JENN Training and Consultancy(Pty)Ltd

The path to enlightened education

PHYSICAL SCIENCES PAPER 1

GRADE 12: REVISION STUDY GUIDE

WINTER CLASSES

Topic 1

Newton's laws and application of Newton's laws.

Topic 2

Work, energy and power

Topic 3

Electric circuits (without internal resistance)

Compiled by

1. Mrs Legegeru
2. Mr Mokoena
3. Mr Ongusona
4. Mr Sealanyane
5. Mr Waswa

ICONS USED IN THE MANUAL AND THEIR DESCRIPTION

	Outcomes		Mind Map		Summative task
	Table of Content		Steps		Key Concepts/Glossary
	Methodology		Activities		Bibliography

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WINTER CLASSES PROGRAMME			
DAY	ACTIVITY	PAGE	TIME
1	Pre-test: Paper 1		45 MIN
	Newton's laws	4 -13	1 HOUR: 15 MIN
2	Newton's laws	14 -18	45 MIN
	Work, energy and Power	19-27	1 HOUR: 15 MIN
3	Work, energy and power	28-31	2 HOURS
4	Electric Circuits (without internal resistance	32-44	2 HOURS
5	Electric Circuits (without internal resistance	45-48	1 HOUR: 10 MIN
	Post-test: Paper 1		50 MIN

NEWTON'S LAWS AND APPLICATION OF NEWTON'S LAWS.

EXAMINATION GUIDELINES:

Newton's laws and application of Newton's laws (This section must be read in conjunction with the CAPS, p. 62–66.)

Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)

- Define *normal force*, N, as 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.
- Define *frictional force*, f, as the force that opposes the motion of an object and which acts parallel to the surface.
  Define *static frictional force*, f_s, as the force that opposes the tendency of motion of a stationary object relative to a surface.
  Define *kinetic frictional force*, f_k, as the force that opposes the motion of a moving object relative to a surface.
  Know that a frictional force:
  - Is proportional to the normal force
  - Is independent of the area of contact
  - Is independent of the velocity of motion
- Solve problems using $f_s^{max} = \mu_s N$ where f_s^{max} is the maximum static frictional force and μ_s is the coefficient of static friction.
  NOTE:
  - If a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.
  - The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
  - If the applied force exceeds f_s^{max}, a resultant (net) force accelerates the object.
- Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.

Force diagrams, free-body diagrams

- Draw force diagrams.
- Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings)
- Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.
- Determine the resultant/net force of two or more forces.

Newton's first, second and third laws of motion

- State 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.
- Discuss why it is important to wear seatbelts using Newton's first law of motion.
- State 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.
- Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.

EXAMINATION GUIDELINES:

- 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
- State Newton's third law of motion: When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A.
- Identify action-reaction pairs.
- List the properties of action-reaction pairs.

Newton's Law of Universal Gravitation

- State 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.
- Solve problems using $F = \frac{Gm_1m_2}{r^2}$.
- Calculate acceleration due to gravity on a planet using $g = \frac{Gm}{r^2}$.
- Describe *weight* as the gravitational force, in newton (N), exerted on an object. Describe mass as the amount of matter in a body measured in kilogram (kg).
- Calculate weight using the expression w = mg.
- Calculate the weight of an object on other planets with different values of gravitational acceleration.
- Explain *weightlessness* as the sensation experienced when all contact forces are removed i.e. no external objects touch one's body. For example, when in free fall, the only force acting on your body is the force of gravity that is a non-contact force. Since the force of gravity cannot be felt without any other opposing forces, you would have no sensation of it and you would feel weightless when in free fall.

IMPORTANT TERMS & DEFINITIONS:

NEWTON'S LAWS AND APPLICATION OF NEWTON'S LAWS	
Normal force (N)	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.
Frictional force (f)	The force that opposes the motion of an object and which acts parallel to the surface.
Static frictional force (f_s)	The force that opposes the tendency of motion of a stationary object relative to a surface.
kinetic frictional force(f_k),	The force that opposes the motion of a moving object relative to a surface.
NEWTON'S FIRST, SECOND AND THIRD LAWS OF MOTION	
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.
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.
Newton's third law of motion	When object A exerts a force on object B, object B SIMULTANEOUSLY exerts an oppositely directed force of equal magnitude on object A.
NEWTON'S LAW OF UNIVERSAL GRAVITATION	
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.
Weight	The gravitational force, in newton (N), exerted on an object.
Mass	The amount of matter in a body measured in kilogram (kg).
Weightlessness	The sensation experienced when all contact forces are removed i.e. no external objects touch one's body.

FORMULAE TABLE:

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
	$w = mg$
$F = G\frac{m_1 m_2}{d^2}$ or/*of* $F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{d^2}$ or/*of* $g = G\frac{M}{r^2}$

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.

A body remains in its **state of rest**

All forces are balanced

A body continues to move with a **constant velocity**

$v_i = v_f = 0$ m.s^{-1}
Acceleration = 0 m.s^{-2}
Resultant force = 0 N

There is no change in velocity ($v_i = v_f$)
Acceleration = 0 m.s^{-2}
Resultant force = 0

Newton's Second Law:

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.

A net force acts on an object. $F_{net} \neq 0$ N
Forces acting on the object are not balanced

Net force cause the object to accelerate in the direction of the force. Acceleration and net force go in the same direction.
There is a change in velocity ($v_i \neq v_f$)
$a \neq 0$ m.s^{-2}

$F_{net} = ma$

$$a \propto F_{net}$$

The greater the net force, the greater the acceleration. The smaller the net force the smaller the acceleration

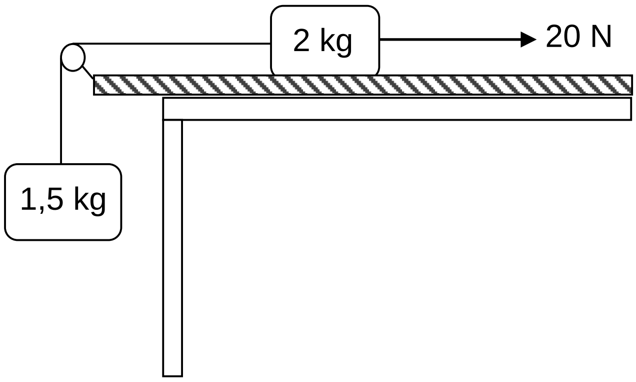
$$a \propto \frac{1}{m}$$

The bigger the mass, the smaller the acceleration. The smaller the mass, the greater the acceleration.

LEARNER & TEACHER MANUAL	
TOPIC: Newton's laws and application of Newton's laws.	**Duration:** 2 hours
Key Concepts: **1.** Newton's Second law of motion. **2.** Free-body diagram. **3.** Solving problems using simultaneous equations. **4.** Application of Newton's laws.	

EXAMPLE 1

A block of mass 2 kg is at rest on a rough horizontal suface. The block is connected to another block of mass 1,5 kg by means of a light inextensible string which hangs over a frictionless pulley. The 2 kg block experiences a constant frictional force of 3,1 N when a force of 20 N is applied to the block as shown in the diagram below. Ignore the effects of air friction.



1.1 Define the term *kinetic frictional force*. (2)

1.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **2 kg block**. (5)

1.3 Apply Newtons' Second Law to each of the blocks and calculate the magnitude of the acceleration of the blocks. (6)

1.4 Calculate the magnitude of tension in the string. (2)

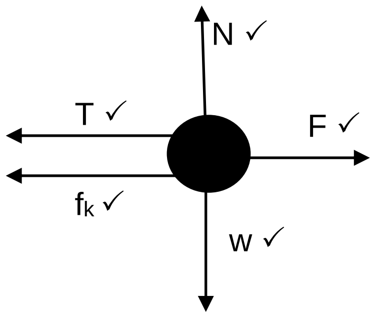
[15]

SOLUTIONS 1

1.1 <u>The force that opposes the motion of a moving object</u> ✓✓ relative to a surface (2)

1.2

Accepted labels	
w	Fg / Fw/force of earth on block/weight / 19,6 N / mg / gravitational force
f_k	f/friction/
T	Tension /
F	F_{app} / F_T
N	Normal force / F_N / Force of surface on block



Notes:

- Any additional forces: max $^4/_5$
- No arrows: $^0/_5$

Force(s) not touching object: max $^4/_5$

(5)

1.3

✓ For either 2a or 1,5a

For 2 kg block:

$F_{net} = ma$ ✓

$F - T - f = 2a$

$20 - T - 3,1 = \underline{2a}$ ✓

$\underline{16,9 - T}$ ✓ $= 2a$

$T = 16,9 - 2a$

For 1,5 kg block:

$F_{net} = ma$

$T - 1,5(9,8) = 1,5a$

$\underline{T - 14,7}$ ✓ $= \underline{1,5a}$

$T = 1,5a + 14,7$

$\therefore \underline{16,9 - 2a = 1,5a + 14,7}$ ✓

$2,2 = 3,5a$

$a = 0,63\ m\cdot s^{-2}$ ✓

OR

$T = 16,9 - 2a$

$\underline{T = 1,5a + 14,7}$

$0 = 2,2 - 3,5a$ (subtract)

$a = 0,63\ m\cdot s^{-2}$ ✓

(6)

1.4

$T = 16,9 - 2a$

$T = 16,9 - 2\ (0,63)$ ✓

$T = 15.64$ ✓

OR

$T = 1,5a + 14,7$

$T = 1,5\ (0,63) + 14,7$ ✓

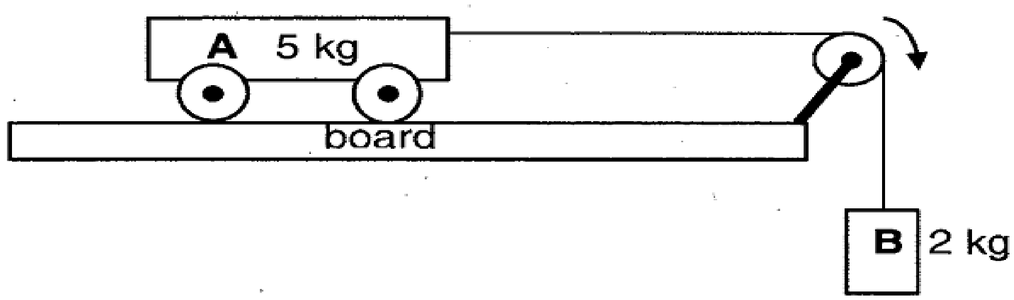
$T = 15.64$ ✓

(2)

[15]

ACTIVITY 1

Trolley A of mass 5kg is placed on the horizontal board. It is connected to block B of mass 2kg by a light, inextensible string over a frictionless pulley as shown in the diagram below. Ignore any effects of air resistance.



1.1 State *Newton's Second Law of motion.* (2)

1.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **2kg block** (5)

1.3 Assuming no frictional force acts between the wheels of the trolley and the surface. Calculate:

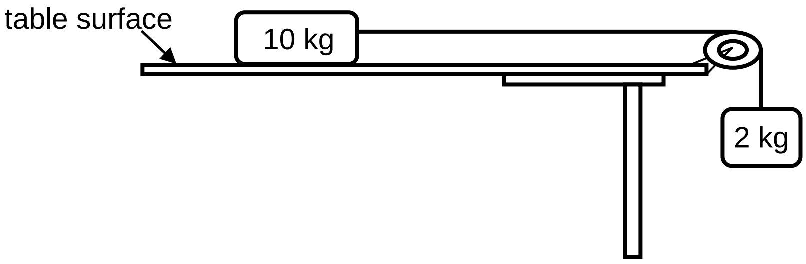
1.3.1 The magnitude of the acceleration of the trolley. (5)

1.3.2 The tension in the string. (2)

[14]

ACTIVITY 2

The diagram below shows a 10 kg block lying on a flat, rough, horizontal surface of a table. The block is connected by a light, inextensible string to a 2 kg block hanging over the side of the table. The string runs over a light, frictionless pulley. The blocks are **stationary**.



2.1 State Newton's FIRST law of motion in words. (2)

2.2 Write down the magnitude of the NET force acting on the 10 kg block. (1)

When a 15 N force is applied vertically downwards on the 2 kg block, the 10 kg block accelerates to the right. The coefficient of kinetic friction between the 5 kg block and the the surface of the table is 0,21. Ignore the effects of air friction.

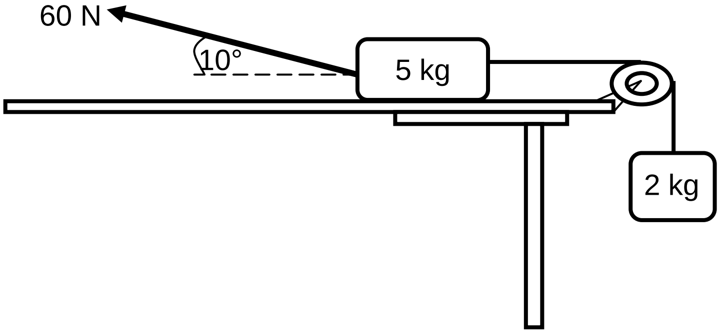
2.3 Draw a free-body diagram for the 2 kg block when the 15 N force is applied to it. (3)

2.4 Calculate the magnitude of tension in the string. (6)

[12]

EXAMPLE 2

A 5 kg block, resting on a rough horizontal table, is connected by a light inextensible string passing over a light frictionless pulley to another block of mass 2 kg. The 2 kg block hangs vertically as shown in the diagram below.
A force of 60 N is applied to the 5 kg block at an angle of 10^{o} to the horizontal, causing the block to accelerate to the left.



The coefficient of kinetic friction between the 5 kg block and the surface of the table is 0,5. Ignore the effects of air friction.

2.1 Draw a labelled free-body diagram showing ALL the forces acting on the 5 kg block. (5)

2.2 Calculate the magnitude of the:

2.2.1 Vertical component of the 60 N force (2)

2.2.2 Horizontal component of the 60 N force (2)

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

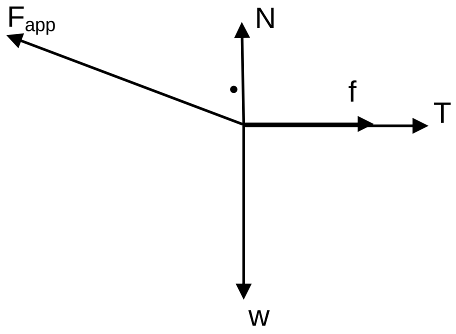
Calculate the magnitude of the:

2.4 Normal force acting on the 5 kg block (2)

2.5 Tension in the string connecting the two blocks (7)
[20]

SOLUTIONS 2

2.1



		Accepted labels
w	✓	F_g / F_w / weight / mg / gravitational force
T	✓	F_T / tension
F	✓	F_a / F_{60} / 60 N / $F_{applied}$ / F_t /
N	✓	F_N
f	✓	F_f

(5)

2.2

2.2.1

$F_{60y} = F_{60}\sin\theta$
$F_{60y} = 60\sin 10°$ ✓
$= 10{,}42$ N ✓

OR $F_{60Y} = F_{60}\cos\theta$
$F_{60y} = 60\cos 80°$ ✓

(2)

2.2.2

$F_{60x} = F_{60}\cos\theta$
$F_{60x} = 60\cos 10°$ ✓
$= 59{,}09$ N ✓

OR $F_{60x} = F_{60}\sin\theta$
$F_{60x} = 60\sin 80°$ ✓

(2)

2.3 When a resultant/net force acts on an object, the object will accelerate in the direction of the force at <u>an acceleration directly proportional to the force</u> ✓ and <u>inversely proportional to the mass of the object</u>. ✓ (2)

2.4

POSITIVE MARKING FROM 3.2. $N = mg - F_{60y}$ $N = \{5(9{,}8) - 10{,}42\}$ ✓ $= 38{,}58$ N ✓	**OR** $F_y + N = w$ $N = w - F_y = mg - F_y$ $= [(5)(9{,}8) - 10{,}42]$ ✓ $= 38{,}58$ N ✓

(2)

2.5 **POSITIVE MARKING FROM 3.2.2 AND 3.4.**

$F_{net} = ma$
$T - m_2g = m_2a$ ✓
$T - 2(9{,}8) = 2a$
<u>$T - 19{,}6$</u> ✓ $= 2a$……………………(1)
<u>$F_{60x} - (f + T) = m_8a$</u>
<u>$60\cos 10^o - (f + T)$</u> $= 5a$. ✓
$60\cos 10^o - [(\mu_kN)$ ✓ $+T)] = 5a$..
<u>$59{,}09 - (0{,}5 \times 38{,}58) \ -T$</u> ✓ $= 5a$
$39{,}8 - T = 5a$......................(2)
$a = 2{,}886 \text{ ms}^{-2}$

$T - 19{,}6 = 2\ (2{,}886)$ ✓
$T = 25{,}37$ N ✓

OR $60\sin 80^o - [f + T) = 5a$

OR

From equation (2)
$T = 25{,}37$ N

OR

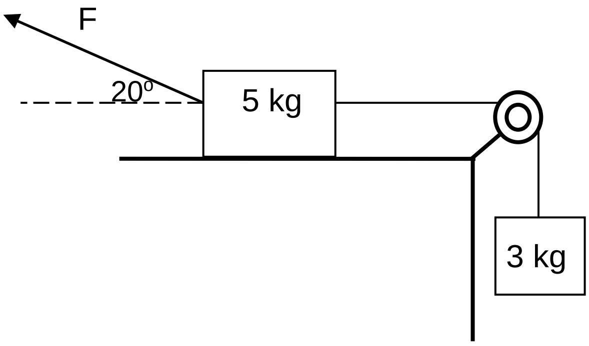
$T - 19{,}6 = 2a$ …………………..(1) x 5
$59{,}09 - 19{,}29 \ - T = 5a$ ………(2) x 2
$7T - 177{,}6 = 0$ ✓
$T = 25{,}37$ N ✓

(7)
[20]

ACTIVITY 3

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.



3.1 Define the term *frictional force.* (2)

3.2. Calculate the magnitude of the:

3.2.1 Vertical component of **F** if the magnitude of the horizontal component of **F** equals 38 N (2)

3.2.2 Normal force acting on the 5 kg block (3)

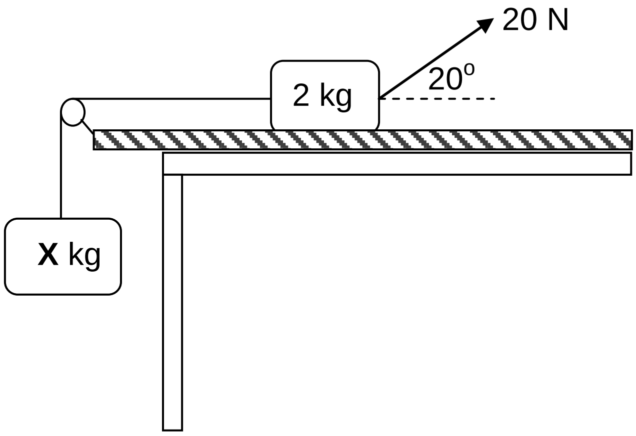
3.3 State *Newton's Second Law of motion.* (2)

3.4 Draw a labelled free-body diagram to indicate all the forces acting on the 3 kg block. (2)

3.5 Calculate the magnitude of the tension in the string connecting the two blocks. (6)
[17]

ACTIVITY 4

A block of mass 2 kg is connected with a light inextensible string that is hanging over a frictionless pulley, to another block of mass **X** kg. A force of 20 N is applied to the right at an angle of 20° to the horizontal on the 2 kg block while the block accelerates at 4 $m \cdot s^{-2}$ to the left.



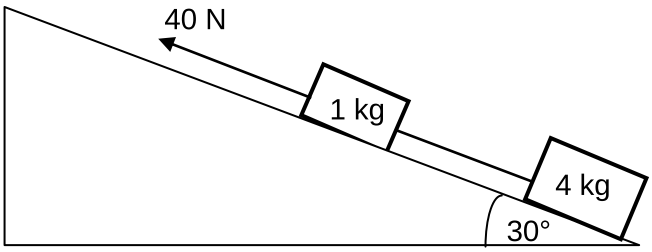
The coefficient of kinetic friction between the 2 kg block and the surface is 0,2. Ignore the effects of air friction.

4.1 Draw a labelled free-body diagram indicating ALL the forces acting on the **2 kg block**. (5)

4.2. Calculate **X**, the mass of the hanging block. (8)
[13]

EXAMPLE 3

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



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

3.1 State Newton's third law of motion in words. (2)

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

3.3 Calculate the magnitude of the:

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

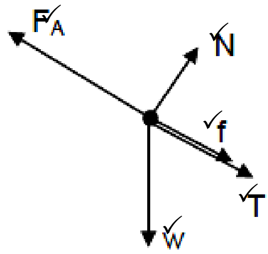
3.3.2 Tension in the string connecting the two blocks (6)

[16]

SOLUTIONS 3

3.1 When body A exerts a force on body B, body B exerts a force of equal magnitude ✓ in the opposite direction ✓on body A. (2)

3.2



Accepted labels	
w	F_g / F_w /force of earth on block / weight / mg / gravitational force
N	Normal force/F_N
T	Tension / F_T
F_A	F / $F_{applied}$/40 N
f	Frictional force / F_f

(5)

3.3

3.3.1

OPTION 1

For the 1 kg block

$f_k = \mu_k N$

$= \mu_k \; mg\cos\theta$ ✓

$= 0{,}29\,(1 \times 9{,}8 \cos 30^\circ)$ ✓

$= 2{,}46$ N ✓

OPTION 2

BY PROPORTION:

The smaller mass = ¼ of the larger mass ✓

$\therefore$ frictional force = ¼ (10) ✓

= 2,5 N ✓

(3)

3.3.2

OPTION 1

$F_{net} = ma$ ✓

For 1 kg block

$F_A - \{(T+f_k) + mg\sin\theta\} = ma$

$40 - \{T + 2{,}46 + 1(9{,}8)(\sin 30^\circ)\}$ ✓ $= (1\text{ x})\,a$ ✓

$40 - T - 7{,}36 = a$

$32{,}64 - T = a$........(1)

For 4 kg block

$T - (mg\sin\theta + f_k) = 4a$

$T - (4 \times 9{,}8 \sin 30^\circ + 10) = 4a$ ✓

T- 29,6 = 4a.........(2)

From (1) and (2)

$a = 0{,}61\ \text{m·s}^{-2}$

$T = 29{,}6 + (4(0{,}61)$ ✓

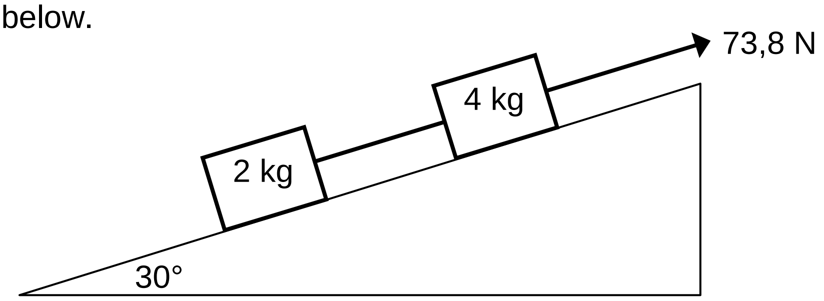
$T = 32{,}04$ N ✓

(6)

[16]

ACTIVITY 5

A block of mass 4 kg is connected to another block of mass 2 kg by a light, inextensible string. The system is pulled up a rough plane, inclined at 30° to the horizontal, by means of a constant force of 73,8 N parallel to the plane, as shown in the diagram below.



The magnitude of the kinetic frictional force on the 4 kg block is 20 N. The coefficient of kinetic friction applicable to the 2 kg block is 0,589.

5.1 Define the concept *frictional force*. (2)

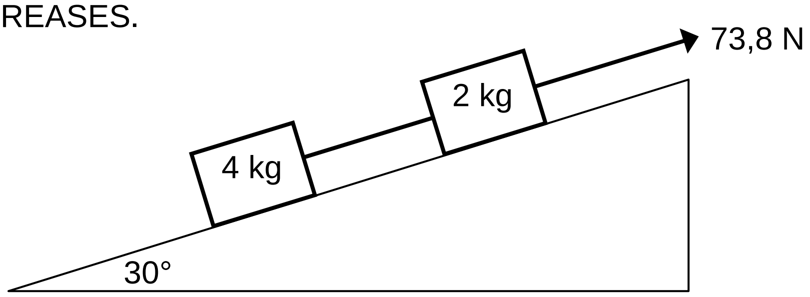
5.2 State *Newton's second law of motion* in words. (3)

5.3 Draw a free-body diagram, with labels, showing ALL the forces acting on the 4 kg block as it moves up the incline. (5)

5.4 Calculate the magnitude of the kinetic frictional force on the 2 kg block. (4)

5.5 Calculate the tension in the string that connects the two blocks. (6)

5.6 The system is pulled up the rough incline once more, but this time the two blocks are swapped as indicated below. How will this influence each of the following? Choose your answer from DECREASES, REMAINS THE SAME or INCREASES.



5.6.1 The acceleration of the 2 kg block (2)

5.6.2 The force of friction on the 4 kg block (2)

5.6.3 The tension in the string (2)

[26]

WORK, ENERGY & POWER

EXAMINATION GUIDELINES:

Work, Energy and Power
(This section must be read in conjunction with the CAPS, p. 117–120.)

Work

- Define the work done on an object by a constant force F as $F\Delta x\cos\theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)
- Draw a force diagram and free-body diagrams.
- Calculate the net/total work done on an object.
- Distinguish between *positive net/total work done* and *negative net/total work done* on the system.

Work-energy theorem

- State the 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.
  In symbols: $W_{net} = \Delta K = K_f - K_i$.
- Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).

Conservation of energy with non-conservative forces present

- Define a *conservative force* as 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).
- Define a *non-conservative force* as 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.
- State the 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.)
- Solve conservation of energy problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$
- Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.

Power

- Define *power* as the rate at which work is done or energy is expended.
  In symbols: $P = \dfrac{W}{\Delta t}$
- Calculate the power involved when work is done.
- Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.
- Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

IMPORTANT TERMS & DEFINITIONS:

The work done on an object by a constant force F	The work done on an object by a constant force F where F Δx cos θ F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement
The 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.
Conservative force	A force for which the work done in moving an object between two points is independent of the path taken.
Non-conservative force	A force for which the work done in moving an object between two points depends on the path taken.
The principle of conservation of mechanical energy	The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant.
Power	The rate at which work is done or energy is expended.

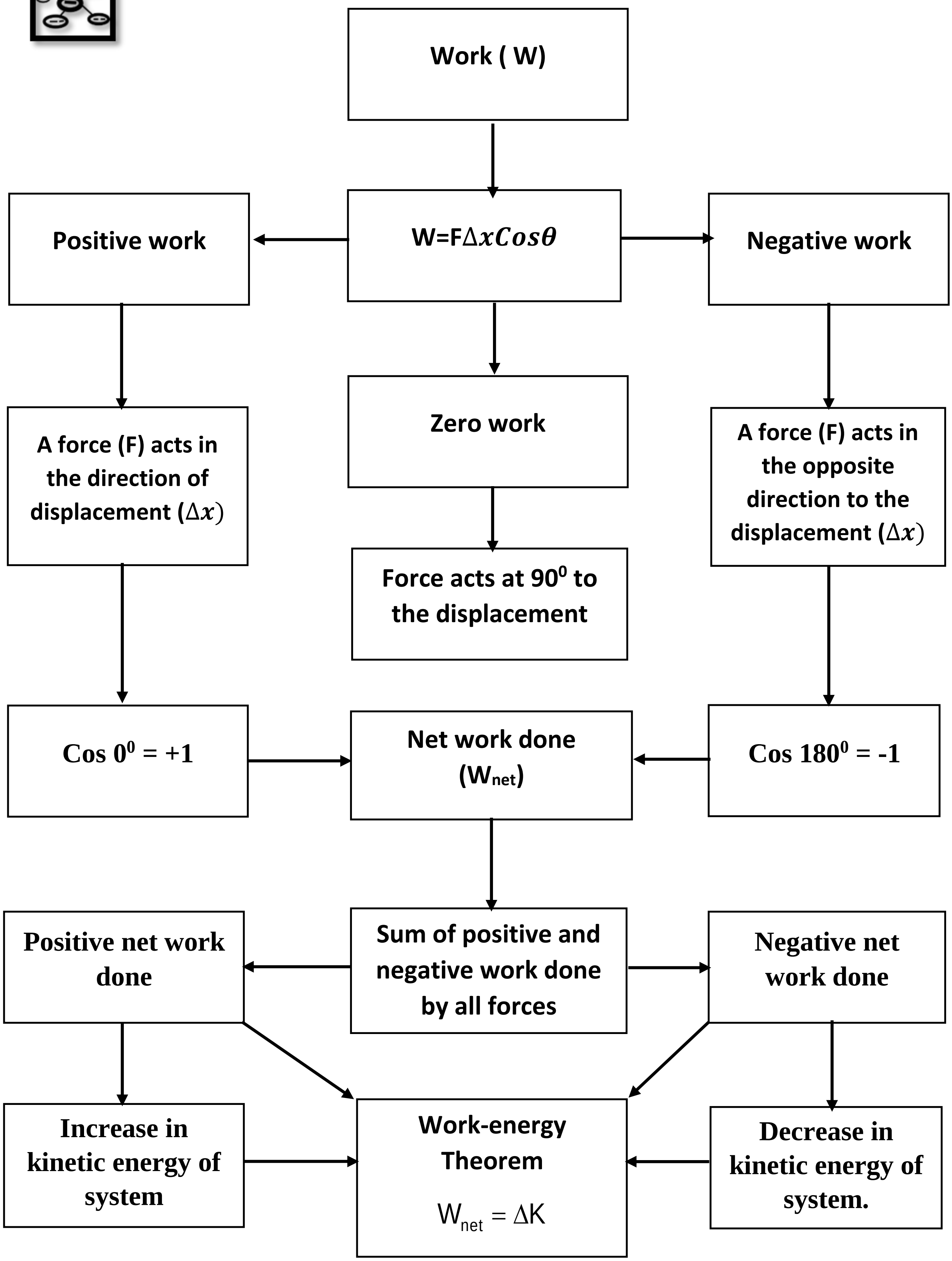
FORMULAE TABLES:

FORCE

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \dfrac{Gm_1 m_2}{d^2}$	$g = G\dfrac{M}{d^2}$

WORK, ENERGY AND POWER

$W = F\Delta x\cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \dfrac{1}{2}mv^2$ or/*of* $E_k = \dfrac{1}{2}mv^2$	$W_{net} = \Delta K$ or/*of* $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/*of* $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/*of* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \dfrac{W}{\Delta t}$
$P_{av} = Fv$	


Work (W)
W=F$\Delta x Cos\theta$
Positive work
Negative work
Zero work
A force (F) acts in the direction of displacement (Δx)
A force (F) acts in the opposite direction to the displacement (Δx)
Force acts at 90^0 to the displacement
Cos 0^0 = +1
Net work done (W_{net})
Cos 180^0 = -1
Positive net work done
Sum of positive and negative work done by all forces
Negative net work done
Increase in kinetic energy of system
Work-energy Theorem
$W_{net} = \Delta K$
Decrease in kinetic energy of system.

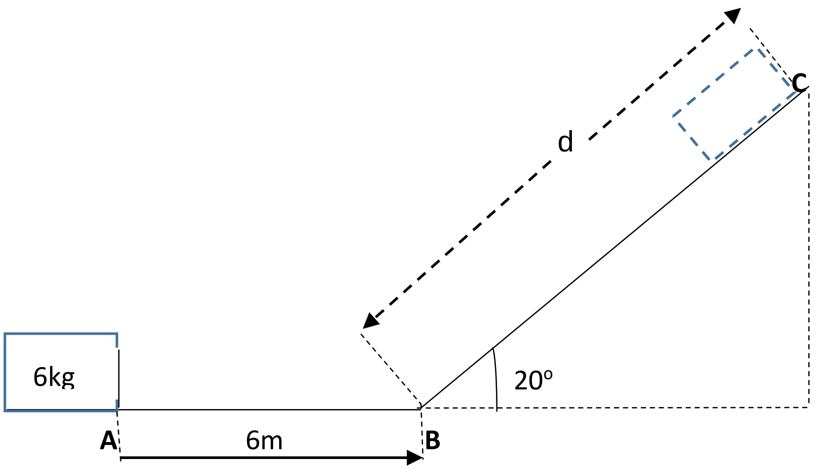
LEARNER & TEACHER MANUAL	
TOPIC: Work, energy and power	**Duration:** 3 hours: 15 min

Key Concepts:

1. Work.
2. Free-body diagrams.
3. Work - Energy theorem.
4. Conservative and non-conservative forces.
5. Principle of conservation of mechanical energy
6. Power

EXAMPLE 1

Initially, a block of mass 5 kg has a speed of 10 $m.s^{-1}$ at point A and moves along a ROUGH horizontal surface AB, 6 m long. The block continues to move along a SMOOTH inclined plane, at an angle of 20^0 to the horizontal. The block finally comes to rest at point C. The magnitude of kinetic frictional force acting on the block along AB is 15 N.



1.1 Draw a labelled free-body diagram indicating all the forces acting on the block as it moves from A to B. (3)

1.2 Use energy principles to calculate the speed of the block at point B. (5)

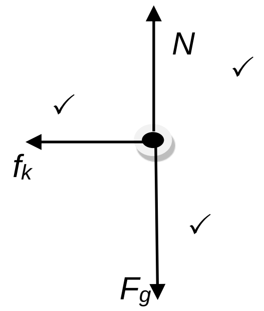
1.3 Write the principle of conservation of mechanical energy in words. (2)

1.4 Use conservation of mechanical energy to determine the distance d moved by the block on the inclined plane. (5)

[15]

SOLUTIONS 1

1.1



(3)

1.2

$$W_{net} = \Delta E_k \ ✓$$

$$f_k \Delta x \cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$(15)(6)\cos 180^o = \frac{1}{2}(6)v_f^2 - \frac{1}{2}(6)(0^2) \ ✓✓✓$$

$$-90 = 3v_f^2 - 0$$

$$v_f = 5.48 m.s^{-1} \ ✓$$

(5)

1.3 The <u>total</u> mechanical energy of an isolated system remains constant. ✓✓

(2)

1.4

$$(E_{mech})_B = (E_{mech})_C$$

$$(mgh + \frac{1}{2}mv^2)_B = (mgh + \frac{1}{2}mv^2)_C \ ✓$$

$$(6)(9.8)(0) + \frac{1}{2}(6)(5.48^2) = (6)(9.8)h + \frac{1}{2}(6)(0^2) \ ✓✓✓$$

$$90.09 = 58.8h$$

$$h = 1.53m$$

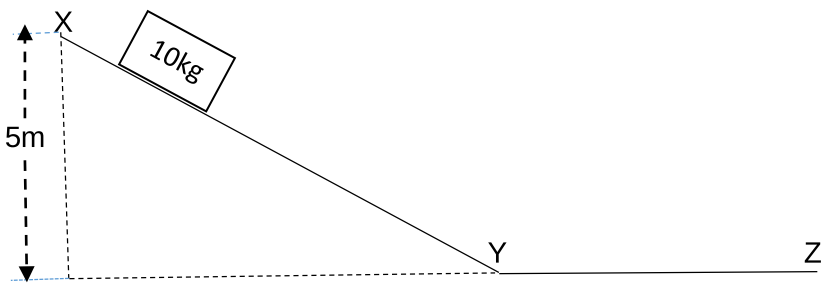
$$d = \frac{1.53}{\sin 20^o}$$

$$d = 4.47m \ ✓$$

(5)

[15]

EXAMPLE 2



A block of mass 10 kg initially at rest at point X slides down a ROUGH inclined plane XY as shown in the figure below. The block continues to move along a smooth horizontal path XY. The speed of the block at point Y is 7.8 $m.s^{-1}$.

2.1 What is meant by the term *non-conservative* force? (2)

2.2 Draw a labelled free-body diagram indicating all the forces acting on the block as it moves down the inclined plane. (3)

2.3 Determine the change in gravitational potential energy of the block as it moves from point X to point Y. (3)

2.4 Calculate the work done by frictional force on the block as it moves from point X to point Y. (3)

2.5 How does the speed of the block at point Z compare with that at point Y? Write down only GREATER THAN, LESS THAN or EQUAL. (1)

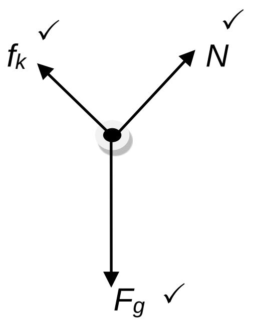
2.6 Briefly explain your answer in QUESTION 2.5 (2)

[14]

SOLUTION 2

2.1 A force for which the work done in moving an object between two points does not depend on the path taken. ✓✓ (2)

2.2



(3)

2.3

$$\Delta E_p = E_{pf} - E_{pi} \checkmark$$
$$\Delta E_p = (10)(9.8)(0) - (10)(9.8)(5) \checkmark$$
$$\Delta E_p = -490 J \checkmark$$

(3)

2.4

$$W_{nc} = \Delta E_p + \Delta E_k \checkmark$$
$$W_{f_k} = -490 + \frac{1}{2}(5)(7.8^2) - 0 \checkmark$$
$$W_{f_k} = -337.9 J \checkmark$$

OR

$$W_{net} = \Delta E_k$$
$$W_{f_k} + W_{F_g} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$
$$W_{f_k} + (10)(9.8)(5)\cos 0^o = \frac{1}{2}(10)(7.8^2) - \frac{1}{2}(10)(0^2)$$
$$W_{f_k} + 490 = 152.1 - 0$$
$$W_{f_k} = -337.9 J$$

(3)

2.5 EQUAL TO ✓ (1)

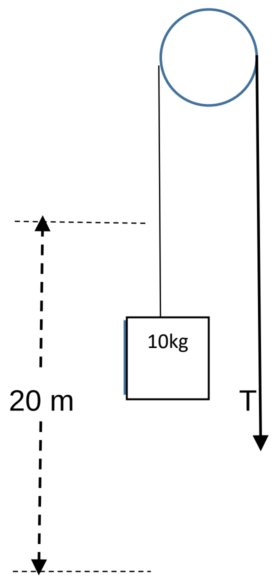
2.6 Total mechanical energy at Y equals total mechanical energy at Z.

Gravitational potential energy remains constant. ✓✓ (Any two)

Kinetic energy remains unchanged. Speed remains constant. (2)

[14]

EXAMPLE 3



A crate of mass 10 kg is lifted vertically upward through a height of 20 m at CONSTANT SPEED of 15 $m.s^{-1}$, by means of a cable as shown in the figure above. The cable passes over a frictionless pulley. The magnitude of the air frictional force acting on the crate as it moves upward through 20 m is 12 N. Assume there is no side-ways movement of the crate.

3.1 Draw a labelled free-body diagram indicating all forces acting on the crate as it's lifted upward. (3)

3.2 Write DOWN the value of the net work done on the crate as it moves 20 m vertically upward. (1)

3.3 State the WORK- ENERGY theorem in words. (2)

3.4 Use the WORK-ENERGY theorem to determine the work done by the tension T in the cable. (5)

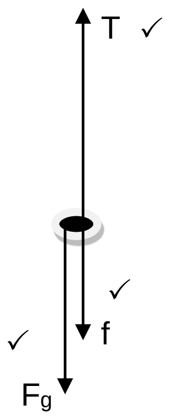
3.5 Calculate the magnitude of the tension in the cable. (3)

3.6 Calculate the power developed in the cable as the crate is lifted vertically upward. (3)

[17]

SOLUTION 3

3.1



(3)

3.2 0 J ✓ (1)

3.3 The <u>net work done</u> on an object is equal to the <u>change in its kinetic energy</u> ✓✓. (2)

3.4

$$W_{net} = \Delta E_k \ ✓$$

$$W_T + W_f + W_{F_g} = 0$$

$$W_T + f\Delta x\cos\theta + F_g\Delta x\cos\theta = 0$$

$$W_T + (12)(20)\cos 180^o ✓ + (10)(9.8)(20)\cos 180^o ✓ = 0 \ ✓$$

$$W_T - 240 - 1960 = 0$$

$$W_T = 2200J \ ✓$$

(5)

3.5

$$W = F\Delta x\cos\theta \ ✓$$

$$2200 = T(20)\cos 0^o \ ✓$$

$$T = 110N \ ✓$$

(3)

3.6 P_{av}= Fv ✓

P_{av}= (110)(15) ✓

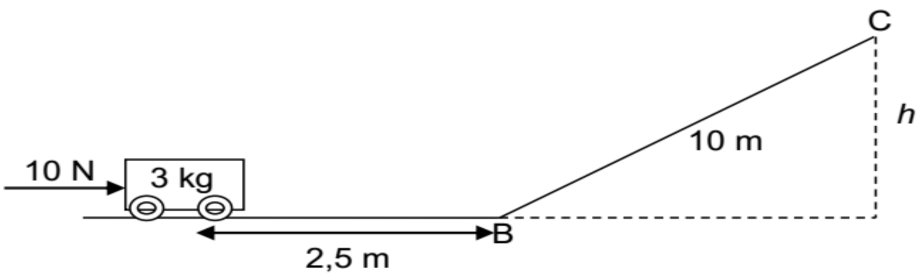
P_{av}=1650 W ✓

(3)

[17]

ACTIVITY 1

A 3 kg trolley is at rest on a horizontal, frictionless surface. A constant horizontal force of 10 N is applied to the trolley over a distance of 2,5 m.



When the force is removed at point B, the trolley moves a distance of 10 m up the incline until it reaches the maximum height at point **C**. While the trolley moves up the incline, there is a constant frictional force of 2 N acting on it.

1.1 Write down the name of a non-conservative force acting on the trolley as it moves up the incline. (1)

1.2 Draw a labelled free body diagram showing all the forces acting on the trolley as it moves along the horizontal surface. (3)

1.3 State the WORK ENERGY THEOREM in words. (2)

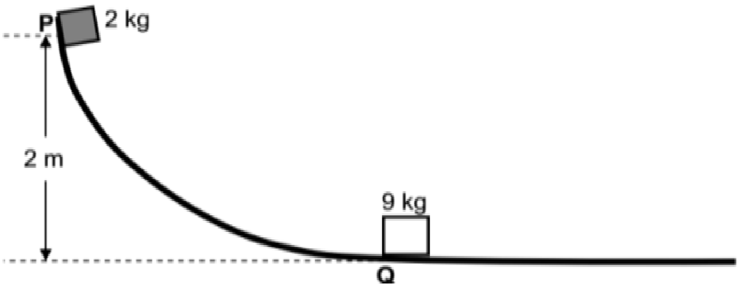
1.4 Use the work-energy theorem to calculate the speed of the trolley when it reaches point **B**. (4)

1.5 Calculate the height, *h*, that the trolley reaches at point **C**. (5)

[15]

ACTIVITY 2

A wooden block of mass 2 kg is released from rest at point **P** and slides down a curved slope from a vertical height of 2 m, as shown in the diagram below. It reaches its lowest position, point **Q**, at a speed of 5 $m \cdot s^{-1}$.



2.1 Define the term *gravitational potential energy*. (2)

2.2 Use the work-energy theorem to calculate the work done by the average frictional force on the wooden block when it reaches point **Q**. (6)

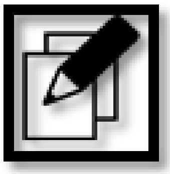
2.3 Is mechanical energy conserved while the wooden block slides down the slope? Give a reason for the answer. (2)

2.4 The wooden block collides with a stationary crate of mass 9kg at point **Q**. After the collision, the crate moves to the right at 1 $m \cdot s^{-1}$.

2.4.1 Calculate the magnitude of the velocity of the wooden block immediately after the collision. (4)

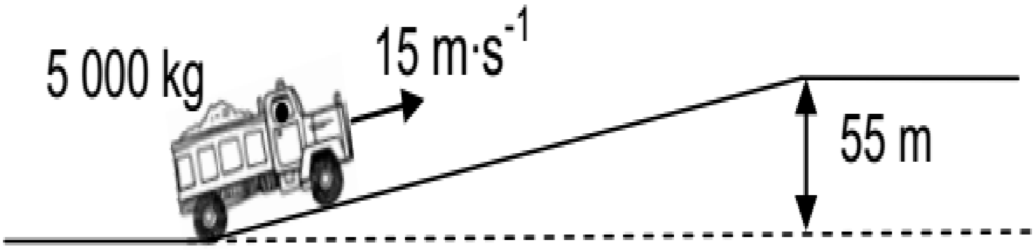
2.4.2 The total kinetic energy of the system before the collision is 25 J. Use a calculation to show that the collision between the wooden block and the crate is inelastic. (5)

[19]



ACTIVITY 3

A loaded truck with a total mass of 5 000 kg travels up a straight incline at a constant velocity of 15 m·s^{-1}. At the top of the incline, the truck is at a height of 55 m above its starting point. The work done by frictional forces is 8,5 x 10^4 J. (Ignore the rotational effects of the wheels of the truck.)



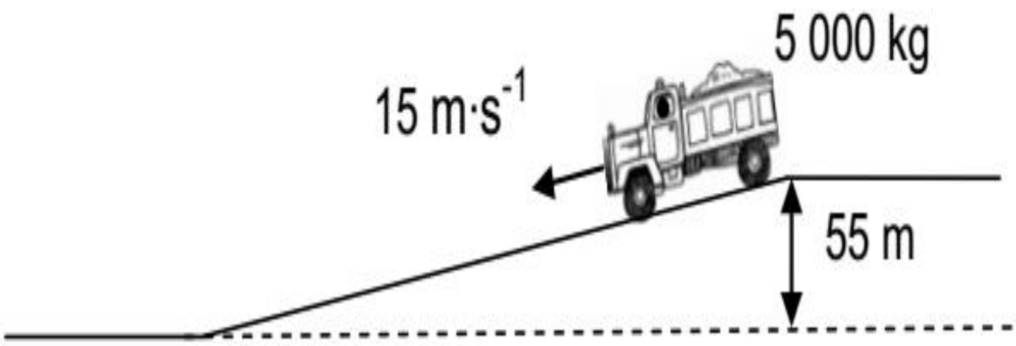
3.1 Define *power* in words. (2)

3.2 Draw a labelled free-body diagram showing ALL the forces acting on the truck as it moves up the incline. (4)

3.3 Use the WORK-ENERGY THEOREM to calculate the work done by the engine of the truck to get it to the top of the incline. (5)

3.4 Calculate the average power delivered by the engine of the truck if the truck takes 60 s to reach the top of the incline. (3)

The truck now returns down the same incline with a constant velocity of 15 m·s^{-1}.

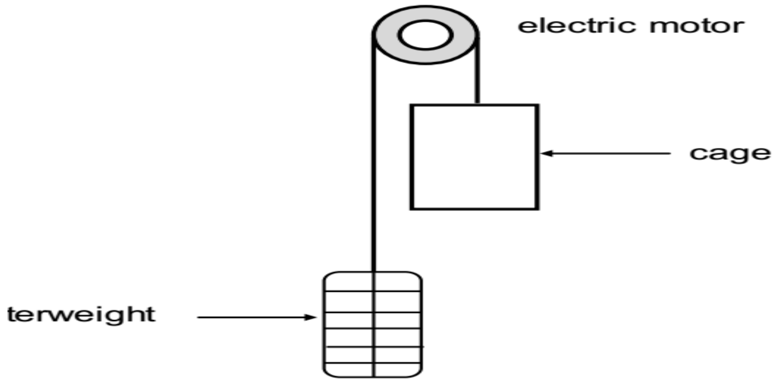


3.5 How will the work done by the engine of the truck on reaching the bottom of the incline compare to that calculated in QUESTION 3.3? Write down GREATER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (2)

[16]

ACTIVITY 4

A lift arrangement comprises an electric motor, a cage and its counterweight. The counterweight moves vertically downwards as the cage moves upwards. The cage and counterweight move at the same constant speed. Refer to the diagram below.



The cage, carrying passengers, moves vertically upwards at a constant speed, covering 55 m in 3 minutes. The counterweight has a mass of 950 kg. The total mass of the cage and passengers is 1 200 kg. The electric motor provides the power needed to operate the lift system. Ignore the effects of friction.

4.1 Define the term *power* in words. (2)

4.2 Calculate the work done by the:

4.2.1 Gravitational force on the cage (3)

4.2.2 Counterweight on the cage (2)

4.3 Calculate the average power required by the motor to operate the lift arrangement in 3 minutes. Assume that there are no energy losses due to heat and sound. (6)

[13]

ELECTRIC CIRCUITS (WITHOUT INTERNAL RESISTANCE)

EXAMINATION GUIDELINES:

Topic 15: Electric Circuits (Grade 11)

Ohm's law

- State **Ohm's law** in words: The **potential difference across a conductor is directly proportional to the current in the conductor at constant temperature**.
- Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.
- State the difference between *ohmic conductors* and *non-ohmic conductors* and give an example of each.
- Solve problems using $R = \frac{V}{I}$ for series and parallel circuits (maximum four resistors).

Power, energy

- Define **power** as the **rate at which work is done.**
- Solve problems using $P = \frac{W}{\Delta t}$.
- Solve problems using $P = VI$,$P = I^2R$ or $P = \frac{V^2}{R}$.
- Solve circuit problems involving the concepts of power and electrical energy.
- Deduce that the kilowatt hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.
- Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.

IMPORTANT TERMS & DEFINITIONS:

ELECTRICITY AND MAGNETISM: ELECTRIC CIRCUITS	
Ohm's law	The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. In symbols: $R = \frac{V}{I}$
Ohmic conductors	A conductor that obeys Ohm's law. The resistance of the conductor remains constant.
Non-ohmic conductors	A conductor that does not obey Ohm's law. The resistance of the conductor does not remain constant, but increases as the current increases. Example: A bulb
Power	Rate at which work is done. In symbols: $P = \frac{W}{\Delta t}$ Unit: watt (W) Other formulae: $P = VI$; $P = I^2R$; $P = \frac{V^2}{R}$
kilowatt hour (kWh)	The use of 1 kilowatt of electricity for 1 hour.

FORMULAE TABLE:

$R = \frac{V}{I}$	
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	$q = I\,\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

LEARNER & TEACHER MANUAL	
TOPIC: Electric circuits without internal resistance	**Duration:** 2 hours

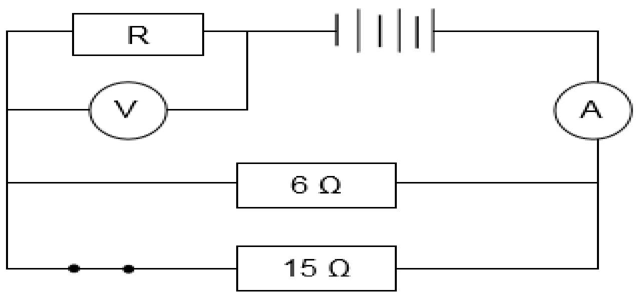
Key Concepts:

1. Ohm's law.
2. Current, potential difference and resistance.
3. Series and parallel connections
4. Ohmic and non-ohmic conductors
5. Power and energy

EXAMPLE 1

The circuit below consists of a 6 Ω and 15 Ω resistor connected in parallel and an

unknown resistor R, in series. An ammeter, a high-resistance voltmeter, a closed
be ignored.
switch and battery are connected, as shown. The resistance of the battery and wires can



The total power dissipated in the parallel part of the circuit is 50 W.

1.1.1 Define the term power. (2)

1.1.2 Calculate the effective resistance of the parallel combination. (2)

1.1.3 Calculate the potential difference across the resistors in parallel. (3)

1.1.4 Calculate the current through resistor R. (3)

The switch in the circuit is now OPENED.

1.1.5 How will the reading on the voltmeter (V) be influenced? Choose from INCREASE, DECREASE or REMAIN THE SAME. (1)

1.1.6 Explain the answer to QUESTION 1.1.5. (3)

A geyser, labelled 2 000 W, is used for an average of 5 hours per day.
The cost of electricity is 80 cents per kWh.

1.2.1 Calculate the energy used by the geyser for 5 hours per day. (4)

1.2.2 Calculate the cost of electricity to operate the geyser for a month with 30 days. (2)

[20]

SOLUTIONS 1

1.1.1 Power is the rate at which work is done. ✓✓ (2)

1.1.2

OPTION 1/*OPSIE 1*	OPTION 2/*OPSIE 2*

$\frac{1}{R_{//}} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_{//}} = \frac{1}{6} + \frac{1}{15}$ ✓
$R_{//} = 4{,}29\ \Omega$ ✓
	$R_{//} = \frac{R_1 \times R_2}{R_1 + R_2}$
	$R_{//} = \frac{6 \times 15}{6 + 15}$ ✓
	$R_{//} = 4{,}29\ \Omega$ ✓

(2)

1.1.3 $P = \frac{V^2}{R}$ ✓

$50 = \frac{V^2}{4{,}29}$ ✓

$V = 14{,}65\ V$ ✓ (3)

1.1.4

OPTION 1/*OPSIE 1*	OPTION 2/*OPSIE 2*
$R = \frac{V}{I}$ ✓ $4{,}29 = \frac{14{,}65}{I}$ ✓ $I = 3{,}41\ A$ ✓	$P = VI$ ✓ $50 = (14{,}65)I$ ✓ $I = 3{,}41\ A$ ✓
OPTION 3/*OPSIE 3*	**OPTION 4/*OPSIE 4***
$P = I^2R$ ✓ $50 = I^2(4{,}29)$ ✓ $I = 3{,}41\ A$ ✓	$V = IR$ ✓ $14{,}65 = I(6)$ $I = 2{,}44\ A$ $V = IR$ $14{,}65 = I(15)$ $I = 0{,}98\ A$ $2{,}44 + 0{,}98$ ✓ $= 3{,}42\ A$ ✓

(3)

1.1.5 DECREASES (1)

1.1.6 The total resistance increases ✓
The current in the circuit decreases ✓
The resistance of R is constant, ✓ then the potential difference across R decreases. (3)

1.2.1 $P = \frac{W}{\Delta t}$ ✓

$2\ 000$ ✓ $= \frac{W}{18\ 000}$ ✓

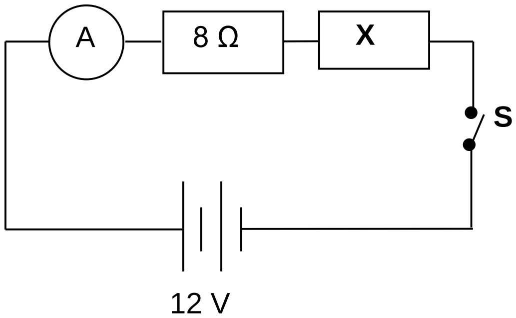
$W = 3{,}6 \times 10^7\ J$ ✓ (4)

1.2.2 Cost = price x unit kWh / *Koste*
Cost = 80(2)(5)(30) ✓
Cost = 24 000 cents = R240 ✓ (2)

[20]

EXAMPLE 2

2.1 The circuit below is used to determine the resistance of resistor **X**.

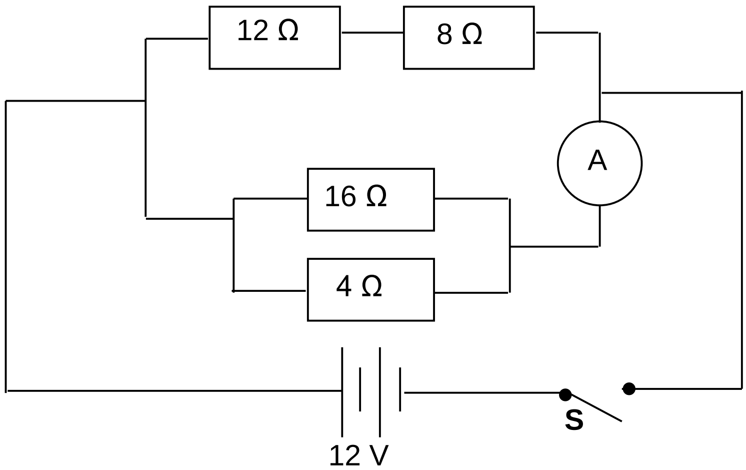


The 12 V battery has negligible internal resistance. When switch **S** is closed, the reading on the ammeter is 0,5 A.

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

2.1.2 Calculate the resistance of resistor **X**. (5)

.2 Study the circuit below. The battery has an emf of 12 V with negligible internal resistance.



Switch **S** is closed.

2.2.1 Write down the potential difference across the 4 Ω resistor. (1)

2.2.2 Calculate the reading on the ammeter. (5)

2.2.3 Calculate the energy dissipated in the 12 Ω resistor in 2 minutes. (5)

[18]

SOLUTIONS 2

2.1.1 The potential difference across a conductor is directly proportional to the current in the conductor ✓at constant temperature.✓

OR

Provided temperature and other physical conditions are constant✓, the potential difference across a conductor is directly proportional to the current✓. (2)

2.1.2

OPTION 1	
$V_{tot} = IR_{tot}$✓ $12 = (0,5)R_{tot}$ ✓ $\therefore R_{tot} = 24\ \Omega$ ✓ $\therefore R_X = (24 - 8)$ ✓ $= 16\ \Omega$ ✓	

(5)

OPTION 2

$V_8 = IR_{8\Omega}$✓

$= (0,5)(8)$ ✓

$= 4$ V

$\therefore V_X = (12 - 4)$ ✓ $= 8$ V

$V_X = IR_x$

$8 = (0,5)(R_X)$ ✓

$\therefore R_X = 16\ \Omega$✓

(5)

2.2.1 12 V✓

2.2.2

OPTION 1

$V_4 = I_4\ R_{4\Omega}$✓

$12 = I_4(4)$✓

$I_{4\Omega} = 3$ A

$V_X = I_{16\Omega}R$

$12 = I_{16\Omega}16$ ✓

$I_{16\Omega} = 0,75$ A

$I_A = (3 + 0,75)$ ✓

$= 3,75$ A✓

(5)

OPTION 2

$V_4 = I_4\ R_{4\Omega}$✓

$12 = I_4(4)$✓

$I_{4\Omega} = 3$ A

$I_4R_4 = I_{16\Omega}R_{16\Omega}$

$(3)(4) = I_{16\Omega}(16)$ ✓

$I_{16\Omega} = 0,75$ A

$I_A = (3 + 0,75)$ ✓

$= 3,75$ A✓

(5)

OPTION 3

Combined resistance of the lower portion:

$R = \dfrac{R_{16}R_4}{R_{16} + R_4}$ ✓

$R = \dfrac{16 \times 4}{20}$ ✓ $= 3{,}2\ \Omega$

$V = I_AR$

12✓ $= I_A\ (3{,}2)$✓

$I_A = 3{,}75$ A✓

(5)

.2.3 **OPTION 1**

$V_{12} = \dfrac{R_{12}}{R_{tot}} V_{tot}$ ✓

$V_{12} = \dfrac{12}{(8 + 12)}(12)$ ✓

$= 7{,}2$ V

Energy/W $= \dfrac{V^2}{R}\Delta t$ ✓

$= \dfrac{(7{,}2)^2}{12}(120)$ ✓

$= 518{,}4$ J✓

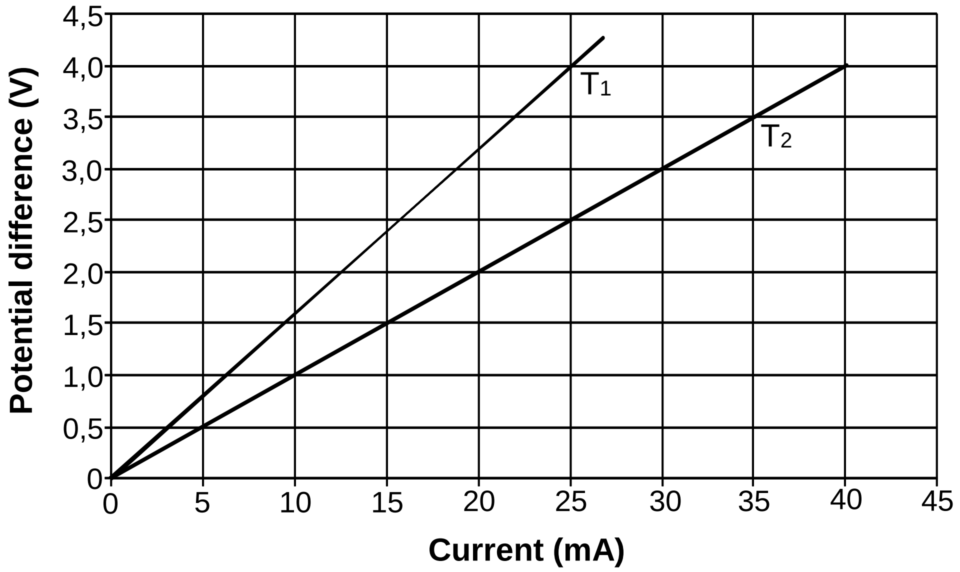
(5)

[18]

EXAMPLE 3

3.1 The two graphs below represent the relationship between potential difference and current in a metal wire at two different constant temperatures, T_1 and T_2.

GRAPHS OF POTENTIAL DIFFERENCE VERSUS CURRENT



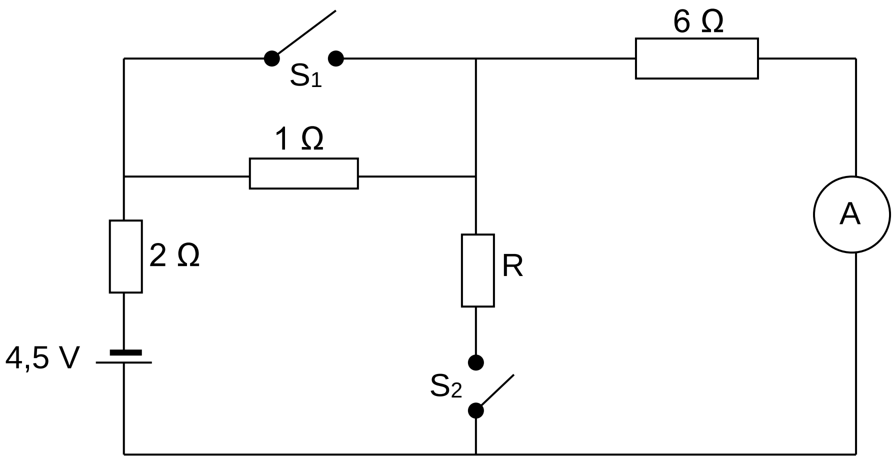
3.1.1 Calculate the resistance of the metal wire at temperature T_1. (3)

3.1.2 Which graph was obtained at the higher temperature? Give a reason for the answer. (3)

3.1.3 The metal wire is an ohmic conductor. Justify this statement by referring to the graphs. (1)

3.1.4 Calculate the power dissipated in the metal wire when the current in it is 25 mA at temperature T_2. (3)

3.2 The ammeter in the circuit below shows the same reading regardless whether switches **S_1** and **S_2** are both open or both closed. (The internal resistance of the cell, as well as the resistances of the ammeter and the connecting wires, are negligible.)



Calculate the:

3.2.1 Reading on the ammeter (4)

3.2.2 Resistance *R* (6)
[20]

SOLUTIONS 3

3.1

3.1.1 Resistance = gradient of graph

$$= \frac{4-0 \checkmark}{25\times10^{-3}-0 \checkmark}$$

$= 160\ \Omega$ ✓ (3)

3.1.2 Graph at T_1 ✓ *1*

Steeper/larger gradient/✓

∴ R is greater/✓

∴ Temperature is higher (3)

3.1.3 V is directly proportional to I at each of the temperatures T_1 and T_2. ✓ (1)

3.1.4 P = VI ✓

$= (2{,}5)(25 \times 10^{-3})$ ✓

$= 0{,}06(2)$ W ✓ (3)

3.2

3.2.1 Both switches open:

$R = 6\ \Omega + 1\Omega + 2\Omega = 9\ \Omega$ ✓

$R = \frac{V}{I}$ ✓

$9 = \frac{4{,}5}{I}$ ✓

∴ I = 0,5 A ✓ (4)

3.2.2 Both switches closed:

$V_{6\Omega} = IR = (0{,}5)(6) = 3$ V ✓

$V_{2\Omega} = 4{,}5 - 3 = 1{,}5$ V ✓

$I_{2\Omega} = \frac{V}{R} = \frac{1{,}5}{2} = 0{,}75$ A ✓

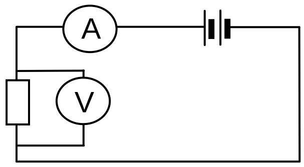
$I_R = 0{,}75 - 0{,}5 = 0{,}25$ A ✓

$R = \frac{V}{I} = \frac{3}{0{,}25}$ ✓ $= 12\ \Omega$ ✓

(6)
[20]

EXAMPLE 4

A learner investigates Ohm's law. He sets up the following circuit.



4.1 Represent Ohm's law in symbols. (1)

The learner obtains the following results:

Potential difference (V)	**Current (A)**
12,0	2,4
9,0	1,8
6,0	1,2
3,0	0,6

4.2 Calculate the resistance of the resistor in the above circuit. (3)

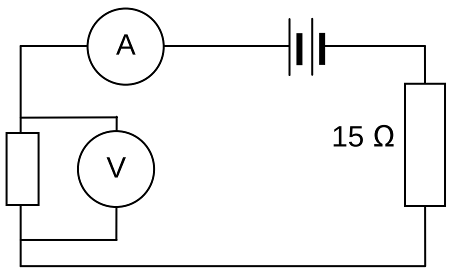
4.3 Is the resistor in the above circuit an OHMIC or a NON-OHMIC resistor? Give a reason for the answer. (2)

4.4 On the same set of axes, sketch graphs of potential difference versus current for an ohmic and a non-ohmic resistor. Clearly label the graph for the ohmic resistor as **P** and the graph for the non-ohmic resistor as **Q**. (2)

4.5 Explain in full why the curve drawn for a non-ohmic resistor differs from that of an ohmic resistor. (3)

4.6 Give an example of a non-ohmic resistor used in

The learner now adds a 15 Ω ohmic resistor to the circuit as shown in the diagram below.

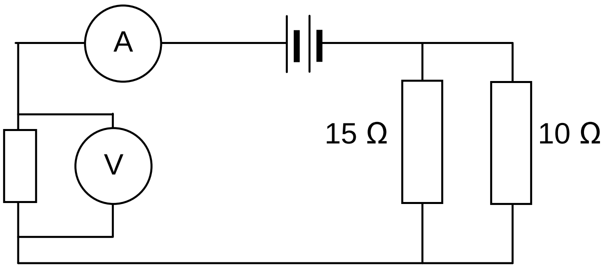


4.7 Calculate the total resistance of the above circuit. (1)

4.8 How will the ammeter reading compare to the reading given in the above table if the learner uses the 6 V cell? Only write down EQUAL TO, GREATER THAN or SMALLER THAN. (1)

4.9 Calculate the potential difference across the 15 Ω resistor if he uses the 6 V cell. (5)

The learner now adds a third resistor with a resistance of 10 Ω to the circuit and replaces the cells with different cells.



4.10 Calculate the total resistance of the above circuit. (4)

4.11 How will the voltmeter reading of a voltmeter connected across the 15 Ω resistor compare to that of a voltmeter connected across the 10 Ω resistor? Only write down EQUAL TO, GREATER THAN or SMALLER THAN. (1)

[24]

SOLUTIONS 4

4.1 $V \propto I$ ✓ Aanvaar ook $R = \frac{V}{I}$ ✓ (1)

4.2

<u>Option 1/*Opsie 1*</u>

$R = \frac{V}{I}$ ✓ $= \frac{12}{2,4}$ ✓ $= 5\ \Omega$ ✓

<u>Option 2/*Opsie 2*</u>

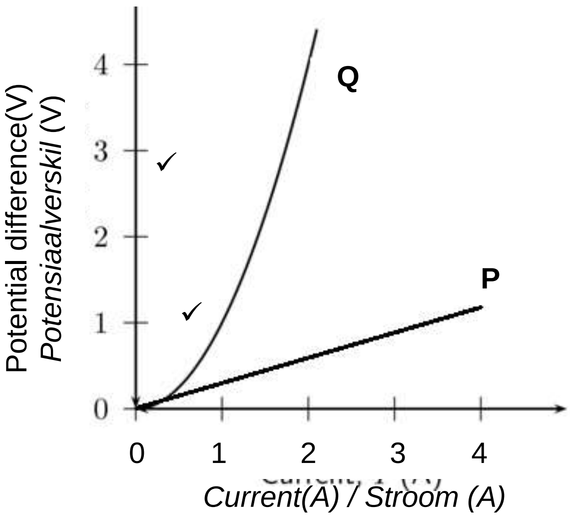
$$\text{Gradient} = \frac{\Delta I}{\Delta V}$$
$$= \frac{2,4 - 0,6}{12 - 3} \checkmark\checkmark$$
$$= 0,2\ \Omega^{-1}$$
$$R = 5\ \Omega \checkmark$$

Option: Any combination from the table can be used.
***Opsie**: Enige kombinasie uit die tabel kan gebruik word.*

(3)

4.3 ✓Ohmic / *Ohmies* ✓
The current is directly proportional to potential difference. ✓
Die stroom is direk eweredig aan die potensiaalverskil.
OR/OF
The ratio of V to I remains constant./*Die verhouding van V tot I bly konstant.* (2)

4.4



(2)

4.5 An increase in the voltage results in an increase in current which causes the temperature of the resistor to increase. ✓
When the temperature increases, the resistance increases. ✓
When the resistance increases, the increase in current is limited. ✓
Therefore the ratio of voltage to current ratio is not constant.
'n Toename in die spanning lei tot 'n toename in die stroom, wat veroorsaak dat die weerstand se temperatuur verhoog.
Wanneer die temperatuur verhoog, verhoog die weerstand.
Wanneer die weerstand verhoog, word die toename in stroom beperk.
Dus bly die verhouding van spanning tot stroom nie konstant nie. (3)

4.6 Light bulb / *Gloeilamp* ✓ (1)

4.7 **POSITIVE MARKING FROM QUESTION 4.2.**
POSITIEWE NASIEN VAN VRAAG 4.2.

$R_t = 15 + 5 = 20\ \Omega$ ✓ (1)

4.8 Smaller than / *Kleiner as* ✓ (1)

4.9 **POSITIVE MARKING FROM QUESTION 4.7.**
POSITIEWE NASIEN VAN VRAAG 4.7.

$R = \frac{V}{I}$ ✓ $\therefore 20 = \frac{6}{I}$ ✓ $\therefore I = 0{,}3\ A$ ✓

$R = \frac{V}{I}$ $\therefore 15 = \frac{V}{0{,}3}$ ✓ $\therefore V = 4{,}5\ V$ ✓ (5)

4.10 **POSITIVE MARKING FROM QUESTION 4.2.**
POSITIEWE NASIEN VAN VRAAG 4.2.

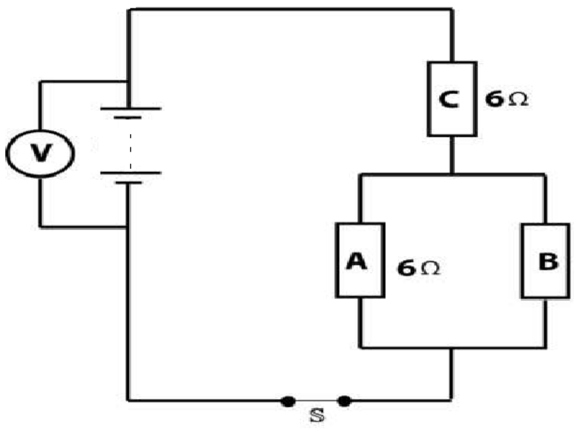
$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2}$ ✓ $= \frac{1}{15} + \frac{1}{10}$ ✓ $\therefore R_e = 6\ \Omega$

$R_t = R_e + R = 6 + 5$ ✓ $= 11\ \Omega$ ✓ (4)

4.11 Equal to / *Gelyk aan* ✓ (1)
[24]

ACTIVITY 1

In the circuit diagram below resistors **A** and **B** are connected in parallel and **C** in series as represented in the circuit below. The effective resistance across the parallel connection is 2 Ω and the reading on the voltmeter **V** is 24 V. The resistance of the connecting wires is negligible.



1.1 State *Ohm's law* in words. (2)

Calculate the:

1.2 Resistance of resistor **B** (5)

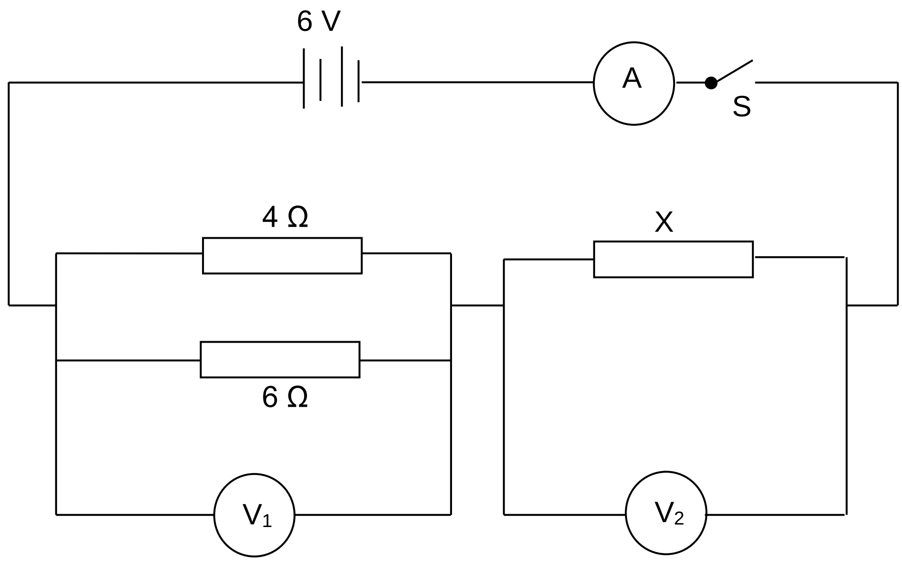
1.3 Current in the circuit (7)

1.4 Potential difference across the resistor **A** (7)

[21]

ACTIVITY 2

In the circuit below the internal resistance of the 6 V battery is negligible. The resistance of the connecting wires is negligible. When switch **S** is closed, the current in the 6 Ω resistor is 0,6 A.



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

Calculate the:

2.2 Current passing through the 4 Ω resistor (4)

2.3 Total current in the circuit (2)

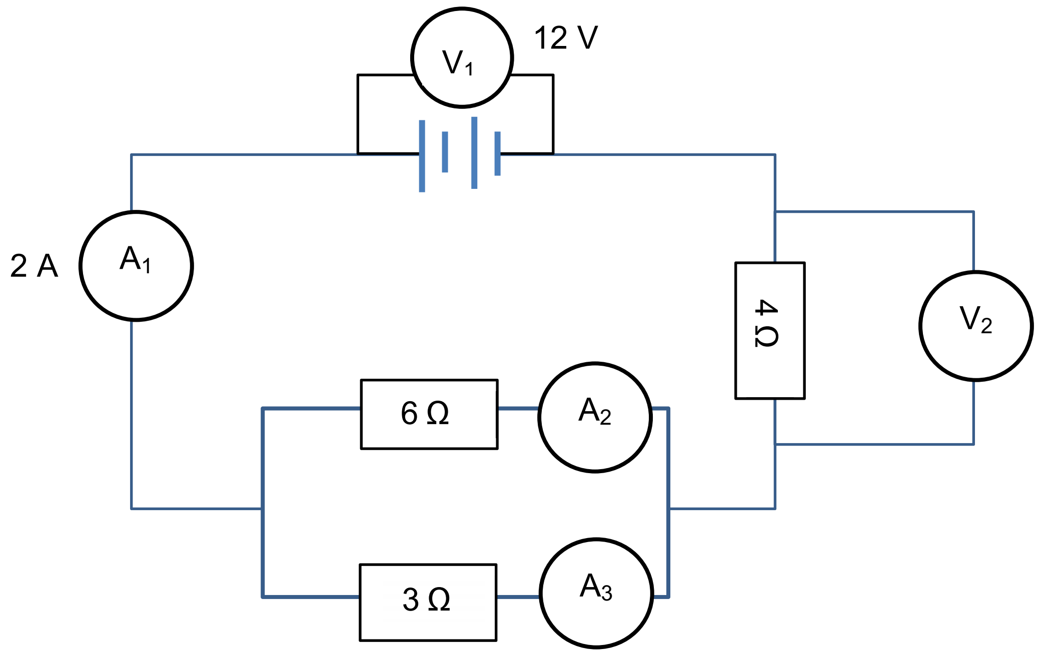
2.4 Resistance **X** (3)

The 4 Ω resistor gets hotter than the 6 Ω resistor after a while.

2.5 Explain this observation. (3)
[14]

ACTIVITY 3

In the circuit diagram below the reading on voltmeter V_1 is 12 V and the reading on ammeter A_1 is 2 A.



3.1 Calculate the:

3.1.1 Total resistance of the circuit (4)

3.1.2 Reading on V_2 (3)

3.1.3 Reading on A_2 (3)

3.1.4 Amount of charge that flows through ammeter A_1 in 120 s (3)

3.2 How will the reading on ammeter A_1 be affected if the 6 Ω resistor is removed from the circuit?

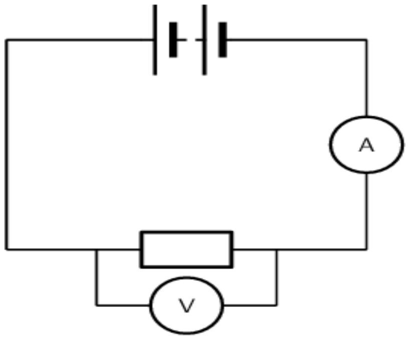
Write down only INCREASE, DECREASE or REMAIN THE SAME. (1)

3.3 Explain the answer to QUESTION 3.2 WITHOUT any calculations. (3)

[17]

ACTIVITY 4

A learner investigates Ohm's law. He sets up the following circuit.



4.1 State Ohm's law in symbols. (1)

The learner obtains the following results:

Potential difference (V)	Current (A)
3,0	0,4
6,0	0,8
9,0	1,2
12,0	1,6

4.2 Calculate the resistance of the resistor in the above circuit. (3)

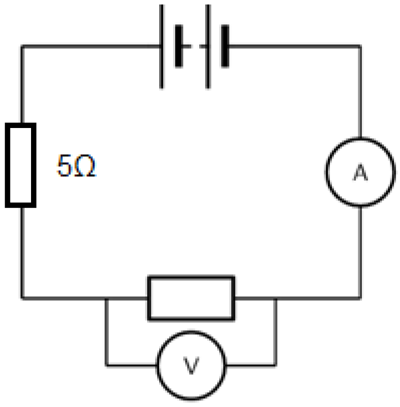
4.3 Is the resistor in the above circuit an OHMIC or a NON-OHMIC resistor? Give a reason for the answer. (2)

4.4 On the same set of axes, sketch a graph of potential difference versus current for an ohmic and a non-ohmic resistor. Clearly label the graph for the ohmic resistor as **P** and the graph for the non-ohmic resistor as **Q**. (2)

4.5 Fully explain why the curve drawn for a non-ohmic resistor differs from that of an ohmic resistor. (3)

4.6 Give an example of a non-ohmic resister used in our daily lives. (1)

The learner now adds a 5 Ω ohmic resistor to the circuit as shown in the diagram below.

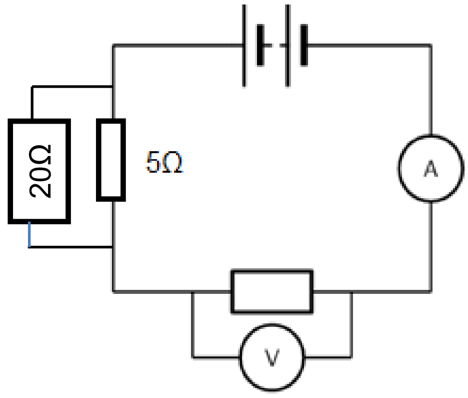


4.7 Calculate the total resistance of the above circuit. (1)

4.8 How will the ammeter reading compare to the reading given in the above table if the learner uses the 6 V cell. Only write down EQUAL TO, GREATER THAN or SMALLER THAN. (1)

4.9 Calculate the potential difference across the 5 Ω resistor if he uses the 6 V cell. (4)

The learner now adds a third resistor with a resistance of 20 Ω to the circuit and replaces the cells with different cells.



4.10 Calculate the total resistance of the above circuit. (4)

4.11 How will the voltmeter reading of a voltmeter connected across the 5 Ω resistor compare to that of a voltmeter connected across the 20 Ω resistor? Only write down EQUAL TO, GREATER THAN or SMALLER THAN. (1)

[23]

Sources of information

1. Doe Physical Sciences November, Feb-March and September Question papers (2014-2017).
2. Physical Sciences Examination Guideline.
3. Mind the Gap (Physics) Grade 12.
4. Doe Physical Sciences Training manuals (2014 -2017).