JENN

Training and Consultancy

The path to enlightened education

SUBJECT: SUBJECT NAME

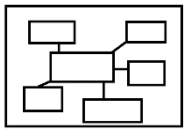
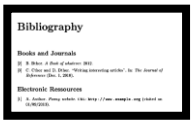
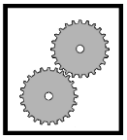
GRADE 12

LAST PUSH 2026

TEACHER AND LEARNER CONTENT MANUAL

PAPER 1 TOPICS

ICON DESCRIPTION

 MIND MAP	 EXAMINATION GUIDELINE	 CONTENTS	 ACTIVITIES
 BIBLIOGRAPHY	 TERMINOLOGY	 WORKED EXAMPLES	 STEPS

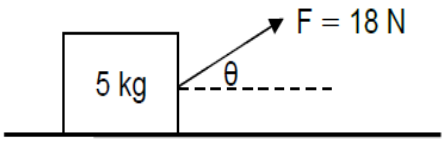
CONTENTS **PAGE**

1. NEWTON'S LAWS OF MOTION.	2-5
2. VERTICAL PROJECTILE MOTION.	6-10
3. MOMENTUM AND IMPULSE.	10-13
4. WORK, ENERGY AND POWER.	13-16
5. DOPPLER EFFECT.	16-19
6. ELECTROSTATICS.	20-23
7. ELECTRIC CIRCUITS.	23-28
8. ELECTRODYNAMICS.	28-32
9. PHOTOELECTRIC EFFECT.	32-36

TOPIC 1: NEWTON'S LAWS OF MOTION

QUESTION 1

A block of mass 5 kg is at rest on a rough horizontal surface. When a constant force **F** of magnitude 18 N acts on the block at an angle θ to the horizontal, the block experiences maximum static friction. See the diagram below.



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

1.2 Draw a labelled free-body diagram showing ALL the forces acting on the block. (4)

1.3 The horizontal component of force F is 15 N.
Calculate:

1.3.1 **θ**. (2)

1.3.2 The coefficient of static friction. (5)

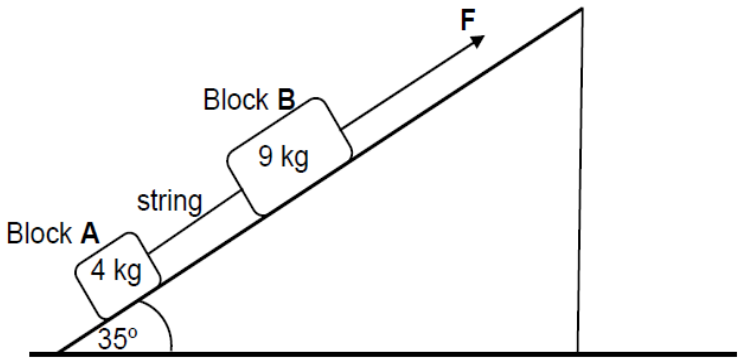
1.4 Angle **θ** is decreased while the magnitude of force **F** remains constant.
How will the friction acting on the block be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME.
Explain the answer. (4)

[17]

QUESTION 2

Two blocks, **A**, of mass 4 kg, and **B**, of mass 9 kg, are connected by a light inextensible string. The blocks are held at rest on a plane which is inclined at an angle of 35º with the horizontal.

A constant force, **F**, acting parallel to the plane, is applied to block **B**, as shown in the diagram below. The blocks now accelerate up the plane at 2 $m \cdot s^{2-}$.



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

The kinetic frictional forces acting on blocks **A** and **B** are 5,88 N and 13,23 N respectively.

2.2 Draw a labelled free-body diagram showing all the forces acting on block **A**. (4)

2.3 Calculate the magnitude of:

2.3.1 The tension in the string. (4)

2.3.2 Force **F**. (3)

2.4 The angle that the plane makes with the horizontal is now decreased.

2.4.1 How will this change the kinetic frictional force acting on block **A**?
Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

2.4.2 Explain the answer to QUESTION 2.4.1. (2)

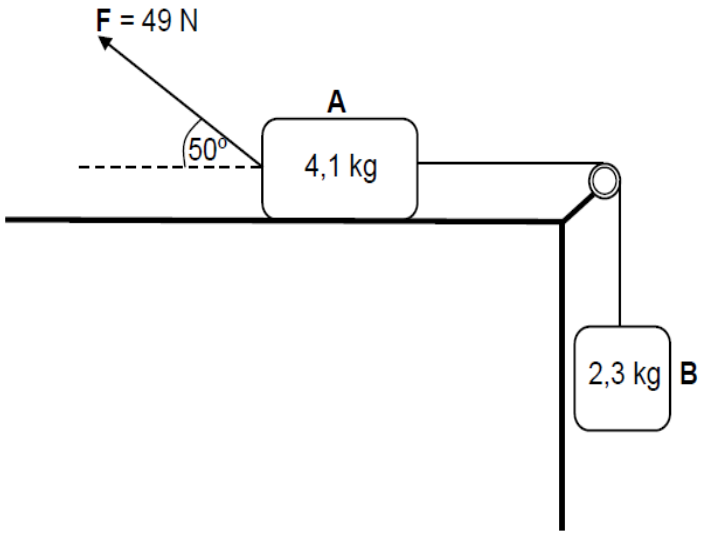
[16]

QUESTION 3

Block **A** of mass 4,1 kg is connected to block **B** of mass 2,3 kg by a light inextensible string passing over a frictionless pulley. Block **A** is at rest on a rough horizontal table and block **B** hangs vertically, as shown in the diagram below.

A force **F** of magnitude 49 N is applied on block **A** at an angle of 50º to the horizontal, causing block **A** to accelerate TO THE LEFT from rest along the table.

The coefficient of kinetic friction between the surface of the table and block **A** is 0,35.



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

3.2 Draw a labelled free-body diagram showing all the forces acting on block **A** while it accelerates to the left. (5)

3.3 Calculate the magnitude of the:

3.3.1 Kinetic frictional force exerted on block **A**. (3)

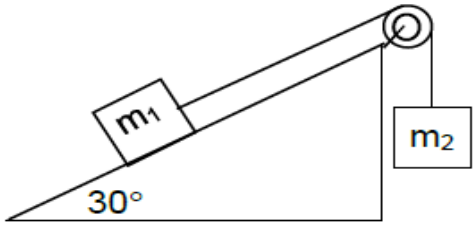
3.3.2 Acceleration of block **A**, by applying Newton's Second Law to each block separately. (5)

3.4 A small hypothetical planet **X** has a mass of 6,5 x 1020 kg and a radius of 550 km.
Calculate the gravitational force (weight) that planet **X** exerts on a 90 kg rock on this planet's surface. (4)

[19]

QUESTION 4

A block m_1 of mass 8 kg is connected by a light inextensible string which runs over a light frictionless pulley to block m_2 also of mass 8 kg. Block $\mathbf{m_1}$ is moving up an incline as shown in the diagram below. The coefficient of kinetic friction between block $\mathbf{m_1}$ and the incline is 0,2.



4.1 State Newton's Second Law of motion in words. (2)

4.2 Draw a labelled free-body diagram showing ALL the forces acting on block $\mathbf{m_1}$. (4)

4.3 Consider the forces acting on each block separately, and calculate the magnitude of the acceleration of the system. (6)

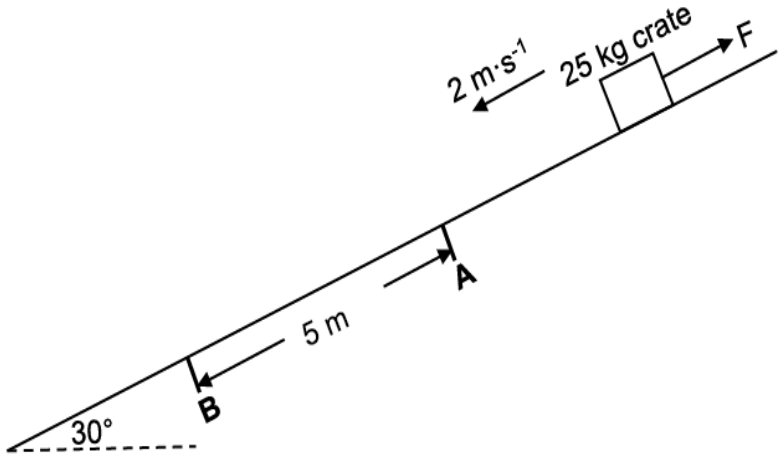
4.4 According to Newton's Third law, which force is the reaction to the weight of block $\mathbf{m_2}$? (2)

4.5 While the blocks are moving, the string breaks. What is the direction of the acceleration of block $\mathbf{m_1}$ immediately after the string breaks? Write only **UP** or **DOWN** the incline. (1)

[15]

QUESTION 5

A crate of mass 25 kg slides down a rough inclined plane at a constant speed of 2 m·s^{-1} towards point **A** while force **F** acts on it, parallel to the incline, as shown below. A constant kinetic frictional force of 40 N acts on the crate when the plane is inclined at an angle of 30° with the horizontal.

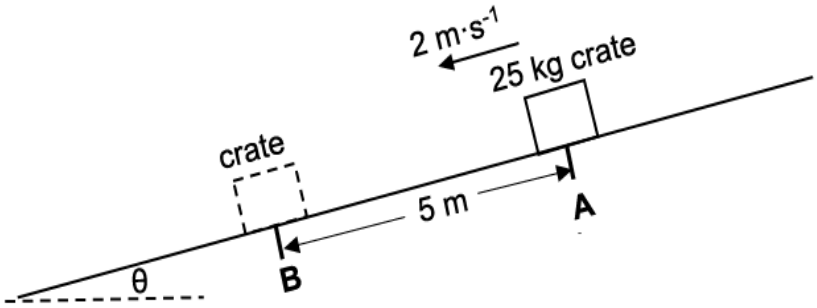


5.1 State Newton's First Law of Motion in words. (2)

5.2 Draw a labelled free-body diagram showing ALL the forces acting on the crate, as it moves towards point **A**. (4)

5.3 Calculate the magnitude of **F**. (3)

When the crate reaches point **A**, force F is removed, and the angle of inclination is decreased immediately to θ so that the crate continues moving at 2 m·s^{-1} towards point **B**.



5.4 Use the relationship between the forces acting on the crate between points **A** and **B** to show that $\mu_k = \frac{sin\,\theta}{\cos\theta}$. (3)

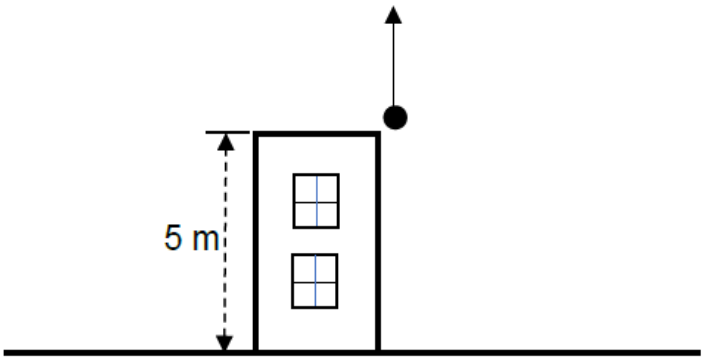
5.5 The coefficient of kinetic friction between the crate and the inclined plane is 0,19. Using the identity $\frac{sin\,\theta}{\cos\theta}$ = tan θ, calculate the frictional force as the crate slides from point **A** to point **B**. (3)

[15]

TOPIC 2: VERTICAL PROJECTILE MOTION

QUESTION 1

A ball is projected vertically upwards from the top of a building that is 5 m high. Ignore the effects of friction.



The table below shows the magnitude of the velocity of the ball at THREE different times during its motion.

TIME (s)	MAGNITUDE OF VELOCITY ($m \cdot s^{-1}$)
0	15
p	0
3,36	q

1.1 Define the term *free fall*. (2)

1.2 Using EQUATIONS OF MOTION ONLY, calculate the value of **p**. (3)

The ball strikes the ground 3,36 seconds after it was thrown upwards.

1.3 Calculate **q**. (3)

The ball bounces to a maximum height of 3 m after it struck the ground.

1.4 Is the collision with the ground ELASTIC or INELASTIC?
Explain the answer WITHOUT the use of calculations. (3)

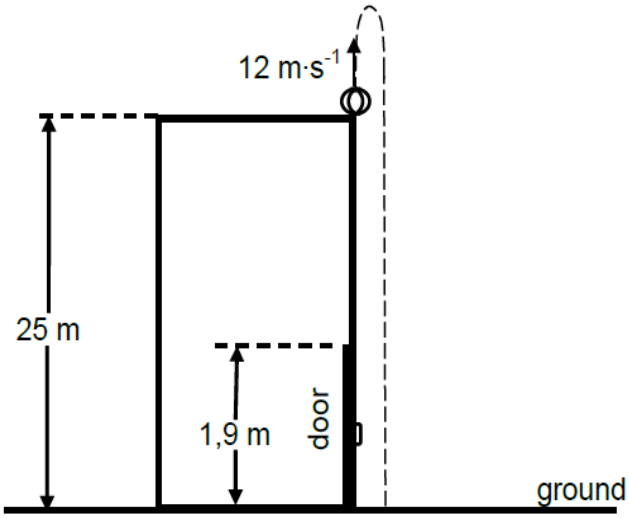
1.5 Sketch a velocity versus time graph for the motion of the ball from the time it was projected until it reached the maximum height after it bounced. Show the following NUMERICAL VALUES on the graph:

- The initial velocity;
- Time **p**;
- Velocity **q**. (4)

[15]

QUESTION 2

A ball is thrown vertically upwards from the top of a building of height 25 m with a velocity of $m \cdot s^{-1}$. On its way down, the ball passes a door which has a height of 1,9 m and then strikes the ground, as shown in the diagram below. Ignore the effects of air friction.



2.1 Define the term free fall. (2)

2.2 Calculate the:

2.2.1 Time taken for the ball to reach its maximum height. (3)

2.2.2 Velocity with which the ball strikes the ground. (4)

2.2.3 Time it took the ball to move from the top of the door to the ground. (4)

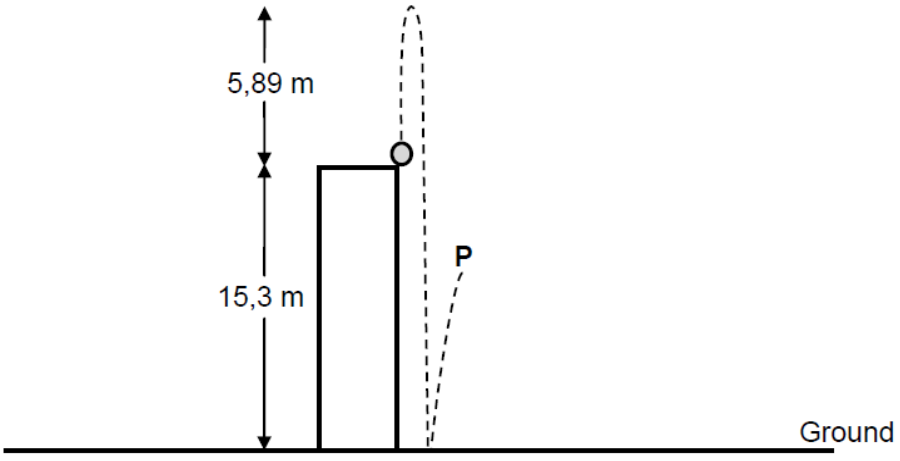
2.3 Draw a velocity versus time graph for the motion of the ball from the moment that the ball is thrown upwards until it strikes the ground.
Use the ground as zero reference.
Clearly indicate the following on your graph:

- The velocity with which the ball was thrown upwards;
- Time taken by the ball to reach its maximum height;
- The velocity with which the ball strikes the ground. (3)

[16]

QUESTION 3

A ball of mass 0,5 kg is thrown vertically upwards from the top edge of a building which is 15,3 m high. The ball reaches a maximum height of 5,89 m above the top of the building. The ball strikes the ground and bounces vertically upwards, reaching a maximum height at point P, as shown in the diagram below.



Ignore the effects of air friction.

3.1 Define the term free fall. (2)

3.2 Using only EQUATIONS OF MOTION, calculate the speed at which the ball was projected upwards. (3)

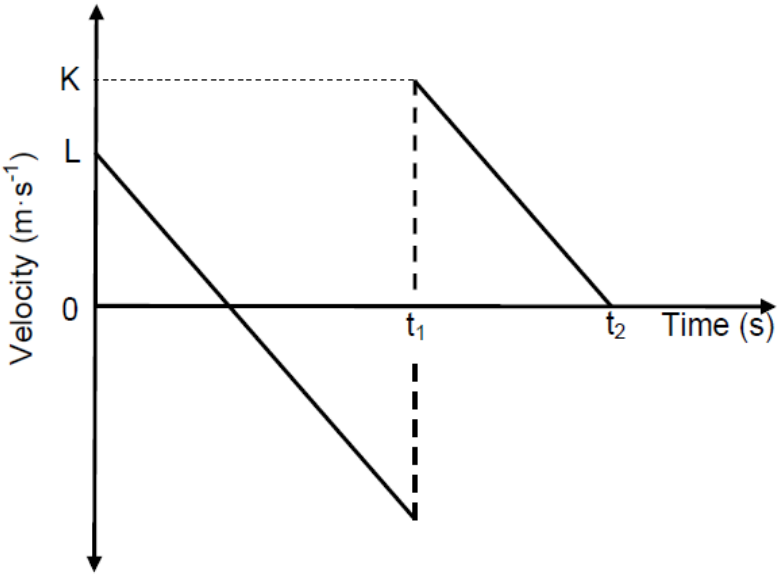
3.3 After the collision with the ground, the ball leaves the ground with a speed of 11,92 $m \cdot s^{-1}$.

Calculate the:

3.3.1 Amount of kinetic energy lost by the ball during the collision with the ground. (5)

3.3.2 Time taken for the ball to reach point **P** after leaving the ground. (3)

3.4 The velocity-time graph for the motion of the ball from the instant it is projected upwards from the top edge of the building until the time it reaches point **P** is shown below.



Write down the numerical values indicated by EACH of the following:

3.4.1 K. (1)

3.4.2 L. (1)

3.4.3 $t_2 - t_1$. (1)

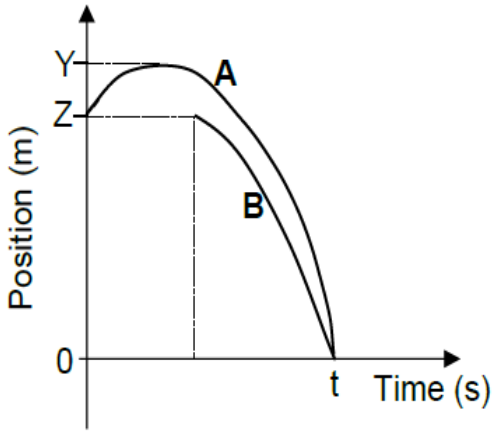
[16]

QUESTION 4

Ball **A** is thrown vertically upwards at 12 $m \cdot s^{-1}$ from the top of a building. Two seconds after ball **A** was thrown upwards, ball **B** is thrown vertically downwards at 5,4 $m \cdot s^{-1}$ from the top of the same building. Both balls, **A** and **B**, strike the ground at time **t** seconds.

Ignore the effects of air friction.

The position-time sketch graphs for both balls are shown below.



4.1 Using EQUATIONS OF MOTION ONLY, calculate the value of EACH of the following, as shown in the graphs:

4.1.1 t. (5)

4.1.2 Z. (3)

4.1.3 Y. (4)

4.2 On the same set of axes, sketch the velocity-time graphs for ball **A** and ball **B** while they are in free fall. Label the graphs **A** and **B** for ball **A** and ball **B** respectively.

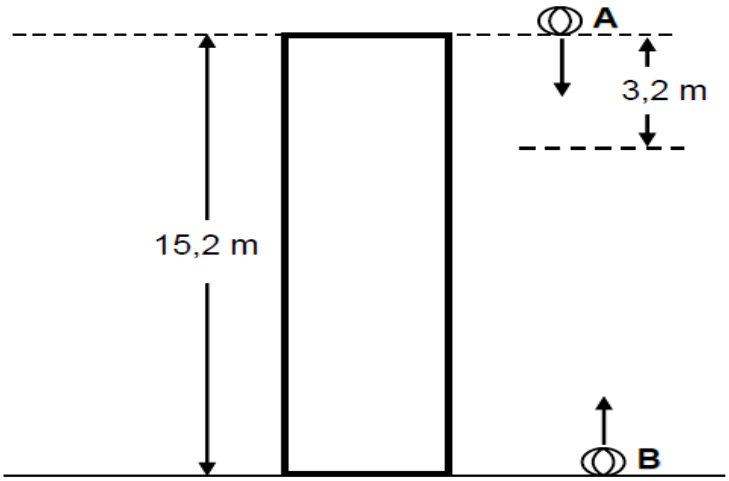
Clearly indicate the following on the graphs:

- The initial velocity of each ball;
- The time at which each ball is thrown;
- The time at which the balls strike the ground. (4)

[16]

QUESTION 5

Ball **A** is dropped from rest from the top of a building 15,2 m high.
After ball **A** has fallen 3,2 m, a second ball **B** is projected vertically upwards from the ground. After a while, the two balls strike the ground at the SAME time.
Ignore the effects of air resistance.



5.1 Define the term free fall. (2)

5.2 Calculate the:

5.2.1 Time taken for ball **A** to strike the ground. (3)

5.2.2 Magnitude of the velocity with which ball **B** was projected from the ground. (5)

5.3 On the same system of axes, draw position-time graphs to show the motions of both ball A and ball B from the instant ball A is dropped until the time it reaches the ground.
Take the ground as the zero position.
Label the graphs **A** and **B**.
Clearly indicate the following on the graphs:

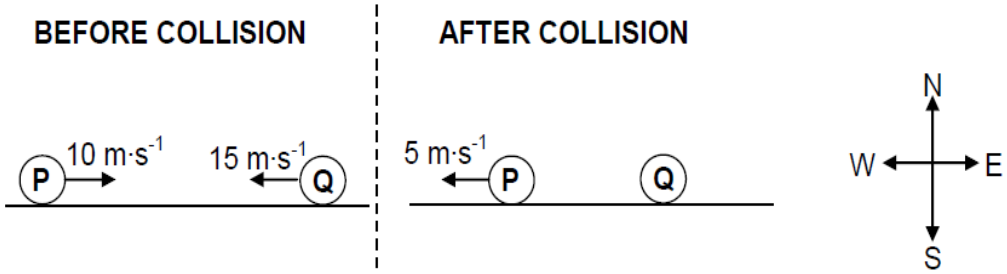
- The starting time for each ball;
- The initial position of each ball;
- The time when the balls strike the ground. (5)

[15]

TOPIC 3: MOMENTUM AND IMPULSE

QUESTION 1

Ball **P** of mass 0,16 kg, moving east at a speed of 10 $m \cdot s^{-1}$, collides head-on with another ball **Q** of mass 0,2 kg, moving west at a speed of 15 $m \cdot s^{-1}$. After the collision, ball **P** moves west at a speed of 5 $m \cdot s^{-1}$, as shown in the diagram below.
Ignore the effects of friction and the rotational effects of the balls.



1.1 Define the term momentum in words. (2)

1.2 Calculate the:

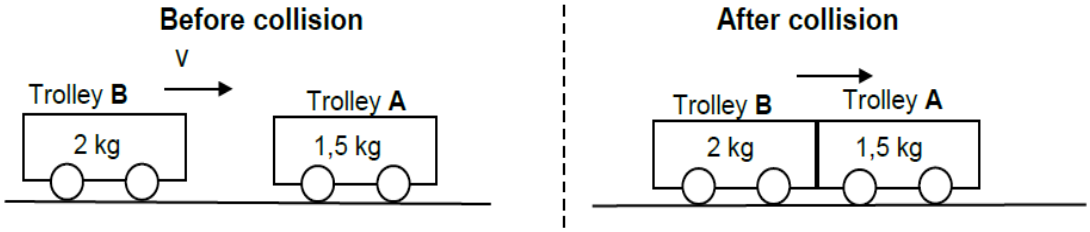
1.2.1 Velocity of ball **Q** after the collision. (5)

1.2.2 Magnitude of the impulse on ball **P** during the collision. (3)

[10]

QUESTION 2

Trolley **A** of mass 1,5 kg is at rest on a frictionless horizontal surface. A second trolley **B**, of mass 2 kg, travelling horizontally at a constant speed **v**, collides with trolley **A**. The trolleys stick together and move at a constant velocity to the right, covering a distance of 0,8 m in 2 s. See the diagram below.
Ignore ALL frictional and rotational effects.



2.1 State the principle of conservation of linear momentum in words. (2)

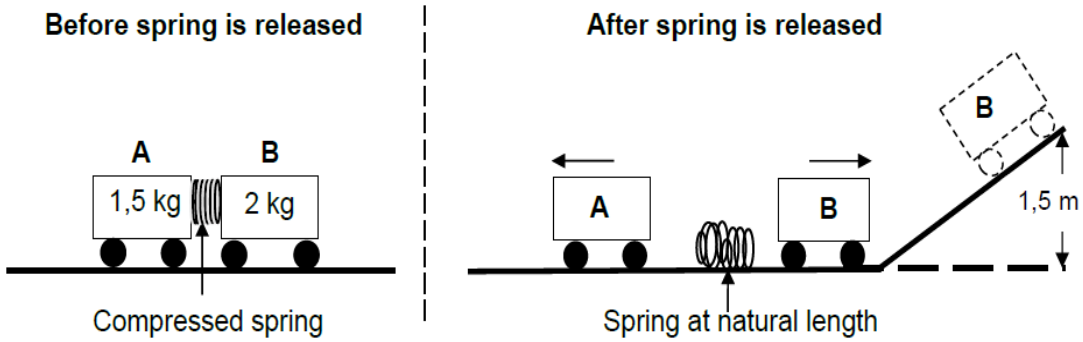
2.2 Calculate speed **v** with which trolley **B** moves before the collision. (5)

2.3 Is the collision ELASTIC or INELASTIC? (1)

2.4 During another collision, trolley **B** exerts a greater force on trolley **A** and the change in momentum of trolley **A** is the same as before. How is the time for the collision affected?
Choose from INCREASES, DECREASES or REMAINS THE SAME.
Write down a relevant equation that supports the answer. (2)
[10]

QUESTION 3

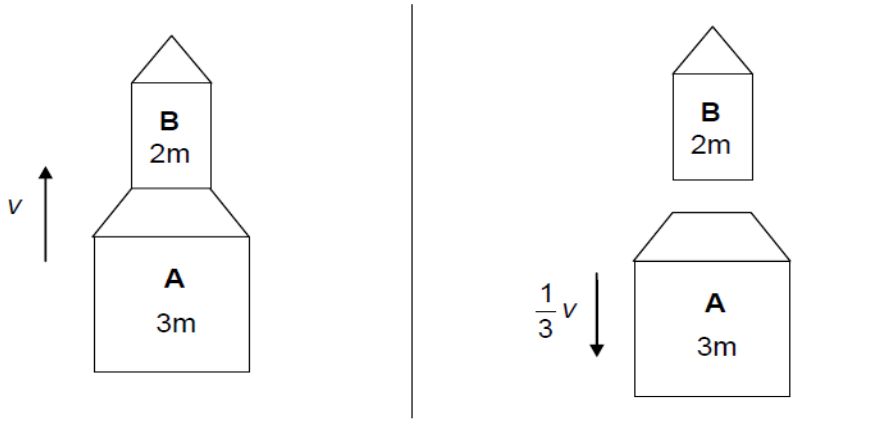
Two trolleys, **A** and **B**, of masses of 1,5 kg and 2 kg respectively, are held in a stationary position on a straight, horizontal, frictionless track, with a compressed spring between them. The trolleys are released and the spring takes t seconds to return to its natural length. The spring then falls to the ground.
Trolley **A** moves to the left, while trolley **B** moves to the right and then up a frictionless inclined plane, rising to a maximum vertical height of 1,5 m, as shown in the diagram below.



Ignore the rotational effects of the wheels.
3.1 Write down the principle of conservation of mechanical energy in words. (2)
3.2 Calculate the speed of trolley **B** at the bottom of the inclined plane. (4)
3.3 For the **t** seconds that the spring takes to return to its natural length:
3.3.1 Calculate the change in momentum of trolley **B**. (3)
3.3.2 Write down the change in momentum of trolley **A**. (1)
3.4 Calculate the speed of trolley **A** after **t** seconds. (2)
[12]

QUESTION 4

A simple rocket system consists of two parts, **A** of mass 3m, and **B** of mass 2m, as shown in the diagram below. **B** is stacked on top of **A**.



BEFORE EXPLOSION **AFTER EXPLOSION**

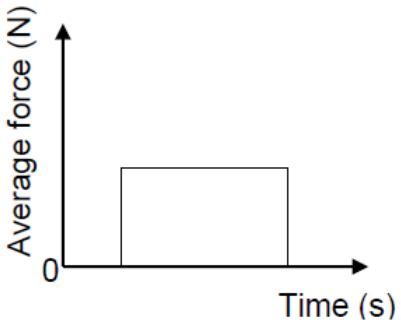
4.1 State the principle of conservation of momentum in words. (2)

The rocket is travelling vertically upwards at a constant speed **v** when an internal explosion causes **A** to move DOWNWARDS at a speed $\frac{1}{3}$ v.

Ignore ALL external forces on the rocket.

4.2 Calculate the velocity of **B** in terms of **v** immediately after the internal explosion. (5)

The graph below shows the average force exerted by **A** on **B** during the internal explosion as a function of time.



4.3 Name the physical quantity represented by the area under the graph. (1)

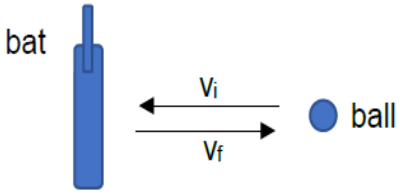
4.4 Redraw the graph in your ANSWER BOOK. On the same set of axes, sketch the graph of the average force that **B** exerts on **A** as a function of time. (2)

[10]

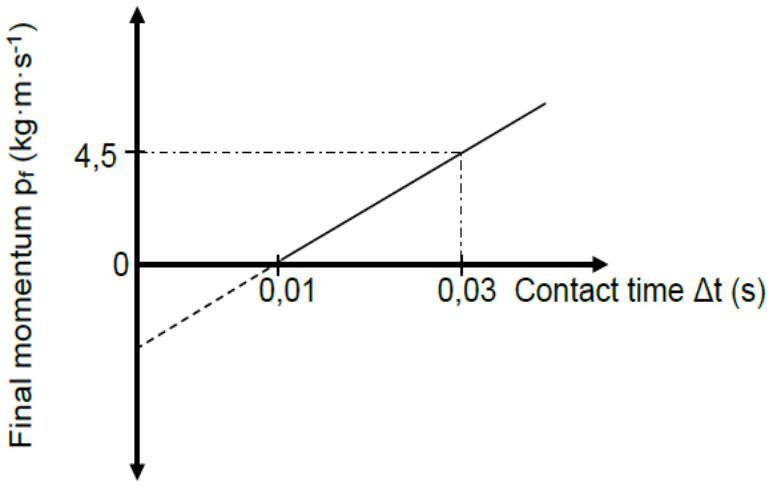
QUESTION 5

Cricketers at an academy conduct an experiment to determine the relationship between the contact time and the final momentum of a ball for a constant average net force.

A cricket ball of mass 150 g is thrown horizontally with a certain initial velocity and is struck by a bat so that the ball moves in the opposite direction, as shown in the diagram below. The average net force acting on the ball is horizontal.



The experiment is repeated using the same ball. The average net force and the initial velocity of the ball are kept constant. The contact time between the bat and the ball is changed EACH time. The results obtained are shown in the sketch graph below.



5.1 Define the term *impulse*. (2)

5.2 Calculate the:

5.2.1 Average net force acting on the ball. (3)

5.2.2 Magnitude of the initial velocity of the ball. (4)

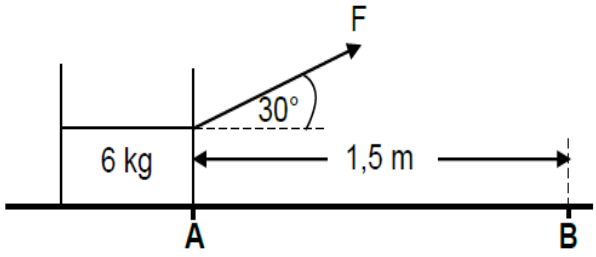
5.3 Redraw the graph in the ANSWER BOOK and label it as **A**.
On the same set of axes, draw the graph that will be obtained when a ball with a bigger mass is used, without changing the initial velocity and average net force. Label this as **B**. (2)

[11]

TOPIC 4: WORK, ENERGY AND POWER

QUESTION 1

A constant force **F** is applied at an angle of 30° to the horizontal on a crate of mass 6 kg that is initially at rest, as shown in the diagram below.
A constant frictional force of 10 N acts on the crate as it moves from rest at point **A** along a horizontal surface to point **B**. The distance between point **A** and point **B** is 1,5 m. The speed of the crate at point **B** is 2 m·s^{-1}.



1.1 Define the term work done by a force. (2)

1.2 Draw a labelled free-body diagram showing ALL the forces acting on the crate as it moves. (4)

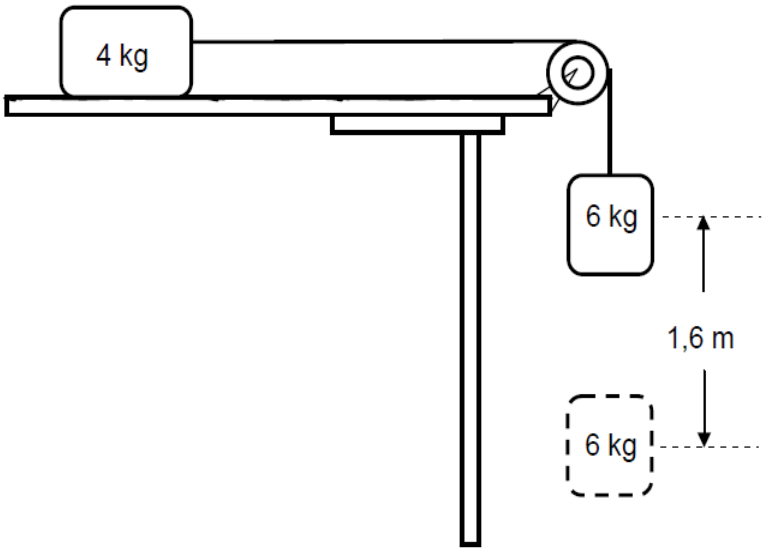
1.3 Using ENERGY PRINCIPLES ONLY, calculate the magnitude of force **F**. (4)

1.4 A 2 kg object is placed in the crate. What effect will this have on the work done by the same force **F** when the crate is again moved from point **A** to point **B**? Write only INCREASES, DECREASES or REMAINS THE SAME. (2)

[12]

QUESTION 2

In the diagram below, a 4 kg block lying on a rough horizontal surface is connected to a 6 kg block by a light inextensible string passing over a light frictionless pulley.
Initially the blocks are HELD AT REST.



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

When the blocks are released, the 6 kg block falls through a vertical distance of 1,6 m.

2.2 Draw a labelled free-body diagram for the 6 kg block. (2)

2.3 Calculate the work done by the gravitational force on the 6 kg block. (3)

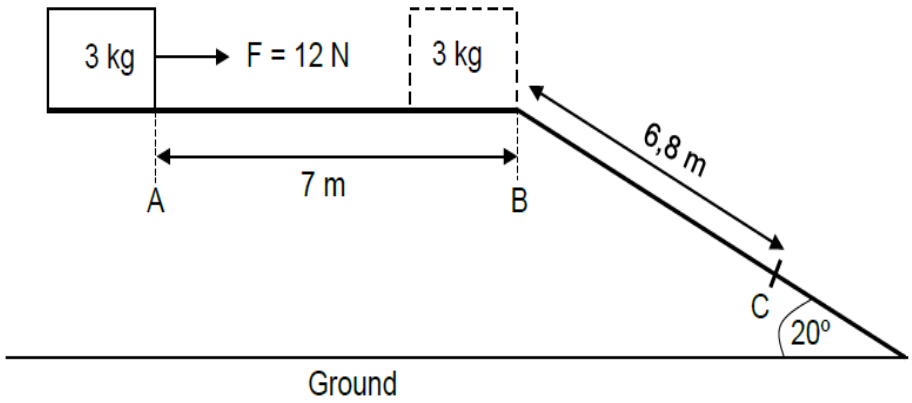
The coefficient of kinetic friction between the 4 kg block and the horizontal surface is 0,4. Ignore the effects of air resistance.

2.4 Use energy principles to calculate the speed of the 6 kg block when it falls through 1,6 m while still attached to the 4 kg block. (5)

[12]

QUESTION 3

A crate of mass 3 kg is at rest at point **A** on a frictionless horizontal surface. A constant horizontal force **F** of 12 N acts on the crate and moves it from point **A** to point **B**. The crate then moves down a rough plane, inclined at 20° to the horizontal. The distance from point **A** to point **B** is 7 m and from point **B** to point **C** is 6,8 m, as shown in the diagram below.



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

3.2 Using ENERGY PRINCIPLES ONLY, calculate the kinetic energy of the crate at point **B**. (3)

Force **F** is removed when the crate reaches point **B**. The crate then experiences a constant frictional force of 21 N as it moves down the incline.

3.3 Draw a free-body diagram showing ALL the forces acting on the crate as it moves down the incline. (3)

3.4 Using ENERGY PRINCIPLES ONLY, determine whether the crate will pass point **C**. (5)

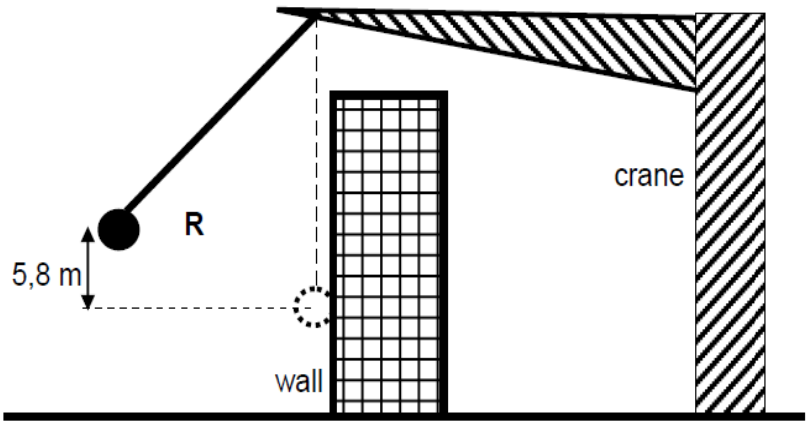
[13]

QUESTION 4

A demolition ball is used by a crane to break the wall of a building.

The demolition ball, of mass 1 250 kg, is lifted by the crane to a point **R** at a height of 5,8 m above its lowest position in 60 s.

Ignore air friction.



4.1 Define the term power in words. (2)

4.2 Calculate the average power dissipated by the crane in lifting the demolition ball to point **R**. (3)

The demolition ball is released from point **R** and strikes the wall at the lowest point of its swing. The ball then moves 0,25 m HORIZONTALLY into the wall before coming to rest.

4.3 Define the term conservative force. (2)

4.4 Is the force which the wall exerts on the ball a CONSERVATIVE or a NON-CONSERVATIVE force? (1)

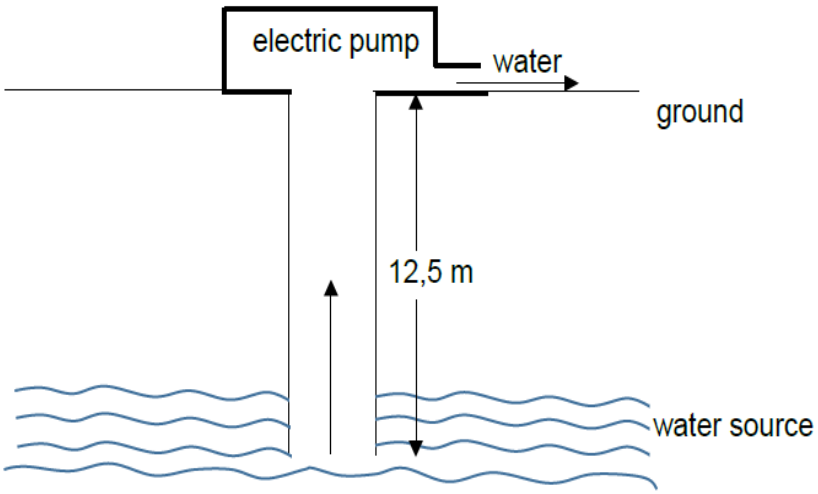
4.5 State the energy conversion that takes place during the downward swing of the demolition ball. (1)

4.6 Using energy principles, calculate the magnitude of the average force exerted on the ball while it moves into the wall. (5)

[14]

QUESTION 5

Water is drawn from a water source 12,5 m below the ground by an electric pump. The water is lifted vertically upwards at a constant speed, as shown in the simplified diagram below.



The pump lifts the water upwards at a rate of 2,5 kg·s^{-1}.
Ignore ALL frictional and capillarity effects.

5.1 Define the term non-conservative force. (2)

5.2 Draw a labelled free-body diagram showing ALL the forces acting on a fixed mass of water as it moves from the source to the ground. (2)

5.3 The pump lifts 200 kg of water from the source to the ground at a constant speed. Calculate the:

5.3.1 Work done by the pump. (3)

5.3.2 Constant speed at which the water is lifted. (3)

5.3.3 Average power dissipated by the pump.
Ignore energy losses in the form of heat and sound. (3)

[13]

TOPIC 5: DOPPLER EFFECT

QUESTION 1

1.1 An ambulance is moving away from a stationary listener with a constant velocity of 25 m·s^{-1}. The siren of the ambulance emits sound waves at a frequency of 550 Hz. The listener detects the frequency of these sound waves to be 512,64 Hz.
Ignore the effects of wind.

1.1.1 State the Doppler effect in words. (2)

1.1.2 Use the given information to calculate the speed of sound in air. (5)

1.1.3 If the ambulance moves away from the stationary listener with a constant velocity which is greater than 25 m·s^{-1}, how will EACH of the following change?
Choose from INCREASES, DECREASES or REMAINS THE SAME.

(a) The speed of sound in air. (1)

(b) The frequency of the sound waves emitted by the siren. (1)

(c) The frequency of the sound waves detected by the listener. (1)

1.2 The spectrum of a distant star when viewed from the Earth is red shifted.

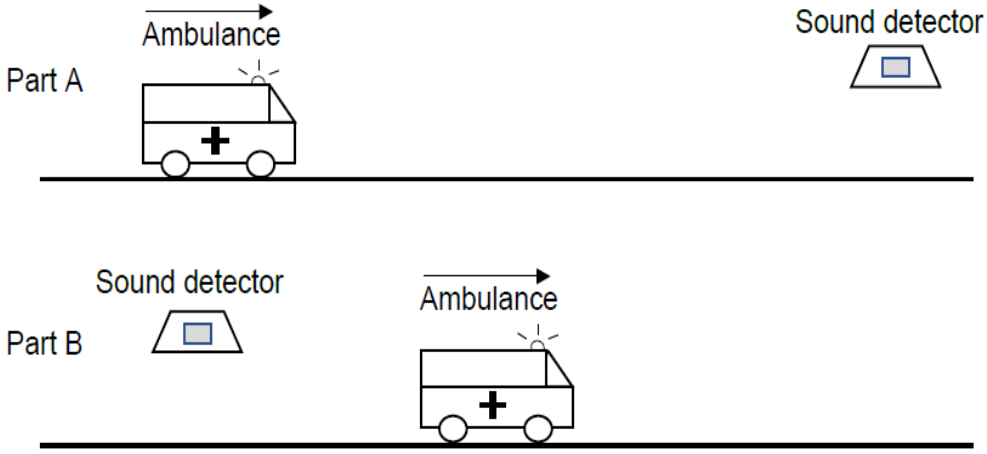
1.2.1 Is the star moving AWAY FROM or TOWARDS the Earth? (1)

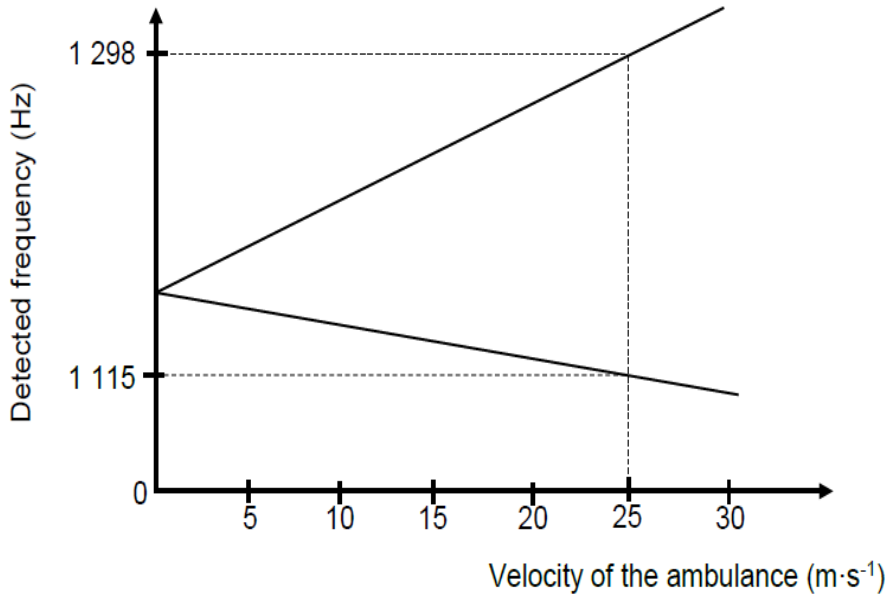
1.2.2 Use the Doppler effect to explain the answer to QUESTION 1.2.1. (2)

[13]

QUESTION 2

An investigation is performed to determine the relationship between the velocity of a moving sound source and the frequency of the sound detected. The siren of an ambulance produces sound with a constant frequency. The ambulance, with its siren on, moves towards a stationary sound detector (**Part A**) and away from the stationary sound detector (**Part B**) at constant velocities. The experiment is repeated for different velocities of the ambulance. The detected frequency is measured for EACH velocity. The results obtained are shown in the graph below.





2.1 STATE the Doppler effect. (2)

2.2 For this experiment, write down:

2.2.1 The independent variable. (1)

2.2.2 A controlled variable. (1)

2.3 What conclusion can be made for Part **B** of this experiment? (2)

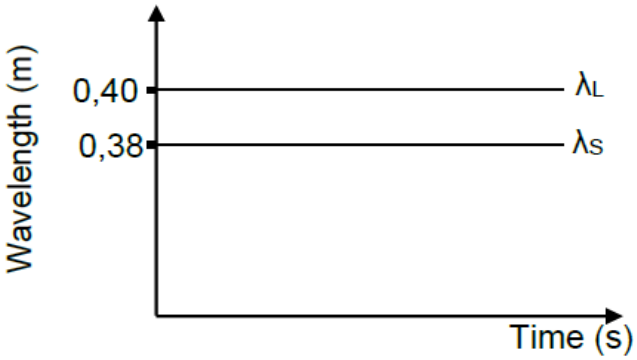
2.4 Calculate the speed of sound in air. (6)

[12]

QUESTION 3

A stationary listener, standing on the roadside, records the wavelength of the sound emitted by the siren of a police car travelling at a constant velocity. In the wavelength-time graph below, NOT drawn to scale, λ_L is the wavelength of the sound recorded by the listener and λ_S is the wavelength of the sound emitted by the siren.

Take the speed of sound in air to be 343 $m \cdot s^{-1}$.



3.1 Name the phenomenon that explains why the wavelengths shown in the graph differ. (1)

3.2 Is the car moving TOWARDS or AWAY FROM the listener? Give a reason for the answer. (2)

3.3 Calculate the:

3.3.1 Frequency of the sound emitted by the siren. (3)

3.3.2 Magnitude of the velocity of the car. (6)

[12]

QUESTION 4

A stationary listener records the frequency of the sound emitted by the siren of a police car. When the car which is travelling at a constant velocity of 26 $m \cdot s^{-1}$, approaches the listener, the recorded frequency is 615 Hz. The car passes the listener at time t1 and then moves away from the listener. The recorded frequency now is 526 Hz.

Ignore the effects of wind.

4.1 State the Doppler effect in words. (2)

4.2 Use the information given to calculate the speed of sound in air. (5)

4.3 Calculate the wavelength of the sound emitted by the police siren. (4)

4.4 Sketch the graph of recorded frequency versus time for the motion of the car as it moved towards the listener, passed the listener and then moved away from the listener.

Label time t_1 on the graph.

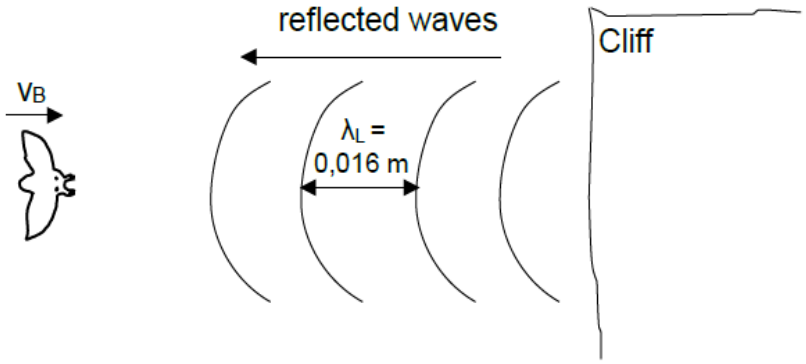
No values need to be indicated on the frequency axis. (3)

[14]

QUESTION 5

A bat emits sound waves with a frequency fs as it flies at a constant speed v_B towards a vertical cliff. The waves reflect off the cliff with the same frequency that they strike the cliff, and with a wavelength of λ_L = 0,016 m, as shown in the simplified diagram below.

Take the speed of sound in air to be 340 $m \cdot s^{-1}$.



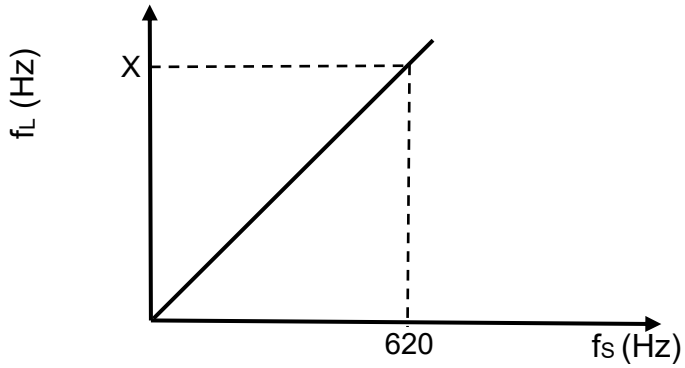
5.1 NAME and STATE the phenomenon that results in a change in frequency of the detected sound waves. (3)

5.2 Show that f_s, the frequency of the sound waves emitted by the bat, is $(21\ 250 - 62{,}5v_B)$. (4)

5.3 The frequency of the reflected sound waves detected by the bat is 850 Hz higher than the frequency of the sound waves emitted by the bat.
Calculate the speed of the bat, v_B. (5)
[12]

QUESTION 6

An ambulance with its siren on is travelling towards a stationary listener at a speed of 10 $m.s^{-1}$.
The graph below shows the relationship between the frequency of the sound emitted by the ambulance and the frequency of the sound recorded by the stationary listener.



The gradient of the graph was found to be 1.03.

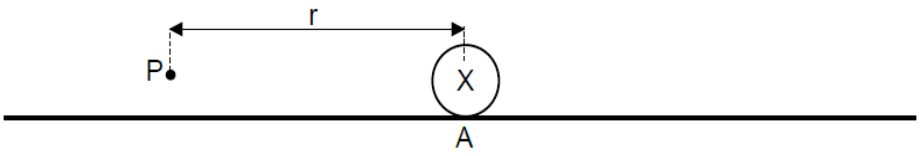
6.1 Calculate the speed of sound in air. (3)

6.2 Calculate the value of x on the graph. (3)
[6]

TOPIC 6: ELECTROSTATICS

QUESTION 1

A sphere **X** is placed at point **A** on a horizontal surface. **X** carries a charge of $+3 \times 10^{-7}$ C. Point **P** is **r** metres to the left of point **A**.



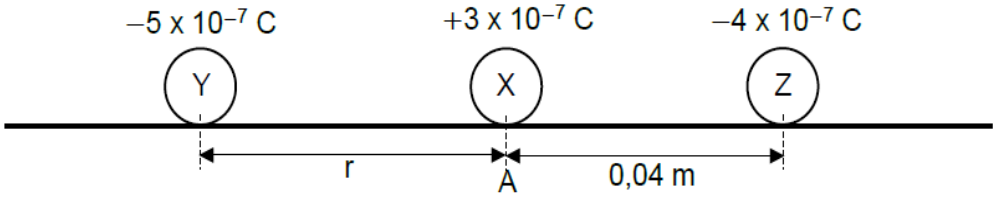
The magnitude of the electric field at point **P** is $1{,}08 \times 10^{6}$ N·C^{-1}.

1.1 Describe an *electric field*. (2)

1.2 Draw the electric field pattern due to the charge on sphere **X**. (2)

1.3 Show, by means of a calculation, that r = 0,05 m. (3)

Sphere **Y**, carrying a charge of -5×10^{-7} C, is now fixed at point **P** and sphere **Z**, carrying a charge of -4×10^{-7} C, is fixed 0,04 m to the right of sphere **X**.



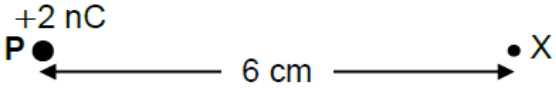
1.4 The NET FORCE acting on sphere **X** is 0,0427 N at point **A**.
Is the surface frictionless? Choose from YES or NO.
Explain the answer by means of a calculation. (6)

1.5 Sphere **Y** is brought into contact with sphere **X** and is placed back in its original position.
How will the magnitude of the force that sphere **X** now exerts on sphere **Y** be affected?
Choose from INCREASES, DECREASES or REMAINS THE SAME. (2)

[15]

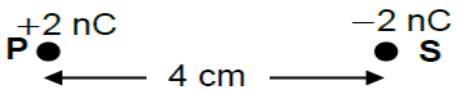
QUESTION 2

P is a +2 nC point charge. **X** is a point 6 cm away from charge **P**, as shown in the diagram below.



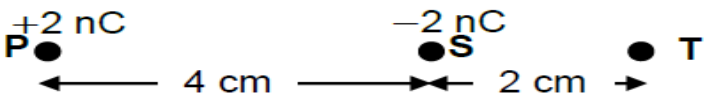
2.1 Calculate the magnitude of the electric field at **X**. (3)

Point charge **S**, with a charge of −2 nC, is placed 4 cm to the right of charge **P**, as shown in the diagram below.



2.2 Draw the resultant electric field pattern due to charges **P** and **S**. (3)

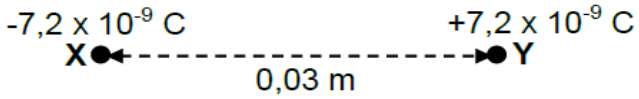
2.3 A third point charge **T** is placed 2 cm to the right of **S**, as shown in the diagram below. Point charge **T** experiences a net electrostatic force of $2{,}5 \times 10^{-4}$ N to the left.



2.3.1 State Coulomb's law in words. (2)
2.3.2 What is the polarity of charge **T**? Choose from POSITIVE or NEGATIVE. (1)
2.3.3 Calculate the magnitude of charge **T**. (5)
[14]

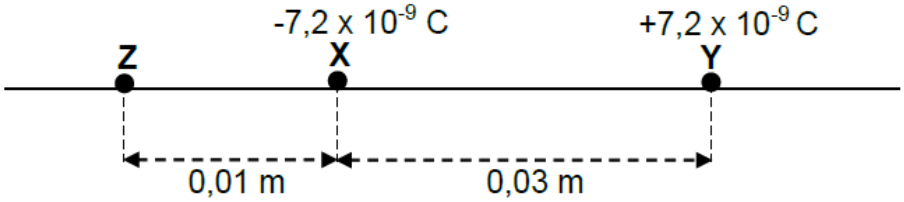
QUESTION 3

Two point charges, **X** and **Y**, are held 0,03 m apart, as shown in the diagram below. The charge of **X** is -7,2 x 10^{-9} C, while the charge of **Y** is +7,2 x 10^{-9} C.



3.1 State Coulomb's law in words. (2)
3.2 Draw the net electric field pattern due to the two point charges. (3)
3.3 Calculate the magnitude of the electrostatic force that **Y** exerts on **X**. (3)

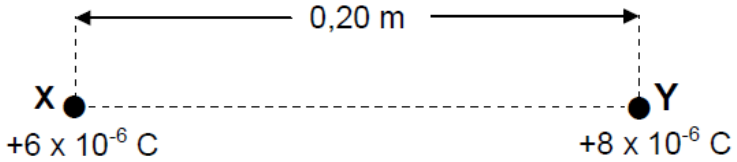
A third point charge, **Z**, of unknown positive charge, is positioned 0,01 m to the left of point charge **X** on the line joining point charges **X** and **Y**, as shown in the diagram below.



3.4 Draw a labelled vector diagram to show the directions of the electric fields at the point where **X** is positioned. (2)
3.5 The magnitude of the resultant electric field at the point where **X** is positioned is 4,91 x 105 N·C^{-1}.
Calculate the magnitude of charge **Z**. (5)
[15]

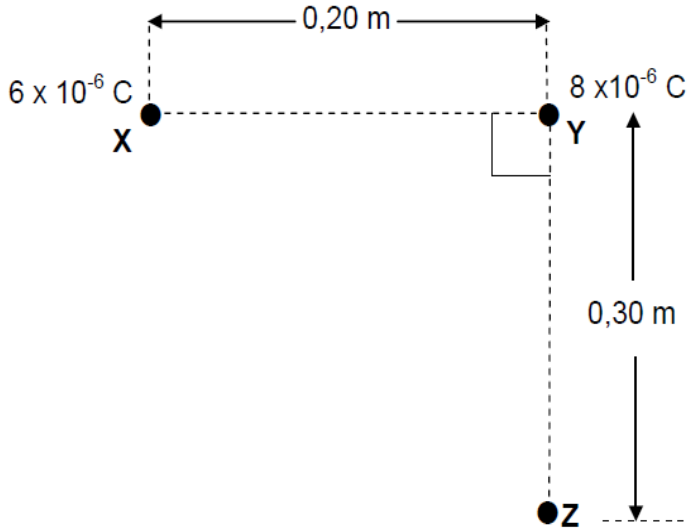
QUESTION 4

Two small spheres, **X** and **Y**, carrying charges of +6 x 10^{-6} C and +8 x 10^{-6} C respectively, are placed 0,20 m apart in air.



4.1 State Coulomb's law in words. (2)
4.2 Calculate the magnitude of the electrostatic force experienced by charged sphere **X**. (4)

A third sphere, **Z**, of unknown negative charge, is now placed at a distance of 0,30 m below sphere **Y**, in such a way that the line joining the charged spheres **X** and **Y** is perpendicular to the line joining the charged spheres **Y** and **Z**, as shown in the diagram below.



4.3 Draw a vector diagram showing the directions of the electrostatic forces and the net force experienced by charged sphere **Y** due to the presence of charged spheres **X** and **Z** respectively. (3)

4.4 The magnitude of the net electrostatic force experienced by charged sphere **Y** is 15,20 N. Calculate the charge on sphere **Z**. (4)

[13]

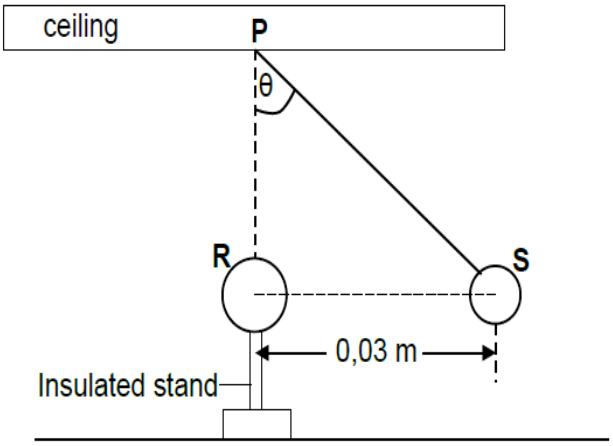
QUESTION 5

5.1 A small negative charge **q** placed at a fixed distance from charged sphere **Q**, experiences a force **F**, as shown in the diagram below.



The charge **q** is now removed.
Draw the electric field pattern for the charged sphere **Q**. (3)

5.2 Sphere **S** is attached to the ceiling at point **P** by a light inextensible string. When sphere **R**, on an insulated stand, is brought close to sphere **S** they repel and sphere **S** comes to rest with the horizontal distance between the centres of the spheres equal to 0,03 m.
Sphere **R** is directly below point **P**. The string makes an angle θ with the vertical, as shown in the diagram below.



5.2.1 State Coulomb's law in words. (2)

5.2.2 Draw a labelled free-body diagram showing ALL the forces acting on sphere **S** when it is at rest. (3)

Sphere **R** has a charge of +6 nC. Sphere **S** has a charge +3 nC and a mass of 0,15 g.

5.2.3 Calculate angle θ. (5)

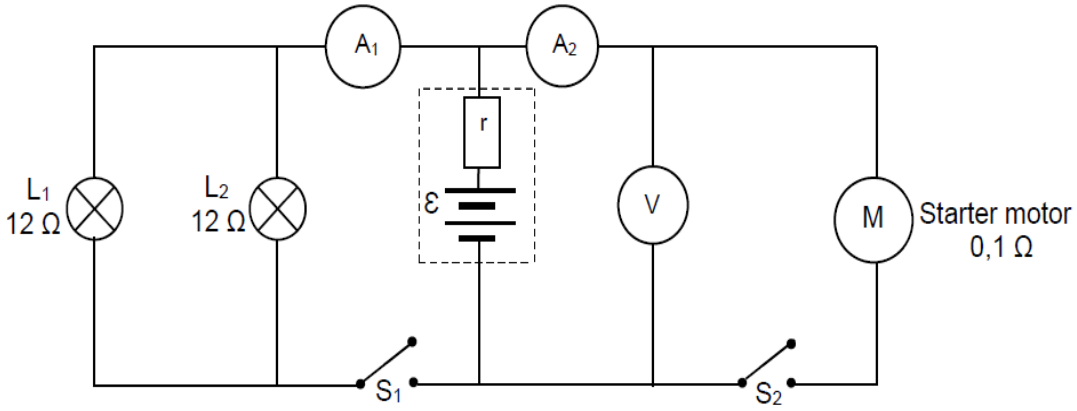
[13]

TOPIC 7: ELECTRIC CIRCUITS

QUESTION 1

Two identical headlights, **L_1** and **L_2**, and a starter motor, **M**, of a car are connected to a battery, as shown in the circuit diagram below. The resistance of each headlight is 12 Ω, while the resistance of the starter motor is 0,1 Ω. The emf (Ɛ) and internal resistance (r) of the battery are unknown.

The ammeters and the connecting wires have negligible resistance, while the voltmeter has a high resistance. Switches **S_1** and **S_2** are initially open.



1.1 Define the term *emf*. (2)

1.2 Switch S_1 remains open while switch S_2 is closed.
The reading on ammeter A_2 is 120 A.
Calculate the reading on the voltmeter. (3)

1.3 Switch **S_1** is now closed and switch **S_2** is opened. The power dissipated by each headlight is 15 W.

1.3.1 Calculate the current passing through **L_1**. (3)

1.3.2 Write down the reading on ammeter **A_1**. (1)

1.4 Calculate the emf of the battery. (6)

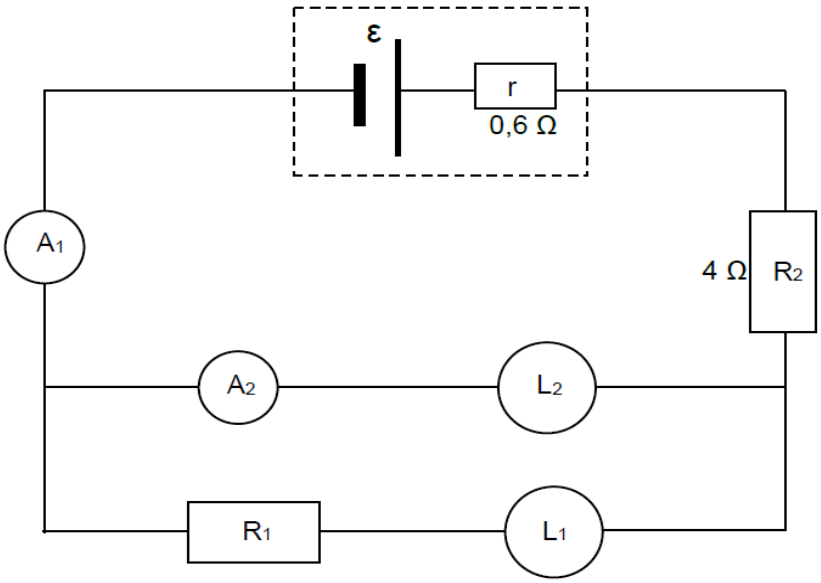
1.5 Both switches are now closed.
How will the reading on ammeter A_1 be affected?
Choose from INCREASES, DECREASES or REMAINS THE SAME.
Explain the answer WITHOUT the use of a calculation. (5)
[20]

QUESTION 2

L_1 and **L_2** are two light bulbs that have the following ratings:

L_1: 36 W ; 20 V and L_2: 48 W ; 32 V

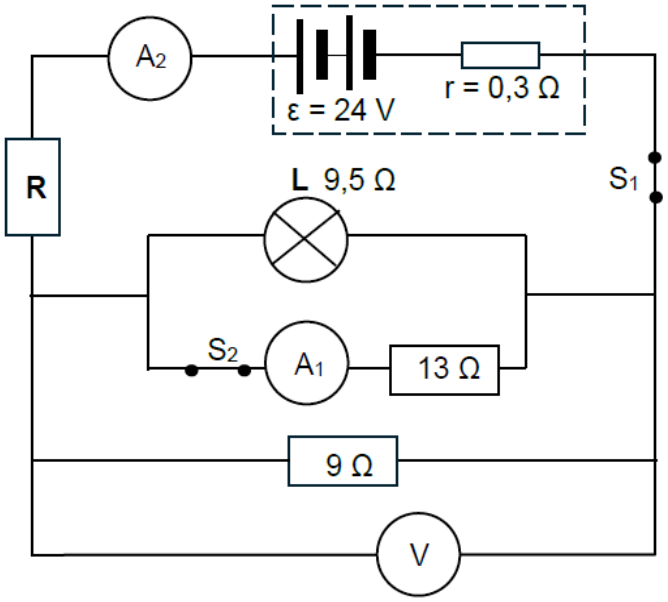
The two bulbs are connected as shown in the circuit diagram below. The battery has an internal resistance of 0,6 Ω while the conducting wires and the ammeters have negligible resistance. R_1 and R_2 are resistors.



2.1 Define the term power. (2)
2.2 If both light bulbs operate as RATED, calculate the:
2.2.1 Reading on ammeter A_2. (3)
2.2.2 Reading on ammeter A_1. (3)
2.2.3 Resistance of resistor R_1. (4)
2.2.4 Emf of the battery. (4)
2.3 Bulb L_1 burns out after a while. Assume that the resistance of bulb L_2 remains constant.
Will bulb L_2 continue to glow after bulb L_1 burns out? Choose from YES or NO. Support your answer with a suitable calculation. (5)
[21]

QUESTION 3

In the circuit diagram below, the battery has an emf of 24 V and an internal resistance of 0,3 Ω. Light bulb L has a resistance of 9,5 Ω and R is a resistor of unknown resistance. Ignore the resistance of the ammeters and the connecting wires.



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

When both switches S_1 and S_2 are CLOSED, the reading on ammeter A_1 is 0,8 A.

3.2 Calculate the:

3.2.1 Current through light bulb L. (3)

3.2.2 Reading on ammeter A_2. (4)

3.2.3 Resistance of resistor R. (5)

Switch S_2 is now OPENED, while switch S_1 remains CLOSED.

3.3 How will this affect the reading on ammeter A_2?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer. (2)

3.4 How will the brightness of bulb L be affected?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Explain the answer. (4)

The letters **A** to **F** represent different quantities in the circuit, as shown in the table below.

A	Voltage across the battery	D	Current through ammeter A_2
B	Internal resistance of the battery	E	Resistance of resistor R
C	Current through ammeter A_1	F	Potential difference across the 9 Ω resistor

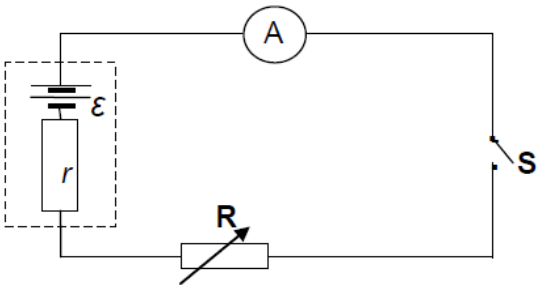
Switch S_1 is now OPENED, while switch S_2 is CLOSED.

3.5 Write down the LETTERS of the quantities that will now be equal to zero. (3)

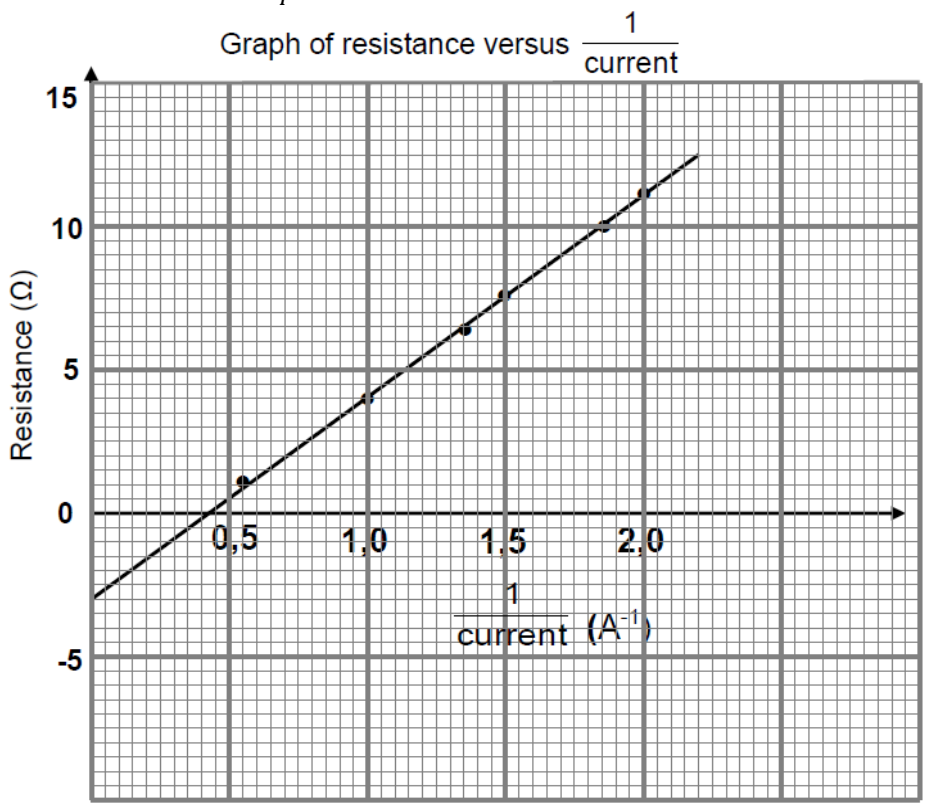
[23]

QUESTION 4

Learners perform an experiment to determine the emf (ε) and the internal resistance (r) of a battery using the circuit below.



The learners use their recorded readings of current and resistance, together with the equation $R = \frac{\varepsilon}{I} - r$, to obtain the graph below.



4.1 Which variable has to be kept constant in the experiment? (1)

4.2 Refer to the **graph**.

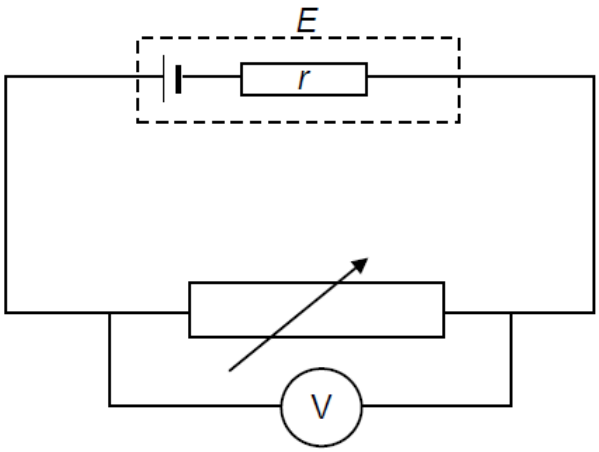
4.2.1 Write down the value of the internal resistance of the cell. (2)

4.2.2 Calculate the emf of the battery. (3)

[6]

QUESTION 5

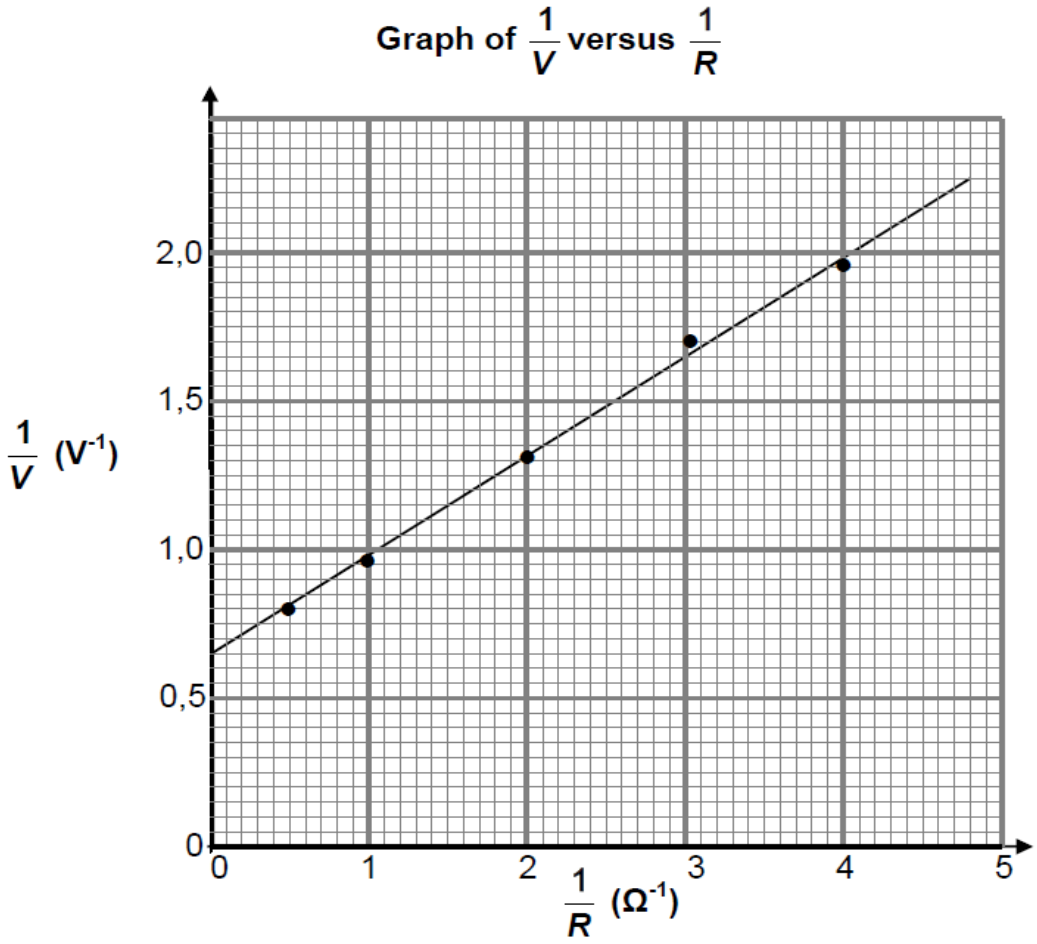
5.1 In an experiment, learners use the circuit below to determine the internal resistance of a cell.



The circuit consists of a cell of emf **E** and internal resistance r.
A voltmeter is placed across a variable resistor which can be set to known values **R**.
The equation used by the learners is:

$$\frac{1}{V} = \frac{r}{\varepsilon R} + \frac{1}{\varepsilon}$$

They obtain the graph below.



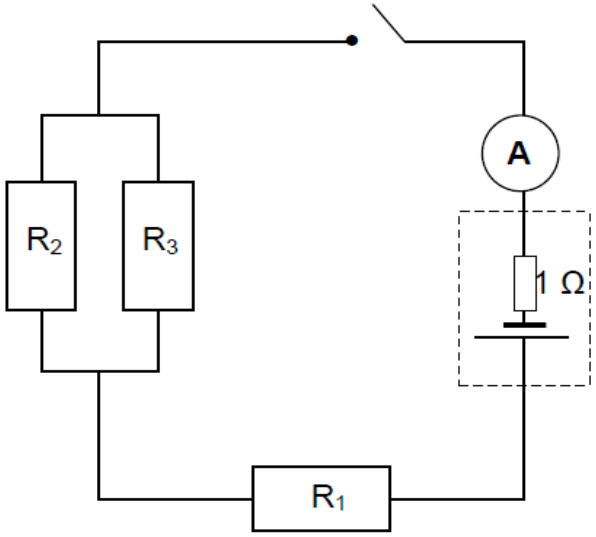
5.1.1 Write down a mathematical relationship for the slope of the graph. (1)

Use the information in the graph and calculate the:

5.1.2 Emf of the cell. (2)

5.1.3 Internal resistance of the cell. (3)

5.2 In the electrical circuit shown below, the battery has an emf of 6 V and an internal resistance of 1 Ω. The total external resistance of the circuit is 9 Ω.



5.2.1 Calculate the current in R_1 when the switch is closed. (3)

The power dissipated in resistor R1 is 1,8 W. The resistance of resistor R_3 is 4 times that of resistor R_2. ($R_3 = 4R_2$)

5.2.2 Calculate the resistance of resistor R_2. (5)

5.3 A hair dryer operates at a potential difference of 240 V and a current of 9,5 A.

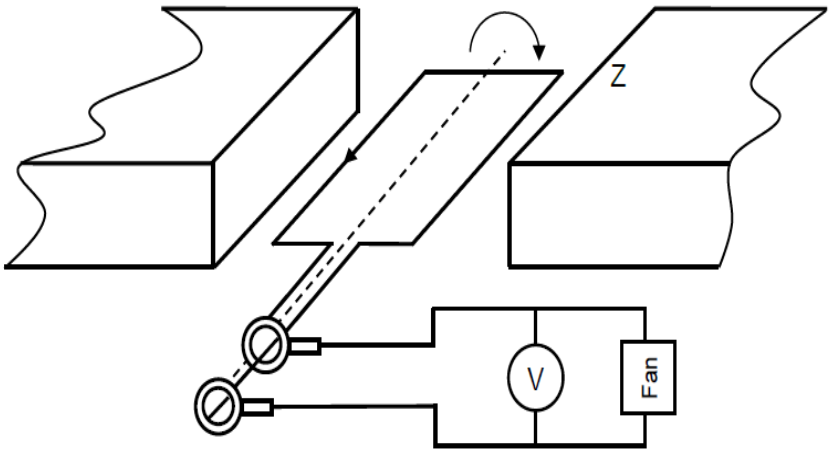
It takes a learner 12 minutes to completely dry her hair. Eskom charges energy usage at R1,47 per unit. Calculate the cost of operating the hairdryer for the 12 minutes. (1 unit = 1 kW·h). (4)

[18]

TOPIC 8: ELECTRODYNAMICS

QUESTION 1

An AC generator operates a fan. The directions of the rotation of the coil and the induced current are shown in the simplified diagram below.

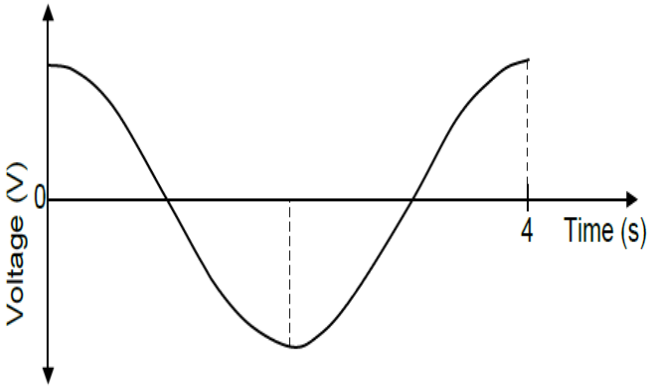


1.1 Define the term *rms potential difference*. (2)

1.2 What is the polarity of the magnet at **Z**? (2)

1.3 The resistance of the fan is 60 Ω and the maximum potential difference produced by the generator is 311,11 V. Calculate the cost of operating the fan for 1,5 hours if the cost of electricity is R3,33 per kWh. (5)

The voltage versus time graph for this generator is given below.



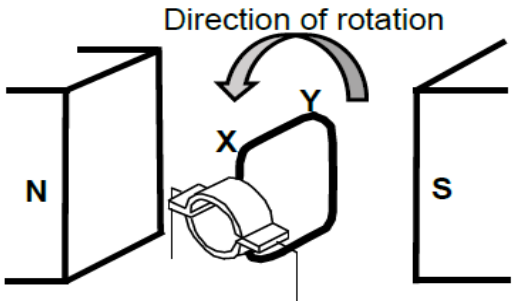
1.4 Redraw this graph in the ANSWER BOOK and label it as **A**. On the same set of axes, draw the graph for ONE rotation of the coil when the speed of rotation is doubled. Label this as graph **B**. (3)

1.5 State ONE way in which this generator can be changed to a DC generator. (1)

[13]

QUESTION 2

2.1 The diagram below shows the initial position of the coil in a simple DC generator. The coil is rotated in an anticlockwise direction, as shown.



2.1.1 Name the component in this generator that ensures that the induced current in the external circuit is in one direction only. (1)

2.1.2 Is the direction of the induced current from **X** to **Y** or from **Y** to **X**? (1)

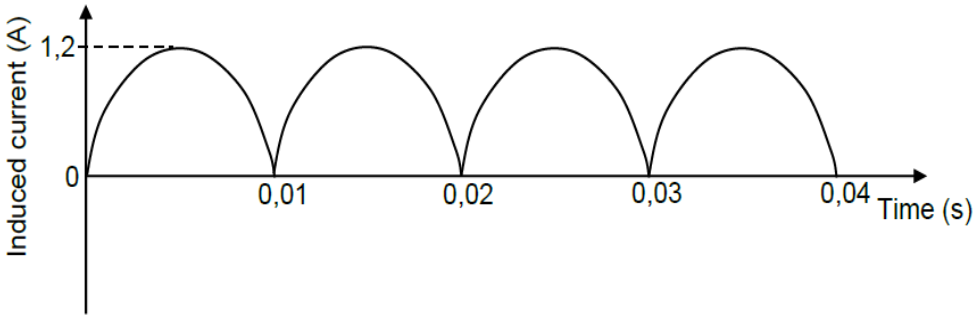
A maximum voltage of 90 V is generated when the coil is rotating at a frequency of 20 Hz.

2.1.3 Write down the time taken for the coil to complete ONE rotation. (1)

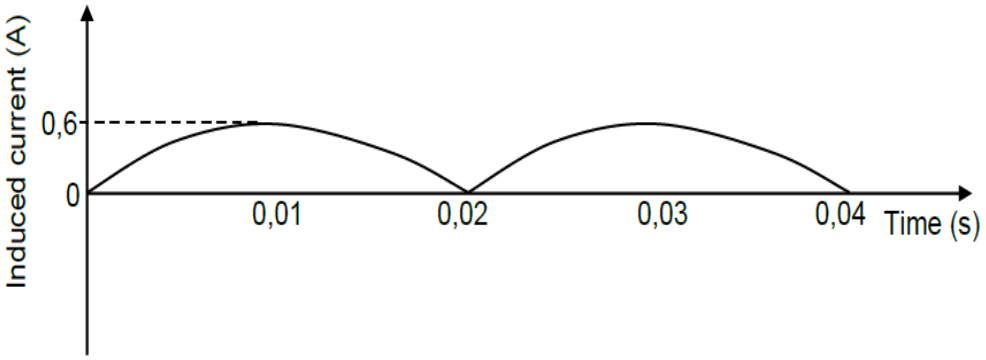
2.1.4 The coil starts rotating from the initial position, as shown in the diagram above.
Sketch a graph of output voltage versus time for one complete rotation of the coil. Indicate the maximum voltage and the relevant time values on the graph. (4)

2.2 Wall sockets supply rms voltage and current.
A 220 V AC voltage is supplied from a wall socket to an electric kettle having a resistance of 32 Ω.
Calculate the average energy dissipated by the kettle in TWO minutes. (4)
[11]

QUESTION 3
The graph below shows how the induced current in a generator varies with time.



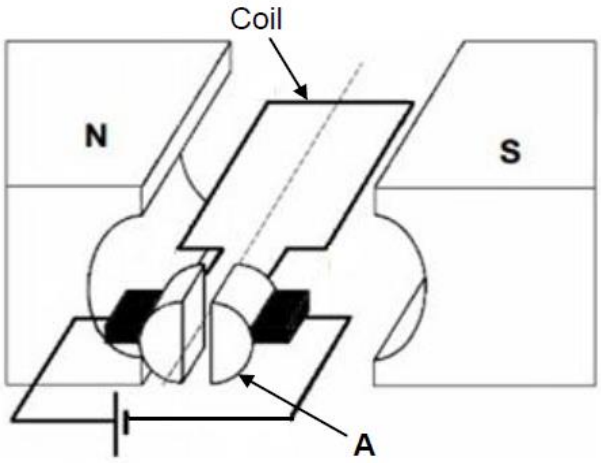
3.1 Name the type of generator. Choose from AC or DC. (1)
3.2 State the energy conversion that takes place in this generator while it is in operation. (2)
3.3 Give a reason why this generator is NOT suitable for the transmission of electricity over long distances. (1)
3.4 Calculate the frequency at which the coil rotates in the generator. (2)
3.5 Define the term root mean square (rms) current. (2)
3.6 Calculate the root-mean-square current delivered by the generator. (3)
3.7 The graph below shows how the induced current varies with time after a change was made to the operation of the generator.



Fully describe the change that was made. (2)
[13]

QUESTION 4

4.1 A simplified diagram of an electrical machine is shown below.



4.1.1 Is this machine a DC motor or a DC generator? (1)

4.1.2 Write down the energy conversion that takes place while this machine is in operation. (2)

4.1.3 Write down the name of component **A** in the diagram. (1)

4.1.4 In which direction will the coil, shown in the diagram above, rotate? Choose from CLOCKWISE or ANTICLOCKWISE. (2)

4.2 An electrical device is marked 200 W ; 220 V.

4.2.1 Define the term rms voltage. (2)

4.2.2 Calculate the resistance of the device. (3)

This device is now connected to a 150 V AC source.

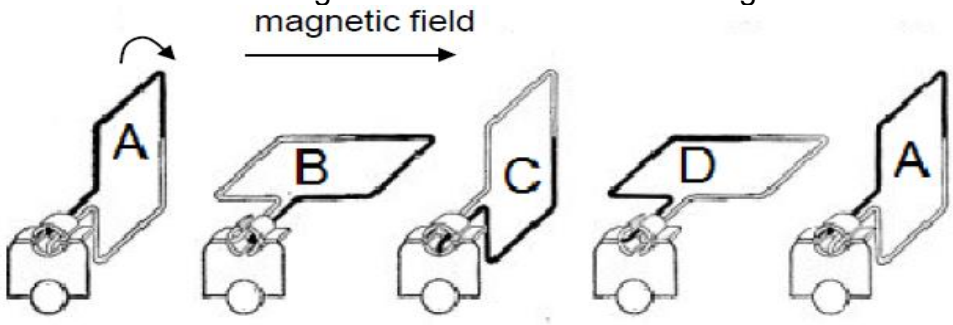
4.2.3 Calculate the energy dissipated by the device in 10 minutes. (5)

[16]

QUESTION 5

5.1 The diagram below shows different positions (ABCDA) of the coil in a DC generator for a complete revolution. The coil is rotated clockwise at a constant speed in a uniform magnetic field.

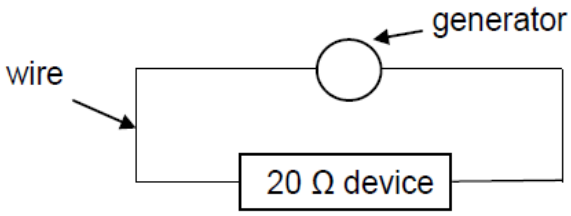
The direction of the magnetic field is shown in the diagram below.



5.1.1 Write down the energy conversion that takes place during the operation of the DC generator. (1)

5.1.2 Sketch a graph to show how the induced emf of the generator varies with time. Clearly indicate positions **A**, **B**, **C**, **D** and **A** on the graph. (2)

5.2 A small AC generator, providing an rms voltage of 25 V, is connected across a device with a resistance of 20 Ω. The wires connecting the generator to the device have a total resistance of 0,5 Ω. Refer to the diagram below.



5.2.1 Write down the total resistance of the circuit. (1)
5.2.2 Calculate the average power delivered to the device. (5)
[9]

TOPIC 9: PHOTOELECTRIC EFFECT

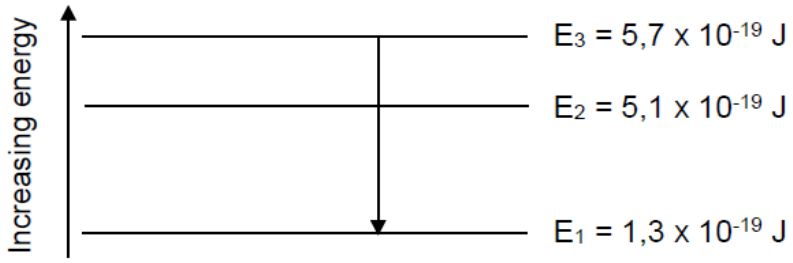
QUESTION 1

1.1 Learners conduct an experiment to determine whether electrons will be emitted from the surface of different metals when light with a single frequency is incident on the metal. The maximum kinetic energy of emitted electrons are measured when light of frequency $1,045 \times 10^{15}$ Hz is used.
The results obtained are shown in the table below.

METALS	ELECTRONS EMITTED	MAXIMUM KINETIC ENERGY (J)
Zinc	Yes	0
Sodium	Yes	$2,53 \times 10^{-19}$
Caesium	Yes	$3,50 \times 10^{-19}$
Metal M	No	–

1.1.1 Define the term work function. (2)
1.1.2 Write down the threshold frequency of zinc. (1)
1.1.3 How does the work function of sodium compare to that of caesium? Choose from SMALLER THAN, GREATER THAN or EQUAL TO. Explain the answer. (3)
1.1.4 Light of the same frequency, but with a higher intensity, is now incident on metal **M**. Will electrons now be ejected? Choose from YES or NO. Give a reason for the answer. (2)

1.2 The energy diagram below (NOT drawn to scale) shows the electron energies in different energy levels, E_1, E_2 and E_3, of a certain atom.



1.2.1 An electron of this atom moves from E_3 to E_1. Photon **X** is emitted. Calculate the frequency of photon **X**. (4)

1.2.2 Is it possible for a photon with an energy of 2,5 x 10^{-19} J to be emitted from this atom? Choose from YES or NO. Give a reason for the answer. (2)

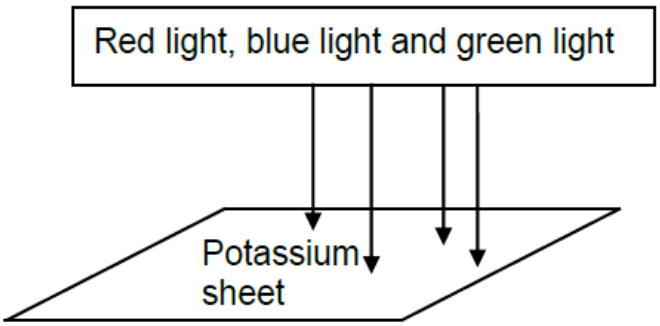
[14]

QUESTION 2

2.1 Define the term photoelectric effect. (2)

2.2 Red light, blue light and green light are shone simultaneously on a sheet of potassium, as shown in the diagram below. Each colour of light consists of a single frequency.

Two maximum kinetic energies of the ejected electrons are possible, namely 6,96 x 10^{-20} J and 2,65 x 10^{-20} J. Each ejected electron has only one of these maximum kinetic energies.



2.2.1 Which colour of light is responsible for ejecting electrons that have a maximum kinetic energy equal to 2,65 x 10^{-20} J? (1)

2.2.2 Explain the answer to QUESTION 2.2.1. (2)

2.2.3 The electrons with a maximum kinetic energy of 2,65 x 10^{-20} J are ejected by light that has a frequency of 5,85 x 10^{14} Hz. Calculate the frequency of the light that ejected electrons with a maximum kinetic energy of 6,96 x 10^{-20} J. (5)

2.2.4 The intensity of the red light is increased, while the intensities of the blue light and green light remain the same.
What effect will this change have on the rate at which electrons are ejected?
Choose from INCREASES, DECREASES or REMAINS THE SAME. (2)

2.3 Some of the atoms of a hot gas, made up of a single element, are in an excited state. The spectrum formed by the hot gas is observed on a screen in a darkened room. The spectrum consists of specific coloured lines on a black background.

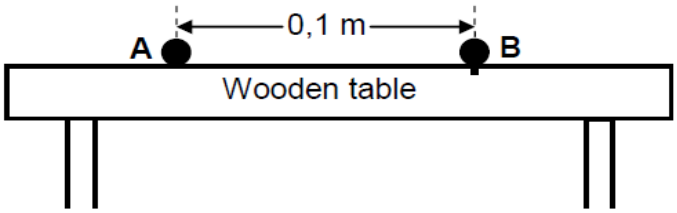
2.3.1 Name the type of spectrum formed. (1)

2.3.2 Explain the presence of the coloured lines in the spectrum. (2)

[15]

QUESTION 3

3.1 Two small spheres, **A** and **B**, made of pure zinc are at rest 0,1 m apart on a wooden table. Sphere **A** is negatively charged and is free to move on the table, while sphere **B** is uncharged and fixed to the table, as shown in the diagram below.



High-intensity ultraviolet light of frequency 2,8 x 10^{16} Hz is now shone continuously onto sphere **B**.
The work function of zinc is 6,63 x 10^{-19} J.

3.1.1 Define the term work function of a metal. (2)

3.1.2 Explain, using a suitable calculation, why the ultraviolet light shone on sphere **B** will eject electrons from its surface. (4)

3.1.3 Sphere **A** carries a charge of -5,4 x 10^{-6} C and requires a minimum force of 0,027 N to move from rest.
Calculate the minimum number of photons of ultraviolet light that must strike sphere **B** which will cause sphere **A** to move from its rest position. (6)

3.2 A beam of white light is shone through a cold gas. The emerging light is dispersed and a line spectrum is observed on a screen.

3.2.1 Name the type of line spectrum observed. (1)

3.2.2 Describe the spectrum referred to in QUESTION 3.2.1. (2)

3.2.3 The diagrams below indicate some possible energy transitions made by atoms.
Which ONE of the diagrams could result in the type of spectrum observed in QUESTION 3.2.1?
Choose from DIAGRAM **A** or DIAGRAM **B**.

DIAGRAM A

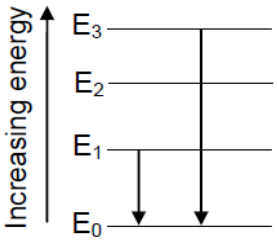
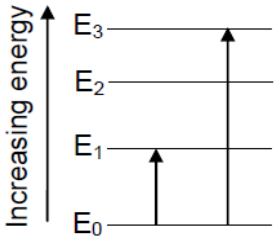


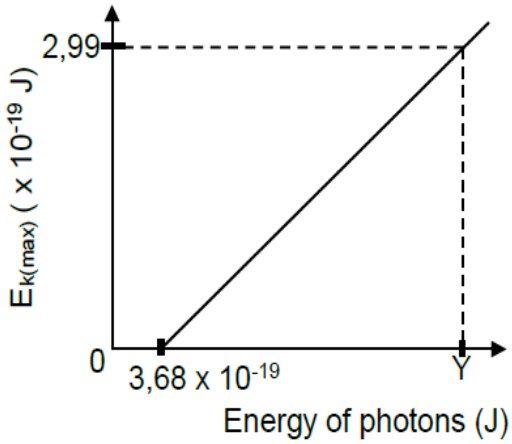
DIAGRAM B



(2)
[17]

QUESTION 4

Light of different frequencies is incident on a metal plate. The sketch graph below shows the relationship between the maximum kinetic energy, $E_{k(max)}$, of the photoelectrons and the energy of the incident photons.



4.1 Define the term work function of a metal. (2)

4.2 Write down the numerical value of the gradient of the above graph. (2)

4.3 Calculate the:

4.3.1 Maximum speed of the photoelectrons when photons with energy **Y**, as shown on the graph, strike the metal plate. (3)

4.3.2 Value of **Y**. (4)

4.4 Photons with energy 4,02 x 10^{-19} J strike the metal plate and photoelectrons are emitted.

The number of photons with energy 4,02 x 10^{-19} J striking the metal plate per second is now increased.

How will the maximum kinetic energy of the photoelectrons be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME.

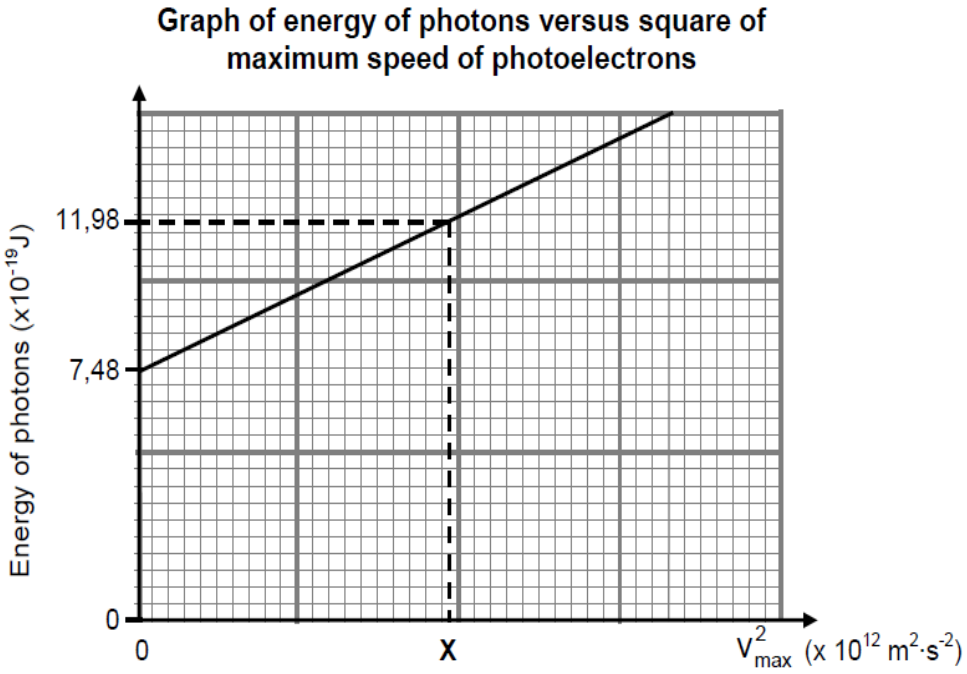
Give a reason for the answer. (2)

[13]

QUESTION 5

During an experiment, light of different frequencies is radiated onto a silver cathode of a photocell and the corresponding maximum speed of the ejected photoelectrons are measured.

A graph of the energy of the incident photons versus the square of the maximum speed of the ejected photoelectrons is shown below.



5.1 Define the term photoelectric effect. (2)

Use the graph to answer the following questions.

5.2 Write down the value of the work function of silver.
Use a relevant equation to justify the answer. (3)

5.3 Which physical quantity can be determined from the gradient of the graph? (1)

5.4 Calculate the value of **X** as shown on the graph. (5)

The experiment above is now repeated using light of higher intensity.

5.5 How will EACH of the following be affected?
Choose from INCREASES, DECREASES or REMAINS THE SAME.

5.5.1 The gradient of the graph. (1)

5.5.2 The number of photoelectrons emitted per unit time. (1)

[13]

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	$9{,}8\ m{\cdot}s^{-2}$
Universal gravitational constant *Universele gravitasiekonstante*	G	$6{,}67 \times 10^{-11}\ N{\cdot}m^2{\cdot}kg^{-2}$
Radius of the Earth *Radius van die Aarde*	R_E	$6{,}38 \times 10^6\ m$
Mass of the Earth *Massa van die Aarde*	M_E	$5{,}98 \times 10^{24}\ kg$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3 \times 10^8\ m{\cdot}s^{-1}$
Planck's constant *Planck se konstante*	h	$6{,}63 \times 10^{-34}\ J{\cdot}s$
Coulomb's constant *Coulomb se konstante*	k	$9 \times 10^9\ N{\cdot}m^2{\cdot}C^{-2}$
Charge on electron *Lading op elektron*	e	$1{,}6 \times 10^{-19}\ C$
Electron mass *Elektronmassa*	m_e	$9{,}11 \times 10^{-31}\ kg$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/*of* $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/*of* $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or/*of* $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

FORCE/*KRAG*

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

WORK, ENERGY AND POWER/*ARBEID, ENERGIE EN DRYWING*

$W = F\Delta x\cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \frac{1}{2}mv^2$ or/*of* $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ 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* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$ / $P_{gemid} = Fv_{gemid}$	

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ / $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or/*of* $E = \frac{hc}{\lambda}$
$E = W_o + E_{k(max)}$ or/*of* $E = W_o + K_{max}$ where/*waar* $E = hf$ and/*en* $W_o = hf_o$ and/*en* $E_{k(max)} = \frac{1}{2}mv^2_{max}$ or/*of* $K_{max} = \frac{1}{2}mv^2_{max}$	

ELECTROSTATICS/*ELEKTROSTATIKA*

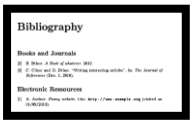
$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{e}$ or/*of* $n = \frac{Q}{q_e}$	

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

$R = \frac{V}{I}$	emf (ε) = I(R + r) emf (ε) = I(R + r)
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	q = IΔt
W = Vq W = VIΔt W = $I^2R\Delta t$ W = $\frac{V^2\Delta t}{R}$	P = $\frac{W}{\Delta t}$ P = VI P = I^2R P = $\frac{V^2}{R}$

ALTERNATING CURRENT/*WISSELSTROOM*

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \frac{I_{maks}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ / $P_{gemid} = V_{wgk}I_{wgk}$
$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \frac{V_{maks}}{\sqrt{2}}$	$P_{ave} = I_{rms}^2R$ / $P_{gemid} = I_{wgk}^2R$
	$P_{ave} = \frac{V_{rms}^2}{R}$ / $P_{gemid} = \frac{V_{wgk}^2}{R}$



BIBLIOGRAPHY

1	DBE PAST QUESTION PAPERS
2	November 2025
3	November 2024
4	November 2023
5	November 2022
6	November 2021
7	November 2019
8	November 2018
9	November 2017
10	Exemplar 2014
11	June 2025
12	June 2024
13	June 2023
14	June 2021
15	FS. September 2023