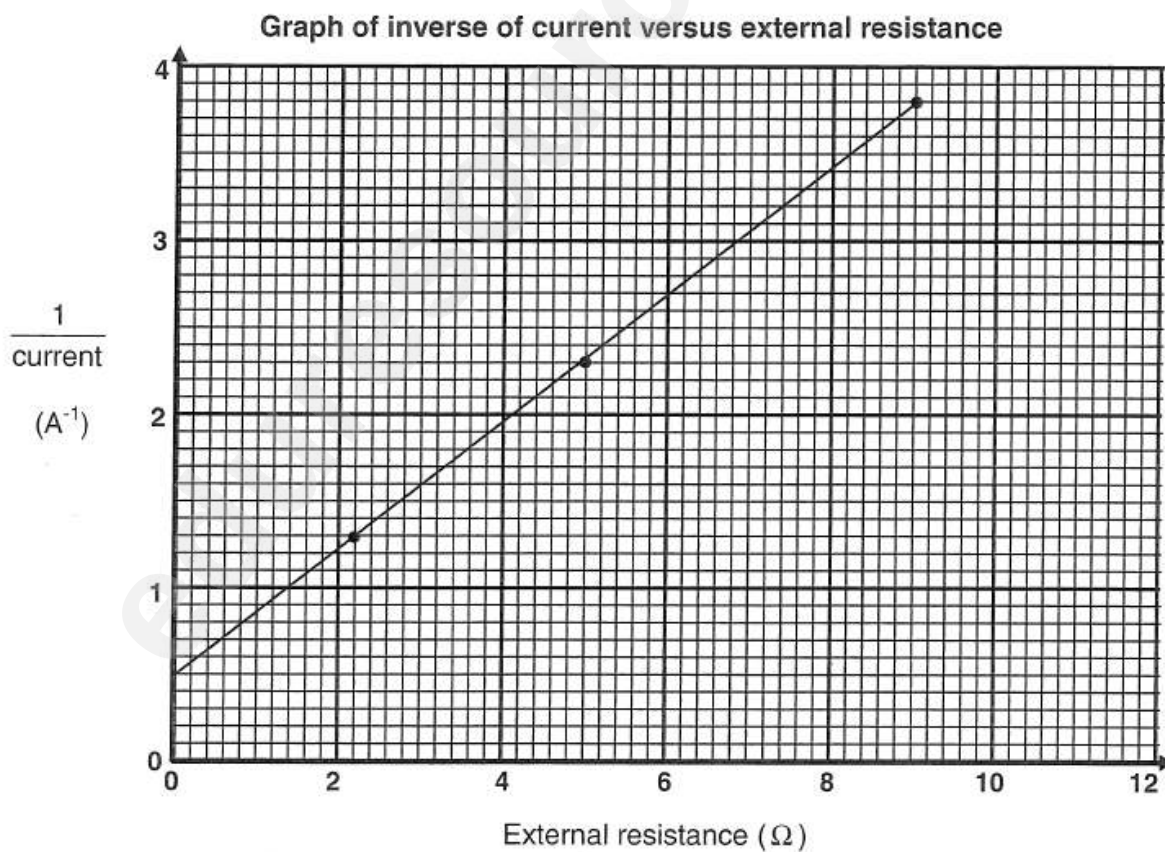
QUESTION 8 (GAUTENG) ELECTRIC CIRCUITS

A learner set up the circuit shown below to measure the internal resistance of a battery.



She records the readings on the voltmeter and ammeter for different resistances of the rheostat.

The graph below was obtained from the results.



- 8.1 Define the term *emf*
- 8.2 Calculate the gradient of the above graph
- 8.3 What is represented by the gradient in Question 8.2?
- 8.4 Use the information on the graph to calculate the:
 - 8.4.1 Emf of the battery
 - 8.4.2 Internal resistance of the battery

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9. ELECTRODYNAMICS

Motor effect and electric motors

Motor effect : a moving load (current-carrying conductor), I , in magnetic field(B) experience a force . Thus $I + B \rightarrow F$ (all three to $\perp$ each other).

To get direction of F : Use **Right-hand motor rule**

Put your right hand out.

Fingers in direction of B : $N \rightarrow S$.

Thumb indicates conventional current ($+\rightarrow -$).

Palm of hand indicates direction of F .

Size of F depends on

- angle between I and B
- strength of I , B
- length of conductor in B -field

Electric motor:

- Current-carrying coil (I) in external magnetic field (B) experiences torque (F) (coil turns).
- Electric motors convert electrical energy into mechanical energy.
- There are two types of motors - AC and DC.

	DC motor	AC motor
Principle of operation	Motor Effect	Motor Effect
Source of electric energy		Alternating current
Energy conversion	Electrical to mechanical	Electrical to mechanical
Coil makes contact with	Split-ring commutator and brushes	Slip rings and brushes
Uses	Smaller appliances, i.e. CD players, computers, fans, laser printers – also in electric trains	Appliances needing large power, i.e. heavy industrial machines
Advantages	Easy speed control. Speed depends on potential difference. Size of force can easily be changed	Works from wall plug. Cheaper than DC motors
Disadvantages	AC must first be converted to DC before motor can work from wall plug. Requires regular maintenance, especially of brushes, thus more expensive than AC motor	Rotation speed same as frequency of AC, cannot be changed easily. Uses large current. Sparks, heat at brushes causes energy loss, reduces lifetime of motor

Electromagnetic Induction and generators

Electromagnetic induction

Change in magnetic flux linkage induces emf in a conductor.

Lenz's law

Direction of induced current opposes inducing action.

Dynamo effect Moving conductor (F) in magnetic field (B) induces an emf (current if circuit closed (I)) i.e. $F + B \rightarrow I$ (all three $\perp$ to each other)

Use Fleming's **RIGHT HAND** Dynamo Rule to get direction of I.

Stretch the fingers of the right hand out.

Fingers indicate the direction of B.

Thumb indicates F.

Hand palm indicates the direction of the conventional current.

Faraday's law

Magnitude of emf directly proportional to rate of change in magnetic flux.

$\text{Emf} \propto \Delta \Phi / \Delta t$.

Generators

- Moving coil in external magnetic field induce emf (current in closed circuit).
- Electrical generators convert mechanical energy into electrical energy.
- There are two types of generators - AC and DC. An AC generator is also called an alternator.

	DC generator	AC generator
Principle of operation	Electromagnetic Induction	Electromagnetic Induction
Energy conversion	Mechanical to electrical	Mechanical to electrical
Coil makes contact with	Split-ring commutator and brushes	Slip rings and brushes
Uses	Electroplating with metals, electrolysis for manufacture of chlorine, refining of aluminium, copper, manganese. Many DC generators are driven by AC motors.	Electricity generation at power stations. Generators at amusement parks, hospitals and other essential services, building sites, for lights at accident scenes, etc.

Improving the efficiency of motors/generators

- Make more windings in the coil,
- Use soft iron core in centre (stronger B-field),
- Use horse shoe-shaped external magnets

Alternating current

Alternating current (AC) has many advantages over direct current (DC).

- Current and potential difference can be stepped up or down by transformers. Low I, high V for transport of electrical energy over long distances so that energy loss is at minimum.
- Build power stations next to coalmines, lower transport costs of coal.
- Moving coil in external magnetic field induce emf (current in closed circuit). Mechanical energy converted to electrical energy.
- The root mean square (rms) value of a quantity is the maximum value the quantity can have divided by $\sqrt{2}$.
- Define the rms (root mean square) values for current and voltage as $I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}}$ and $V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$ respectively, and explain why these values are useful.
- The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.
- The average power dissipated in a purely resistive circuit with alternating current is $P_{\text{average}} = V_{\text{rms}} I_{\text{rms}} = I_{\text{rms}}^2 R = \frac{V_{\text{rms}}^2}{R}$
- Sketch graphs of voltage versus time and current versus time for an AC circuit. .
- The relation between rms values and maximum values for potential difference and current are as follows:

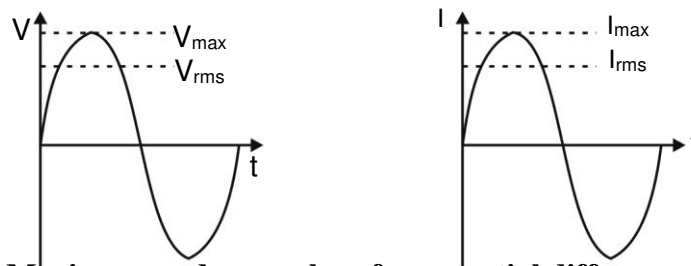
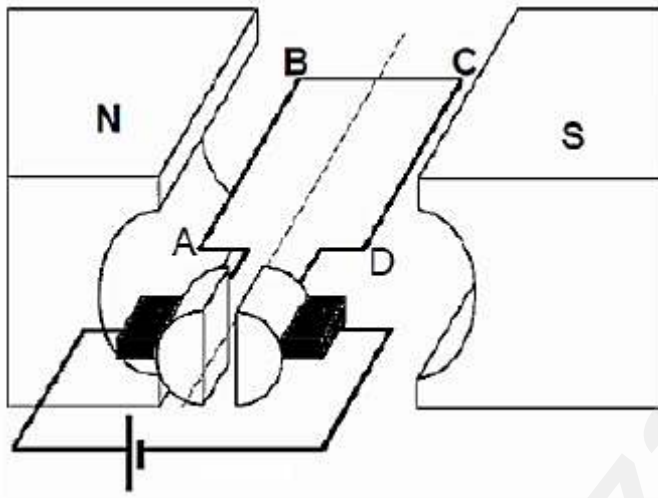


Figure 1: Maximum and rms values for potential difference and current

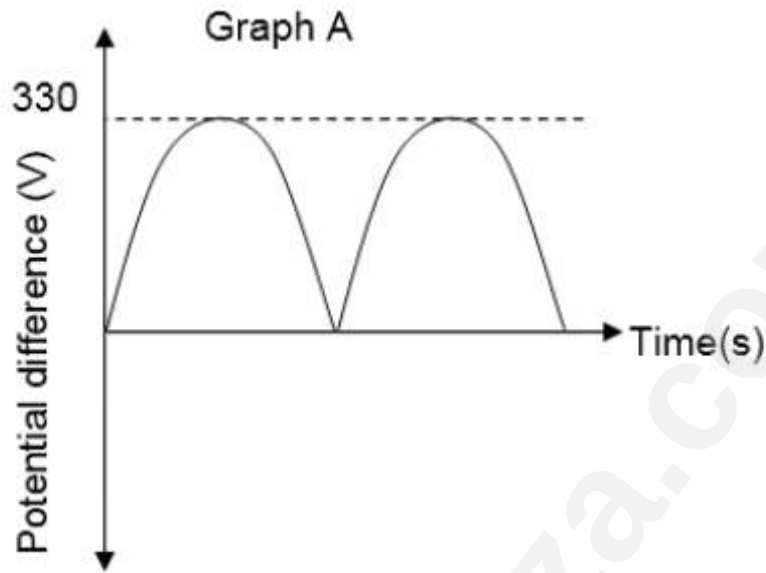
QUESTION 9 (EASTERN CAPE) ELECTRODYNAMICS

The simplified sketch below represents an electrical motor.



- 9.1 Name the type of electrical motor that is shown above.
- 9.2 What energy conversion takes place in the above electrical motor?
- 9.3 The turning effect of the electrical motor can be increased by increasing the number of turns of coil or by increasing the strength of the magnetic field.
- 9.3.1 Write down another way in which this turning effect can be increased.
- It is intended to produce a maximum potential difference in the electrical motor when a constant current is supplied.
- 9.3.2 In which position should the coil relative to the magnetic field be positioned in order to produce maximum potential difference?
Write only PARALLEL or PERPENDICULAR.

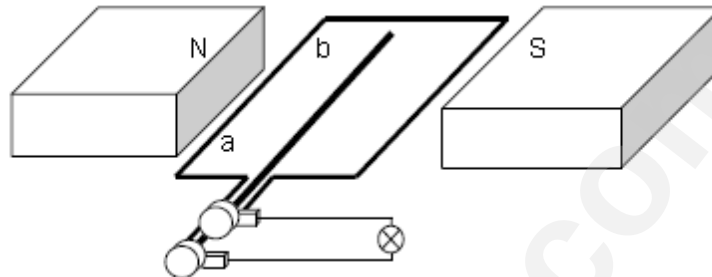
9.4 The graphs below shows the output of a generator.



- 9.4.1 Is the reading indicated as 330 V on the graph above a root mean square voltage (V_{rms}) or a maximum voltage (V_{max})?
- 9.4.2 The generator produces the root mean square current (I_{rms}) of 12 A. Determine the rate at which the generator will transfer energy.

QUESTION 9 (FREE STATE) ELECTRODYNAMICS

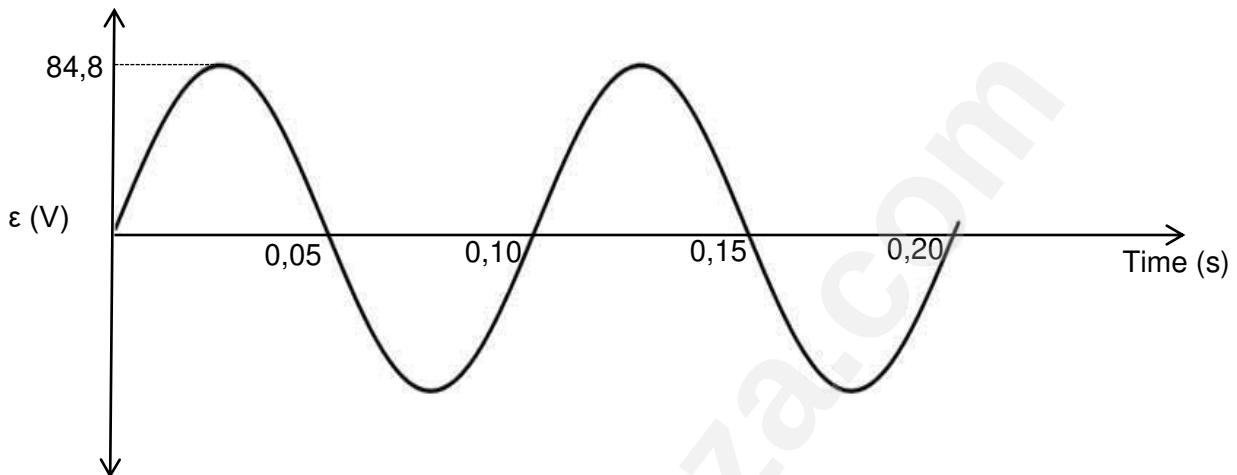
- 9.1 A simplified diagram of an AC generator is shown below. The direction of the current in the coil is from b to a.



- 9.1.1 In which direction is the coil being rotated? Write only CLOCKSISE or ANTICLOCKWISE
- 9.1.2 A maximum voltage is generated if the coil moves through the position indicated in the diagram above. Give an explanation for this observation.
- 9.1.3 Starting from the position shown in the diagram above, sketch a graph of output voltage versus time for one complete cycle of the coil
- 9.1.4 State ONE way in which the generator shown above can be used to produce a higher output voltage
- 9.1.5 Give ONE advantage for the use of alternating current
- 9.2 An electric fan with a power rating of 80 W is connected to an AC source which produces 7 A maximum current. Calculate the resistance of the fan.

QUESTION 9 (WESTERN CAPE)ELECTRODYNAMICS

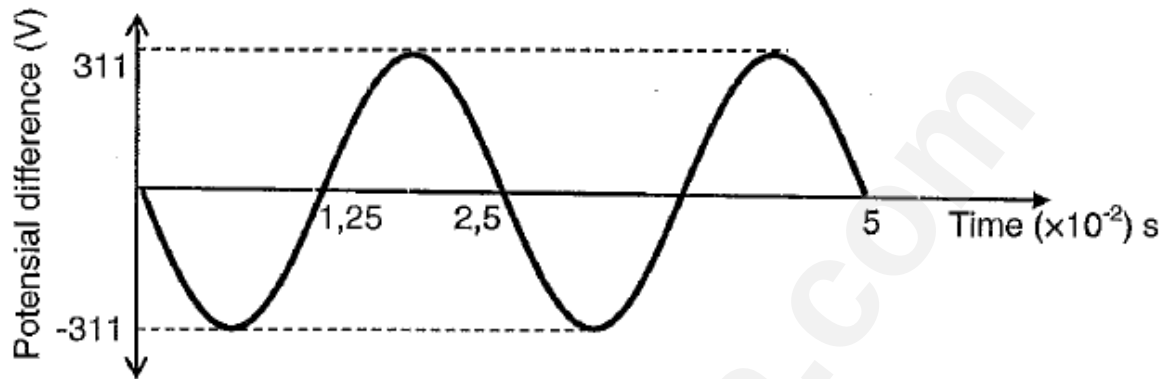
An alternating current (AC) generator installed on a farm produces the following graph of emf against time.



- 9.1 What is the period for one rotation of the armature of the generator?
- 9.2 Calculate the root mean square voltage (V_{rms}) for this generator.
- 9.3 An ohmic lightbulb rated 100 V; 40 W is supplied with energy from this generator.
 - 9.3.1 Calculate the resistance of the lightbulb.
 - 9.3.2 Describe the brightness of the lightbulb under these conditions. Choose from TOO BRIGHT, CORRECT BRIGHTNESS or TOO DIM. Explain your answer.
- 9.4 Draw a graph of current strength vs. time over the same time interval. Do not show any values on the y-axis.

QUESTION 9 (MPUMALANGA) ELECTRODYNAMICS

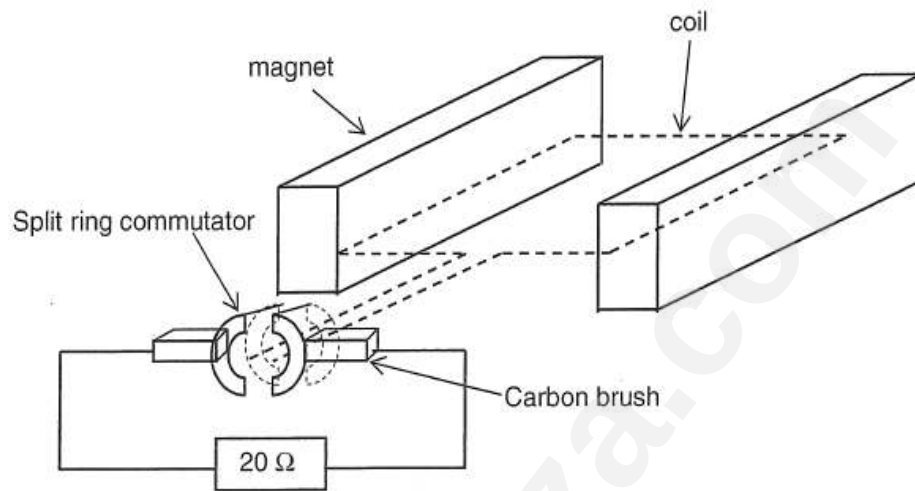
A generator is used to deliver current through a 120 W bulb. The graph below shows the change in potential difference against time in the bulb.



- 9.1 What type of generator is used? Choose from ALTERNATING CURRENT (AC) or DIRECT CURRENT (DC).
- 9.2 Write down the energy conversion that takes place in the bulb.
- 9.3 Write down the name of the principle on which the functioning of the generator is based.
- 9.4 Calculate the frequency of the current.
- 9.5 Calculate that rms-current through the bulb.
- 9.6 Calculate the resistance of the bulb.

QUESTION 9 (GAUTENG) ELECTRODYNAMICS

The diagram below shows the essential parts of a generator.



9.1 The coil rotates within the magnetic field

Write down the type of current (AC or DC)

9.1.1 Induced in the coil

9.1.2 Passing through the $20\ \Omega$ resistor

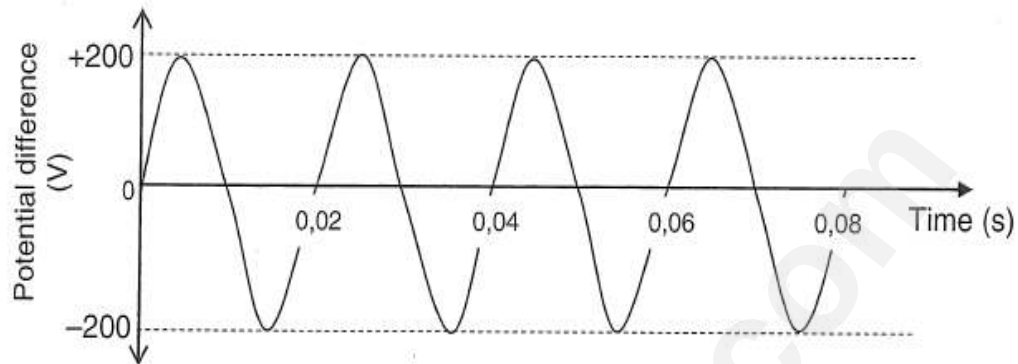
Give a reason for the answer

9.2 An AC generator is used in the commercial production of electricity

9.2.1 State ONE fundamental difference in construction between an AC generator and a DC generator

9.2.2 Fully explain why AC is preferred to DC for transmission of electricity over long distances

- 9.3 The diagram below shows the output of the above AC generator. A 20Ω resistor is connected in the circuit.

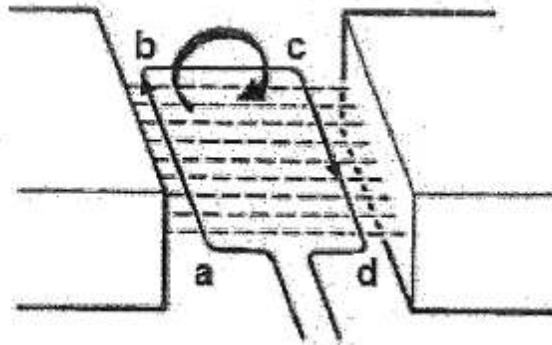


Calculate the:

- 9.3.1 Frequency of the power source
9.3.2 Average power dissipated in the resistor

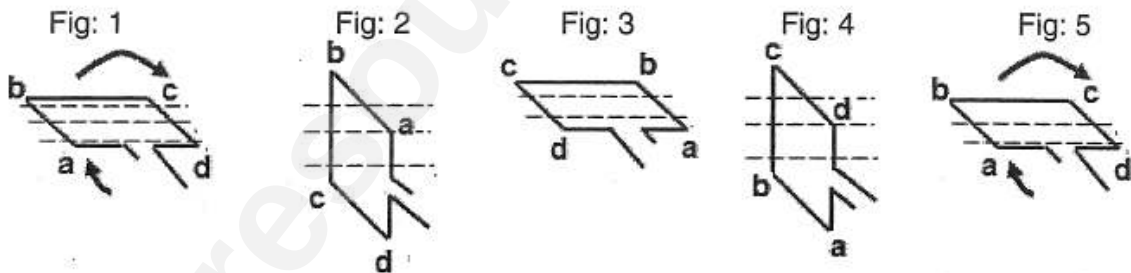
QUESTION 9 (NORTH WEST) ELECTRODYNAMICS

Consider the following simplified diagram of a portion of an AC generator



- 9.1 What is the direction of the magnetic field if the direction of the current is as shown in the diagram? Write from LEFT TO RIGHT or RIGHT TO LEFT
- 9.2 How will the magnitude of the induced current in the coil change when the speed of rotation of the coil in the magnetic field is increased? Write INCREASES, DECREASES or STAYS THE SAME
- 9.3 What type of energy conversion takes place in the electric generator?

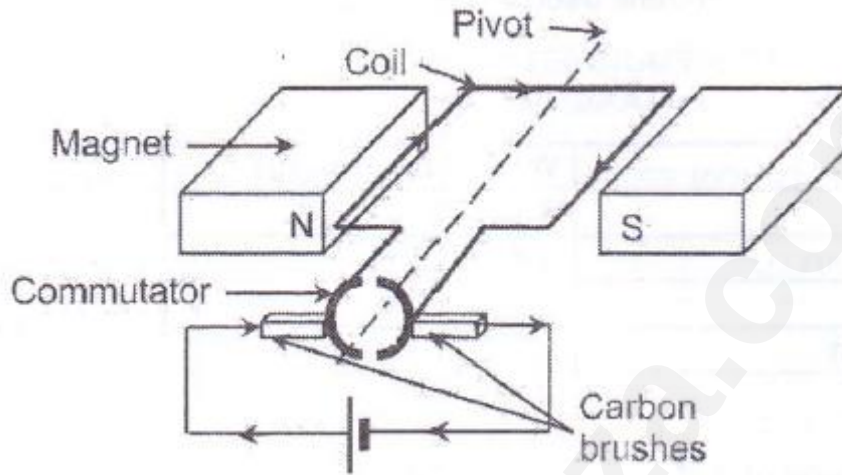
The following figures (1, 2, 3, 4 and 5) represents one full clockwise rotation of the coil



- 9.4 Draw a sketch graph of current versus time for one complete rotation of the coil. Show the position of the coil corresponding to the current values of 1, 2, 3, 4 and 5
- 9.5 A lamp of average power 20 W is connected to the output terminals of the generator mentioned above. The peak voltage produced by the generator is 12 V. Calculate the peak through the lamp

QUESTION 9 (LIMPOPO)ELECTRODYNAMICS

9.1 The diagram below represents a simplified sketch of a DC motor.



- 9.1.1 Name the component which ensures continuous rotation of the coil of the above motor.
- 9.1.2 Name the part of the motor which becomes an electromagnet when the motor is in operation.
- 9.2 The electricity supply to a house decreases from 240 V to 200 V **rms**.
- 9.2.1 Calculate the peak voltage during the power decrease.
- 9.2.2 An electric iron dissipates 2 200 W when it is operated on an rms voltage of 240 V. Calculate the power at which it will operate during the power decrease.

10. PHOTOELECTRIC EFFECT

- Describe the *photoelectric effect* as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.
- Give the significance of the photo-electric effect: *it establishes the quantum theory and it illustrates the particle nature of light.*
- Define *cut-off frequency/threshold frequency*, f_0 , as the minimum frequency of light needed to emit electrons from a certain metal surface.
- Define *work function*, W_0 , is the minimum energy that an electron in the metal needs to be emitted from the metal surface.
- Know that the cut-off frequency corresponds to a maximum wavelength.
- **A photon** is a particle of light with a certain frequency, while **a photoelectron** is an electron which has been emitted from a metal by a photon with sufficient energy.
- **Perform calculations using the photoelectric equation:**

Energy of photon = work function + kinetic energy of photoelectron

$$\therefore E = W_0 + K_{\max}, \text{ where } E = hf \text{ and } W_0 = hf_0 \text{ and } K_{\max} = \frac{1}{2}mv_{\max}^2$$

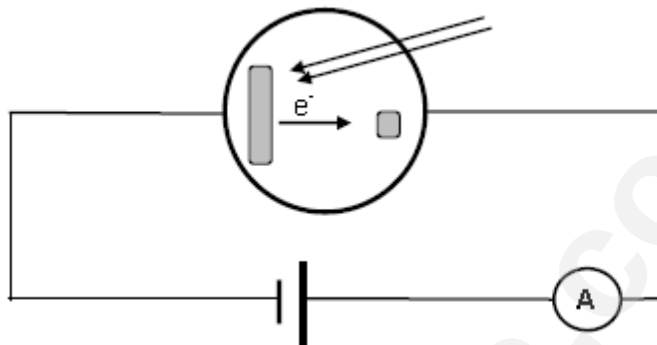
NOTE:

- $E = W_0 + \frac{1}{2}mv^2$
- $E < W_0$ energy absorbed converted to internal energy
- $E = W_0$ electron emitted without any kinetic energy
- $E > W_0$ electron emitted with kinetic energy
- **h**: proportionality constant - Planck's constant ($h = 6,63 \times 10^{-34} \text{ J}\cdot\text{s}$).

- **Explain the effect of intensity and frequency on the photoelectric effect.**
 - Know that the number of electrons ejected per second increases with the intensity of the incident radiation.
 - Know that if the frequency of the incident radiation is below the cut-off frequency, then increasing the intensity of the radiation has no effect i.e. it does not cause electrons to be ejected.
- Higher intensity light = more photons → rate of emission increases, kinetic energy stays the same.
- Higher frequency light = photons have more energy → kinetic energy of electrons higher, rate of emission stays the same.
- The photoelectric effect illustrates the particle nature of light and establishes the quantum theory.
- On a **graph** of maximum kinetic energy vs. frequency ...
 - all curves are linear with slope equal to **Planck's Constant**.
 - the intercept on the energy-axis is the threshold frequency of the material.

QUESTION 10 (FREE STATE) PHOTOELECTRIC EFFECT

A learner investigates the photoelectric effect with the use of a photocell. The photocell is irradiated by light of different wavelengths as shown below.



- 10.1 Define, in words, the *photoelectric effect*
- 10.2 The wavelengths of three sources of light are shown in the table below.

LIGHT	WAVELENGTH (nm)
Blue	4,92
Violet	4,48
Ultraviolet	4,30

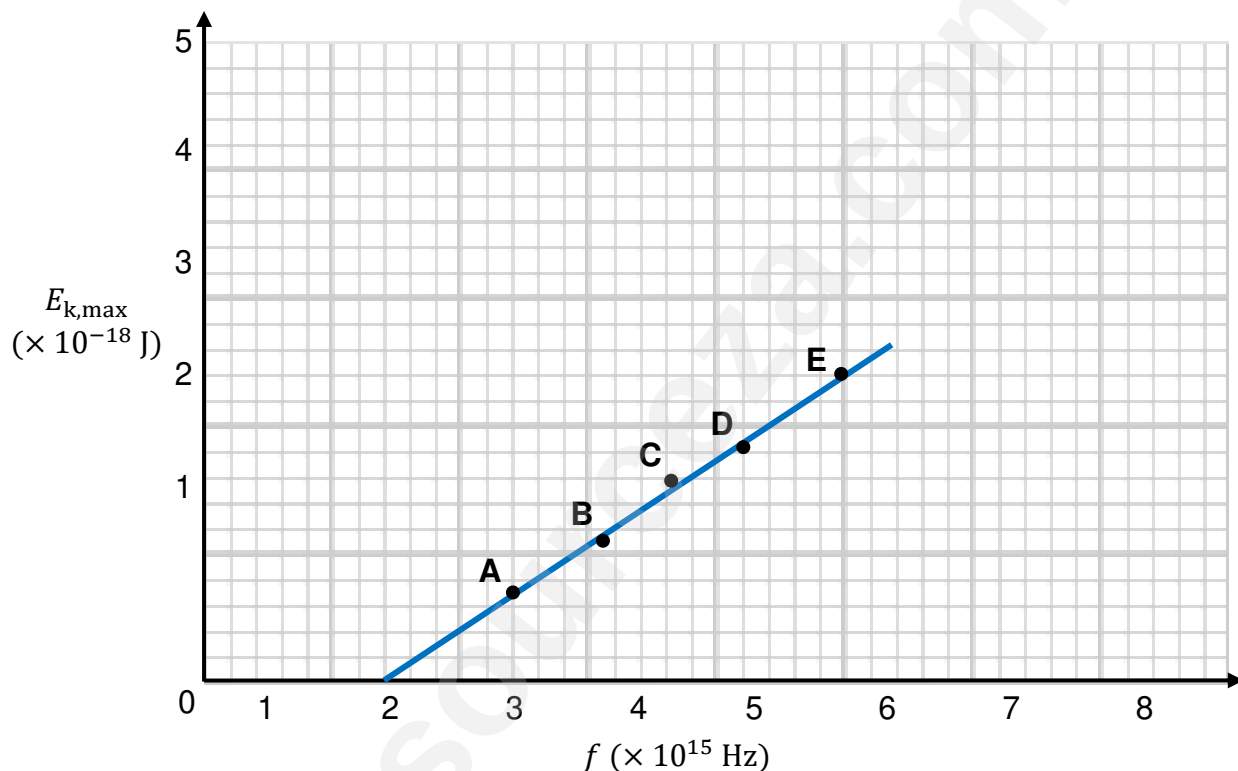
The threshold frequency of the metal used in the photocell is 6.45×10^{14} . The average speed of the emitted photoelectrons are $2,78 \times 10^5 \text{ m.s}^{-1}$. Identify the light used to irradiate the photocell.

- 10.3 The intensity of the incident light is now decreased. How will this DECREASE or STAY THE SAME
- 10.3.1 The ammeter reading. Write down only INCREASE, DECREASE or STAYS THE SAME
- 10.3.2 The kinetic energy of the photoelectrons. Write down only INCREASE, DECREASE or STAYS THE SAME
- 10.3.3 Give an explanation to your answer in QUESTION 10.3.2
- 10.4 Light emitted by gas discharge tubes as used in fluorescent lights produces a line emission spectrum. Briefly explain how this type of spectrum is formed.

QUESTION 10 (WESTERN CAPE)PHOTOELECTRIC EFFECT

A group of physicists perform an experiment where they shine five different light sources (A, B, C, D and E) onto the platinum cathode of a photocell.

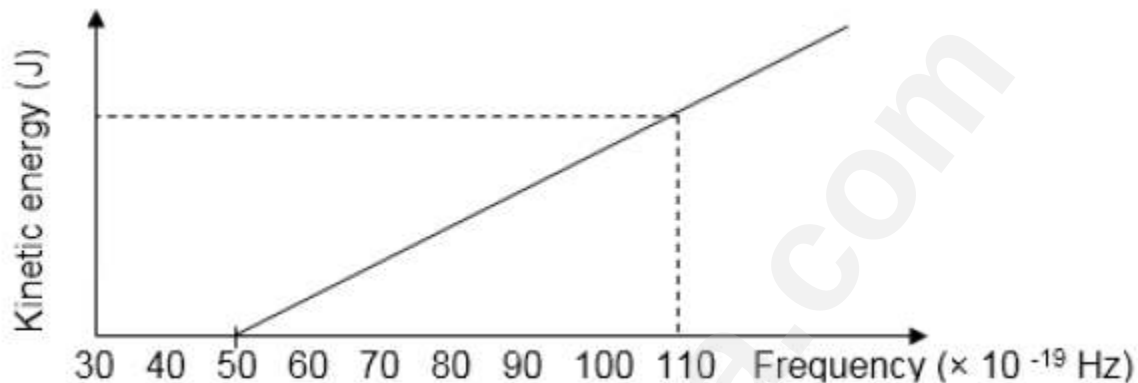
They measure the maximum kinetic energies of the ejected photoelectrons and produce the following graph of their results.



- 10.1 What does the gradient of the above graph represent?
- 10.2 Define the term *threshold frequency*.
- 10.2 Use the x -intercept of the graph in order to calculate the work function of the metal.
- 10.3 In one of the experiments the brightness of one of the light sources was increased. How would this affect... (Answer only INCREASES, DECREASES or REMAINS THE SAME for both of the following subquestions.)
 - 10.3.1 the number of electrons ejected per second?
 - 10.3.2 the kinetic energy of the ejected electrons?
- 10.4 Calculate the speed of an ejected electron when light source E is used.

QUESTION 10 (EASTERN CAPE) PHOTOELECTRIC EFFECT

Different frequencies of light are shone onto the surface of a metal. The graph below shows the relationship between the kinetic energy of photo-electrons and frequency of the incident light.



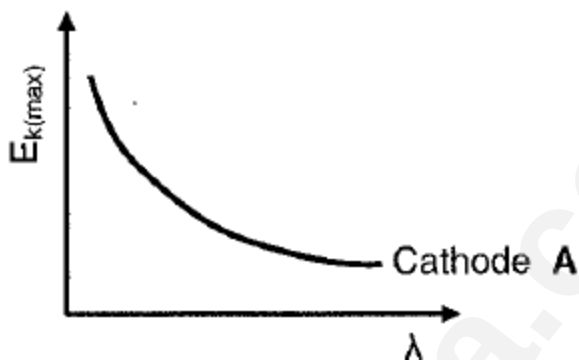
- 10.1 Refer to the graph and write down the threshold frequency of the metal.
- 10.2 Give a reason why no photo-electrons are released when light of frequency $45 \times 10^{-19} \text{ Hz}$ is used.
- 10.3 Calculate the velocity of the ejected electrons when a light with a frequency of $110 \times 10^{-19} \text{ Hz}$ is shone onto the metal.
- 10.4 What effect will an increases in the intensity of radiation have on the velocity of ejected electrons?

Write only INCREASE, DECREASE or STAYS THE SAME.

Explain your answer.

QUESTION 10 (MPUMALANGA) PHOTOELECTRIC EFFECT

Light of different wavelengths is used to investigate the maximum kinetic energy of photoelectrons ejected from a specific type of cathode (A). The following graph is drawn from the results.

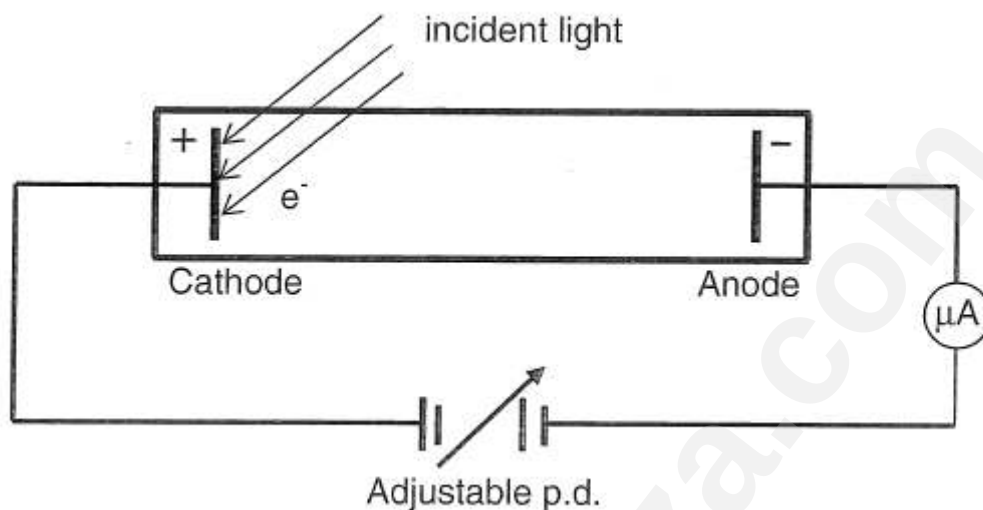


- 10.1 Define the term *threshold frequency* in words.
- 10.2 Write down the mathematical relationship between the wavelength (λ) of the light and the maximum kinetic energy ($E_{k(max)}$) of the photoelectrons.
- 10.3 How will an increase in the intensity of the light influence the maximum kinetic energy of the photoelectrons? Choose from INCREASES, DECREASES, or REMAINS THE SAME. Give a reason for the answer.
- 10.4 The threshold frequency of cathode A is $1,18 \times 10^{15}$ Hz. Calculate the maximum speed of an emitted photoelectron if cathode A is irradiated with light of wavelength 160 nm.
- 10.5 The photoelectric cell is replaced with one which has a cathode B of LOWER THRESHOLD FREQUENCY and the experiment is repeated.

Redraw the above graph $E_{k(max)}$ versus λ for cathode A and on the same system of axes use a dotted line to draw the graph for cathode B.

QUESTION 10 (GAUTENG) PHOTOELECTRIC EFFECT

Incident light of different wavelengths was shone on a metal cathode in an evacuated tube as shown in the diagram below.

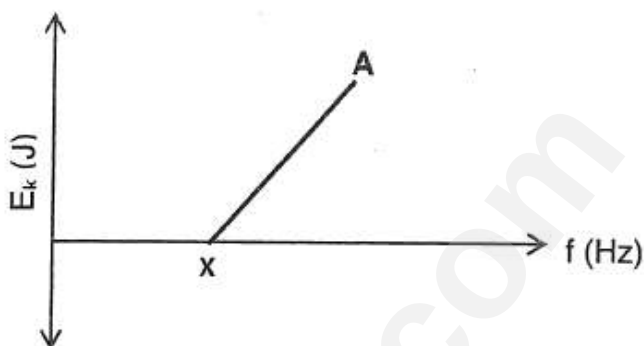


It was found that light of 500 nm releases electrons with zero kinetic energy. The micro-ammeter gives a zero reading.

- 10.1 Define the term *work function*
- 10.2 Calculate the work function of the metal used as cathode
- 10.3 How will each of the following affect the reading on the micro-ammeter?
Choose from INCREASES, DECREASES or REMAIN THE SAME
 - 10.3.1 The intensity of the light is increased
 - 10.3.2 Light of a wavelength 550 nm is used
- 10.4 The metal cathode is now irradiated with light of wavelength 400 nm
Calculate the maximum kinetic energy of an emitted photo-electron

QUESTION 10 (NORTH WEST) PHOTOELECTRIC EFFECT

The graph below shows how the maximum kinetic energy (E_K) of the photoelectrons emitted from the surface of Lithium (Li) metal varies with the frequency (f) of the incident radiation.



- 10.1 What name is given to the frequency at x ?
- 10.2 Write down how the value of Planck's constant can be determined graphically
- 10.3 Explain why no photoelectrons are emitted at frequencies below x
- 10.4 Calculate the work function of Lithium if the value of x is $5,6 \times 10^{14}$ Hz
- 10.5 Calculate the maximum speed of emitted electrons when the frequency of the light shone on the lithium metal (Li) surface is double the value of x
- 10.6 Copy the above into your ANSWER BOOK. ON THE SAME AXES draw the graph that will be obtained if Magnesium metal (Mg) with work function greater than Lithium is used, label this graph as B.

QUESTION 10 (LIMPOPO) PHOTOELECTRIC EFFECT

A learner conducts an experiment to determine which metal(s) will release electrons when green light of WAVELENGTH 510 nm is shone on it. The table below shows the different metals used in the experiment with their respective work functions.

Metal	Work Function (J)
Gold	$8,16 \times 10^{-19}$
Aluminum	$6,88 \times 10^{-19}$
Sodium	$4,32 \times 10^{-19}$
Caesium	$3,36 \times 10^{-19}$

- 10.1 Calculate the energy of a photon of green light.
- 10.2 Using the data from the above table, identify the metal(s) which will release photoelectrons when green light is shone onto their surfaces.
Explain your answer.
- 10.3 Calculate the maximum kinetic energy of a photoelectron when green light shines onto the metal in question 10.2.
- 10.4 The intensity of the green light is DOUBLED. State the effects that this has on each of the following:
(Choose from **INCREASES**, **DECREASES** or **REMAINS THE SAME**)
 - 10.4.1 The work function of each metal
 - 10.4.2 The maximum kinetic energy of each emitted photoelectron
 - 10.4.3 The energy of each photon of green light.

11. EMISSION AND ABSORPTION SPECTRA

- Emission : electrical current through gas $\rightarrow$ gas glows
- Bright coloured lines of frequencies radiated when electrons fall back from excited state
- Frequency correspond to difference between energy levels
- Absorption : light through cold gas $\rightarrow$ frequencies absorbed cause black lines in continuous spectrum
- Infrared absorption: bonds in molecules vibrate with the absorption of light energy in infrared part of spectrum. Energy absorbed if dipole moment of molecule changes with vibration

QUESTION 11EMISSION& ABSORPTION SPECTRA 1

The following table represents the different energy levels of the hydrogen atom as well as the corresponding energy values, in joule (J) of each energy level.

<u>ENERGY LEVEL</u>		<u>ENERGY VALUE</u>
n = 4	_____	$E = -1,36 \times 10^{-19} \text{J}$
n=3	_____ 	$E = -2,40 \times 10^{-19} \text{J}$
n = 2	_____	$E = -5,44 \times 10^{-19} \text{J}$
n = 1	_____	$E = -2,18 \times 10^{-18} \text{J}$

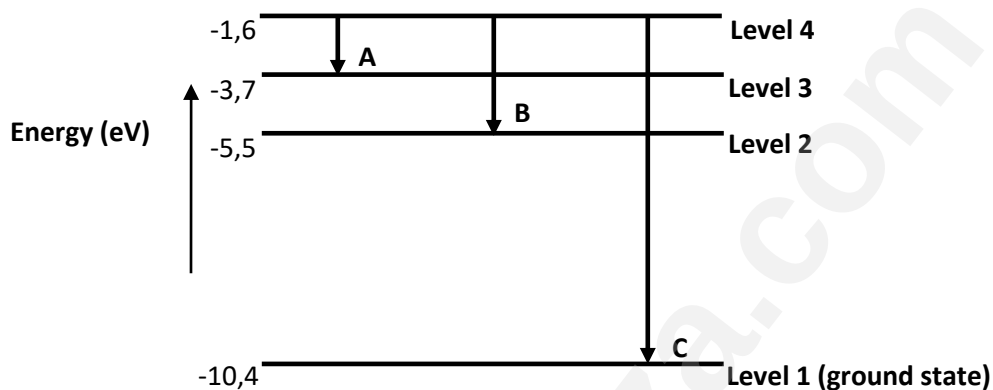
11.1 The colour of light and its corresponding wavelength is given in the table below.

COLOUR	WAVELENGTH($\times 10^{-9} \text{m}$)
Red	650
Orange	590
Yellow	570
Green	510
Blue	475
Violet	400

Determine the colour of light emitted when an electron falls back from the third to second energy level. Show ALL calculations

QUESTION 11EMISSION & ABSORPTION SPECTRA 2

Line emission spectra are produced as a result of electron transitions between energy levels of the atom. The diagram below shows some of the outer energy levels of the mercury atom. An electron has been excited to the $-1,6$ eV energy level (Level 4). The diagram shows three possible ways that it can return to the $-10,4$ eV energy level (Level 1, ground state).



11.1 The three energy transitions produce three different spectral lines. Which transition (**A, B or C**) will produce the spectral line with:

11.1.1 the longest wavelength

11.1.2 the most energy

11.2 Calculate the frequency of the electromagnetic radiation emitted when an electron falls from Level 4 back to its ground state (Level 1) as shown by the transition labelled C.

11.3 Write down ONE important use of line emission spectra.

12. IMPORTANT DEFINITIONS/LAWS/PRINCIPLES

PAPER 1: PHYSICS FOCUS:

MECHANICS:

1. **Force (F):** A force can be defined as something that attempts to change the condition of rest or motion of an object.
2. **Contact force:** Is the force that acts on an object by making contact with it.
3. **Non Contact Force:** Is a force that acts on an object without making physical contact with it.
4. **Net force (F_{net}):** A net force is a single force that has the same effect as the original forces acting together on an object. OR A net force is the combined effect of all the forces acting on an object OR the net force is the SUM of the individual forces acting on an object.
5. **Normal force (N):** Is the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.
6. **Frictional force (f):** Is the force that opposes the motion of an object and which acts parallel to the surface.
7. **Static frictional force (f_s):** Is the force that opposes the tendency of motion of a stationary object relative to a surface.
8. **Kinetic frictional force, f_k :** Is the force that opposes the motion of a moving object *relative* to a surface.
9. **Newton's first law of motion:** A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.
10. **Newton's second law of motion:** When a resultant/net 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.
11. **Newton's third law of motion:** When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.
12. **Newton's Law of Universal Gravitation:** Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
13. **Weight:** is the gravitational force the Earth exerts on any object on or near its surface.
14. **Momentum** is the product of an object's mass and its velocity.
15. **Newton's second law of motion in terms of momentum:** The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.
16. **Impulse:** is the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.
17. **Closed/an isolated system** (in Physics), i.e. a system on which the resultant/net external force is zero.
18. **Principle of conservation of linear momentum:** The total (linear) momentum remains constant/is

conserved in an isolated/a closed system/the absence of external forces.

19. **Elastic collision:** An elastic collision is a collision in which both momentum and kinetic energy are conserved.
20. **Inelastic collision:** An elastic collision in which only momentum is conserved and not kinetic energy.
21. **A projectile**, i.e. an object upon which the only force acting is the force of gravity.
22. **Free fall:** The motion of an object in the gravitational field of the earth under the influence of only the gravitational force.
23. **Terminal velocity:** Maximum velocity reached by a falling object at the instant when the force of air friction (air resistance) equals the gravitational force of the earth on the object.
24. **Work is done** on an object when displacement takes place in the direction of the force.
25. **Work-energy theorem:** The net/total work done on an object is equal to the change in the object's kinetic energy OR the work done on an object by a resultant/net force is equal to the change in the object's kinetic energy.
26. **Conservative force:** is a force for which the work done in moving an object between two points is independent of the path taken.

Examples are gravitational force, the elastic force in a spring and electrostatic forces (coulomb forces).
27. **Non-conservative force:** is a force for which the work done in moving an object between two points depends on the path taken.

Examples are frictional force, air resistance, tension in a chord, etc.
28. **Energy (E)** is the ability to do work.
29. **Gravitational potential energy (U):** is the energy it possesses by virtue of its position in the gravitational field of the earth.
30. **Kinetic Energy (K)** is the energy it possesses by virtue of its state of motion.
31. **Mechanical Energy (ME)** is the sum of the kinetic and gravitational potential energy of the object.
32. **Principle of conservation of mechanical energy:** The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero).
33. **Power** is the rate at which work is done or energy is expended (transferred).

WAVES, SOUND & LIGHT (DOPPLER EFFECT)

34. **Doppler effect:** is the change in frequency (or pitch) of the sound detected by a listener because the

sound source and the listener have different velocities relative to the medium of sound propagation.

ELECTRICITY AND MAGNETISM

35. **Coulomb's law:** The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them
36. **Electric field** is a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.
37. **Electric field at a point:** The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point.
38. **Emf:** measure of the amount of energy transferred per coulomb of charge passing through the battery/cell.
39. **Ohm's law in words:** The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
40. **Faraday's law:** the magnitude of emf is directly proportional to rate of change in magnetic flux.
 $\text{Emf} \propto \Delta \Phi / \Delta t$.
41. **Rms** for an alternating voltage or an alternating current. The *rms* value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.

PHOTOELECTRIC EFFECT, ABSORPTION AND EMISSION SPECTRA

42. **Photoelectric effect** is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.
43. **Photon** is a Quantum/packet of energy found in light *OR* a particle of light with a certain frequency.
44. **Photoelectron** is an electron which has been emitted from a metal by a photon with sufficient energy.
45. **Cut-off frequency/threshold frequency, f_0 ,** is the minimum frequency of light needed to emit electrons from a certain metal surface.
46. **Work function, W_0 ,** is the minimum energy that an electron in the metal needs to be emitted from the metal surface.
47. **Atomic absorption spectrum** is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.
48. **Atomic emission spectrum** is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.