education

Department of Education
FREE STATE PROVINCE

PHYSICAL SCIENCES PAPER 1 (PHYSICS)

GRADE 12

TERMS & DEFINITIONS, QUESTIONS & ANSWERS PER TOPIC

2021

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HOW TO USE THIS DOCUMENT

Dear Grade 12 Learner

1. This document was compiled as an extra resource to help you to perform well in Physical Sciences.

2. Firstly, you must make sure that you study the terms and definitions provided for each topic. Theory always forms part of any test or examination, and you should ensure that you obtain full marks for ALL theory questions. Always be prepared to write a test on terms and definitions as soon as a topic is completed in class. Revise terms and definitions of topics already completed frequently so that you know them by the time you are sitting for a test or an examination.

3. Answer all the questions on a certain topic in your homework book as soon as the topic is completed. DO NOT look at the answers before attempting the questions. First try it yourself. Compare your answers with the answers at the back of the document. Mark your work with a pencil and do corrections for your incorrect answers. If you do not know how to answer a question, the answers are there to guide you. Acquaint yourself with the way in which a particular type of question should be answered. Answers supplied are from memoranda used to mark the questions in previous years.

4. Your teacher can, for example, give you two of the questions in this document as homework. The following day he/she will just check whether you answered them and whether you marked your answers. The teacher will only discuss those questions in which you do not understand the answers supplied in the document. Therefore, a lot of time will be saved.

5. The answers at the back of the document are included to help you to prepare for your tests and examinations. If you choose to copy answers into your homework book without trying them out yourself, you will be the losing party in the end!

6. Work through all the questions and answers of a particular topic before you sit for an examination, even if you answered the questions before.

7. Any additional resource is only of help when used correctly. Ensure that you make use of all help provided in the correct way to enable you to be successful. All the best and may you perform very well in Physical Sciences.

Credits
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TERMS AND DEFINITIONS

MECHANICS: NEWTON'S LAWS	
Acceleration	The rate of change of velocity.
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.
Kinetic frictional force (f_k)	The force acting parallel to a surface and opposes the motion of a MOVING object relative to the surface.
Mass	The amount of matter in a body measured in kilogram (kg).
Maximum static frictional force (f_s^{max})	The static frictional force is a maximum (f_s^{max}) just before the object starts to move across the surface.
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.
Inertia	The resistance of a body to a change in its state of rest or uniform motion in a straight line. Mass is a measure of an object's inertia.
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. In symbols: $F_{net} = ma$
Newton's third law of motion	When object A exerts a force on object B, object B SIMULTANEOUSLY exerts a force equal in magnitude but opposite in direction on object A.
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. In symbols: $F = \frac{Gm_1m_2}{r^2}$
Normal force	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.
Static frictional force (f_s)	The force acting parallel to a surface and opposes the tendency of motion of a STATIONARY object relative to the surface.
Weight	The gravitational force, in newton (N), exerted on an object.
Weightlessness	The sensation experienced when all contact forces are removed i.e. no external objects touch one's body.

MECHANICS: MOMENTUM AND IMPULSE	
Contact forces	Contact forces arise from the physical contact between two objects (e.g. a soccer player kicking a ball.)
Non-contact forces	Non-contact forces arise even if two objects do not touch each other (e.g. the force of attraction of the earth on a parachutist even when the earth is not in direct contact with the parachutist.)
Momentum	Linear momentum is the product of an object's mass and its velocity. In symbols: $p = mv$ Unit: N·s or $kg{\cdot}m{\cdot}s^{-1}$
Newton's Second Law of motion in terms of momentum	The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force. In symbols: $F_{net} = \frac{\Delta p}{\Delta t}$
Principle of conservation of linear momentum	The total linear momentum in an isolated system remains constant (is conserved). In symbols: $\Sigma p_{before} = \Sigma p_{after}$
Closed system	A system in which the net external force acting on the system is zero.
Impulse	The product of the resultant/net force acting on an object and the time the resultant/net force acts on the object. In symbols: Impulse = $F_{net}\Delta t$ Unit: N·s or $kg{\cdot}m{\cdot}s^{-1}$
Impulse-momentum theorem	In symbols: $F_{net}\Delta t = m\Delta v = m(v_f - v_i)$ Unit: N·s or $kg{\cdot}m{\cdot}s^{-1}$
Elastic collision	A collision in which both total momentum and total kinetic energy are conserved.
Inelastic collision	A collision during which kinetic energy is not conserved.

MECHANICS: VERTICAL PROJECTILE MOTION	
1-D motion	One-dimensional motion./Linear motion./Motion in one line.
Acceleration	The rate of change of velocity. Symbol: a Unit: meters per second squared ($m \cdot s^{-2}$)
Gravitational acceleration (g)	The acceleration of a body due to the force of attraction of the earth.
Displacement	Change in position. Symbol: Δx (horizontal displacement) or Δy (vertical displacement) Unit: meters (m)
Free fall	Motion of an objects under the influence of the gravitational force only.
Gravitational force	A force of attraction of one body on another due to their masses.
Position	Where an object is relative to a reference point. Symbol: x (horizontal position) or y (vertical position) Unit: meters (m)
Projectile	An object which has been given an intial velocity and on which the only force acting is the gravitational force/weight.
Velocity	The rate of change of position. Symbol: v Unit: meters per second ($m \cdot s^{-1}$)

MECHANICS: WORK, ENERGY AND POWER	
Work	Work done on an object by a constant force is the product of the magnitude of the force, the magnitude of the displacement and the angle between the force and the displacement. In symbols: $W = F \Delta x \cos \theta$
Positive work	The kinetic energy of the object increases.
Negative work	The kinetic energy of the object decreases.
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: $W_{net} = \Delta K = K_f - K_i$.
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.) In symbols: $E_{M(intial)} = E_{M(final)}$ OR $(E_p + E_k)_{initial} = (E_p + E_k)_{final}$
Conservative force	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).
Non-conservative force	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.
Power	The rate at which work is done or energy is expended. In symbols: $P = \frac{W}{\Delta t}$ Unit: watt (W)

WAVES, SOUND AND LIGHT: DOPPLER EFFECT	
Doppler Effect	The apparent change in frequency/pitch of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. **OR:** The change in frequency/pitch of the sound detected by a listener due to relative motion between the sound source and the listener.
Red shift	Observed when light from an object increased in wavelength (decrease in frequency). A red shift occurs when a light source moves away from an observer.
Blue shift	Observed when light from an object decreased in wavelength (increase in frequency). A blue shift occurs when a light source moves towards an observer.
Frequency	The number of vibrations per second. Symbol: f Unit: hertz (Hz) or per second (s^{-1})
Wavelength	The distance between two successive points in phase. Symbol: λ Unit: meter (m)
Wave equation	Speed = frequency x wavelength

ELECTRICITY AND MAGNETISM: ELECTROSTATICS	
Coulomb's law	The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them. In symbols: $F = \frac{kQ_1Q_2}{r^2}$
Electric field	A region of space in which an electric charge experiences a force.
Electric field at a point	The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: $E = \frac{F}{q}$ Unit: $N \cdot C^{-1}$
Direction of electric field	The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.

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 i.e the ratio of potential difference to current remains constant. (Resistance of the conducter remains constant.)
Non-ohmic conductors	A conductor that does not obey Ohm's law i.e the ratio of potential difference to current does NOT remain constant. (Resistance of the conductor increases as the current increases e.g. 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.
Internal resistance	The resistance within a battery that causes a drop in the potential difference of the battery when there is a current in the circuit.
emf	Maximum energy provided/work done by a battery per coulomb/unit charge passing through it. (It is the potential difference across the ends of a battery when there is NO current in the circuit.)
Terminal potential difference	The energy transferred to or the work done per coulomb of charge passing through the battery when the battery delivers a current. (It is the potential difference across the ends of a battery when there is a current in the circuit.)

ELECTRICITY AND MAGNETISM: ELECTRICAL MACHINES	
Generator	A device that transfers mechanical energy into electrical energy.
Faraday's law of electromagnetic induction	The magnitude of the induced emf across the ends of a conductor is directly proportional to the rate of change in the magnetic flux linkage with the conductor. (When a conductor is moved in magnetic field, a potential difference is induced across the conductor.)
Fleming's Right Hand Rule for generators	Hold the thumb, forefinger and second finger of the RIGHT hand at right angles to each other. If the forefinger points in the direction of the magnetic field (N to S) and the thumb points in the direction of the force (movement), then the second finger points in the direction of the induced current.
Electric motor	A device that transfers electrical energy into mechanical energy.
Fleming's Left Hand Rule for electric motors	Hold the thumb, forefinger and second finger of the LEFT hand at right angles to each other. If the forefinger points in the direction of the magnetic field (N to S) and the second finger points in the direction of the conventional current, then the thumb will point in the direction of the force (movement).
Coventional current	Flow of electric charge from positive to negative.
AC	Alternating current The direction of the current changes each half cycle.

DC	Direct current The direction of the current remains constant. (The direction of conventional current is from the positive to the negative pole of a battery. The direction of electron current is from the negative to the positive pole of the battery.)
Root-mean-square potential difference (V_{rms})	The root-mean-square potential difference is the AC potential difference that produces the same amount of electrical energy (power) as an equivalent DC potential difference.
Peak potential difference (V_{max})	The maximum potential difference value reached by the alternating current as it fluctuates i.e. the peak of the sine wave representing an AC potential difference.
Root-mean-square current (I_{rms})	Root-mean-square current is the alternating current that produces the same amount of energy (power) as and equivalent DC current.
Peak current (I_{max})	The maximum current value reached by the alternating current as it fluctuates i.e. the peak of the sine wave representing an AC current.

MATTER AND MATERIALS: OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS	
Photo-electric effect	The process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on /shines on the surface.
Threshold frequency (f_o)	The minimum frequency of light needed to emit electrons from a certain metal surface.
Work function (W_o)	The minimum energy that an electron in the metal needs to be emitted from the metal surface.
Photo-electric equation	$E = W_o + K_{max}$, where $E = hf$ and $W_o = hf_o$ and $K_{max} = \frac{1}{2}mv^2_{max}$
Atomic absorption spectrum	Formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.
Atomic emission spectrum	Formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.

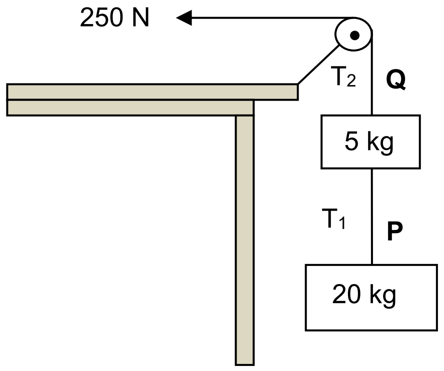
QUESTIONS

NEWTON'S LAWS

QUESTION 1

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley.

A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.



1.1 State *Newton's second law of motion* in words. (2)

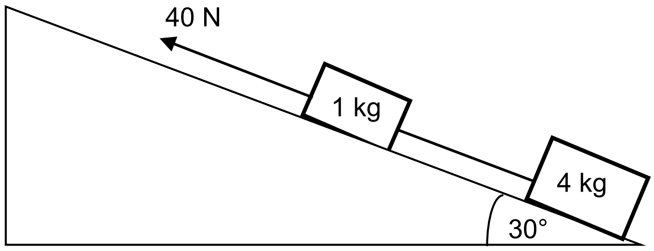
1.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**. (3)

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

1.4 When the 250 N force is replaced by a sharp pull on the string, one of the two strings break. Which ONE of the two strings, **P** or **Q**, will break? (1)

[12]

QUESTION 2



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

The magnitude of the kinetic frictional force between the surface and the 4 kg block is 10 N.

The coefficient of kinetic friction between the 1 kg block and the surface is 0,29.

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

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

2.3 Calculate the magnitude of the:

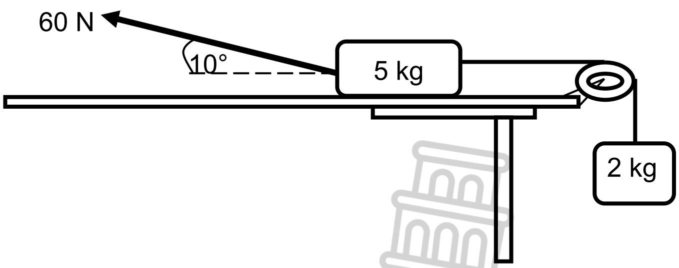
2.3.1 Kinetic frictional force between the 1 kg block and the surface (3)

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

[16]

QUESTION 3

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 10º 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.

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

3.2 Calculate the magnitude of the:

3.2.1 Vertical component of the 60 N force (2)

3.2.2 Horizontal component of the 60 N force (2)

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

Calculate the magnitude of the:

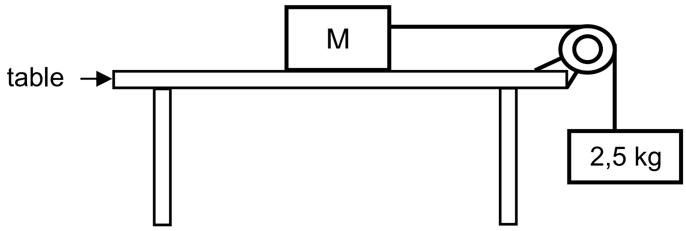
3.4 Normal force acting on the 5 kg block (2)

3.5 Tension in the string connecting the two blocks (7)

[20]

QUESTION 4

4.1 Two blocks of mass M kg and 2,5 kg respectively are connected by a light, inextensible string. The string runs over a light, frictionless pulley, as shown in the diagram below. The blocks are **stationary**.



4.1.1 State Newton's THIRD law of motion in words. (2)

4.1.2 Calculate the tension in the string. (3)

The coefficient of static friction (μ_s) between the unknown mass M and the surface of the table is 0,2.

4.1.3 Calculate the minimum value of M that will prevent the blocks from moving. (5)

The block of unknown mass M is now replaced with a block of mass 5 kg. The 2,5 kg block now accelerates downwards. The coefficient of kinetic friction (μ_k) between the 5 kg block and the surface of the table is 0,15.

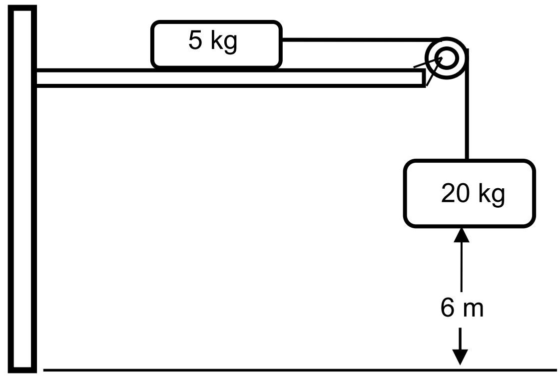
4.1.4 Calculate the magnitude of the acceleration of the 5 kg block. (5)

4.2 A small hypothetical planet **X** has a mass of 6,5 x 10^{20} 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 5

5.1 A 5 kg mass and a 20 kg mass are connected by a light inextensible string which passes over a light frictionless pulley. Initially, the 5 kg mass is held stationary on a horizontal surface, while the 20 kg mass hangs vertically downwards, 6 m above the ground, as shown in the diagram, not drawn to scale. When the *stationary* 5 kg mass is released, the two masses begin to move. The coefficient of kinetic friction, μ_k, between the 5 kg mass and the horizontal surface is 0,4. Ignore the effects of air friction.

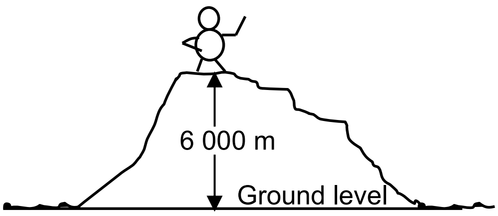


5.1.1 Calculate the acceleration of the 20 kg mass. (5)

5.1.2 Calculate the speed of the 20 kg mass as it strikes the ground. (4)

5.1.3 At what minimum distance from the pulley should the 5 kg mass be placed initially, so that the 20 kg mass just strikes the ground? (1)

5.2 A person of mass 60 kg climbs to the top of a mountain which is 6 000 m above ground level.



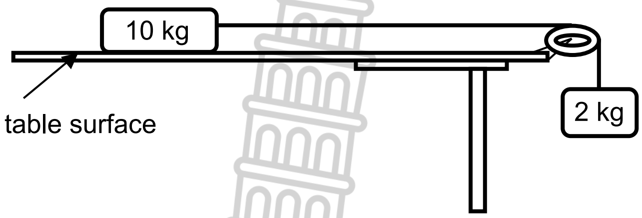
5.2.1 State *Newton's Law of Universal Gravitation* in words. (2)

5.2.2 Calculate the *difference* in the weight of the climber at the top of the mountain and at ground level. (6)

[18]

QUESTION 6

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**.



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

6.2 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 at 1,2 m·s^{-2}.

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

6.4 Calculate the coefficient of kinetic friction between the 10 kg block and the surface of the table. (7)

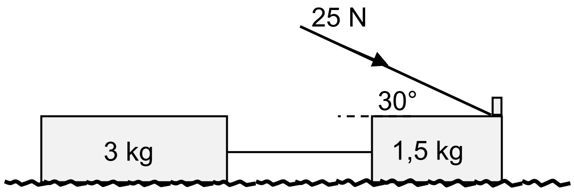
6.5 How does the value, calculated in QUESTION 6.4, compare with the value of the coefficient of STATIC friction for the 10 kg block and the table? Write down only LARGER THAN, SMALLER THAN or EQUAL TO. (1)

6.6 If the 10 kg block had a larger surface area in contact with the surface of the table, how would this affect the coefficient of kinetic friction calculated in QUESTION 6.4? Assume that the rest of the system remains unchanged. Write down only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[16]

QUESTION 7

A learner constructs a push toy using two blocks with masses 1,5 kg and 3 kg respectively. The blocks are connected by a massless, inextensible cord. The learner then applies a force of 25 N at an angle of 30° to the 1,5 kg block by means of a light rigid rod, causing the toy to move across a flat, rough, horizontal surface, as shown in the diagram.



The coefficient of kinetic friction (μ_k) between the surface and each block is 0,15.

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

7.2 Calculate the magnitude of the kinetic frictional force acting on the 3 kg block. (3)

7.3 Draw a labelled free-body diagram showing ALL the forces acting on the 1,5 kg block. (5)

7.4 Calculate the magnitude of the:

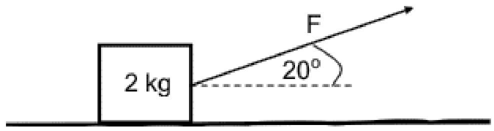
7.4.1 Kinetic frictional force acting on the 1,5 kg block (3)

7.4.2 Tension in the cord connecting the two blocks (5)

[18]

QUESTION 8

8.1 A crate of mass 2 kg is being pulled to the right across a rough horizontal surface by constant force **F**. The force **F** is applied at an angle of 20° to the horizontal, as shown in the diagram.



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

A constant frictional force of 3 N acts between the surface and the crate. The coefficient of kinetic friction between the crate and the surface is 0,2. Calculate the magnitude of the:

8.1.2 Normal force acting on the crate (3)

8.1.3 Force **F** (4)

8.1.4 Acceleration of the crate (3)

8.2 A massive rock from outer space is moving towards the Earth.

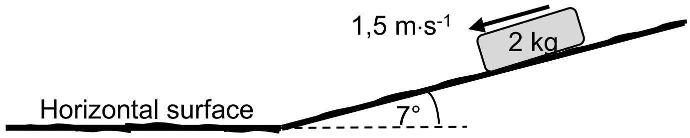
8.2.1 State Newton's Law of Universal Gravitation in words. (2)

8.2.2 How does the magnitude of the gravitational force exerted by the Earth on the rock change as the distance between the rock and the Earth becomes smaller? Choose from INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[18]

QUESTION 9

A small object of mass 2 kg is sliding <u>*at a constant velocity*</u> of 1,5 m·s^{-1} down a rough plane inclined at 7° to the horizontal surface. At the bottom of the plane, the object continues sliding onto a rough horizontal surface and eventually comes to a stop. The coefficient of kinetic friction between the object and both the inclined and the horizontal surfaces is the same.



9.1 Write down the magnitude of the net force acting on the object. (1)

9.2 Draw a labelled free-body diagram for the object while it is on the inclined plane. (3)

9.3 Calculate the:

9.3.1 Magnitude of the frictional force acting on the object while it is sliding down the inclined plane (3)

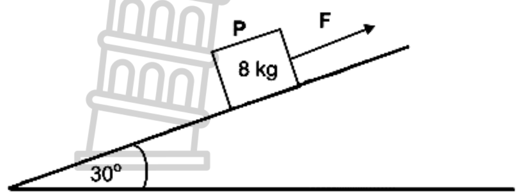
9.3.2 Coefficient of kinetic friction between the object and the surfaces (3)

9.3.3 Distance the object travels on the horizontal surface before it comes to a stop (5)

[15]

QUESTION 10

10.1 An 8 kg block, **P**, is being pulled by constant force **F** up a rough inclined plane at an angle of 30° to the horizontal, at CONSTANT SPEED. Force **F** is parallel to the inclined plane, as shown in the diagram.



10.1.1 State Newton's First Law in words. (2)

10.1.2 Draw a labelled free-body diagram for block **P**. (4)

The kinetic frictional force between the block and the surface of the inclined plane is 20,37 N.

10.1.3 Calculate the magnitude of force **F**. (5)

Force **F** is now removed and the block ACCELERATES down the plane. The kinetic frictional force remains 20,37 N.

10.1.4 Calculate the magnitude of the acceleration of the block. (4)

10.2 A 200 kg rock lies on the surface of a planet. The acceleration due to gravity on the surface of the planet is 6,0 m·s^{-2}.

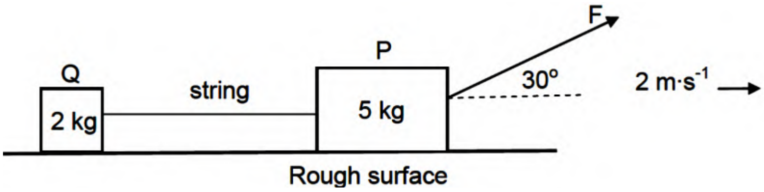
10.2.1 State *Newton's Law of Universal Gravitation* in words. (2)

10.2.2 Calculate the mass of the planet if its radius is 700 km. (4)

[21]

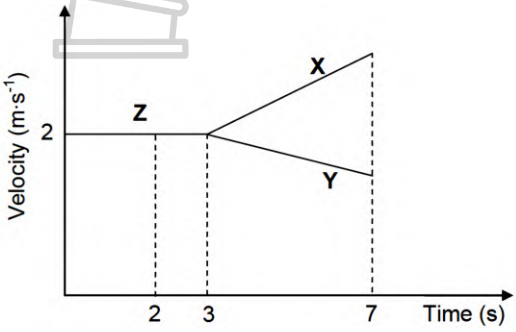
QUESTION 11

Two boxes, **P** and **Q**, resting on a rough horizontal surface, are connected by a light inextensible string. The boxes have masses 5 kg and 2 kg respectively. A constant force **F**, acting at an angle of 30° to the horizontal, is applied to the 5 kg box, as shown. The two boxes now move to the right at a **constant speed** of 2 m·s⁻¹.



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

11.2 Draw a labelled free-body diagram for box **Q**. (4)



Box **P** experiences a constant frictional force of 5 N and box **Q** a constant frictional force of 3 N.

11.3 Calculate the magnitude of force **F**. (6)

The string connecting **P** and **Q** suddenly breaks after 3 s while force **F** is still being applied. Learners draw the velocity-time graph for the motion of **P** and **Q** before and after the string breaks, as shown alongside.

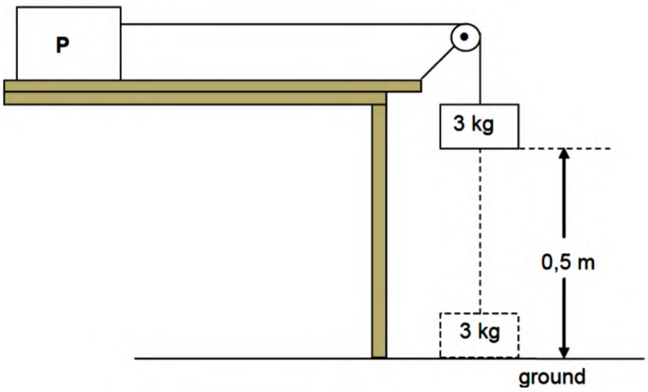
11.4 Write down the time at which the string breaks.

11.5 Which portion (**X**, **Y** or **Z**) of the graph represents the motion of box **Q**, after the string breaks? Use the information in the graph to fully support the answer. (4)

[17]

QUESTION 12

Block **P**, of unknown mass, is placed on a rough horizontal surface. It is connected to a second block of mass 3 kg, by a light inextensible string passing over a light, frictionless pulley, as shown. Initially the system of masses is held stationary with the 3 kg block, 0,5 m above the ground. When the system is released the 3 kg block moves vertically downwards and strikes the ground after 3 s. Ignore the effects of air resistance.



12.1 Define the term *acceleration* in words. (2)

12.2 Calculate the magnitude of the *acceleration* of the 3 kg block using equations of motion. (3)

12.3 Calculate the magnitude of the tension in the string. (3)

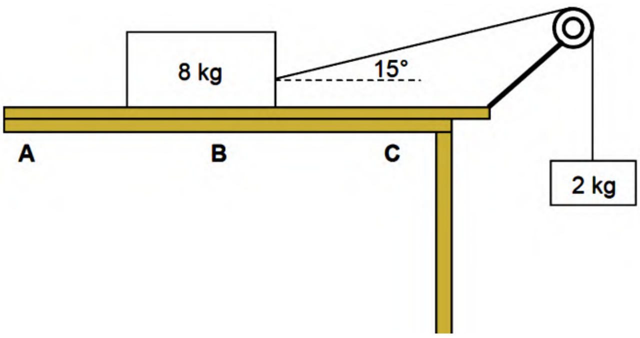
The magnitude of the kinetic frictional force experienced by block **P** is 27 N.

12.4 Draw a labelled free-body diagram for block **P**. (4)

12.5 Calculate the mass of block **P**. (3)

[15]

QUESTION 13



A block, of mass 8 kg, is placed on a rough horizontal surface. The 8 kg block, which is connected to a 2 kg block by means of a light inextensible string passing over a light frictionless pulley, starts sliding from point **A**, as shown.

13.1 State Newton's Second Law in words. (2)

13.2 Draw a labelled free-body diagram for the 8 kg block. (4)

13.3 When the 8 kg block reaches point **B**, the angle between the string and the horizontal is 15° and the acceleration of the system is 1,32 m·s⁻².

13.3.1 Give a reason why the system is NOT in equilibrium. (1)

13.3.2 Use the 2 kg mass to calculate the tension in the string. (3)

13.3.3 Calculate the kinetic frictional force between the 8 kg block and the horizontal surface. (4)

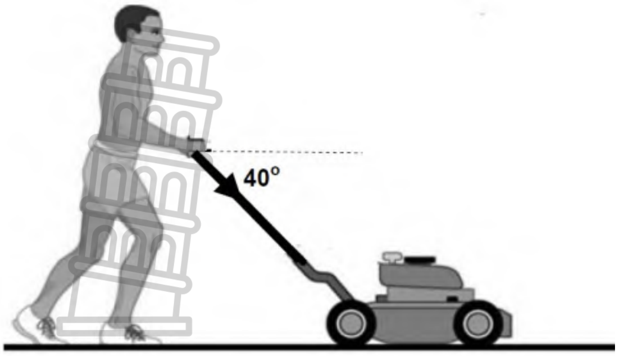
13.4 As the 8 kg block moves from **B** to **C**, the kinetic frictional force between the 8 kg block and the horizontal surface is not constant. Give a reason for this statement. (1)

The horizontal surface on which the 8 kg block is moving, is replaced by another horizontal surface made from a different material.

13.5 Will the kinetic frictional force, calculated in QUESTION 13.3.3 above, change? Choose from: YES or NO. Give a reason for the answer. (2)

[17]

QUESTION 14



14.1 A person pushes a lawn mower of mass 15 kg at a **constant speed** in a straight line over a flat grass surface with a force of 90 N. The force is directed along the handle of the lawn mower. The handle has been set at an angle of 40° to the horizontal. Refer to the diagram.

14.1.1 Draw a labelled free-body diagram for the lawn mower. (4)

14.1.2 Why is it CORRECT to say that the moving lawn mower is in equilibrium? (1)

14.1.3 Calculate the magnitude of the frictional force acting between the lawn mower and the grass. (3)

The lawn mower is now brought to a stop.

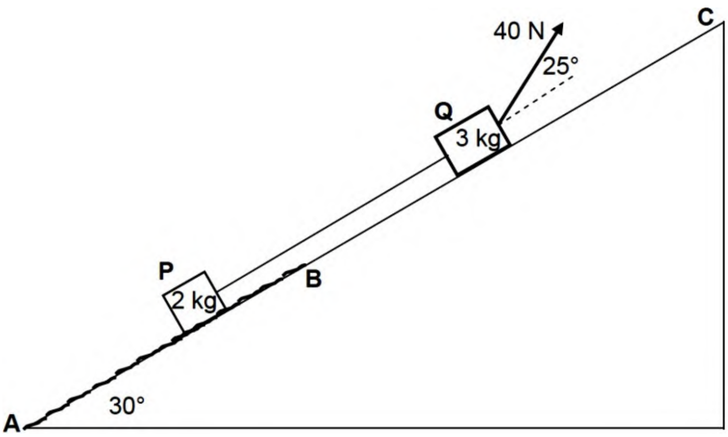
14.1.4 Calculate the magnitude of the constant force that must be applied through the handle in order to accelerate the lawn mower *from rest* to 2 $m{\cdot}s^{-1}$ in a time of 3 s. Assume that the frictional force between the lawn mower and grass remains the same as in QUESTION 14.1.3. (6)

14.2 Planet **Y** has a radius of 6 x 10^5 m. A 10 kg mass weighs 20 N on the surface of planet **Y**. Calculate the mass of planet **Y**. (4)

[18]

QUESTION 15

Block **P**, of mass 2 kg, is connected to block **Q**, of mass 3 kg, by a light inextensible string. Both blocks are on a plane inclined at an angle of 30° to the horizontal. Block **Q** is pulled by a constant force of 40 N at an angle of 25° to the incline.



Block **P** moves on a rough section, **AB**, of the incline, while block **Q** moves on a frictionless section, **BC**, of the incline. See diagram.

An average constant frictional force of 2,5 N acts on block **P** as it moves from **A** to **B** up the incline.

15.1 State Newton's Second Law in words. (2)

15.2 Draw a labelled free-body diagram for block **P**. (4)

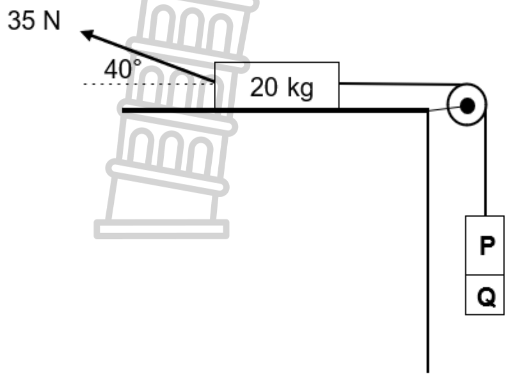
15.3 Calculate the magnitude of the acceleration of block **P** while block **P** is moving on section **AB**. (8)

15.4 If block **P** has now passed point **B**, how will its acceleration compare to that calculated in QUESTION 15.3? Choose from GREATER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (2)

[16]

QUESTION 16

A 20 kg block, resting on a rough horizontal surface, is connected to blocks **P** and **Q** by a light inextensible string moving over a frictionless pulley. Blocks **P** and **Q** are glued together and have a combined mass of *m*. A force of 35 N is now applied to the 20 kg block at an angle of 40° with the horizontal, as shown. The 20 kg block experiences a frictional force of magnitude 5 N as it moves to the RIGHT at a CONSTANT SPEED.



16.1 Define the term *normal force*. (2)

16.2 Draw a labelled free-body diagram of the 20 kg block. (5)

16.3 Calculate the combined mass *m* of the two blocks. (5)

16.4 At a certain stage of the motion, block **Q** breaks off and falls down. How will EACH of the following be affected when this happens?

16.4.1 The tension in the string. Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

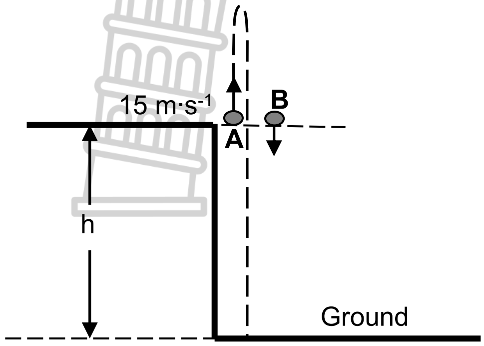
16.4.2 The velocity of the 20 kg block. Explain the answer. (3)

[16]

VERTICAL PROJECTILE MOTION

QUESTION 1

A ball, **A**, is thrown vertically upward from a height, h, with a speed of 15 m·s^{-1}. AT THE SAME INSTANT, a second identical ball, **B**, is dropped from the same height as ball **A** as shown in the diagram below. Both balls undergo free fall and eventually hit the ground.



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

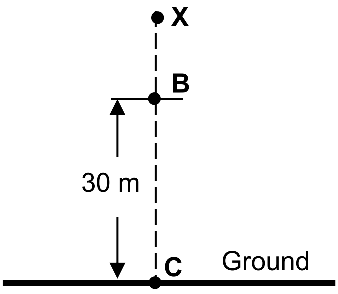
1.2 Calculate the time it takes for ball **A** to return to its starting point. (4)

1.3 Calculate the distance between ball **A** and ball **B** when ball **A** is at its maximum height. (7)

1.4 Sketch a velocity-time graph in the ANSWER BOOK for the motion of ball **A** from the time it is projected until it hits the ground. Clearly show the following on your graph:
- The initial velocity
- The time it takes to reach its maximum height
- The time it takes to return to its starting point (4)

[17]

QUESTION 2



An object is released from rest from a point **X,** above the ground as shown in the diagram. It travels the last 30 m (**BC**) in 1,5 s before hitting the ground. Ignore the effects of air friction.

2.1 Name the type of motion described above. (1)

2.2 Calculate the magnitude of the velocity of the object at point **B**. (4)

2.3 Calculate the height of point **X** above the ground. (5)

After hitting the ground, the object bounces once and then comes to rest on the ground.

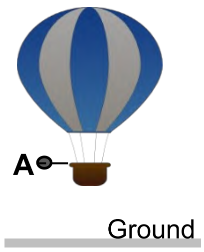
2.4 Sketch an acceleration-time graph for the entire motion of the object. (3)

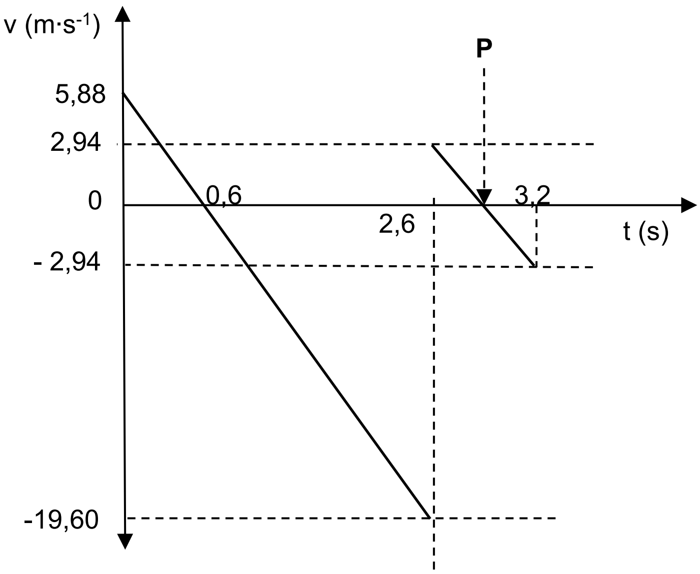
[17]

QUESTION 3

A hot air balloon is rising vertically at a constant velocity. When the hot air balloon reaches point **A** a few metres above the ground, a man in the hot air balloon drops a ball which hits the ground and bounces. Ignore the effects of friction.

The velocity-time graph below represents the motion of the ball from the instant it is dropped until after it bounces for the first time. The time interval between bounces is ignored. THE UPWARD DIRECTION IS TAKEN AS POSITIVE. USE INFORMATION FROM THE GRAPH TO ANSWER THE QUESTIONS THAT FOLLOW.





3.1 Write down the magnitude of the velocity of the hot air balloon. (1)

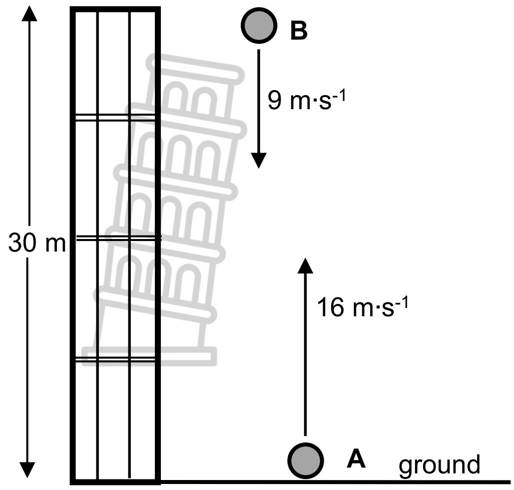
3.2 Calculate the height above the ground from which the ball was dropped. (3)

3.3 Calculate the time at the point **P** indicated on the graph (2)

3.4 Calculate the maximum height the ball reaches after the first bounce. (3)

3.5 Calculate the distance between the ball and hot air balloon when the ball is at its maximum height after the first bounce (4)

[13]



QUESTION 4

Ball **A** is projected vertically upwards at a velocity of 16 m·s^{-1} from the ground. Ignore the effects of air resistance. **Use the ground as zero reference.**

4.1 Calculate the time taken by ball **A** to return to the ground. (4)

4.2 Sketch a velocity-time graph for ball **A**. Show the following on the graph:
- (a) Initial velocity of ball **A**
- (b) Time taken to reach the highest point of the motion
- (c) Time taken to return to the ground (3)

ONE SECOND after ball **A** is projected upwards, a second ball, **B**, is thrown vertically downwards at a velocity of 9 m·s^{-1} from a balcony 30 m above the ground. Refer to the diagram.

4.3 Calculate how high above the ground ball **A** will be at the instant the two balls pass each other. (6)

[13]

QUESTION 5

A man throws ball **A** downwards with a speed of 2 m·s^{-1} from the edge of a window, 45 m above a dam of water. One second later he throws a second ball, ball **B**, downwards and observes that both balls strike the surface of the water in the dam at the same time. Ignore air friction.

5.1 Calculate the:

5.1.1 Speed with which ball **A** hits the surface of the water (3)

5.1.2 Time it takes for ball **B** to hit the surface of the water (3)

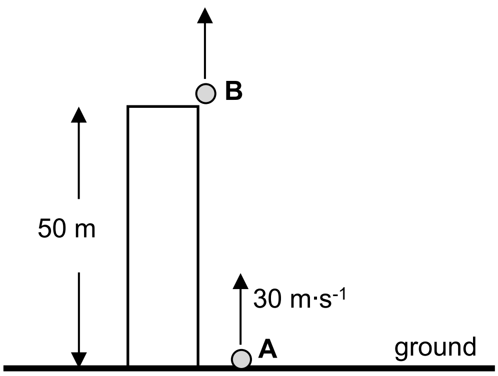
5.1.3 Initial velocity of ball **B** (5)

5.2 On the same set of axes, sketch a velocity versus time graph for the motion of balls **A** and **B**. Clearly indicate the following on your graph:
- Initial velocities of both balls **A** and **B**
- The time of release of ball **B**
- The time taken by both balls to hit the surface of the water (5)

[16]

QUESTION 6

Ball **A** is projected vertically upwards from the ground, near a tall building, with a speed of 30 m·s^{-1}. Ignore the effects of air friction.



6.1 Explain what is meant by a *projectile*. (2)

6.2 Calculate the total time that ball **A** will be in the air. (4)

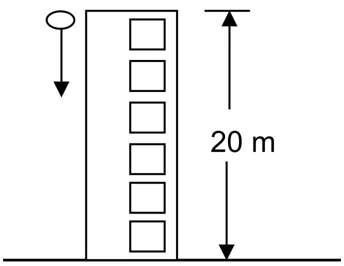
6.3 Calculate the distance travelled by ball **A** during the last second of its fall. (4)

6.4 TWO SECONDS after ball **A** is projected upwards, ball **B** is projected vertically upwards from the roof of the same building. The roof the building is 50 m above the ground. Both balls **A** and **B** reach the ground *at the same time*. Refer to the diagram. Ignore the effects of air friction.
Calculate the speed at which ball **B** was projected upwards from the roof. (4)

6.5 Sketch velocity-time graphs for the motion of both balls **A** and **B** on the *same set of axes.* Clearly label the graphs for balls **A** and **B** respectively. Indicate the following on the graphs:
- (a) Time taken by both balls **A** and **B** to reach the ground
- (b) Time taken by ball **A** to reach its maximum height (4)

[18]

QUESTION 7



A ball is dropped from the top of a building 20 m high. Ignore the effects of air resistance.

7.1 Define the term *free fall*. (4)

7.2 Calculate the speed at which the ball hits the ground. (4)

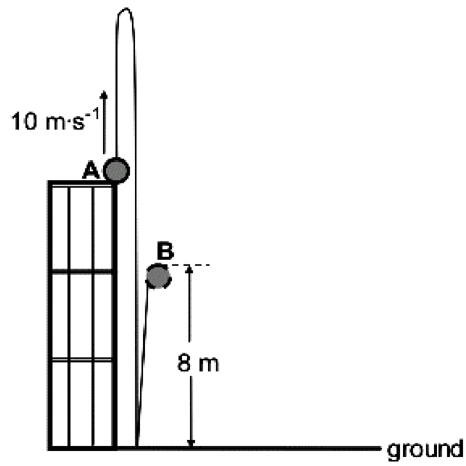
7.3 Calculate the time it takes the ball to reach the ground. (3)

7.4 Sketch a velocity-time graph for the motion of the ball (no values required). (2)

[11]

QUESTION 8

A ball is projected vertically upwards with a speed of 10 m·s^{-1} from point **A**, which is at the top edge of a building. The ball hits the ground after 3 s. It is in contact with the ground for 0,2 s and then bounces vertically upwards, reaching a maximum height of 8 m at point **B**. See the diagram. Ignore the effects of friction.



8.1 Why is the ball considered to be in free fall during its motion? (2)

8.2 Calculate the:

8.2.1 Height of the building (3)

8.2.2 Speed with which the ball hits the ground (3)

8.2.3 Speed with which the ball leaves the ground (3)

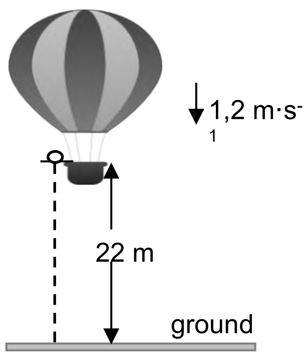
8.3 Draw a velocity versus time graph for the complete motion of the ball from **A** to **B**. Show the following on the graph:

- The magnitude of the velocity with which it hits the ground
- The magnitude of the velocity with which it leaves the ground
- The time taken to reach the ground, as well as the time at which it leaves the ground (4)

[15]

QUESTION 9

A hot-air balloon moves vertically downwards at a constant velocity of 1,2 m·s^{-1}. When it reaches a height of 22 m from the ground, a ball is dropped from the balloon. Refer to the diagram.



Assume that the dropping of the ball has no effect on the speed of the hot-air balloon. Ignore air friction for the motion of the ball.

9.1 Explain the term projectile motion. (2)

9.2 Is the hot-air balloon in free fall? Give a reason for the answer. (2)

9.3 Calculate the time it takes for the ball to hit the ground after it is dropped. (4)

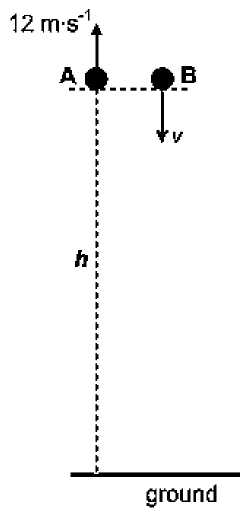
When the ball lands on the ground, it is in contact with the ground for 0,3 s and then it bounces vertically upwards with a speed of 15 m·s^{-1}.

9.4 Calculate how high the balloon is from the ground when the ball reaches its maximum height after the first bounce. (6)

[14]

QUESTION 10

Stone **A** is projected vertically upwards at a speed of 12 m·s^{-1} from a height *h* above the ground. Ignore the effects of air resistance.



10.1 Calculate the time taken for stone **A** to reach its maximum height. (3)

At the same instant that stone **A** is projected upwards, stone **B** is thrown vertically downwards from the same height at an unknown speed, v. Refer to the diagram. When stone A reaches its maximum height, the speed of stone B is 3*v*.

10.2 Calculate the speed, v, with which stone **B** is thrown downwards. (4)

At the instant stone **A** passes its initial position on its way down, stone **B** hits the ground.

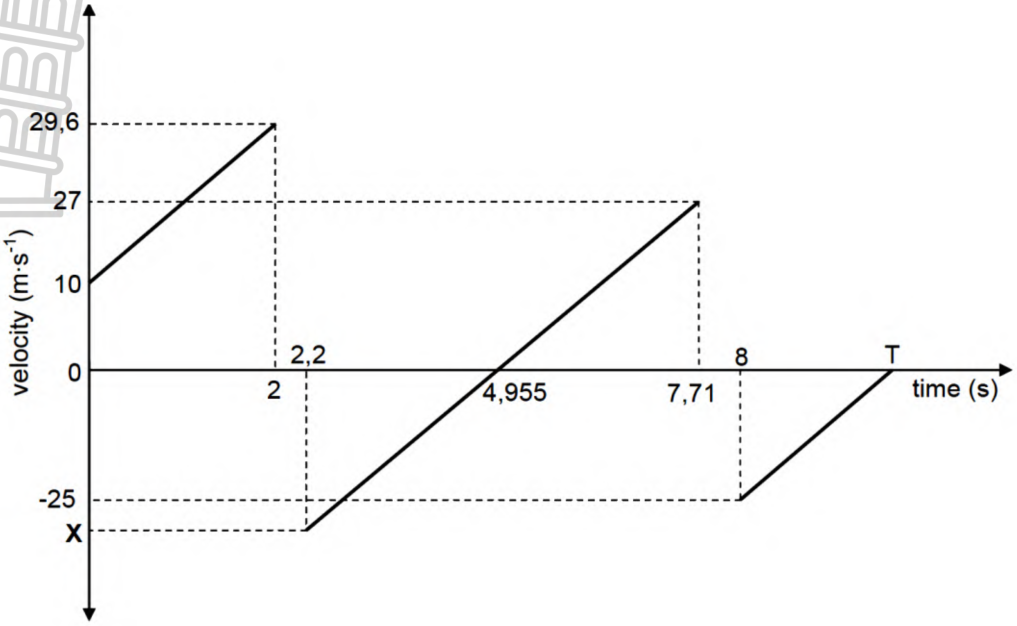
10.3 Calculate the height *h*. (3)

10.4 Sketch velocity-time graphs for the complete motions of stones **A** and **B** on the same set of axes. Label your graphs for stones **A** and **B** clearly. Show the time taken for stone **A** to reach its maximum height AND the velocity with which stone **B** is thrown downwards on the graphs. (4)

[14]

QUESTION 11

A ball is thrown **vertically downwards** from the top of a building and bounces a few times as it hits the ground. The velocity-time graph below describes the motion of the ball from the time it is thrown, up to a certain time **T**. Take downwards as the positive direction and the ground as zero reference. The graph is NOT drawn to scale. The effects of air friction are ignored.



11.1 Write down the speed with which the ball is thrown downwards. (1)

11.2 ALL parts of the graph have the same gradient. Give a reason for this. (2)

11.3 Calculate the height from which the ball is thrown. (3)

11.4 Calculate the time (**T**) shown on the graph. (4)

11.5 Write down the:

11.5.1 Time that the ball is in contact with the ground at the first bounce (1)

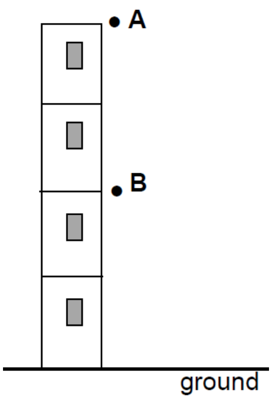
11.5.2 Time at which the ball reaches its maximum height after the first bounce (2)

11.5.3 Value of **X** (1)

11.6 Is the collision of the ball with the ground elastic or inelastic? Give a reason for the answer using information in the graph. (2)

[16]

QUESTION 12



In the diagram shown, point **A** is at the top of a building. Point **B** is exactly **halfway** between the point **A** and the ground. Ignore air resistance.

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

A ball of mass 0,4 kg is dropped from point **A**. It passes point **B** after 1 s.

12.2 Calculate the height of point **A** above the ground. (3)

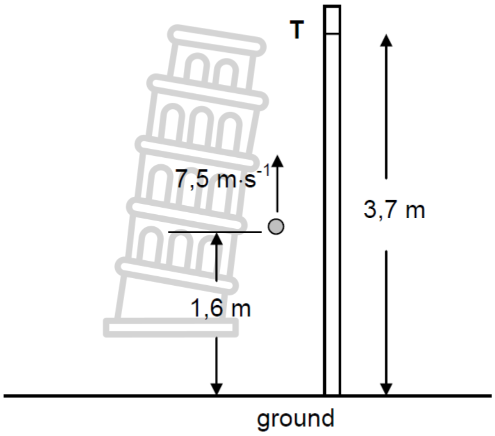
When the ball strikes the ground it is in contact with the ground for 0,2 s and then bounces vertically upwards, reaching a maximum height at point **B**.

12.3 Calculate the magnitude of the velocity of the ball when it strikes the ground. (3)

12.4 Calculate the magnitude of the average net force exerted on the ball while it is in contact with the ground. (6)

[14]

QUESTION 13



In a competition, participants must attempt to throw a ball vertically upwards past point **T**, marked on a tall vertical pole. Point **T** is 3,7 m above the ground. Point **T** may, or may not, be the highest point during the motion of the ball. One participant throws the ball vertically upwards at a velocity of 7,5 $m \cdot s^{-1}$ from a point that is 1,6 m above the ground, as shown in the diagram. Ignore the effects of air resistance.

13.1 In which direction is the net force acting on the ball while it moves towards point **T**? Choose from: UPWARDS or DOWNWARDS. Give a reason for the answer. (2)

13.2 Calculate the time taken by the ball to reach its highest point. (3)

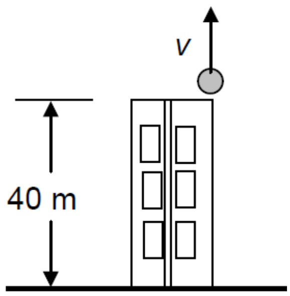
13.3 Determine, by means of a calculation, whether the ball will pass point **T** or not. (6)

13.4 Draw a velocity-time graph for the motion of the ball from the instant it is thrown upwards until it reaches its highest point. Indicate the following on the graph:
- The initial velocity and final velocity
- Time taken to reach the highest point (2)

[13]

QUESTION 14

A ball is thrown vertically upwards, with velocity *v*, from the edge of a roof of a 40 m tall building. The ball takes 1,53 s to reach its maximum height. Ignore air resistance.



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

14.2 Calculate the:

14.2.1 Magnitude of the initial velocity *v* of the ball (3)

14.2.2 Maximum height reached by the ball above the edge of the roof (3)

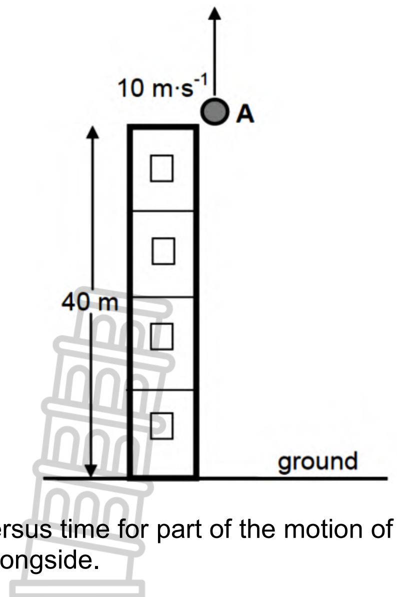
14.3 Take the edge of the roof as reference point. Determine the position of the ball relative to the edge of the roof after 4 s. (3)

14.4 Will any of the answers to QUESTIONS 3.2 and 3.3 change if the height of the building is 30 m? Choose from YES or NO. Give a reason for the answer. (3)

[14]

QUESTION 15

Stone **A** is thrown vertically upwards with a speed of 10 $m \cdot s^{-1}$ from the edge of the roof of a 40 m high building, as shown in the diagram. Ignore the effects of air friction. Take the ground as reference.



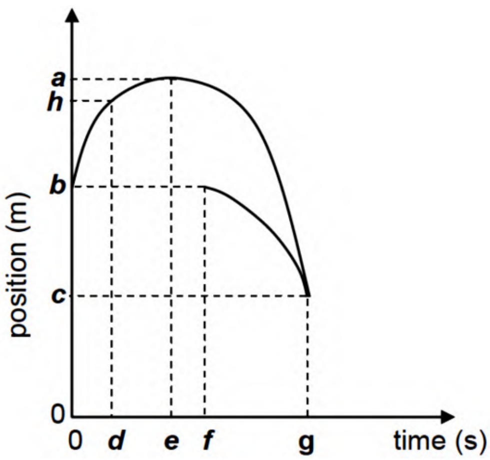
15.1 Define the term *free fall*. (2)

15.2 Calculate the maximum HEIGHT ABOVE THE GROUND reached by stone **A**. (4)

15.3 Write down the magnitude and direction of the acceleration of stone **A** at this maximum height. (2)

Stone **B** is dropped from rest from the edge of the roof, **x** seconds after stone **A** was thrown upwards.

15.4 Stone **A** passes stone **B** when the two stones are 29,74 m *above the ground*.Calculate the value of **x**. (6)



15.5 The graphs of position versus time for part of the motion of both stones are shown alongside.

Which of labels **a** to **h** on the graphs above represents EACH of the following?

15.5.1 The time at which stone **A** has a positive velocity (1)

15.5.2 The maximum height reached by stone **A** (1)

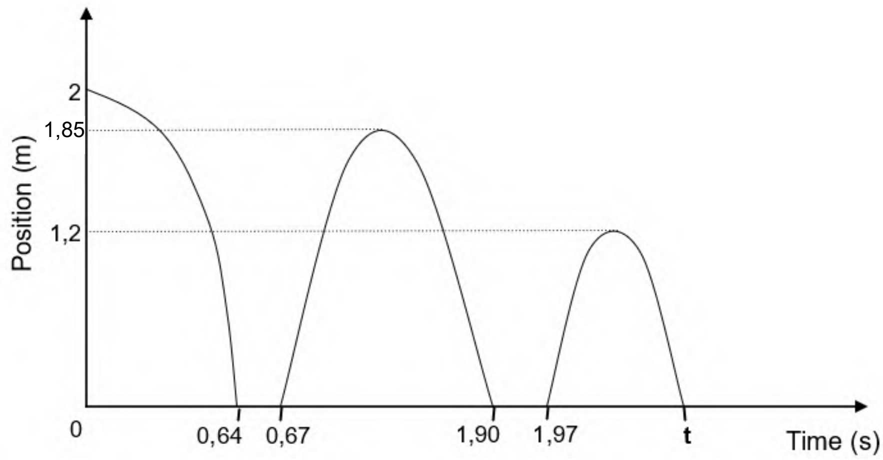
15.5.3 The time when stone **B** was dropped (1)

15.5.4 The height at which the stones pass each other (1)

[18]

QUESTION 16

A small ball is dropped from a height of 2 m and bounces a few times after landing on a cement floor. Ignore air friction. The position-time graph, not drawn to scale, represents the motion of the ball.



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

16.2 Use the graph and determine:

16.2.1 The time that the ball is in contact with the floor before the first bounce (2)

16.2.2 The time it takes the ball to reach its maximum height after the first bounce (2)

16.2.3 The speed at which the ball leaves the floor at the first bounce (3)

16.2.4 Time **t** indicated on the graph (6)

[15]

MOMENTUM AND IMPULSE

QUESTION 1

Dancers have to learn many skills, including how to land correctly. A dancer of mass 50 kg leaps into the air and lands feet first on the ground. She lands on the ground with a velocity of 5 $m \cdot s^{-1}$. As she lands, she bends her knees and comes to a complete stop in 0,2 seconds.

1.1 Calculate the momentum with which the dancer reaches the ground. (3)

1.2 Define the term *impulse of a force*. (2)

1.3 Calculate the magnitude of the net force acting on the dancer as she lands. (3)

Assume that the dancer performs the same jump as before but lands without bending her knees.

1.4 Will the force now be GREATER THAN, SMALLER THAN or EQUAL TO the force calculated in QUESTION 1.3? (1)

1.5 Give a reason for the answer to QUESTION 1.4. (3)

[12]

QUESTION 2

Percy, mass 75 kg, rides at 20 $m \cdot s^{-1}$ on a quad bike (motorcycle with four wheels) with a mass of 100 kg. He suddenly applies the brakes when he approaches a red traffic light on a wet and slippery road. The wheels of the quad bike lock and the bike slides forward in a straight line. The force of friction causes the bike to stop in 8 s.

2.1 Define the concept *momentum* in words. (2)

2.2 Calculate the change in momentum of Percy and the bike, from the moment the brakes lock until the bike comes to a stop. (4)

2.3 Calculate the average frictional force exerted by the road on the wheels to stop the bike. (4)

[10]

QUESTION 3

Two stationary steel balls, **A** and **B**, are suspended next to each other by massless, inelastic strings as shown in **Diagram 1** below.

Diagram 1

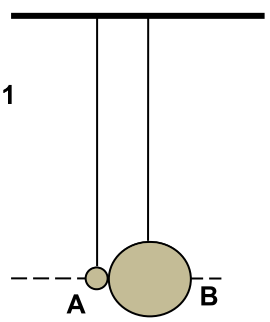
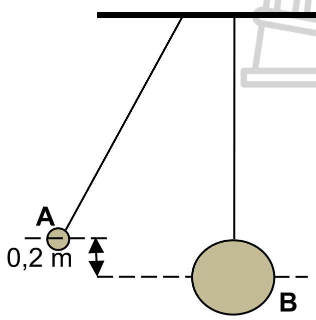


Diagram 2



Ball **A** of mass 0,2 kg is displaced through a vertical distance of 0,2 m, as shown in **Diagram 2** above. When ball **A** is released, it collides elastically and head-on with ball **B**. Ignore the effects of air friction.

3.1 What is meant by an *elastic collision*? (2)

Immediately after the collision, ball **A** moves horizontally backwards (to the left). Ball **B** acquires kinetic energy of 0,12 J and moves horizontally forward (to the right). Calculate the:

3.2 Kinetic energy of ball **A** just before it collides with ball **B** (Use energy principles only.) (3)

3.3 Speed of ball **A** immediately after the collision (4)

3.4 Magnitude of the impulse on ball **A** during the collision (5)

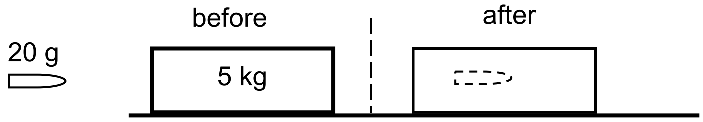
[14]

QUESTION 4

A bullet of mass 20 g is fired from a stationary rifle of mass 3 kg. Assume that the bullet moves horizontally. Immediately after firing, the rifle recoils (moves back) with a velocity of 1,4 $m{\cdot}s^{-1}$.

4.1 Calculate the speed at which the bullet leaves the rifle. (4)

The bullet strikes a stationary 5 kg wooden block **fixed** to a flat, horizontal table. The bullet is brought to rest after travelling a distance of 0,4 m **into the block**. Refer to the diagram below.



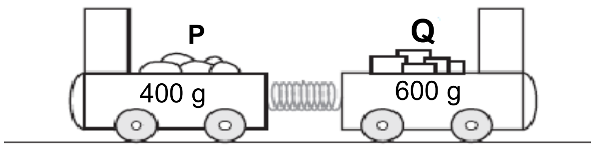
4.2 Calculate the magnitude of the average force exerted by the block on the bullet. (5)

4.3 How does the magnitude of the force calculated in QUESTION 3.2 compare to the magnitude of the force exerted by the bullet on the block? Write down only LARGER THAN, SMALLER THAN or THE SAME. (1)

[10]

QUESTION 5

The diagram shows two trolleys, **P** and **Q**, held together by means of a compressed spring on a flat, frictionless horizontal track. The masses of **P** and **Q** are 400 g and 600 g respectively. When the trolleys are released, it takes 0,3 s for the spring to unwind to its natural length. Trolley **Q then** moves to the right at 4 $m{\cdot}s^{-1}$.



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

5.2 Calculate the:

5.2.1 Velocity of trolley **P** after the trolleys are released (4)

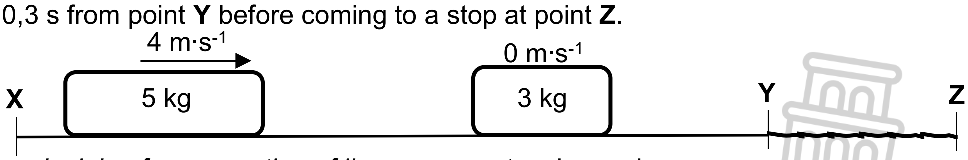
5.2.2 Magnitude of the average force exerted by the spring on trolley **Q** (4)

5.3 Is this an elastic collision? Only answer YES or NO. (1)

[11]

QUESTION 6

The diagram below shows two sections, **XY** and **YZ**, of a horizontal, flat surface. Section **XY** is smooth, while section **YZ** is rough. A 5 kg block, moving with a velocity of 4 $m{\cdot}s^{-1}$ to the right, collides head-on with a stationary 3 kg block. After the collision, the two blocks stick together and move to the right, past point **Y**. The combined blocks travel for 0,3 s from point **Y** before coming to a stop at point **Z**.



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

6.2 Calculate the magnitude of the:

6.2.1 Velocity of the combined blocks at point **Y** (4)

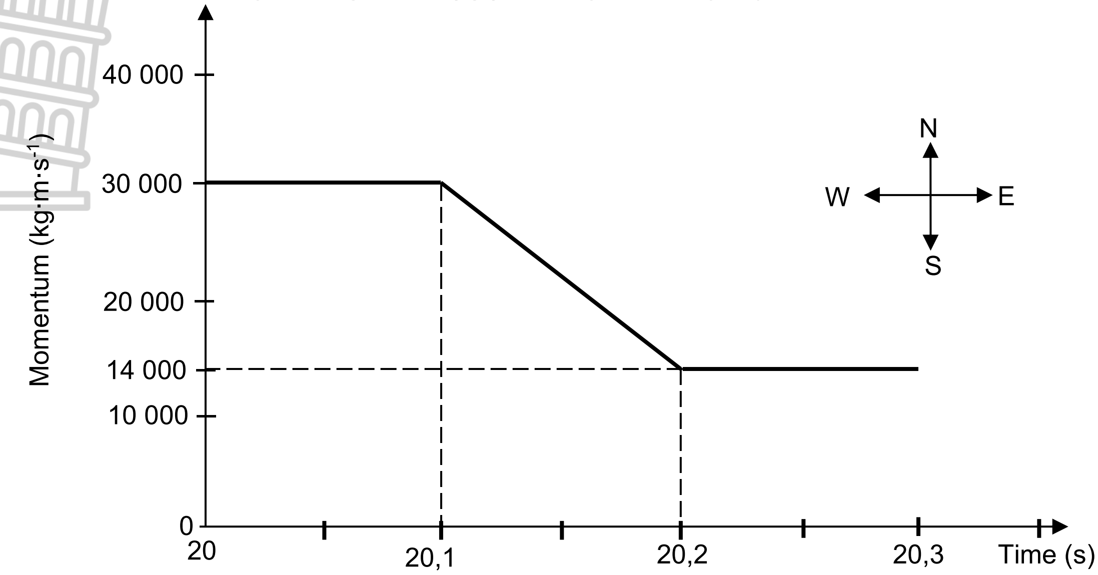
6.2.2 Net force acting on the combined blocks when they move through section **YZ** (4)

[10]

QUESTION 7

The graph below shows how the momentum of car **A** changes with time *just before* and *just after* a head-on collision with car **B**. Car **A** has a mass of 1 500 kg, while the mass of car **B** is 900 kg. Car **B** was travelling at a constant velocity of 15 m·s^{-1} west before the collision. Take east as positive and consider the system as isolated.

MOMENTUM VERSUS TIME GRAPH FOR CAR A



7.1 What do you understand by the term *isolated system* as used in physics? (1)

Use the information in the graph to answer the following questions.

7.2 Calculate the:

7.2.1 Magnitude of the velocity of car **A** just before the collision (3)

7.2.2 Velocity of car **B** just after the collision (5)

7.2.3 Magnitude of the net average force acting on car **A** during the collision (4)

[13]

QUESTION 8

A teacher demonstrates the principle of conservation of linear momentum using two trolleys. The teacher first places the trolleys, **A** and **B**, some distance apart on a flat frictionless horizontal surface, as shown in the diagram. The mass of trolley **A** is 3,5 kg and that of trolley **B** is 6,0 kg.

Trolley **A** moves towards trolley **B** at constant velocity. The table below shows the position of trolley **A** for time intervals of 0,4 s before it collides with trolley **B**.

RELATIONSHIP BETWEEN POSITION AND TIME FOR TROLLEY A				
Position of trolley **A** (m)	0	0,2	0,4	0,6
Time (s)	0	0,4	0,8	1,2

8.1 Use the table above to prove that trolley **A** is moving at constant velocity before it collides with trolley **B**. (3)

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

At time t = 1,2 s, trolley **A** collides with stationary trolley **B**. The collision time is 0,5 s after which the two trolleys move off together.

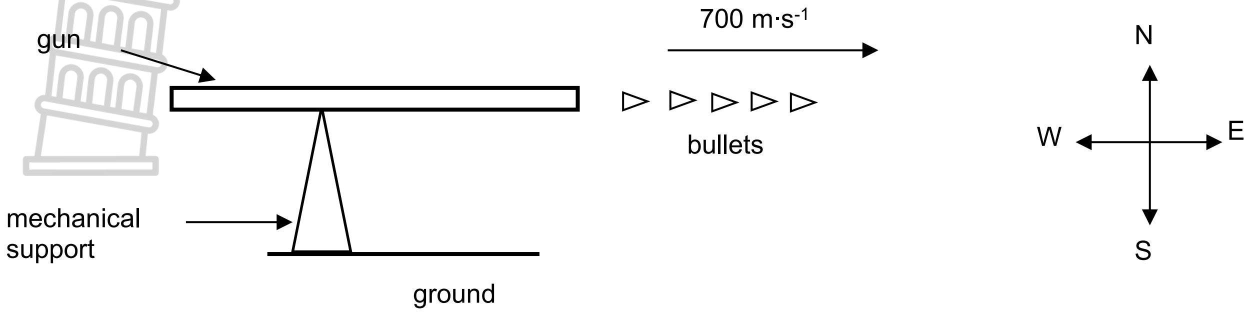
8.3 Calculate the magnitude of the average net force exerted on trolley **B** by trolley **A**. (6)

[11]

QUESTION 9

9.1 Define the term *impulse* in words. (2)

9.2 The diagram below shows a gun mounted on a mechanical support which is fixed to the ground. The gun is capable of firing bullets rapidly in a horizontal direction. Each bullet travels at a speed of 700 m·s^{-1} in an easterly direction when it leaves the gun.
(Take the initial velocity of a bullet, before being fired, as zero.)



The gun fires 220 bullets per minute. The mass of each bullet is 0,03 kg.
Calculate the:

9.2.1 Magnitude of the momentum of each bullet when it leaves the gun (3)

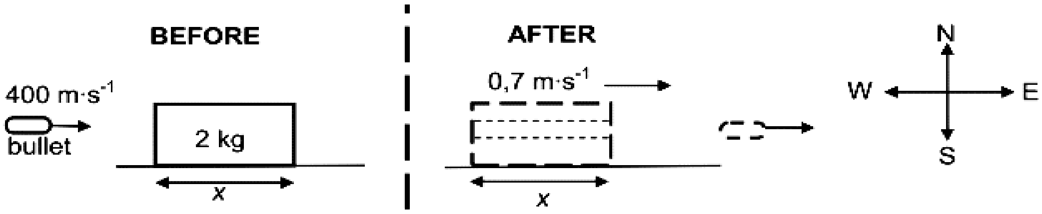
9.2.2 The net average force that each bullet exerts on the gun (5)

9.3 Without any further calculation, write down the net average horizontal force that the mechanical support exerts on the gun. (2)

[12]

QUESTION 10

A 2 kg block is at rest on a smooth, frictionless, horizontal table. The length of the block is x. A bullet of mass 0,015 kg, travelling east at 400 m·s^{-1}, strikes the block and passes straight through it with constant acceleration. Refer to the diagram below. Ignore any loss of mass of the bullet and the block.



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

The block moves eastwards at 0,7 m·s^{-1} after the bullet has emerged from it.

10.2 Calculate the magnitude of the velocity of the bullet immediately after it emerges from the block. (4)

10.3 If the bullet takes 0,002 s to travel through the block, calculate the length, x, of the block. (5)

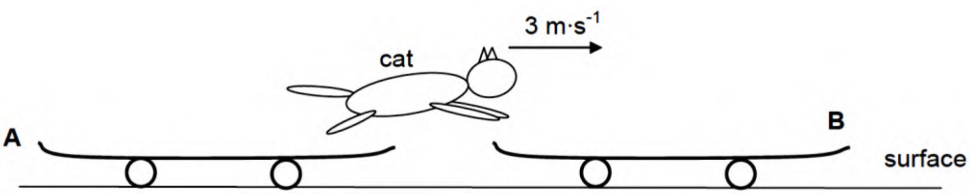
[11]

QUESTION 11

The diagram below shows two skateboards, **A** and **B**, initially at rest, with a cat standing on skateboard **A**. The skateboards are in a straight line, one in front of the other and a short distance apart. The surface is flat, frictionless and horizontal.

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

EACH skateboard has a mass of 3,5 kg. The cat, of mass 2,6 kg, jumps from skateboard **A** with a horizontal velocity of 3 m·s^{-1} and lands on skateboard **B** with the same velocity. Refer to the diagram below.



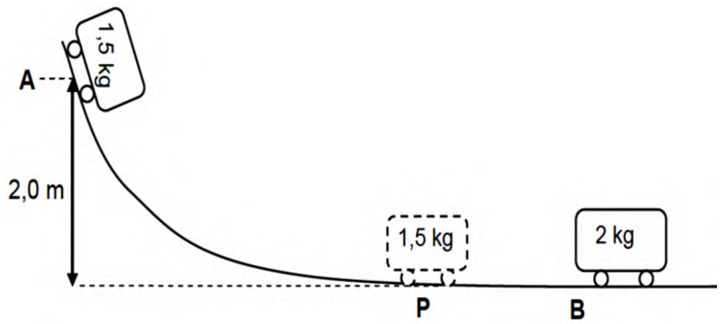
11.2 Calculate the velocity of skateboard **A** just after the cat has jumped from it. (5)

11.3 Immediately after the cat has landed, the cat and skateboard **B** move horizontally to the right at $1{,}28\ m{\cdot}s^{-1}$. Calculate the magnitude of the impulse on skateboard **B** as a result of the cat's landing. (3)

[10]

QUESTION 12

A trolley of mass 1,5 kg is held stationary at point **A** at the top of a frictionless track. When the 1,5 kg trolley is released, it moves down the track. It passes point **P** at the bottom of the incline and collides with a stationary 2 kg trolley at point **B**. Refer to the diagram. Ignore air resistance and rotational effects.



12.1 Use the principle of conservation of mechanical energy to calculate the speed of the 1,5 kg trolley at point **P**. (4)

When the two trolleys collide, they stick together and continue moving with constant velocity.

12.2 The principle of conservation of linear momentum is given by the incomplete statement below.
In a/an … system, the … linear momentum is conserved.
Rewrite the complete statement and fill in the missing words or phrases. (2)

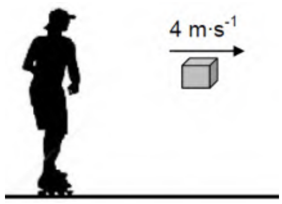
12.3 Calculate the speed of the combined trolleys immediately after the collision. (4)

12.4 Calculate the distance travelled by the combined trolleys in 3 s after the collision. (3)

[13]

QUESTION 13

Initially a girl on roller skates is at rest on a smooth horizontal pavement. The girl throws a parcel, of mass 8 kg, horizontally to the right at a speed of $4\ m{\cdot}s^{-1}$. Immediately after the parcel has been thrown, the girl-roller-skate combination moves at a speed of $0{,}6\ m{\cdot}s^{-1}$. Ignore the effects of friction and rotation.



13.1 Define the term *momentum* in words. (2)

13.2 Will the girl-roller-skate combination move TO THE RIGHT or TO THE LEFT after the parcel is thrown? NAME the law in physics that can be used to explain your choice of direction. (2)

The total mass of the roller skates is 2 kg.

13.3 Calculate the mass of the girl. (5)

13.4 Calculate the magnitude of the impulse that the girl-roller-skate combination is experiencing while the parcel is being thrown. (3)

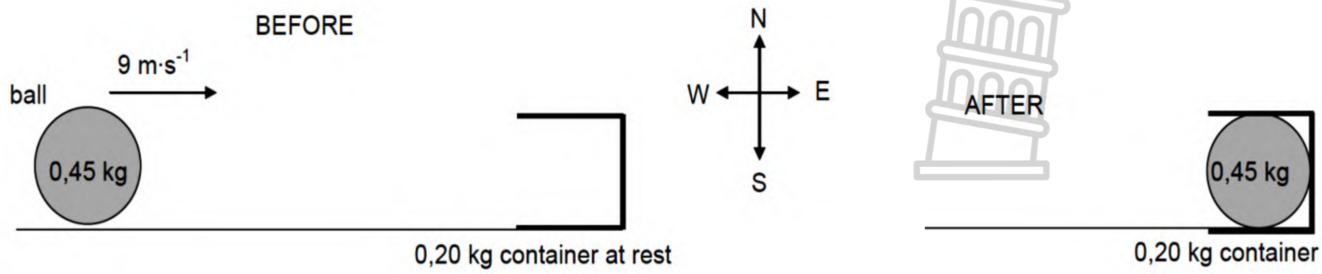
13.5 Without any further calculation, write down the change in momentum experienced by the parcel while it is being thrown. (2)

[14]

QUESTION 14

A soccer player kicks a ball of mass 0,45 kg to the east. The ball travels horizontally at a velocity of $9\ m{\cdot}s^{-1}$ along a straight line, without touching the ground, and enters a container lying at rest on its side, as shown in the diagram below. The mass of the container is 0,20 kg.

The ball is stuck in the container after the collision. The ball and container now move together along a straight line towards the east. Ignore friction and rotational effects.



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

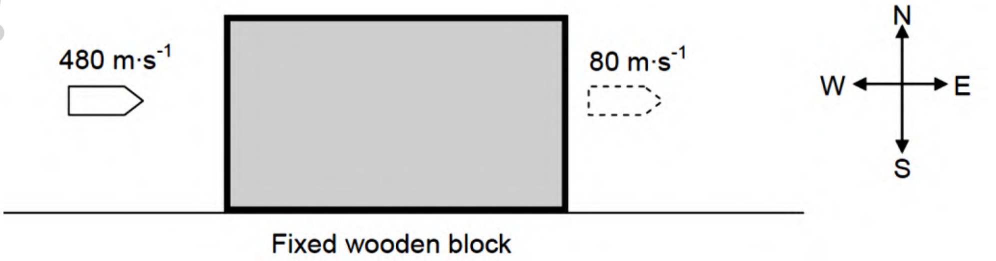
14.2 Calculate the magnitude of the velocity of the ball-container system immediately after the collision. (4)

14.3 Determine, by means of a suitable calculation, whether the collision between the ball and container is elastic or inelastic. (5)

[11]

QUESTION 15

A bullet moves east at a velocity of 480 m·s^{-1}. It hits a wooden block that is fixed to the floor. The bullet takes 0,01 s to move through the stationary block and emerges from the block at a velocity of 80 m·s^{-1} east.
See the diagram below. Ignore the effects of air resistance. Consider the block-bullet system as an isolated system.



15.1 Explain what is meant by an *isolated system* as used in Physics. (2)

The magnitude of the momentum of the bullet before it enters the block is 24 kg·m·s^{-1}.

15.2 Calcualte the:

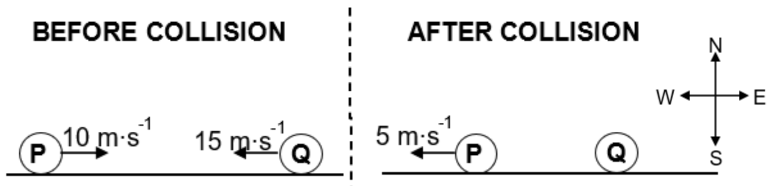
15.2.1 Mass of the bullet (3)

15.2.2 Average net force exerted by the wooden block on the bullet (5)

[10]

QUESTION 16

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



16.1 Define the term *momentum* in words. (2)

16.2 Calculate the:

16.2.1 Velocity of ball **Q** after the collision (5)

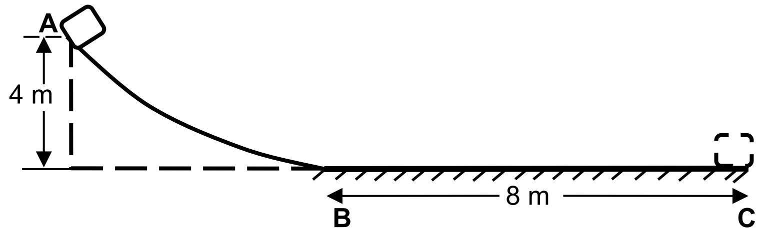
16.2.2 Magnitude of the impulse on ball **P** during the collision (3)

[10]

WORK, ENERGY AND POWER

QUESTION 1

1.1 The diagram below shows a track, **ABC**. The curved section, **AB**, is frictionless. The rough horizontal section, **BC**, is 8 m long.



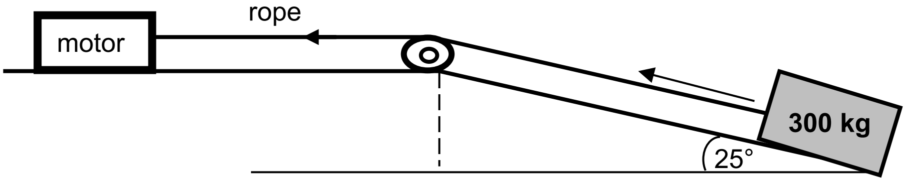
An object of mass 10 kg is released from point **A** which is 4 m above the ground. It slides down the track and comes to rest at point **C**.

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

1.1.2 Is mechanical energy conserved as the object slides from **A** to **C**? Write YES or NO. (1)

1.1.3 Using ENERGY PRINCIPLES only, calculate the magnitude of the frictional force exerted on the object as it moves along **BC**. (6)

1.2 A motor pulls a crate of mass 300 kg with a constant force by means of a light inextensible rope running over a light frictionless pulley as shown below. The coefficient of kinetic friction between the crate and the surface of the plane is 0,19.



1.2.1 Calculate the magnitude of the frictional force acting between the crate and the surface of the inclined plane. (3)

The crate moves up the incline at a constant speed of 0,5 m·s^{-1}.

1.2.2 Calculate the average power delivered by the motor while pulling the crate up the incline. (6)

[18]

QUESTION 2

A 5 kg block is released from rest from a height of 5 m and slides down a frictionless incline to **P** as shown below. It then moves along a frictionless horizontal portion **PQ** and finally moves up a second rough inclined plane. It comes to a stop 3 m above the horizontal at point **R**.

The frictional force, a non-conservative force, between the surface and the block is 18 N.

2.1 Using ENERGY PRINCIPLES only, calculate the speed of the block at point P. (4)

2.2 Explain why the kinetic energy at point **P** is the same as that at point Q. (2)

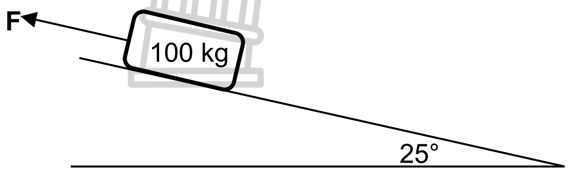
2.3 Explain the term non-conservative force. (2)

2.4 Calculate the angle (θ) of the slope **QR**. (7)

[15]

QUESTION 3

The diagram below shows a heavy block of mass 100 kg sliding **down** a rough 25° inclined plane. A constant force **F** is applied on the block parallel to the inclined plane as shown in the diagram below, so that the block slides down at a **constant velocity**. The magnitude of the kinetic frictional force (f_k) between the block and the surface of the inclined plane is 266 N.



3.1 Friction is a non-conservative force. What is meant by the term non- conservative force? (2)

3.2 A learner states that the net work done on the block is greater than zero.

3.2.1 Is the learner correct? Answer only YES or NO. (1)

3.2.2 Explain the answer to QUESTION 3.2.1 using physics principles. (2)

3.3 Calculate the magnitude of the force **F**. (4)

If the block is released from rest without the force **F** being applied, it moves 3 m down the inclined plane.

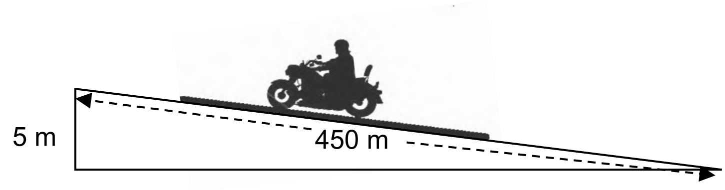
3.4 Calculate the speed of the block at the bottom of the inclined plane. (6)

[15]

QUESTION 4

The track for a motorbike race consists of a straight, horizontal section that is 800 m long. A participant, such as the one in the picture, rides at a certain average speed and completes the 800 m course in 75 s. To maintain this speed, a constant driving force of 240 N acts on the motorbike.

4.1 Calculate the average power developed by the motorbike for this motion. (3)

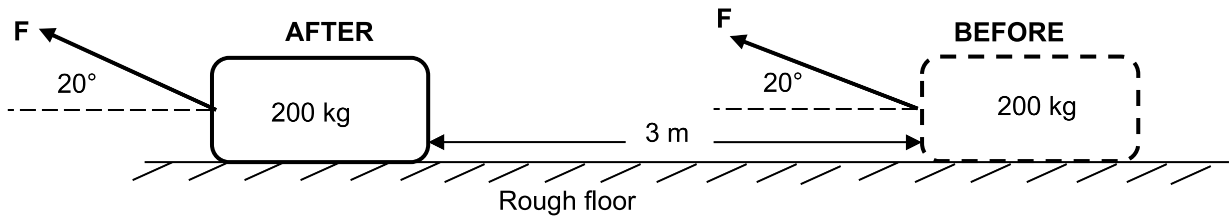


Another person practises on the same motorbike on a track with an incline. Starting from rest, the person rides a distance of 450 m up the incline which has a vertical height of 5 m, as shown. The total frictional force acting on the motorbike is 294 N. The combined mass of rider and motorbike is 300 kg. The average driving force on the motorbike as it moves up the incline is 350 N. Consider the motorbike and rider as a single system.

4.2 Draw a labelled free-body diagram for the motorbike-rider system on the incline. (4)
4.3 State the WORK-ENERGY theorem in words. (2)
4.4 Use energy principles to calculate the speed of the motorbike at the end of the 450 m ride. (6)
[15]

QUESTION 5

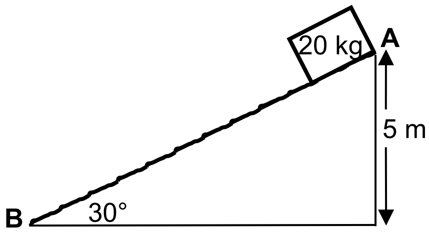
A constant force **F**, applied at an angle of 20° above the horizontal, pulls a 200 kg block, over a distance of 3 m, on a rough, horizontal floor as shown in the diagram below.



The coefficient of kinetic friction, μ_k, between the floor surface and the block is 0,2.

5.1 Give a reason why the coefficient of kinetic friction has no units. (1)
5.2 State the work-energy theorem in words. (2)
5.3 Draw a free-body diagram indicating ALL the forces acting on the block while it is being pulled. (4)
5.4 Show that the work done by the kinetic frictional force (W_{fk}) on the block can be written as W_{fk} = (-1 176 + 0,205 **F**) J. (4)
5.5 Calculate the magnitude of the force **F** that has to be applied so that the net work done by all forces on the block is zero. (4)
[15]

QUESTION 6



A 20 kg block is released from rest from the top of a ramp at point **A** at a construction site as shown in the diagram. The ramp is inclined at an angle of 30° to the horizontal and its top is at a height of 5 m above the ground.

6.1 State the principle of conservation of mechanical energy in words. (2)

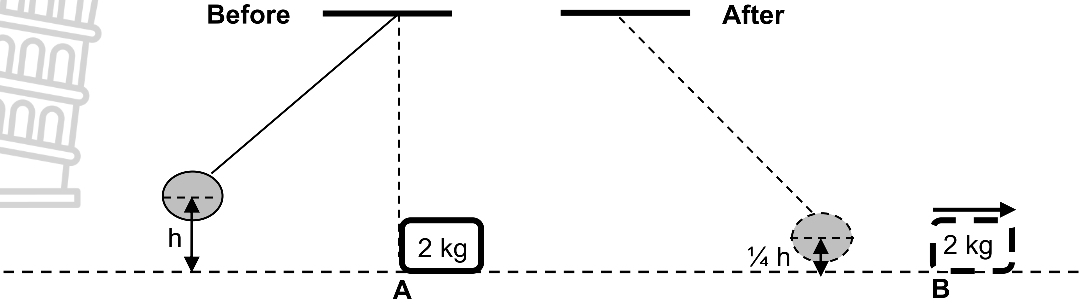
6.2 The kinetic frictional force between the 20 kg block and the surface of the ramp is 30 N. Use energy principles to calculate the:

6.2.1 Work done by the kinetic frictional force on the block (3)
6.2.2 Speed of the block at point **B** at the bottom of the ramp (5)

6.3 A 100 kg object is pulled up the SAME RAMP at a constant speed of 2 $m \cdot s^{-1}$ by a small motor. The kinetic frictional force between the 100 kg object and the surface of the ramp is 25 N. Calculate the average power delivered by the small motor in the pulling of the object up the incline. (4)
[14]

QUESTION 7

A pendulum with a bob of mass 5 kg is held stationary at a height h metres above the ground. When released, it collides with a block of mass 2 kg which is stationary at point **A**. The bob swings past **A** and comes to rest momentarily at a position ¼ h above the ground.he diagrams below are NOT drawn to scale.

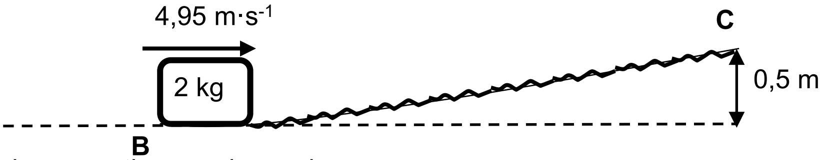


Immediately after the collision the 2 kg block begins to move from **A** to **B** at a constant speed of 4,95 m·s^{-1}. Ignore frictional effects and assume that no loss of mechanical energy occurs during the collision.

7.1 Calculate the kinetic energy of the block immediately after the collision. (3)

7.2 Calculate the height *h* (4)

The block moves from point **B** at a velocity of 4,95 m·s^{-1} up a rough inclined plane to point **C**. The speed of the block at point **C** is 2 m·s^{-1}. Point **C** is 0,5 m above the horizontal, as shown in the diagram below. During its motion from **B** to **C** a uniform frictional force acts on the block.



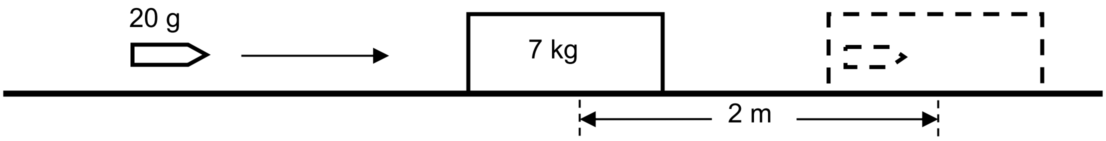
7.3 State the work-energy theorem in words. (2)

7.4 Use energy principles to calculate the work done by the frictional force when the 2 kg block moves from point **B** to point **C**. (4)

[13]

QUESTION 8

The diagram below shows a bullet of mass 20 g that is travelling horizontally. The bullet strikes a stationary 7 kg block and becomes embedded in it. The bullet and block together travel on a rough horizontal surface a distance of 2 m before coming to a stop.



8.1 Use the work-energy theorem to calculate the magnitude of the velocity of the bullet-block system immediately after the bullet strikes the block, given that the frictional force between the block and surface is 10 N. (5)

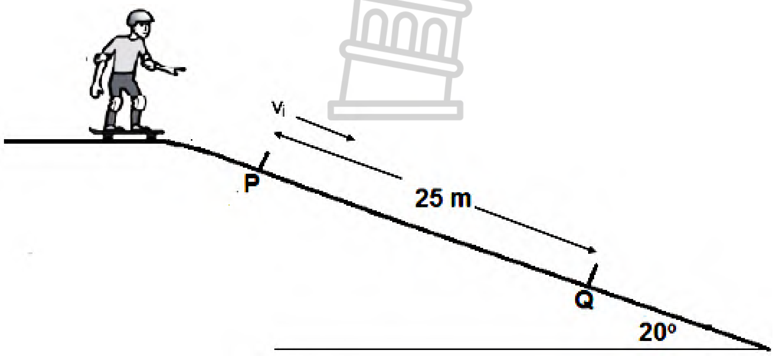
8.2 State the principle of conservation of linear momentum in words. (2)

8.3 Calculate the magnitude of the velocity with which the bullet hits the block. (4)

[11]

QUESTION 9

The diagram below shows a boy skateboarding on a ramp which is inclined at 20° to the horizontal. A constant frictional force of 50 N acts on the skateboard as it moves from **P** to **Q**. Consider the boy and the skateboard as a single unit of mass 60 kg. Ignore the effects of air friction.



9.1 Draw a labelled free-body diagram, showing ALL the forces acting on the boy-skateboard unit while moving down the ramp from **P** to **Q**. (3)

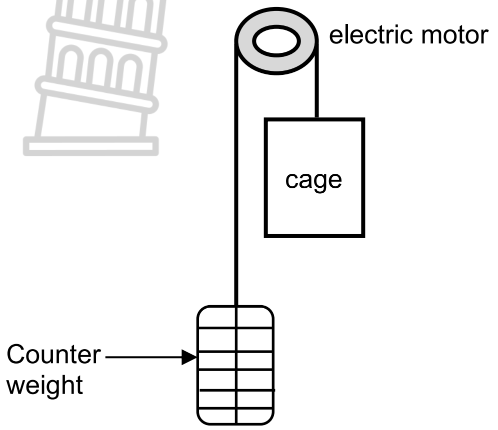
Points **P** and **Q** on the ramp are 25 m apart. The skateboarder passes point **P** at a speed v_i and passes point **Q** at a speed of 15 m·s^{-1}. Ignore rotational effects due to the wheels of the skateboard.

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

9.3 Use energy principles to calculate the speed vi of the skateboarder at point **P**. (5)
9.3 Calculate the average power dissipated by the skateboarder to overcome friction between **P** and **Q**. (4)
[14]

QUESTION 10

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.

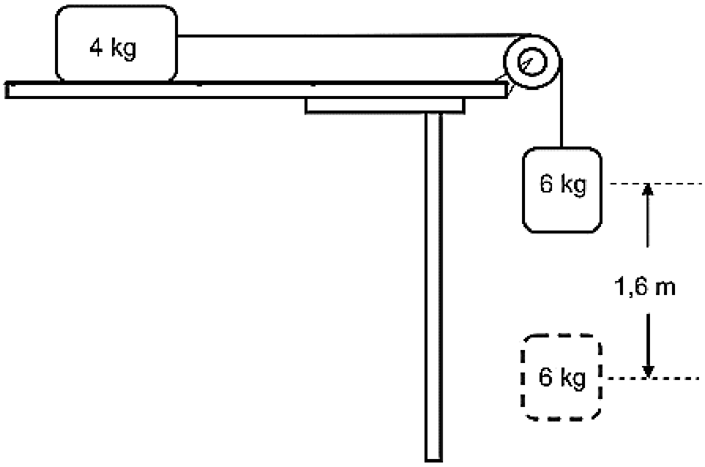


The cage, carrying passengers, moves vertically upwards at a constant speed, covering 55 m in 3 minutes. The counterweight has a mass of 950 kg. The total mass of the cage and passengers is 1 200 kg.

The electric motor provides the power needed to operate the lift system. Ignore the effects of friction.

10.1 Define the term *power* in words. (2)
10.2 Calculate the work done by the:
10.2.1 Gravitational force on the cage (3)
10.2.2 Counterweight on the cage (2)
10.3 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]

QUESTION 11



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.

11.1 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.

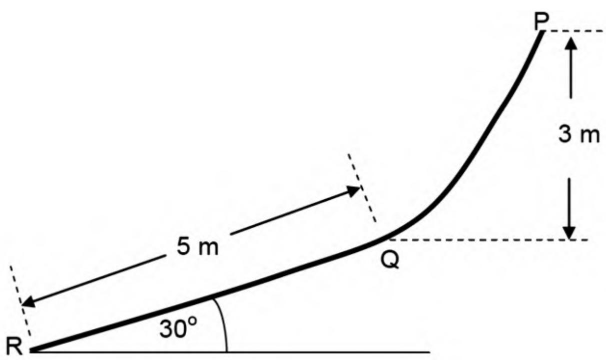
11.2 Draw a labelled free-body diagram for the 6 kg block. (2)
11.3 Calculate the work done by the gravitational force on the 6 kg block. (3)

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

11.4 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 12

A slide, **PQR**, at an amusement park consists of a curved *frictionless* section, **PQ**, and a section, **QR**, which is rough, straight and inclined at 30° to the horizontal. The starting point, **P**, is 3 m above point **Q**. The straight section, **QR**, is 5 m long.



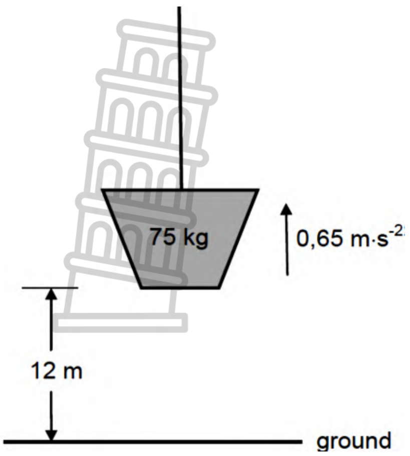
A learner, with mass 50 kg, starting from rest at **P**, slides down section **PQ**, then continues down the straight section, **QR**.

12.1 State the *law of conservation of mechanical energy* in words. (2)
12.2 Calculate the speed of the learner at **Q**. (4)
12.3 Draw a labelled free-body diagram for the learner while he/she is on section **QR**. (3)

The coefficient of kinetic friction (μ_k) between the learner and the surface **QR** is 0,08.

12.4 Calculate the magnitude of the kinetic frictional force acting on the learner when the learner is on section **QR**. (3)
12.5 Use energy principles to calculate the speed of the learner at point **R**. (5)
[17]

QUESTION 13



A load of mass 75 kg is initially at rest on the ground. It is then pulled vertically upwards at a constant acceleration of 0,65 m·s^{-2} by means of a light inextensible rope. Refer to the diagram below. Ignore air resistance, rotational effects and the mass of the rope.

13.1 Draw a labelled free-body diagram for the load while it moves upward. (2)
13.2 Name the non-conservative force acting on the load. (1)
13.3 Calculate the work done on the load by the gravitational force when the load has reached a height of 12 m. (3)
13.4 State the *work-energy theorem* in words. (2)
13.5 Use the work-energy theorem to calculate the speed of the load when it is at a height of 12 m. (5)
[13]

QUESTION 14

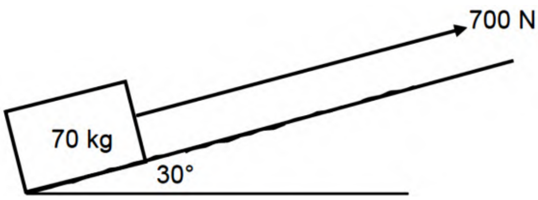
The diagram, not drawn to scale, shows a vehicle with a mass of 1 500 kg starting from rest at point **A** at the bottom of a rough incline. Point **B** is 200 m vertically above the horizontal. The total work done by force **F** that moves the vehicle from point **A** to point **B** in 90 s is 4,80 x 10^6 J.

14.1 Define the term non-conservative force. (2)
14.2 Is force **F** a conservative force? Choose from: YES or NO. (1)
14.3 Calculate the average power generated by force **F**. (3)

The speed of the vehicle when it reaches point **B** is 25 m·s^{-1}.
14.4 State the *work-energy theorem* in words. (2)
14.5 Use **energy principles** to calculate the total work done on the vehicle by the frictional forces. (5)
[13]

QUESTION 15

A 70 kg box is initially at rest at the bottom of a ROUGH plane inclined at an angle of 30° to the horizontal. The box is pulled up the plane by means of a light inextensible rope, held parallel to the plane, as shown in the diagram below. The force applied to the rope is 700 N.



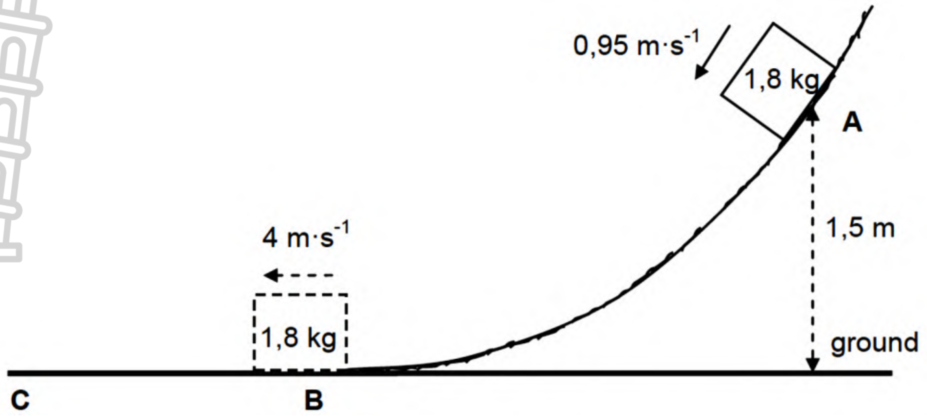
15.1 What is the name given to the force in the rope? (1)
15.2 Give a reason why the mechanical energy of the system will NOT be conserved as the box is pulled up the plane. (1)

The box is pulled up over a distance of 4 m along the plane. The kinetic frictional force between the box and the plane is 178,22 N.

15.3 Draw a labelled free-body diagram for the box as it moves up the plane. (4)
15.4 Calculate the work done on the box by the frictional force over the 4 m. (3)
15.5 Use energy principles to calculate the speed of the box after it has moved 4 m. (5)
15.6 When the box is 4 m up the incline, the rope accidentally breaks, causing the box to slide back down to the bottom of the inclined plane. What will be the total work done by friction when the box moves up and then down to the bottom of the inclined plane? (1)
[15]

QUESTION 16

An object of mass 1,8 kg slides down a rough curved track and passes point **A**, which is 1,5 m above the ground, at a speed of 0,95 m·s^{-1}. The object reaches point **B** at the bottom of the track at a speed of 4 m·s^{-1}.



16.1 Define the term *conservative force*. (2)

16.2 Name the conservative force acting on the object. (1)

16.3 Is mechanical energy conserved as the object slides from point **A** to point **B**? Choose from YES or NO. Give a reason for the answer. (2)

16.4 Calculate the gravitational potential energy of the object when it was at point **A.** (3)

16.5 Using energy principles, calculate the work done by friction on the object as it slides from point **A** to point **B**. (4)

Surface **BC** in the diagram above is frictionless.

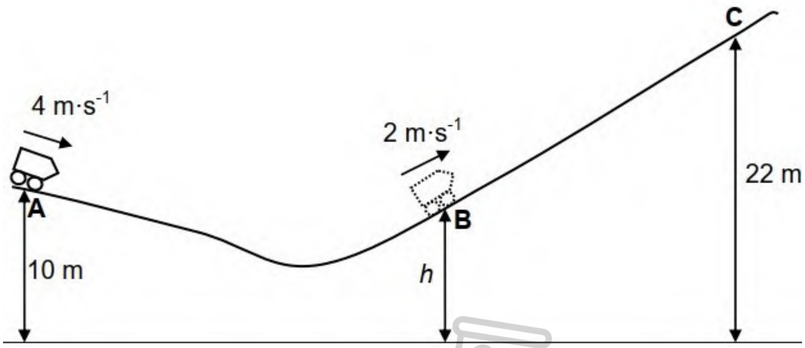
16.6 What is the value of the net work done on the object as it slides from point **B** to point **C**? (1)

[13]

QUESTION 17

A roller-coaster car of mass 200 kg, with the engine switched off, travels along track **ABC**, which has a rough surface, as shown in the diagram. At point **A**, which is 10 m above the ground, the speed of the car is 4 m·s^{-1}.

At point **B**, which is at a height h above the ground, the speed of the car is 2 m·s^{-1}. During the motion from point **A** to point **B**, 3,40 × 10^3 J of energy is used to overcome friction. Ignore rotational effects due to the wheels of the car.



17.1 Define the term *non-conservative force*. (2)

17.2 Calculate the change in the kinetic energy of the car after it has travelled from point **A** to point **B**. (3)

17.3 Use energy principles to calculate the height h. (4)

17.4 On reaching point **B**, the car's engine is switched on in order to move up the incline to point **C**, which is 22 m above the ground. While moving from point **B** to point **C**, the car travels for 15 s at a constant speed of 2 m·s^{-1} while an average frictional force of 50 N acts on it. Calculate the power delivered by the engine to move the car from point **B** to point **C**. (5)

[14]

DOPPLER EFFECT

QUESTION 1

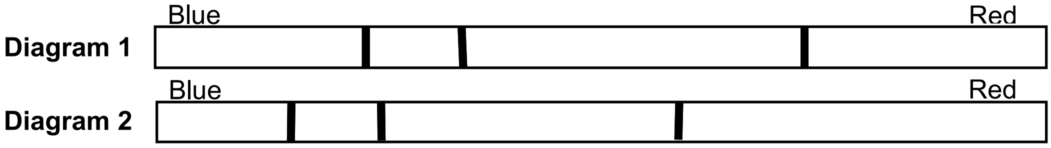
1.1 The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.

1.1.1 State the *Doppler effect* in words. (2)

1.1.2 Is the ambulance moving towards or away from the observer? Give a reason. (2)

1.1.3 Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as 343 $m \cdot s^{-1}$. (5)

1.2 A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars. The two diagrams below represent different spectral lines of an element. Diagram **1** represents the spectrum of the element in a laboratory on Earth. Diagram **2** represents the spectrum of the same element from a distant star.



Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above. (2)

[11]

QUESTION 2

The Doppler effect is applicable to both sound and light waves. It also has very important applications in our everyday lives.

2.1 A hooter on a stationary train emits sound with a frequency of 520 Hz, as detected by a person standing on the platform. Assume that the speed of sound is 340 $m \cdot s^{-1}$ in still air. Calculate the:

2.1.1 Wavelength of the sound detected by the person (2)

2.1.2 Wavelength of the sound detected by the person when the train moves towards him/her at a constant speed of 15 $m \cdot s^{-1}$ with the hooter still emitting sound (6)

2.2 Explain why the wavelength calculated in QUESTION 2.1.1 differs from that obtained in QUESTION 2.1.2. (2)

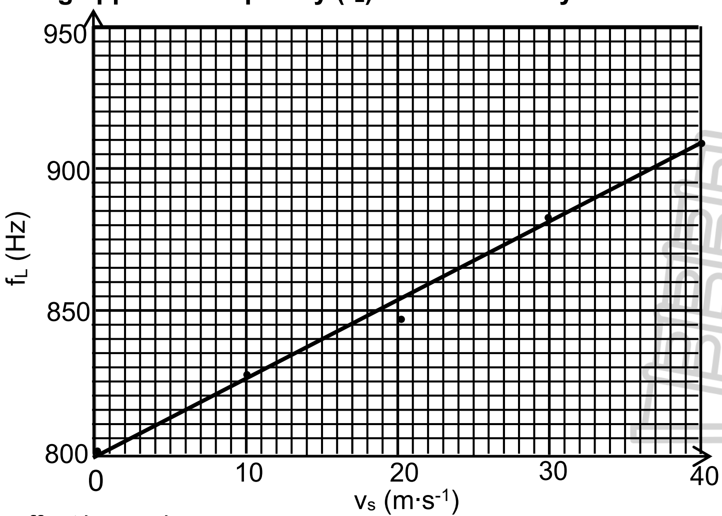
2.3 Use your knowledge of the Doppler effect to explain red shifts. (2)

[12]

QUESTION 3

The graph below shows the relationship between the apparent frequency (f_L) of the sound heard by a STATIONARY listener and the velocity (v_s) of the source travelling TOWARDS the listener.

Graph showing apparent frequency (f_L) versus velocity of sound source (v_s)



3.1 State the *Doppler effect* in words. (2)

3.2 Use the information in the graph to calculate the speed of sound in air. (5)

3.3 Sketch a graph of apparent frequency (f_L) versus velocity (v_s) of the sound source if the source was moving AWAY from the listener. It is not necessary to use numerical values for the graph. (2)

[9]

QUESTION 4

4.1 The data below was obtained during an investigation into the relationship between the different velocities of a moving sound source and the frequencies detected by a stationary listener for **each** velocity. The effect of wind was ignored in this investigation.

Experiment number	1	2	3	4
Velocity of the sound source ($m \cdot s^{-1}$)	0	10	20	30
Frequency (Hz) of the sound detected by the stationary listener	900	874	850	827

4.1.1 Write down the dependent variable for this investigation. (1)

4.1.2 State the Doppler effect in words. (2)

4.1.3 Was the sound source moving TOWARDS or AWAY FROM the listener? Give a reason for the answer. (2)

4.1.4 Use the information in the table to calculate the speed of sound during the investigation. (5)

4.2 The spectral lines of a distant star are shifted towards the longer wavelengths of light. Is the star moving TOWARDS or AWAY FROM the Earth? (1)

[11]

QUESTION 5

Reflection of sound waves enables bats to hunt for moths. The sound wave produced by a bat has a frequency of 222 kHz and a wavelength of $1,5 \times 10^{-3}$ m.

5.1 Calculate the speed of this sound wave through the air. (3)

5.2 A stationary bat sends out a sound signal and receives the same signal reflected from a moving moth at a frequency of 230,3 kHz.

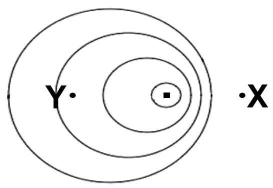
5.2.1 Is the moth moving TOWARDS or AWAY FROM the bat? (1)

5.2.2 Calculate the magnitude of the velocity of the moth, assuming that the velocity is constant. (6)

[10]

QUESTION 6

An ambulance is travelling towards a hospital at a constant velocity of 30 $m \cdot s^{-1}$. The siren of the ambulance produces sound of frequency 400 Hz. Take the speed of sound in air as 340 $m \cdot s^{-1}$. The diagram shows the wave fronts of the sound produced from the siren as a result of this motion.



6.1 At which side of the diagram, **X** or **Y**, is the hospital situated? (1)

6.2 Explain the answer to QUESTION 6.1. (3)

6.3 Calculate the frequency of the sound of the siren heard by a person standing at the hospital. (5)

6.4 A nurse is sitting next to the driver in the passenger seat of the ambulance as it approaches the hospital. Calculate the wavelength of the sound heard by the nurse. (3)

[12]

QUESTION 7

7.1 An ambulance is moving towards a stationary listener at a constant speed of 30 $m \cdot s^{-1}$. The siren of the ambulance emits sound waves having a wavelength of 0,28 m. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

7.1.1 State the *Doppler effect* in words. (2)

7.1.2 Calculate the frequency of the sound waves emitted by the siren as heard by the ambulance driver. (3)

7.1.3 Calculate the frequency of the sound waves emitted by the siren as heard by the listener. (5)

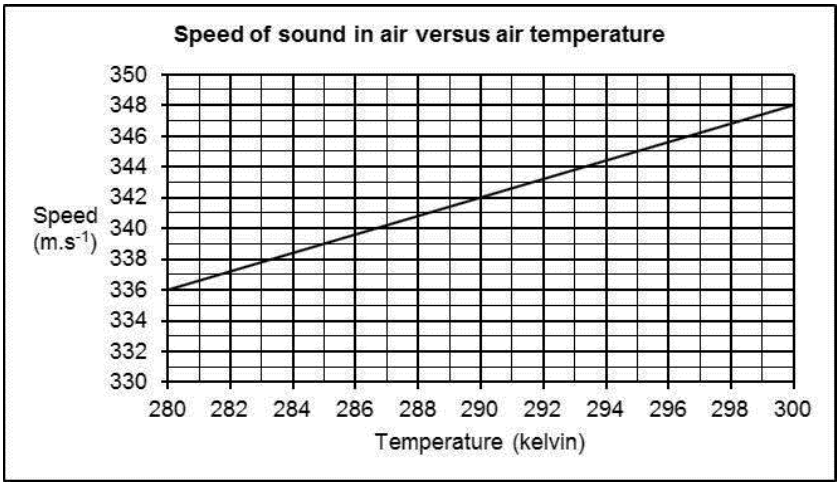
7.1.4 How would the answer to QUESTION 7.1.3 change if the speed of the ambulance were LESS THAN 30 $m \cdot s^{-1}$? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

7.2 An observation of the spectrum of a distant star shows that it is moving away from the earth. Explain, in terms of the frequencies of the spectral lines, how it is possible to conclude that the star is moving away from the earth. (2)

[13]

QUESTION 8

The speed of sound in air depends among others on the air temperature. The following graph shows this relationship.



8.1 Which one of temperature or speed is the dependent variable? (1)

8.2 The gradient of this graph is equal to 0,6 $m \cdot s^{-1} \cdot K^{-1}$. With how much does the speed, in $m \cdot s^{-1}$, increase for every 5 K increase in temperature? (1)

8.3 Two experiments are done to verify the Doppler effect. In the first experiment, an object approaches a stationary observer **X** at a constant speed of 57,5 $m \cdot s^{-1}$. The object is equipped with a siren that emits sound waves at a fixed frequency of 1 000 Hz. The motion takes place in still air at a temperature of 295 K.

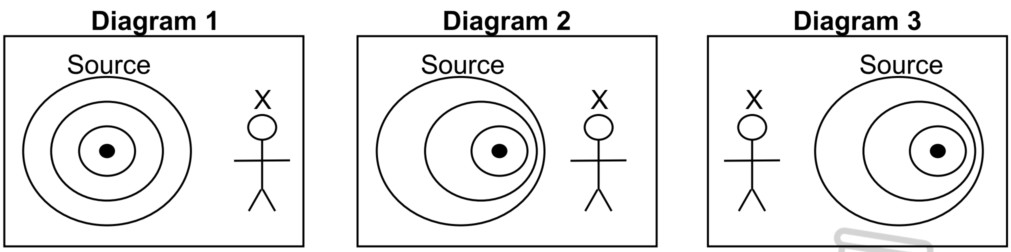
8.3.1 Describe what the Doppler effect is. (2)

8.3.2 What is the speed of sound, in $m \cdot s^{-1}$, in air at 295 K? (Use the graph.) (1)

8.3.3 Calculate the frequency measured by observer **X**. (4)

8.3.4 In the second experiment, the object moves away from observer **X** at the same constant speed as before. What should the air temperature, in kelvin, be to make it a fair test between the two experiments? (1)

8.4 Consider the three diagrams below. Each one represents the source (with the siren) and observer **X**. Two of the diagrams are applicable on the above-mentioned experiments.



8.4.1 Which diagram is applicable to experiment **2**? (1)

8.4.2 Which diagram is NOT applicable to any of the experiments? Give a reason for your answer. (2)

[13]

QUESTION 9

9.1 A police car is moving at constant velocity on a freeway. The siren of the car emits sound waves with a frequency of 330 Hz. A stationary sound detector measures the frequency of the sound waves of the approaching siren as 365 Hz.

9.1.1 State the Doppler Effect in words. (2)

9.1.2 Calculate the speed of the car. (Speed of sound in air is 340 $m \cdot s^{-1}$.) (5)

9.2 The spectrum of a distant star when viewed from an observatory on Earth appears to have undergone a red shift. Explain the term red shift. (3)

[10]

QUESTION 10

10.1 A sound source is moving at constant velocity past a stationary observer. The frequency detected as the source approaches the observer is 2 600 Hz. The frequency detected as the source moves away from the observer is 1 750 Hz. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

10.1.1 Name the phenomenon that describes the apparent change in frequency detected by the observer. (1)

10.1.2 State ONE practical application of the phenomenon in QUESTION 10.1.1 in the field of medicine. (1)

10.1.3 Calculate the speed of the moving source. (6)

10.1.4 Will the observed frequency INCREASE, DECREASE or REMAIN THE SAME if the velocity of the source increased as it:

(a) Moves towards the observer (1)

(b) Moves away from the observer (1)

10.2 Spectral lines of star **X** at an observatory are observed to be red shifted.

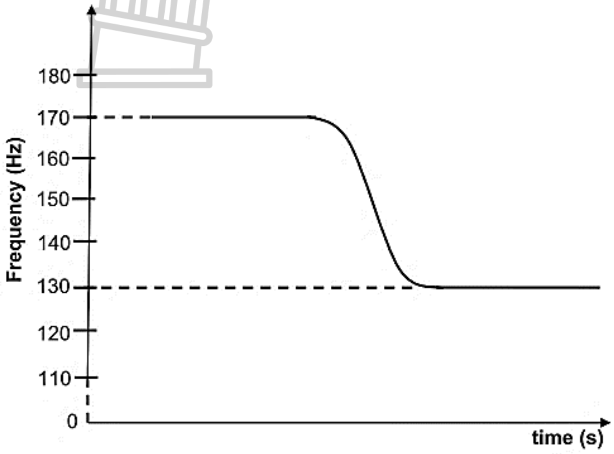
10.2.1 Explain the term *red shifted* in terms of wavelength. (2)

10.2.2 Will the frequency of the light observed from the star INCREASE, DECREASE or REMAIN THE SAME? (1)

[13]

QUESTION 11

A police car moving at a constant velocity with its siren on, passes a stationary listener. The graph shows the changes in the frequency of the sound of the siren detected by the listener.



11.1 State the *Doppler Effect* in words. (2)

11.2 Write down the frequency of the sound detected by the listener as the police car:

11.2.1 Approaches the listener (1)

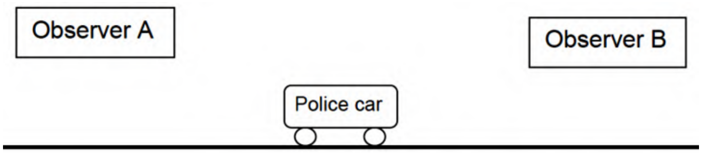
11.2.2 Moves away from the listener (1)

11.3 Calculate the speed of the police car. Take the speed of sound in air to be 340 $m \cdot s^{-1}$. (6)

[10]

QUESTION 12

A police car is moving at a constant speed on a straight horizontal road. The siren of the car emits sound of constant frequency. EACH of two observers, **A** and **B**, standing some distance apart on the same side of the road, records the frequency of the detected sound. Observer **A** records a frequency of 690 Hz and observer **B** records a frequency of 610 Hz.



12.1 State the *Doppler effect* in words. (2)

12.2 In which direction is the car moving? Choose from TOWARDS A or AWAY FROM A. Give a reason for the answer. (2)

12.3 Determine the speed of the police car. Take the speed of sound in air as 340 m·s-1. (6)

12.4 Name ONE application of the Doppler effect. (1)

[11]

QUESTION 13

A sound source, moving at a constant speed of 240 $m \cdot s^{-1}$ towards a detector, emits sound at a constant frequency. The detector records a frequency of 5 100 Hz. Take the speed of sound in air to be 340 $m \cdot s^{-1}$.

13.1 State the *Doppler effect* in words. (2)

13.2 Calculate the wavelength of the sound emitted by the source. (7)

Some of the sound waves are reflected from the detector towards the approaching source.

13.3 Will the frequency of the reflected sound wave detected by the sound source be EQUAL TO, GREATER THAN or SMALLER THAN 5 100 Hz? (1)

[10]

QUESTION 14

The alarm of a vehicle parked next to a straight horizontal road goes off, emitting sound with a wavelength of 0,34 m. A patrol car is moving at a constant speed on the same road. The driver of the patrol car hears a sound with a frequency of 50 Hz lower than the sound emitted by the alarm.
Take the speed of sound in air as 340 $m \cdot s^{-1}$.

14.1 State the *Doppler effect* in words. (2)

14.2 Is the patrol car driving TOWARDS or AWAY FROM the parked vehicle? Give a reason for the answer. (2)

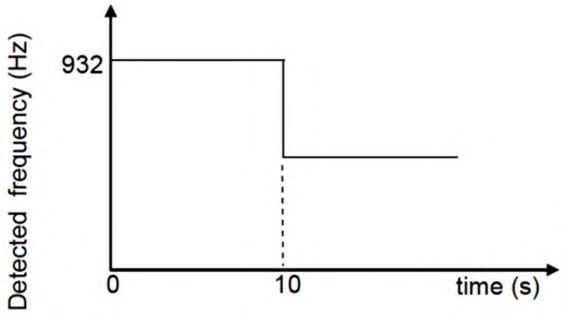
14.3 Calculate the frequency of the sound emitted by the alarm. (3)

14.4 The patrol car moves a distance of x metres in 10 seconds. Calculate the distance x. (6)

[13]

QUESTION 15

15.1 A patrol car is moving at a constant speed towards a stationary observer. The driver switches on the siren of the car when it is 300 m away from the observer.
The observer records the detected frequency of the sound waves of the siren as the patrol car *approaches*, *passes* and *moves away* from him. The information obtained is shown in the graph.

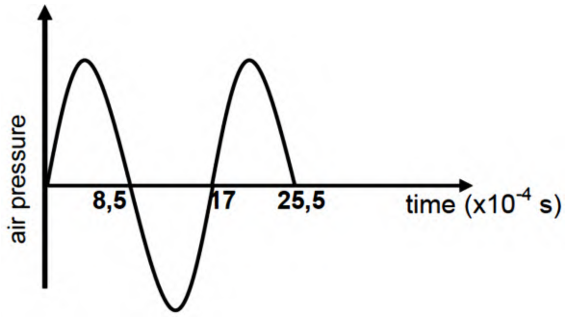


15.1.1 Calculate the speed of the patrol car. (2)
15.1.2 State the *Doppler effect*. (2)
15.1.3 The detected frequency suddenly changes at t = 10 s. Give a reason for this change. (2)
Take the speed of sound in air as 340 m·s^{-1}.
15.1.4 Calculate the frequency of the sound emitted by the siren. (4)
15.2 State TWO applications of the Doppler effect. (2)
[12]

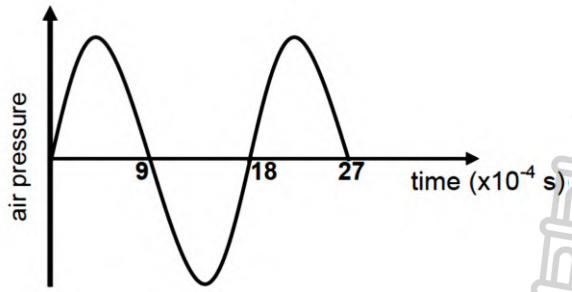
QUESTION 16

The siren of a police car, which is travelling at a constant speed along a straight horizontal road, emits sound waves of constant frequency. Detector **P** is placed inside the police car and detector **Q** is placed next to the road at a certain distance away from the car. The two detectors record the changes in the air pressure readings caused by the sound waves emitted by the siren as a function of time.
The graphs below were obtained from the recorded results.

GRAPH A: AIR PRESSURE VS TIME RECORDED BY DETECTOR P IN THE CAR



GRAPH B: AIR PRESSURE VS TIME RECORDED BY DETECTOR Q NEXT TO THE ROAD



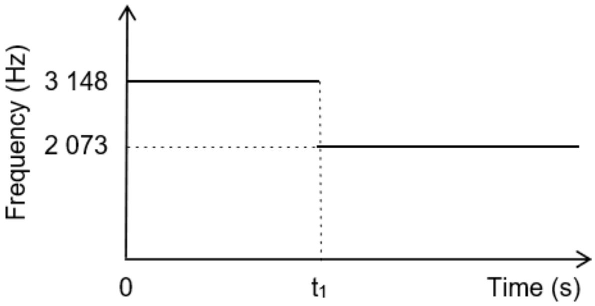
16.1 Different patterns are shown above for the same sound wave emitted by the siren. What phenomenon is illustrated by the two detectors showing the different patterns? (1)

The police car is moving AWAY from detector **Q**.

16.2 Use the graphs and give a reason why it can be confirmed that the police car is moving away from detector **Q**. (1)
16.3 Calculate the frequency of the sound waves recorded by detector **P**. (3)
16.4 Use the information in the graphs to calculate the speed of the police car. Take the speed of sound in air as 340 m·s^{-1}. (6)
[11]

QUESTION 17

The siren of a train, moving at a constant speed along a straight horizontal track, emits sound with a constant frequency. A detector, placed next to the track, records the frequency of the sound waves. The results obtained are as shown in the graph.



17.1 State the Doppler effect in words. (2)

17.2 Does the detector record the frequency of 3 148 Hz when the train moves TOWARDS the detector or AWAY from the detector? (1)

17.3 Calculate the speed of the train. Take the speed of sound in air as 340 $m \cdot s^{-1}$. (6)

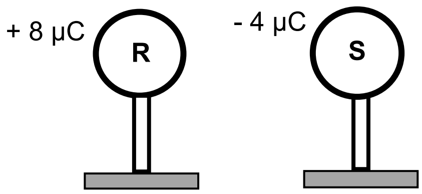
17.4 The detector started recording the frequency of the moving train's siren when the train was 350 m away. Calculate time t_1 indicated on the graph above. (2)

[11]

ELECTROSTATICS

QUESTION 1

The diagram shows two small identical metal spheres, **R** and **S**, each placed on a wooden stand. Spheres **R** and **S** carry charges of + 8 μC and - 4 μC respectively. Ignore the effects of air.



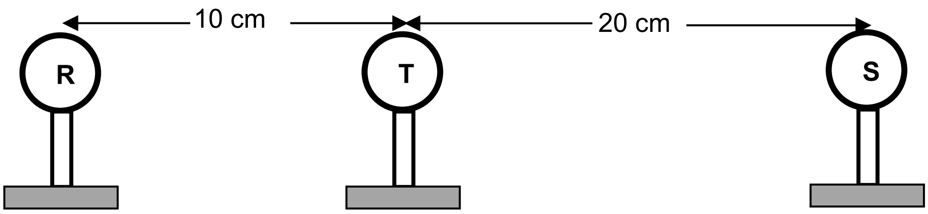
1.1 Explain why the spheres were placed on wooden stands. (1)

Spheres **R** and **S** are brought into contact for a while and then separated by a small distance.

1.2 Calculate the net charge on each of the spheres. (2)

1.3 Draw the electric field pattern due to the two spheres **R** and **S**. (3)

After **R** and **S** have been in contact and separated, a third sphere, **T**, of charge + 1 μC is now placed between them as shown in the diagram below.



1.4 Draw a free-body diagram showing the electrostatic forces experienced by sphere **T** due to spheres **R** and **S**. (2)

1.5 Calculate the net electrostatic force experienced by **T** due to **R** and **S**. (6)

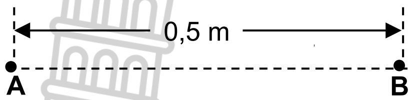
1.6 Define the *electric field at a point*. (2)

1.7 Calculate the magnitude of the net electric field at the location of **T** due to **R** and **S**. (Treat the spheres as if they were point charges.) (3)

[19]

QUESTION 2

Two identical negatively charged spheres, **A** and **B**, having charges of the **same magnitude**, are placed 0,5 m apart in vacuum. The magnitude of the electrostatic force that one sphere exerts on the other is 1,44 x 10^{-1} N.



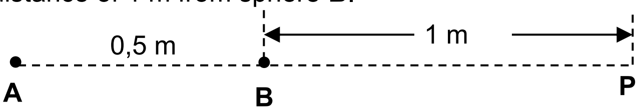
2.1 State *Coulomb's law* in words. (2)

2.2 Calculate the:

2.2.1 Magnitude of the charge on each sphere (4)

2.2.2 Excess number of electrons on sphere **B** (3)

2.3 **P** is a point at a distance of 1 m from sphere **B**.



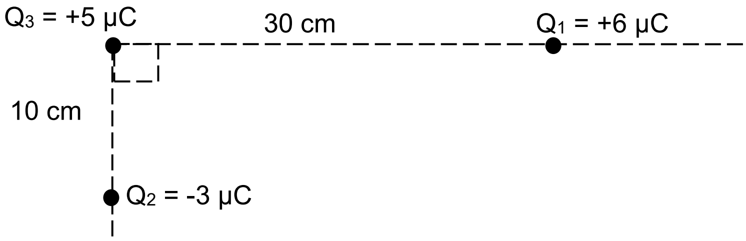
2.3.1 What is the direction of the net electric field at point **P**? (1)

2.3.2 Calculate the number of electrons that should be removed from sphere **B** so that the net electric field at point **P** is 3 x 10^4 $N \cdot C^{-1}$ to the right. (8)

[18]

QUESTION 3

Three point charges, Q_1, Q_2 and Q_3, carrying charges of +6 μC, -3 μC and +5 μC respectively, are arranged in space as shown in the diagram below. The distance between Q_3 and Q_1 is 30 cm and that between Q_3 and Q_2 is 10 cm.



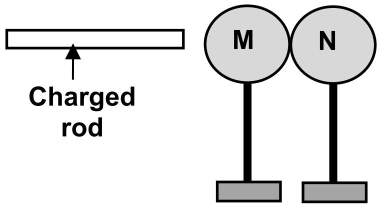
3.1 State *Coulomb's law* in words. (2)

3.2 Calculate the net force acting <u>on charge Q_3</u> due to the presence of Q_1 and Q_2. (7)

[9]

QUESTION 4

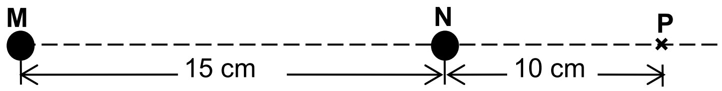
Two identical neutral spheres, **M** and **N**, are placed on insulating stands. They are brought into contact and a charged rod is brought near sphere **M**. When the spheres are separated it is found that 5 x 10^6 electrons were transferred from sphere **M** to sphere **N**.



4.1 What is the net charge on sphere **N** after separation? (3)

4.2 Write down the net charge on sphere **M** after separation. (2)

The charged spheres, **M** and **N**, are now arranged along a straight line, in space, such that the distance between their centres is 15 cm. A point **P** lies 10 cm to the right of **N** as shown in the diagram below.

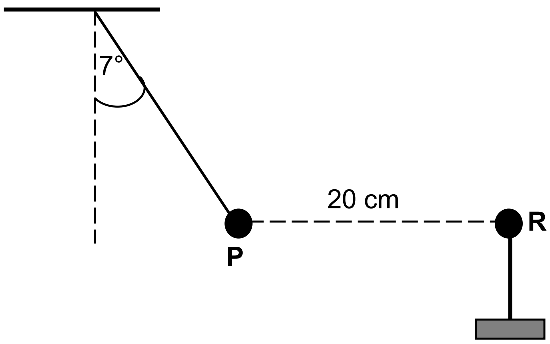


4.3 Define the *electric field* at a point. (2)

4.4 Calculate the net electric field at point **P** due to **M** and **N**. (6)

[13]

QUESTION 5



A very small graphite-coated sphere **P** is rubbed with a cloth. It is found that the sphere acquires a charge of + 0,5 μC.

5.1 Calculate the number of electrons removed from sphere **P** during the charging process. (3)

Now the charged sphere **P** is suspended from a light, inextensible string. Another sphere, **R**, with a charge of – 0,9 μC, on an insulated stand, is brought close to sphere **P**. As a result sphere **P** moves to a position where it is 20 cm from sphere **R**, as shown. The system is in equilibrium and the angle between the string and the vertical is 7°.

5.2 Draw a labelled free-body diagram showing ALL the forces acting on sphere **P**. (3)

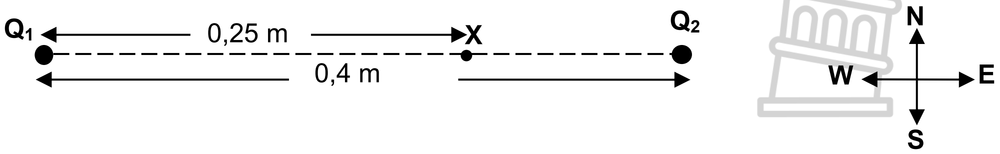
5.3 State Coulomb's law in words. (2)

5.4 Calculate the magnitude of the tension in the string. (5)

[13]

QUESTION 6

Two charged particles, Q_1 and Q_2, are placed 0,4 m apart along a straight line. The charge on Q_1 is + 2 x 10^{-5} C, and the charge on Q_2 is – 8 x 10^{-6} C. Point **X** is 0,25 m **east** of Q_1, as shown in the diagram below.



Calculate the:

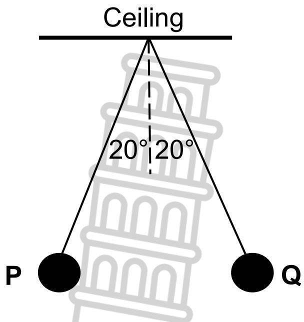
6.1 Net electric field at point **X** due to the two charges (6)

6.2 Electrostatic force that a – 2 x 10^{-9} C charge will experience at point **X** (4)

The – 2 x 10^{-9} C charge is replaced with a charge of – 4 x 10^{-9} C at point **X**.

6.3 Without any further calculation, determine the magnitude of the force that the – 4 x 10^{-9} C charge will experience at point **X**. (1)

[11]



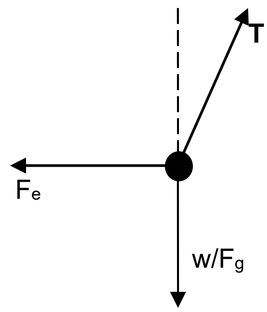
QUESTION 7

Two identical spherical balls, **P** and **Q**, each of mass 100 g, are suspended at the same point from a ceiling by means of identical light, inextensible insulating strings. Each ball carries a charge of +250 nC. The balls come to rest in the positions shown in the diagram.

7.1 in the diagram, the angles between each string and the vertical are the same. Give a reason why the angles are the same. (1)

7.2 State *Coulomb's law* in words. (2)

7.3 The free-body diagram, not drawn to scale, of the forces acting on ball **P** is shown below.



Calculate the:

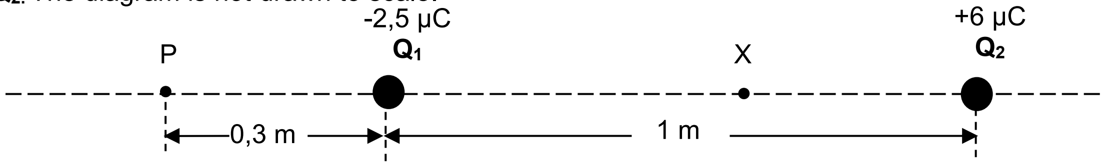
7.3.1 Magnitude of the tension (**T**) in the string (3)

7.3.2 Distance between balls **P** and **Q** (5)

[11]

QUESTION 8

A sphere $\mathbf{Q_1}$, with a charge of -2,5 µC, is placed 1 m away from a second sphere $\mathbf{Q_2}$, with a charge +6 µC. The spheres lie along a straight line, as shown in the diagram below. Point **P** is located a distance of 0,3 m to the left of sphere $\mathbf{Q_1}$, while point **X** is located between $\mathbf{Q_1}$ and $\mathbf{Q_2}$. The diagram is not drawn to scale.



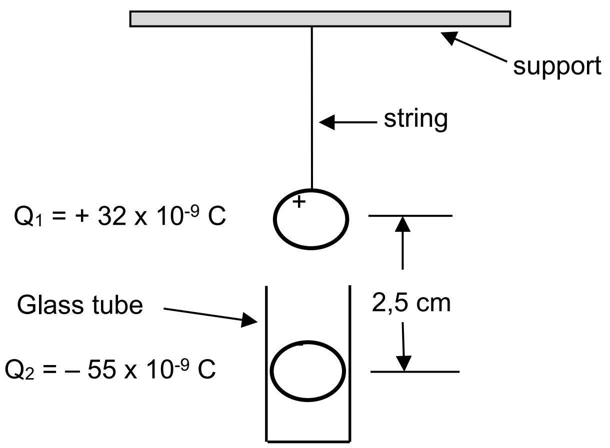
8.1 Show, with the aid of a VECTOR DIAGRAM, why the net electric field at point **X** cannot be zero. (4)

8.2 Calculate the net electric field at point **P**, due to the two charged spheres $\mathbf{Q_1}$ and $\mathbf{Q_2}$. (6)

[10]

QUESTION 9

A small sphere, Q_1, with a charge of + 32 x 10^{-9} C, is suspended from a light string secured to a support.



A second, identical sphere, Q_2, with a charge of – 55 x 10^{-9} C, is placed in a narrow, cylindrical glass tube vertically below Q_1. Each sphere has a mass of 7 g. Both spheres come to equilibrium when Q_2 is 2,5 cm from Q_1, as shown in the diagram. Ignore the effects of air friction.

9.1 Calculate the number of electrons that were removed from Q_1 to give it a charge of + 32 x 10^{-9} C. Assume that the sphere was neutral before being charged. (3)

9.2 Draw a labelled free-body diagram showing all the forces acting on sphere Q_1. (3)

9.3 Calculate the magnitude of the tension in the string. (5)

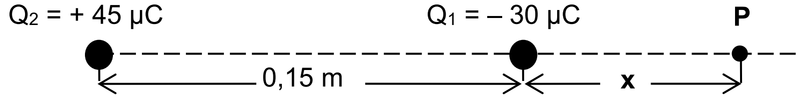
[11]

QUESTION 10

10.1 Define *electric field at a point* in words. (2)

10.2 Draw the electric field pattern for two identical positively charged spheres placed close to each other. (3)

10.3 A – 30 µC point charge, Q_1, is placed at a distance of 0,15 m from a + 45 µC point charge, Q_2, in space, as shown in the diagram below. The net electric field at point **P**, which is on the same line as the two charges, is zero.

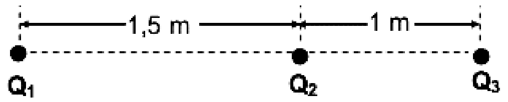


Calculate **x**, the distance of point **P** from charge Q_1. (5)

[10]

QUESTION 11

In the diagram below, **Q_1**, **Q_2** and **Q_3** are three stationary point charges placed along a straight line. The distance between **Q_1** and **Q_2** is 1,5 m and that between **Q_2** and **Q_3** is 1 m, as shown in the diagram.



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

11.2 The magnitude of charges **Q_1** and **Q_2** are unknown. The charge on **Q_1** is positive. The charge on **Q_3** is $+2 \times 10^{-6}$ C and it experiences a net electrostatic force of 0,3 N to the left.

11.2.1 Write down the sign (POSITIVE or NEGATIVE) of charge **Q_2**. (2)

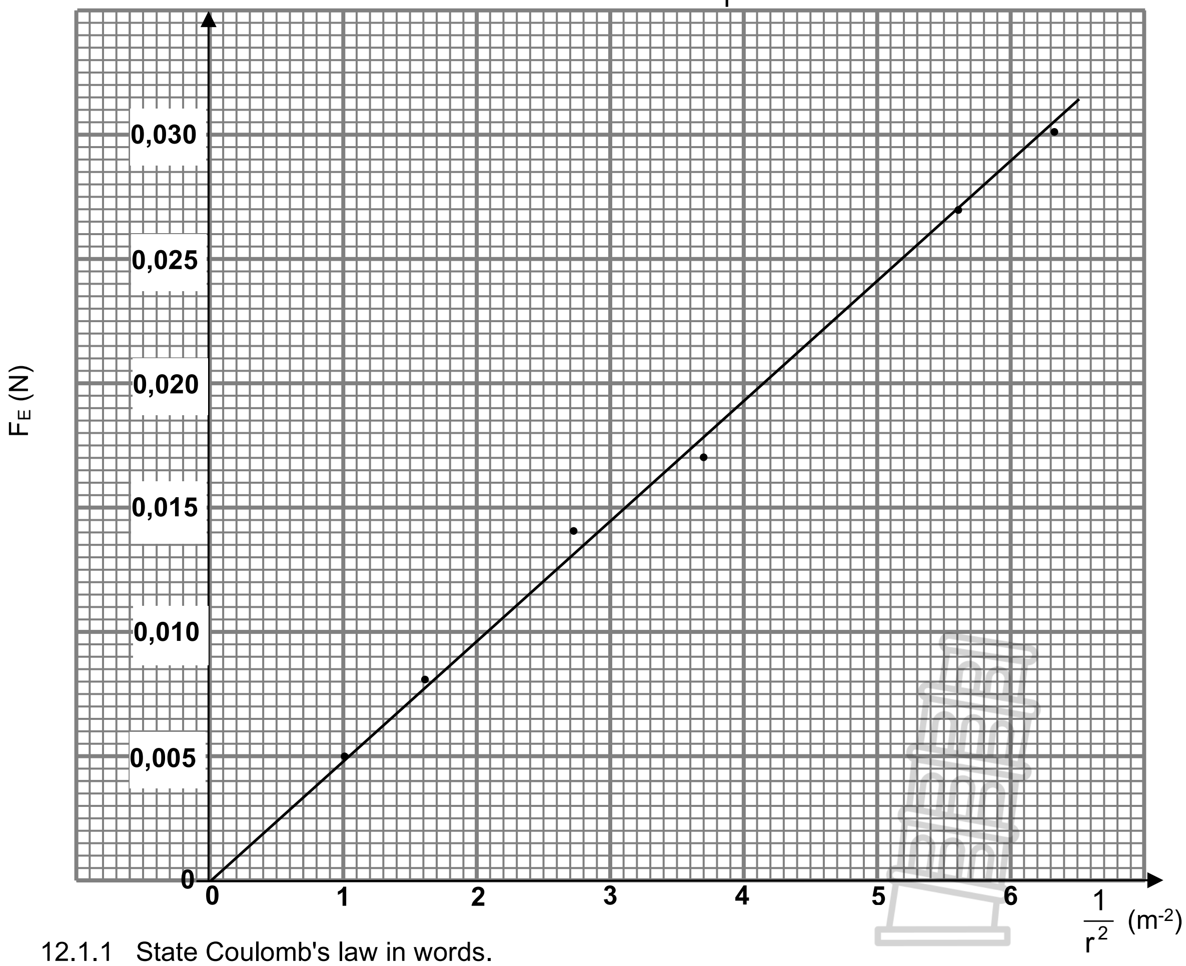
Charge **Q_2** is now removed. The magnitude of the electrostatic force experienced by charge **Q_3** due to **Q_1** now becomes 0,012 N.

11.2.2 Calculate the magnitudes of the unknown charges **Q_1** and **Q_2**. (7)
[11]

QUESTION 12

12.1 In an experiment to verify the relationship between the electrostatic force, F_E, and distance, r, between two **identical**, positively charged spheres, the graph below was obtained.

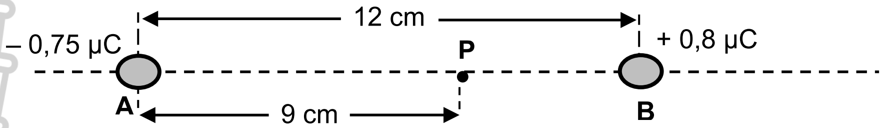
Graph of F_e versus $\frac{1}{r^2}$



12.1.1 State Coulomb's law in words. (2)
12.1.2 Write down the dependent variable of the experiment. (1)
12.1.3 What relationship between the electrostatic force F_E and the square of the distance, r^2, between the charged spheres can be deduced from the graph? (1)
12.1.4 Use the information in the graph to calculate the charge on each sphere. (6)

12.2 A charged sphere, **A**, carries a charge of – 0,75 μC.
12.2.1 Draw a diagram showing the electric field lines surrounding sphere **A**. (2)

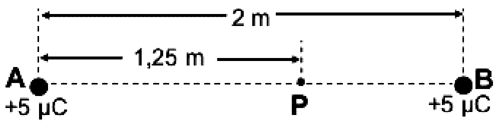
Sphere **A** is placed 12 cm away from another charged sphere, B, along a straight line in a vacuum, as shown below. Sphere **B** carries a charge of +0,8 μC. Point **P** is located 9 cm to the right of sphere **A**.



12.2.2 Calculate the magnitude of the net electric field at point P. (5)
[17]

QUESTION 13

Two small identical spheres, **A** and **B**, each carrying a charge of +5 μC, are placed 2 m apart. Point **P** is in the electric field due to the charged spheres and is located 1,25 m from sphere **A**. Study the diagram.



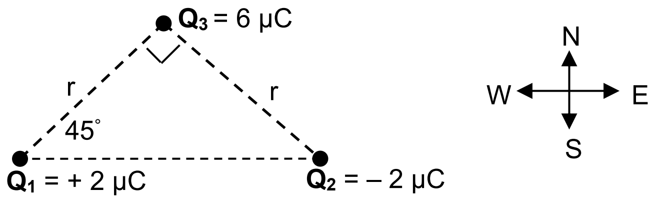
13.1 Describe the term *electric field*. (2)
13.2 Draw the resultant electric field pattern due to the two charged spheres. (3)
13.3 Calculate the magnitude of the net electric field at point **P**. (5)
[10]

QUESTION 14

14.1 A metal sphere **A**, suspended from a wooden beam by means of a non-conducting string, has a charge of +6 μC.

14.1.1 Were electrons ADDED TO or REMOVED FROM the sphere to obtain this charge? Assume that the sphere was initially neutral. (1)
14.1.2 Calculate the number of electrons added to or removed from the sphere. (3)

14.2 Point charges $\mathbf{Q_1}$, $\mathbf{Q_2}$ and $\mathbf{Q_3}$ are arranged at the corners of a right-angled triangle, as shown in the diagram. The charges on $\mathbf{Q_1}$ and $\mathbf{Q_2}$ are + 2 μC and – 2 μC respectively and the magnitude of the charge on $\mathbf{Q_3}$ is 6 μC. The distance between $\mathbf{Q_1}$ and $\mathbf{Q_3}$ is r. The distance between $\mathbf{Q_2}$ and $\mathbf{Q_3}$ is also r. The charge $\mathbf{Q_3}$ experiences a resultant electrostatic force of 0,12 N to the west.



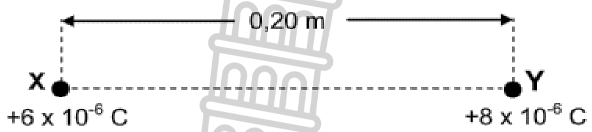
14.2.1 Without calculation, identify the sign (positive or negative) on the charge $\mathbf{Q_3}$. (1)
14.2.2 Draw a vector diagram to show the electrostatic forces acting on $\mathbf{Q_3}$ due to charges $\mathbf{Q_1}$ and $\mathbf{Q_2}$ respectively. (2)
14.2.3 Write down an expression, in terms of ***r***, for the horizontal component of the electrostatic force exerted on $\mathbf{Q_3}$ by $\mathbf{Q_1}$. (3)
14.2.4 Calculate the distance r. (4)

14.3 The magnitude of the electric field is 100 $N{\cdot}C^{-1}$ at a point which is 0,6 m away from a point charge **Q**.

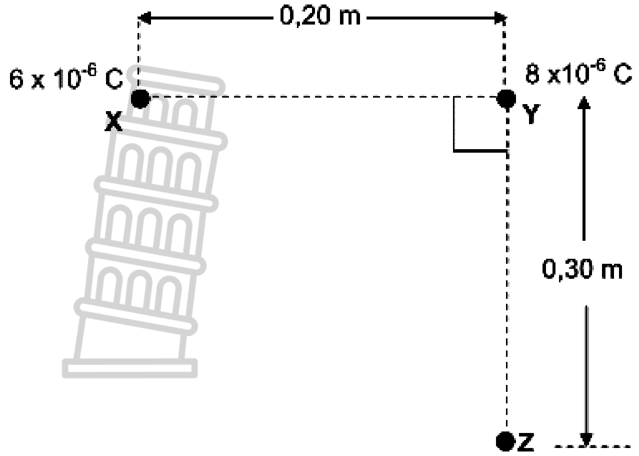
14.3.1 Define the term *electric field at a point* in words. (2)
14.3.2 Calculate the distance from point charge **Q** at which the magnitude of the electric field is 50 $N{\cdot}C^{-1}$. (5)
[21]

QUESTION 15

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.



15.1 State *Coulomb's law* in words. (2)
15.2 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 alongside.

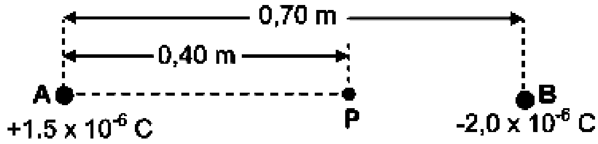
15.3 Draw a vector diagram showing the directions of the electrostatic forces andthe net force experienced by charged sphere **Y** due to the presence of charged spheres **X** and **Z** respectively. (3)

15.4 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 16

A and **B** are two small spheres separated by a distance of 0,70 m. Sphere **A** carries a charge of +1,5 x 10^{-6} C and sphere **B** carries a charge of -2,0 x 10^{-6} C. **P** is a point between spheres **A** and **B** and is 0,40 m from sphere **A**, as shown in the diagram.



16.1 Define the term *electric field at a point*. (2)

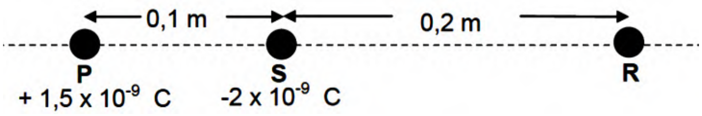
16.2 Calculate the magnitude of the net electric field at point **P**. (4)

16.3 A point charge of magnitude 3,0 x 10^{-9} C is now placed at point **P**. Calculate the magnitude of the electrostatic force experienced by this charge. (3)

[9]

QUESTION 17

Two point charges, **P** and **S**, are placed a distance 0,1 m apart. The charge on **P** is +1,5 x 10^{-9} C and that on **S** is -2 x 10^{-9} C. A third point charge, **R**, with an unknown positive charge, is placed 0,2 m to the right of point charge **S**, as shown in the diagram.



17.1 State *Coulomb's law* in words. (2)

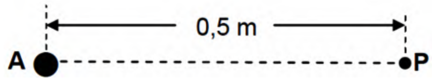
17.2 Draw a labelled force diagram showing the electrostatic forces acting on **R** due to **P** and **S**. (2)

17.3 Calculate the magnitude of the charge on **R**, if it experiences a net electrostatic force of 1,27 x 10^{-6} N to the left. Take forces directed to the right as positive. (7)

[11]

QUESTION 18

P is a point 0,5 m from charged sphere **A**. The electric field at **P** is 3 x 10^{7} N·C^{-1} directed towards **A**. Refer to the diagram.



18.1 Draw the electric field pattern due to charged sphere **A**. Indicate the sign of the charge on the sphere in your diagram. (2)

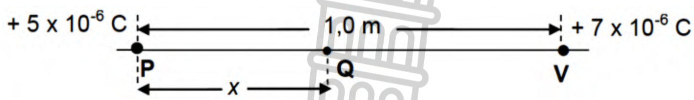
18.2 Calculate the magnitude of the charge on sphere **A**. (3)

18.3 Another charged sphere, **B**, having an excess of 10^{5} electrons, is now placed at point **P**. Calculate the electrostatic force experienced by sphere **B**. (6)

[11]

QUESTION 19

A particle, **P**, with a charge of + 5 x 10^{-6} C, is located 1,0 m along a straight line from particle **V**, with a charge of +7 x 10^{-6} C. Refer to the diagram.



A third charged particle, **Q**, at a point ***x*** metres away from **P**, as shown above, experiences a net electrostatic force of zero newton.

19.1 How do the electrostatic forces experienced by **Q** due to the charges on **P** and **V** respectively, compare with each other? (2)

19.2 State *Coulomb's law* in words. (2)

19.3 Calculate the distance **x**. (5)

[9]

QUESTION 20

A small metal sphere **Y** carries a charge of + 6 x 10^{-6} C.

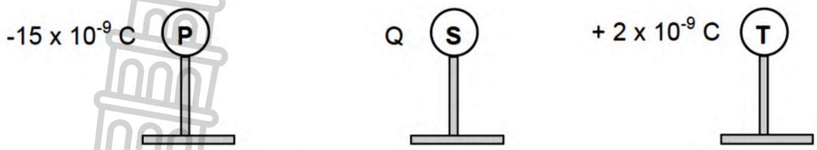
20.1 Draw the electric field pattern associated with sphere **Y**. (2)

20.2 If 8 x 10^{13} electrons are now transferred to sphere **Y**, calculate the electric field at a point 0,5 m from the sphere. (7)

[9]

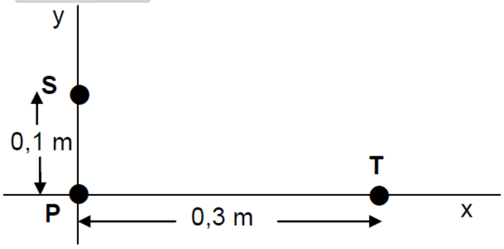
QUESTION 21

Three small identical metal spheres, **P**, **S** and **T**, on insulated stands, are **initially neutral**. They are then charged to carry charges of -15×10^{-9} C, **Q** and $+2 \times 10^{-9}$ C respectively, as shown. The charged spheres are brought together so that all three spheres touch each other at the same time, and are then separated. The charge on each sphere, after separation, is -3×10^{-9} C.



21.1 Determine the value of charge **Q**. (2)

21.2 Draw the electric field pattern associated with the charged spheres, **S** and **T**, after they are separated and returned to their original positions. (3)



The spheres, each with the **new charge** of -3×10^{-9} C, are now placed at points on the *x*-axis and the *y*-axis, as shown in the diagram, with sphere **P** at the origin.

21.3 State *Coulomb's law* in words. (2)

21.4 Calculate the magnitude of the net electrostatic force acting on sphere **P**. (5)

21.5 Calculate the magnitude of the net electric field at the origin due to charges **S** and **T**. (3)

21.6 ONE of the charged spheres, **P** and **T**, experienced a very small increase in mass after it was charged initially.

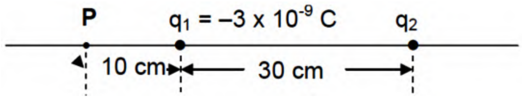
21.6.1 Which sphere, **P** or **T**, experienced this very small increase in mass? (1)

21.6.2 Calculate the increase in mass by the sphere in QUESTION 21.6.1. (3)

[19]

QUESTION 22

Two point charges, q_1 and q_2, are placed 30 cm apart along a straight line. Charge $q_1 = -3 \times 10^{-9}$ C. Point **P** is 10 cm to the left of q_1, as shown in the diagram below. The **net** electrostatic field at point **P** is **zero.**



22.1 Define the term *electric field at a point*. (2)

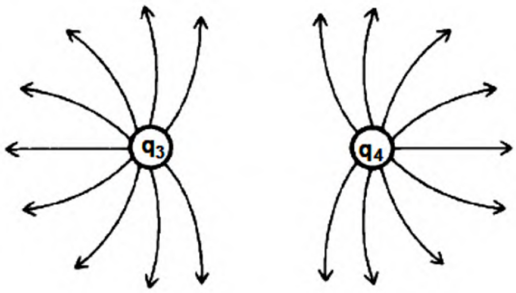
22.2 State, giving reasons, whether point charge q_2 is POSITIVE or NEGATIVE. (3)

22.3 Calculate the magnitude of charge q_2. (4)

22.4 State *Coulomb's law* in words. (2)

22.5 Calculate the magnitude of the electrostatic force exerted by charge q_1 on charge q_2. (3)

22.6 The two charges are now brought into contact with each other and are then separated. A learner draws the electric field pattern for the new charges q_3 and q_4 after contact, as shown below.

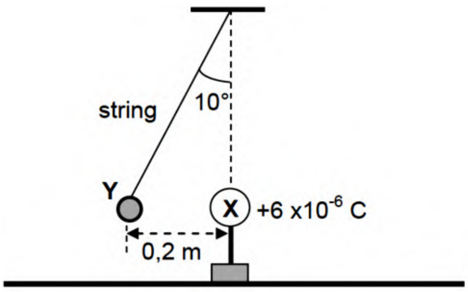


22.7 Is the diagram CORRECT? Give a reason for the answer. (2)

[16]

QUESTION 23

23.1 A small sphere, **Y**, carrying an unknown charge, is suspended at the end of a light inextensible string which is attached to a fixed point. Another sphere, **X**, carrying a charge of +6 x10-6 C, on an insulated stand is brought close to sphere **Y**.



Sphere **Y** experiences an electrostatic force and comes to rest 0,2 m away from sphere **X**, with the string at an angle of 10° with the vertical, as shown in the diagram.

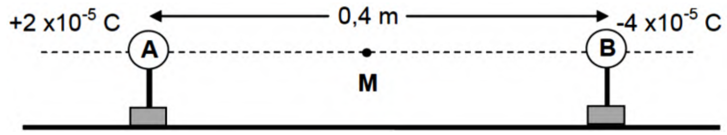
23.1.1 What is the nature of the charge on sphere **Y**? Choose from POSITIVE or NEGATIVE. (1)

23.1.2 Calculate the magnitude of the charge on sphere **Y** if the magnitude of the electrostatic force acting on it is 3,05 N. (3)

23.1.3 Draw a labelled free-body diagram for sphere **Y**. (3)

23.1.4 Calculate the magnitude of the tension in the string. (3)

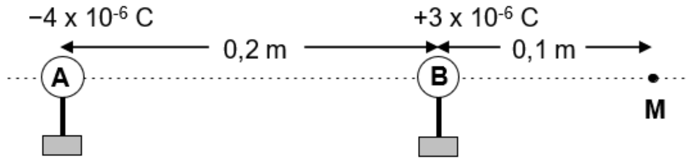
23.2 Two small charged spheres, **A** and **B**, on insulated stands, with charges +2 x10^{-5} C and -4 x10^{-5} C respectively, are placed 0,4 m apart, as shown in the diagram below. **M** is the midpoint between spheres **A** and **B**.



23.2.1 Define the term *electric field at a point*. (2)
23.2.2 Calculate the net electric field at point **M**. (6)
[18]

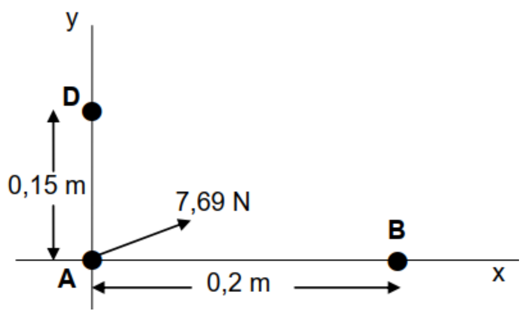
QUESTION 24

Two small, charged spheres, **A** and **B**, are placed on insulated stands, 0,2 m apart, as shown in the diagram. They carry charges of −4 x 10^{-6} C and +3 x 10^{-6} C respectively.



M is a point that is a distance of 0,1 m to the right of sphere **B**.
24.1 Calculate the number of electrons in excess on sphere **A**. (3)
24.2 Calculate the magnitude of the electrostatic force exerted by sphere **A** on sphere **B**. (3)
24.3 Describe the term *electric field*. (2)
24.4 Calculate the magnitude of the net electric field at point **M**. (5)

Charged spheres **A** and **B** and another charged sphere **D** are now arranged along a rectangular system of axes, as shown in the diagram. The net electrostatic force experienced by sphere **A** is 7,69 N in the direction as shown in the diagram.

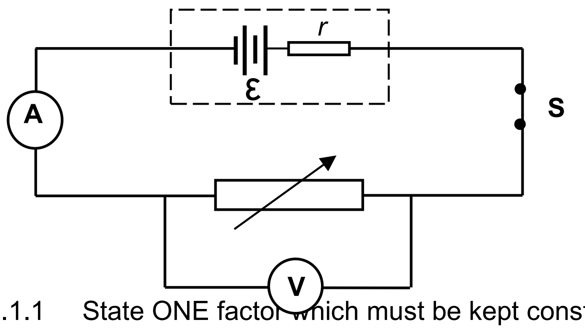


24.5 Is the charge on sphere **D** POSITIVE or NEGATIVE? (1)
24.6 Calculate the magnitude of the charge on sphere **D**. (3)
[17]

ELECTRIC CIRCUITS

QUESTION 1

1.1 A group of learners conduct an experiment to determine the emf (ε) and internal resistance (*r*) of a battery. They connect a battery to a rheostat (variable resistor), a low-resistance ammeter and a high-resistance voltmeter as shown in the diagram below. The data obtained from the experiment is displayed in the table below.

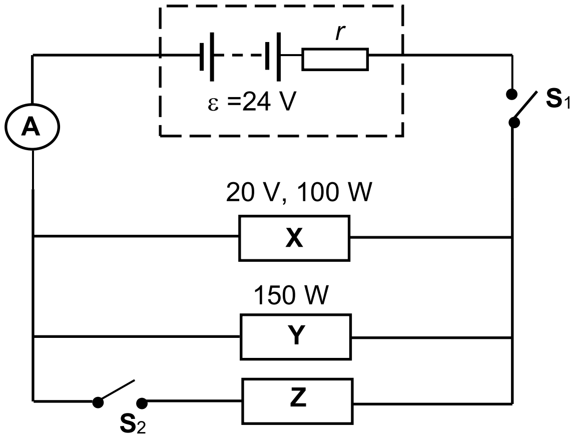


READING ON VOLTMETER (V)	READING ON AMMETER (A)
2	0,58
3	0,46
4	0,36
5	0,24
6	0,14

1.1.1 State ONE factor which must be kept constant during the experiment. (1)
1.1.2 Using the information in the table above, plot the points and draw the line of best fit on a graph paper. (3)

Use the graph drawn in QUESTION 1.1.2 to determine the following:
1.1.3 Emf (ε) of the battery (1)
1.1.4 Internal resistance of the battery, WITHOUT USING ANY FORM OF THE EQUATION ε = I(R + r) (3)

1.2 Three electrical devices, **X**, **Y** and **Z**, are connected to a 24 V battery with internal resistance *r* as shown in the circuit diagram. The power rating of each of the devices **X** and **Y** are indicated in the diagram.



With switch S_1 closed and S_2 open, the devices function as rated. Calculate the:

1.2.1 Current in **X** (3)

1.2.2 Resistance of **Y** (3)

1.2.3 Internal resistance of the battery (5)

Now switch S_2 is also closed.

1.2.4 Identify device **Z** which, when placed in the position shown, can still enable **X** and **Y** to operate as rated. Assume that the resistances of all the devices remain unchanged. (1)

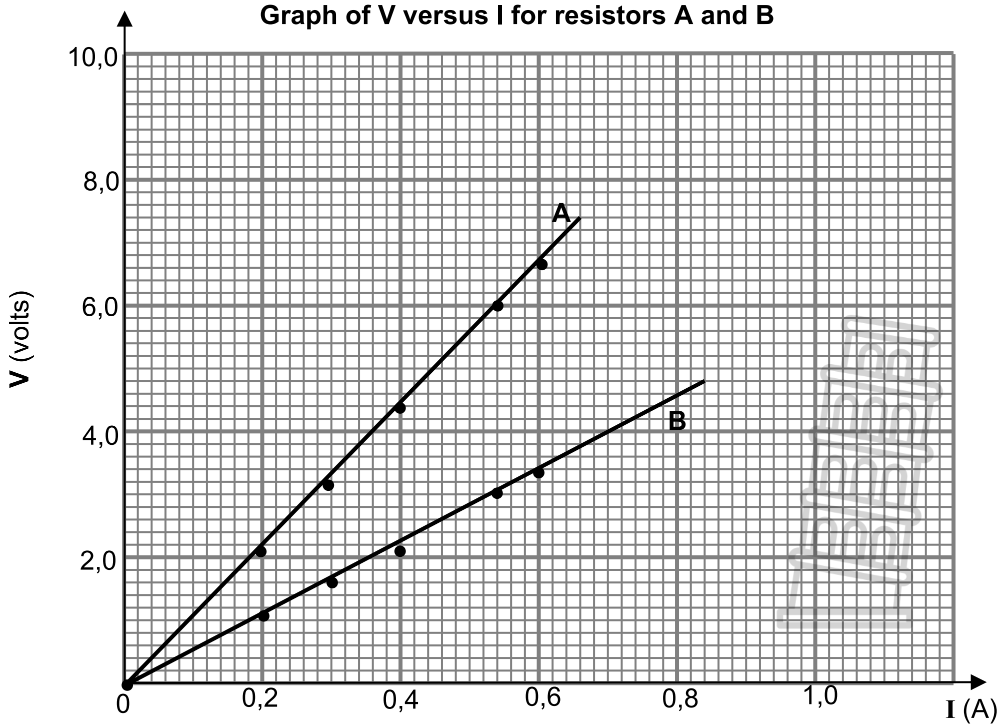
1.2.5 Explain how you arrived at the answer to QUESTION 1.2.4. (2)

[22]

QUESTION 2

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

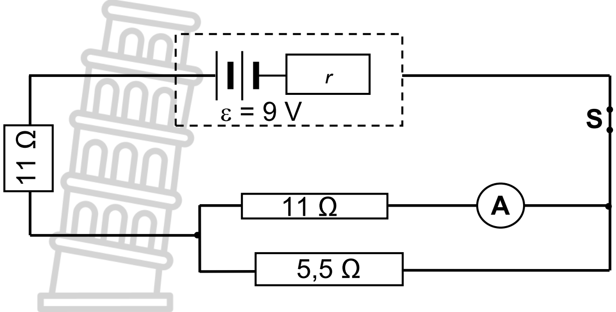
Graph of V versus I for resistors A and B



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

2.1.2 Assuming all other factors are kept constant, state which ONE of the two wires will be the most suitable to use in the heater. Use suitable calculations to show clearly how you arrive at the answer. (8)

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



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

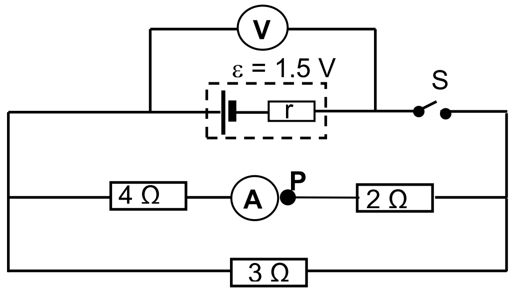
2.2.2 Calculate the internal resistance of the battery. (7)

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

[22]

QUESTION 3

A cell of unknown internal resistance, *r*, has emf (ε) of 1,5 V. It is connected in a circuit to three resistors, a high-resistance voltmeter, a low-resistance ammeter and a switch **S** as shown. When switch **S** is closed, the voltmeter reads 1,36 V.



3.1 Which terminal of the ammeter is represented by point **P**? Write down POSITIVE or NEGATIVE. (1)

3.2 Calculate the ammeter reading. (3)

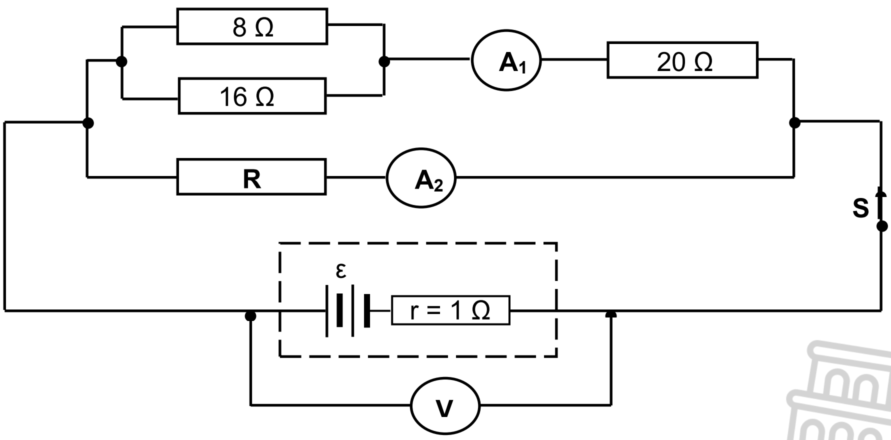
3.3 Determine the internal resistance of the cell. (7)

3.4 An additional resistor **X** is connected parallel to the 3 Ω resistor in the circuit. Will the reading on the ammeter INCREASE, DECREASE or REMAIN UNCHANGED? Give a reason for the answer. (4)

[15]

QUESTION 4

A battery with an internal resistance of 1 Ω and an unknown emf (ε) is connected in a circuit, as shown below. A high-resistance voltmeter (V) is connected across the battery. **A$_1$** and **A$_2$** represent ammeters of negligible resistance.



With switch **S** closed, the current passing through the 8 Ω resistor is 0,5 A.

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

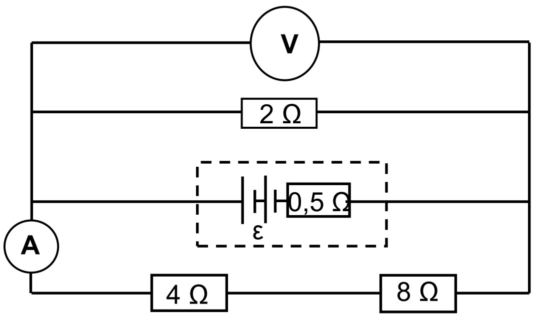
4.2 Calculate the reading on ammeter **A$_1$**. (4)

4.3 If device **R** delivers power of 12 W, calculate the reading on ammeter A$_2$. (5)

4.4 Calculate the reading on the voltmeter when switch **S** is open. (3)

[14]

QUESTION 5



A battery of an unknown emf and an internal resistance of 0,5 Ω is connected to three resistors, a high-resistance voltmeter and an ammeter of negligible resistance, as shown. The reading on the ammeter is 0,2 A.

5.1 Calculate the:

5.1.1 Reading on the voltmeter (3)

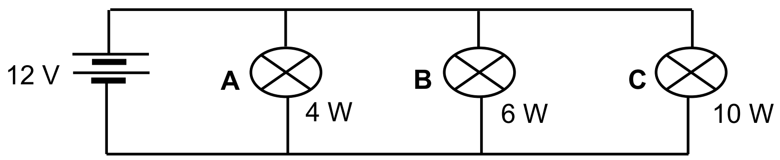
5.1.2 Total current supplied by the battery (4)

5.1.3 Emf of the battery (5)

5.2 How would the voltmeter reading change if the 2 Ω resistor is removed? Write down INCREASE, DECREASE or REMAIN THE SAME. Explain the answer. (3)
[15]

QUESTION 6

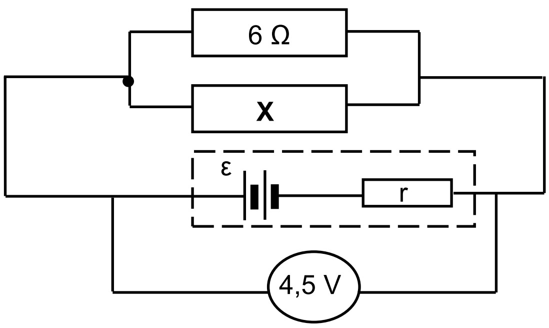
6.1 In the diagram below, three light bulbs, **A**, **B** and **C**, are connected in parallel to a 12 V source of negligible internal resistance. The bulbs are rated at 4 W, 6 W and 10 W respectively and are all at their maximum brightness.



6.1.1 Calculate the resistance of the 4 W bulb. (3)
6.1.2 How will the equivalent resistance of the circuit change if the 6 W bulb burns out? Write down only INCREASES, DECREASES or NO CHANGE. (1)
6.1.3 How will the power dissipated by the 10 W bulb change if the 6 W bulb burns out? Write down only INCREASES, DECREASES or NO CHANGE. Give a reason for the answer. (2)

6.2 A learner connects a high-resistance voltmeter across a battery. The voltmeter reads 6 V. She then connects a 6 Ω resistor across the battery. The voltmeter now reads 5 V.

6.2.1 Calculate the internal resistance of the battery. (4)

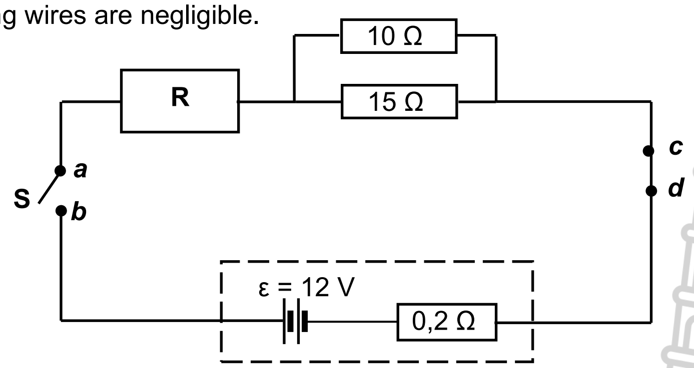


The learner now builds the circuit alongside, using the same 6 V battery and the 6 Ω resistor. She connects an unknown resistor **X** in parallel with the 6 Ω resistor. The voltmeter now reads 4,5 V.

6.2.2 Define the term *emf of a cell*. (2)
6.2.3 Calculate the resistance of **X** when the voltmeter reads 4,5 V. (5)
[17]

QUESTION 7

7.1 In the circuit below the battery has an emf (ε) of 12 V and an internal resistance of 0,2 Ω. The resistances of the connecting wires are negligible.

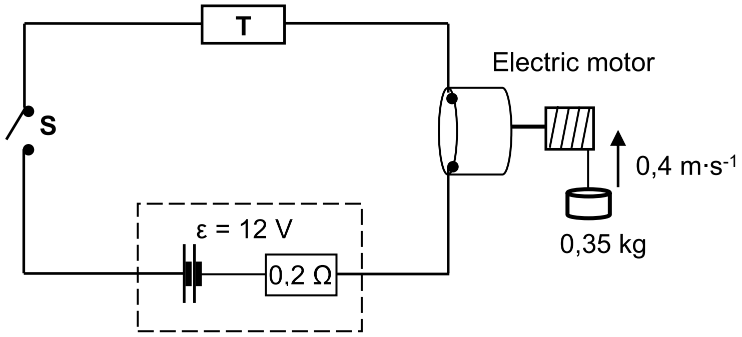


7.1.1 Define the term *emf of a battery*. (2)
7.1.2 Switch **S** is open. A high-resistance voltmeter is connected across points **a** and **b**. What will the reading on the voltmeter be? (1)
7.1.3 Switch **S** is now closed. The same voltmeter is now connected across points **c** and **d**. What will the reading on the voltmeter be? (1)

When switch **S** is closed, the potential difference across the terminals of the battery is 11,7 V.

Calculate the:
7.1.4 Current in the battery (3)
7.1.5 Effective resistance of the parallel branch (2)
7.1.6 Resistance of resistor **R** (4)

7.2 A battery with an emf of 12 V and an internal resistance of 0,2 Ω are connected in series to a very small electric motor and a resistor, **T**, of unknown resistance, as shown in the circuit below. The motor is rated **X** watts, 3 volts, and operates at optimal conditions. When switch **S** is closed, the motor lifts a 0,35 kg mass vertically upwards at a constant speed of 0,4 $m \cdot s^{-1}$. Assume that there is no energy conversion into heat and sound.



7.2.1 Calculate the value of **X**. (3)

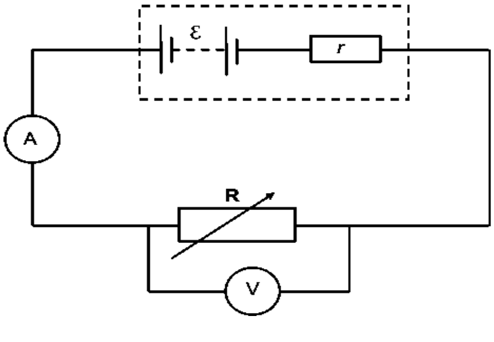
7.2.2 Calculate the resistance of resistor **T**. (5)

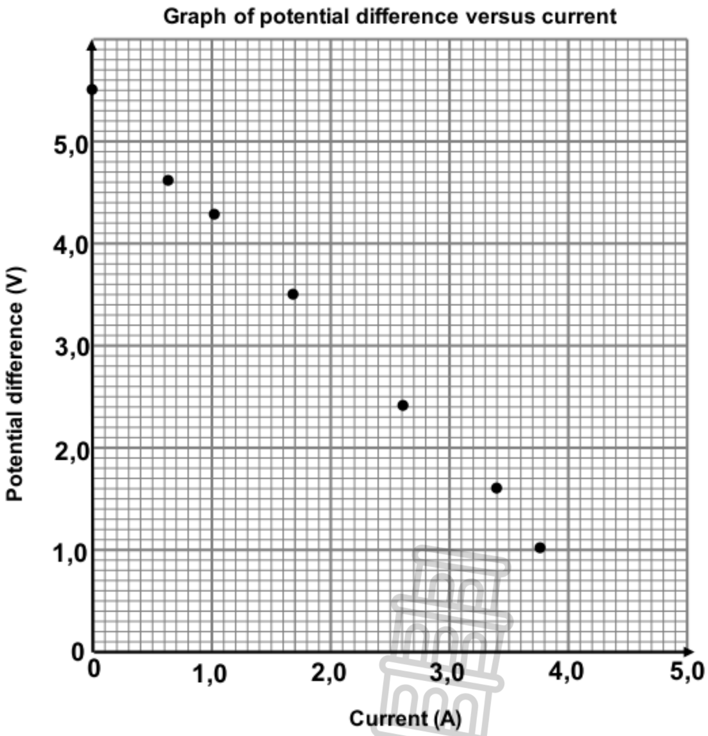
[21]

QUESTION 8

8.1 The emf and internal resistance of a certain battery were determined experimentally. The circuit used for the experiment is shown in the diagram below.

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





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

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

Use information in the graph to answer QUESTIONS 8.1.3 and 8.1.4.

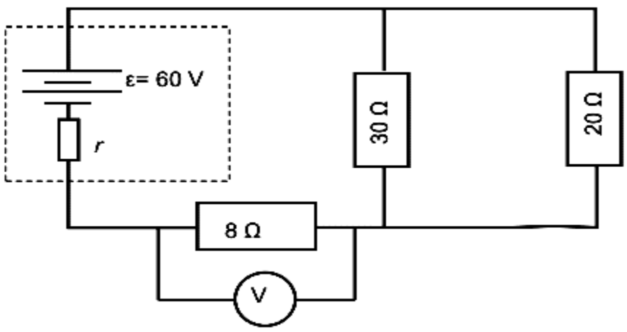
8.1.3 Write down the value of the emf (ε) of the battery. (1)

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

8.2 The circuit diagram shows a battery with an emf (ε) of 60 V and an unknown internal resistance r, connected to three resistors. A voltmeter connected across the 8 Ω resistor reads 21,84 V. Calculate the:

8.2.1 Current in the 8 Ω resistor (3)

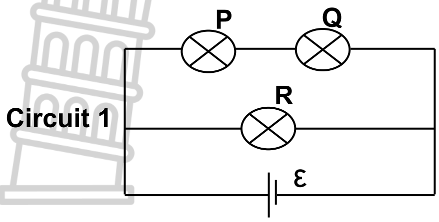
8.2.2 Equivalent resistance of the resistors in parallel (2)



8.2.3 Internal resistance r of the battery .... (4)
8.2.4 Heat dissipated in the external circuit in 0,2 seconds (3)
[20]

QUESTION 9

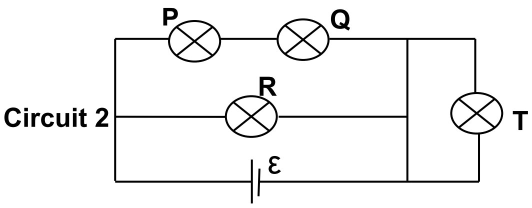
9.1 In **Circuit 1**, three identical light bulbs, **P**, **Q** and **R**, with the same resistance, are connected to a battery with emf ε and negligible internal resistance.



9.1.1 How does the brightness of bulb **P** compare with that of bulb **Q**? Give a reason. (2)

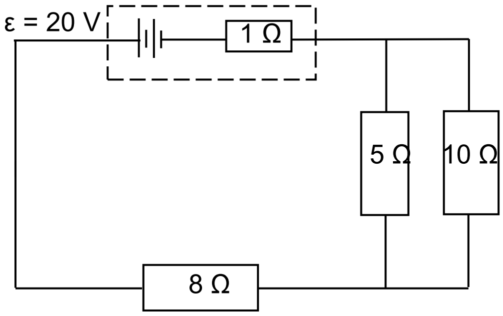
9.1.2 How does the brightness of bulb **P** compare with that of bulb **R**? Give a reason. (2)

A fourth, identical bulb **T**, with the same resistance as the other three, is connected to the circuit by means of an ordinary wire of negligible resistance, as shown in **Circuit 2**.



9.1.3 How does the brightness of bulb **T** compare with that of bulb **R**? Give a reason for the answer. (2)

9.2 A battery with an emf of 20 V and an internal resistance of 1 Ω is connected to three resistors, as shown in the circuit alongside.



Calculate the:

9.2.1 Current in the 8 Ω resistor (6)

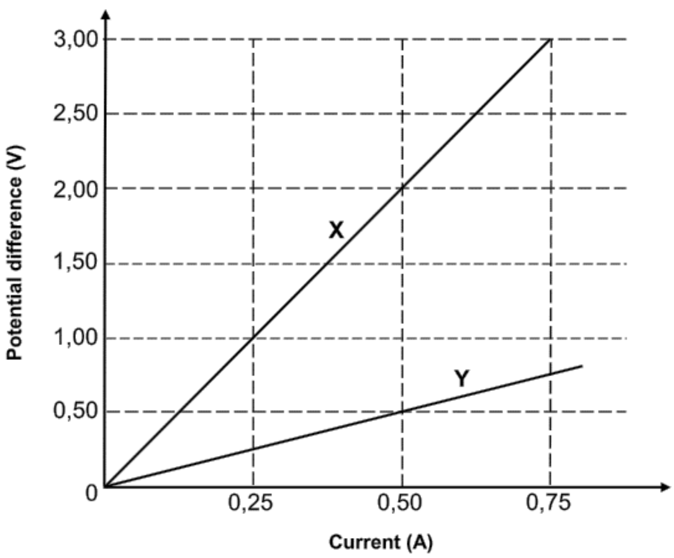
9.2.2 Potential difference across the 5 Ω resistor (4)

9.2.3 Total power supplied by the battery (3)
[19]

QUESTION 10

10.1 Learners investigated the relationship between potential difference (V) and current (I) for the combination of two resistors, R_1 and R_2.

GRAPHS OF POTENTIAL DIFFERENCE VERSUS CURRENT FOR THE COMBINATION OF TWO RESISTORS IN SERIES AND IN PARALLEL



In one experiment, resistors R_1 and R_2 were connected in parallel.

In a second experiment, resistors R_1 and R_2 were connected in series.

The learners then plotted graph **X**, the results of one of the experiments, and graph **Y**, the results of the other experiment, as shown.

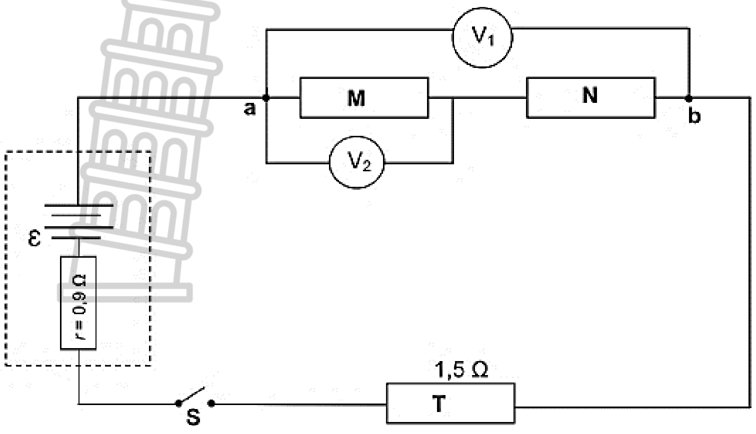
10.1.1 State Ohm's law in words. (2)

10.1.2 What physical quantity does the gradient (slope) of the V-I graph represent? (1)

10.1.3 Calculate the gradient (slope) of graph **X**. (2)

10.1.4 Determine the resistance of resistor R_1. (4)

10.2 The circuit below consists of three resistors, **M**, **N** and **T**, a battery with emf Ɛ and an internal resistance of 0,9 Ω. The effective resistance between points **a** and **b** in the circuit is 6 Ω. The resistance of resistor **T** is 1,5 Ω. When switch **S** is closed, a high-resistance voltmeter, V_1, across **a** and **b** reads 5 V.



Calculate the

10.2.1 Current delivered by the battery (3)

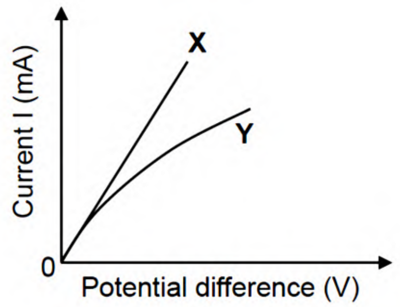
10.2.2 Emf (Ɛ) of the battery (4)

V_2 reads 2,5 V when the switch is closed.

10.2.3 Write down the resistance of **N**. (No calculations required.) Give a reason for the answer. (2)

[18]

QUESTION 11

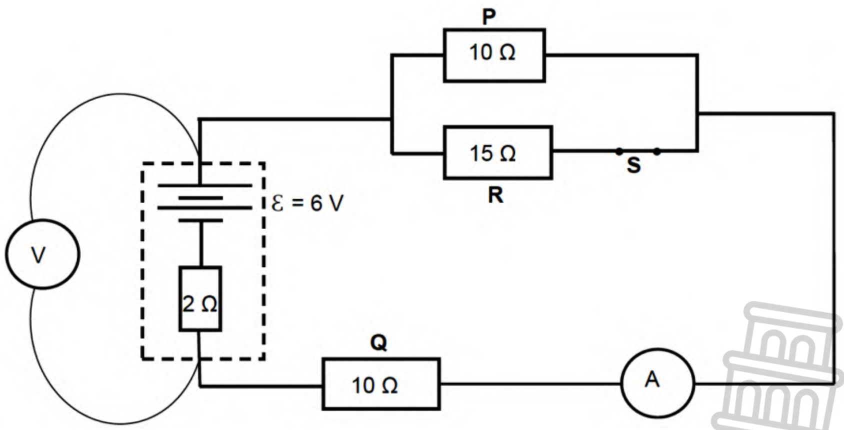


11.1 The two graphs alongside show the relationship between current and potential difference for two different conductors, **X** and **Y**.

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

11.1.2 Which ONE of the two conductors, **X** or **Y**, is ohmic? Refer to the graph and give a reason for the answer. (2)

11.2 In the diagram below, a battery with an emf of 6 V and an internal resistance of 2 Ω, is connected to three resistors **P**, **Q** and **R**. A voltmeter **V** is connected across the battery. The ammeter **A** has a negligible resistance.



11.2.1 Calculate the ammeter reading when switch **S** is closed. (5)

The switch **S** is now open.

11.2.2 Will the ammeter reading in QUESTION 11.2.1 INCREASE, DECREASE or REMAIN THE SAME? Give a reason for the answer. (2)

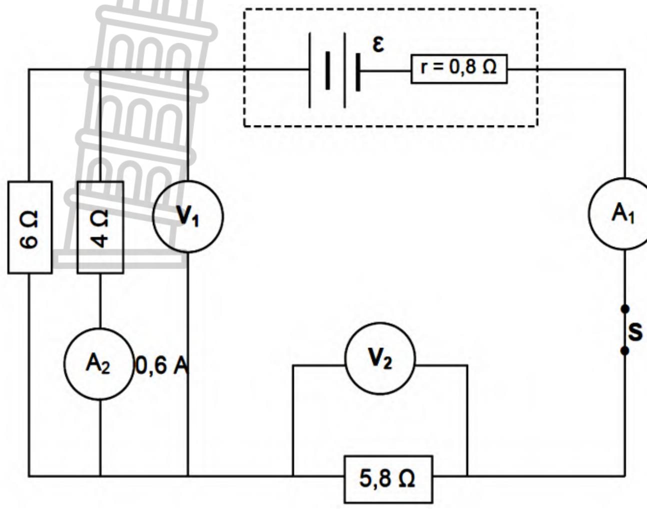
11.2.3 How will the voltmeter reading now compare with the voltmeter reading when the switch is closed? Choose from INCREASE, DECREASE or REMAIN THE SAME. (1)

11.2.4 Explain the answer to QUESTION 11.2.3. (3)

[15]

QUESTION 12

12.1 In the circuit diagram below the battery has an unknown emf (ε) and an internal resistance (r) of 0,8 Ω.

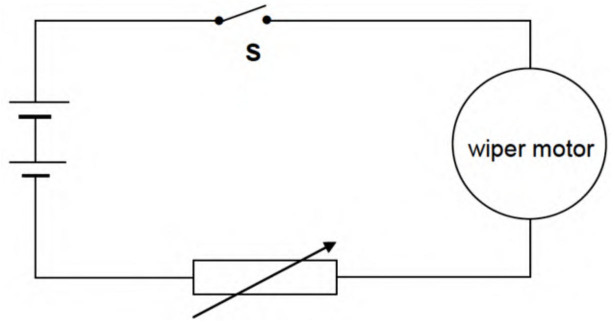


12.1.1 State *Ohm's law* in words. (2)

The reading on ammeter $\mathbf{A_2}$ is 0,6 A when switch **S** is closed. Calculate the:

12.1.2 Reading on voltmeter $\mathbf{V_1}$ (3)
12.1.3 Current through the 6 Ω resistor (2)
12.1.4 Reading on voltmeter $\mathbf{V_2}$ (2)
12.1.5 Emf (ε) of the battery (3)
12.1.6 Energy dissipated as heat inside the battery if the current flows in the circuit for 15 s (3)

12.2 A simplified circuit diagram for the windscreen wiper of a car consists of a variable resistor and a wiper motor connected to a 12 volt battery. When switch **S** is closed, the potential difference across the variable resistor is 2,8 V and the current passing through it is 0,7 A.



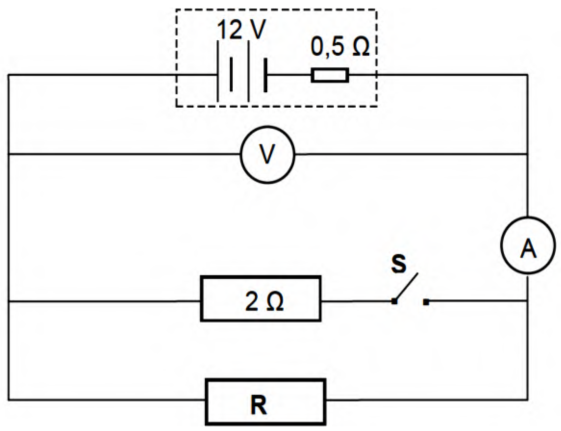
12.2.1 Calculate the resistance of the variable resistor. (2)

The resistance of the variable resistor is now decreased.

12.2.2 State whether the speed at which the wiper turns will INCREASE, DECREASE or REMAIN THE SAME. Give a reason for the answer. (3)
[20]

QUESTION 13

The battery in the circuit diagram below has an emf of 12 V and an internal resistance of 0,5 Ω. Resistor **R** has an unknown resistance.



13.1 What is the meaning of the following statement?
The emf of the battery is 12 V. (2)

The reading on the ammeter is 2 A when switch **S** is OPEN. Calculate the:

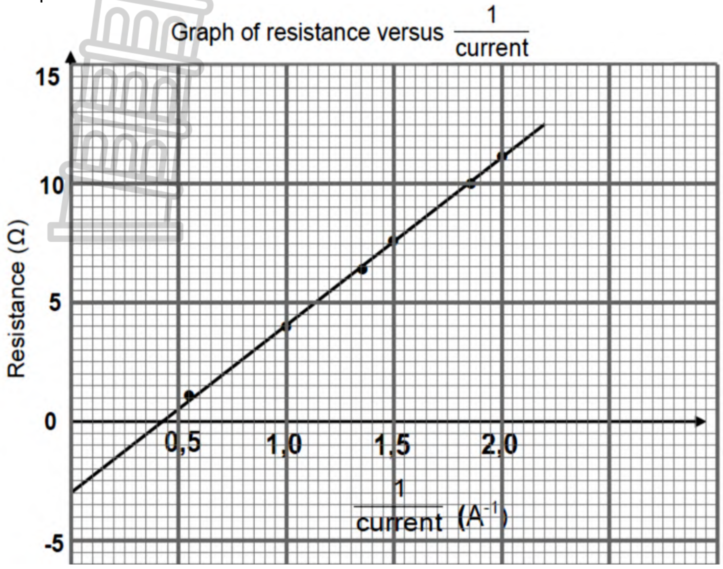
13.2 Reading on the voltmeter (3)
13.3 Resistance of resistor **R** (2)

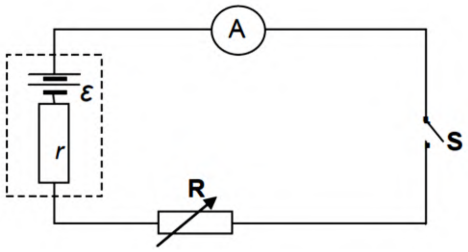
Switch **S** is now CLOSED.

13.4 How does this change affect the reading on the voltmeter? Choose from: INCREASES, DECREASES or REMAINS THE SAME. Explain the answer. (4)
[11]

QUESTION 14

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.





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

Refer to the graph.

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

14.3 Calculate the emf of the battery. (3)
[6]

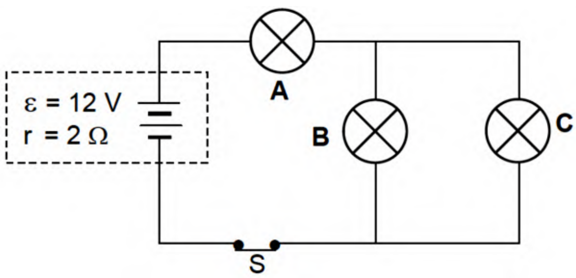
QUESTION 15

15.1 Three identical light bulbs, **A**, **B** and **C**, are each rated at 6 W, 12 V.

15.1.1 Define the term *power*. (2)

15.1.2 Calculate the resistance of EACH bulb when used as rated. (3)

The light bulbs are connected in a circuit with a battery having an emf (ε) of 12 V and internal resistance (*r*) of 2 Ω. Refer to the diagram.
Assume that the resistance of each light bulb is the same as that calculated in QUESTION 15.1.2.
Switch **S** is closed.

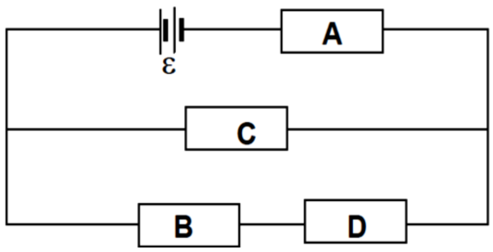


15.1.3 Calculate the total current in the circuit. (5)

15.1.4 Calculate the potential difference across light bulb **C**. (3)

15.1.5 Explain why light bulb **C** in the circuit will NOT burn at its maximum brightness. (3)

15.2 Resistors **A**, **B**, **C** and **D** are connected to a battery having emf (ε) and negligible internal resistance, as shown in the diagram below.

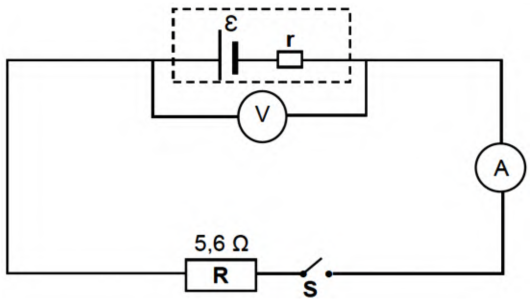


15.2.1 Give a reason why the current in resistor **A** is greater than that in resistor **C**. (2)

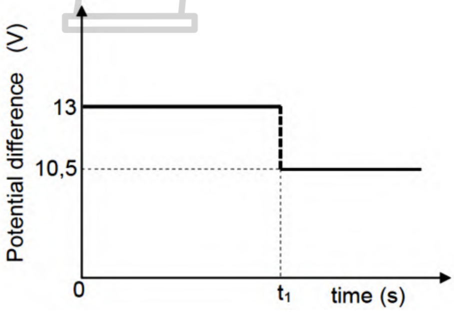
15.2.2 Resistor **C** is removed. How will the current in resistor **B** compare to the current in **A**? Give a reason for the answer. (2)
[20]

QUESTION 16

In the circuit diagram, resistor **R,** with a resistance of 5,6 Ω, is connected, together with a switch, an ammeter and a high-resistance voltmeter, to a battery with an unknown internal resistance, **r**.
The resistance of the connecting wires and the ammeter may be ignored.



The graph below shows the potential difference across the terminals of the battery as a function of time. At time t_1, switch **S** is closed.



16.1 Define the term *emf of a battery*. (2)

16.2 Write down the value of the emf of the battery. (1)

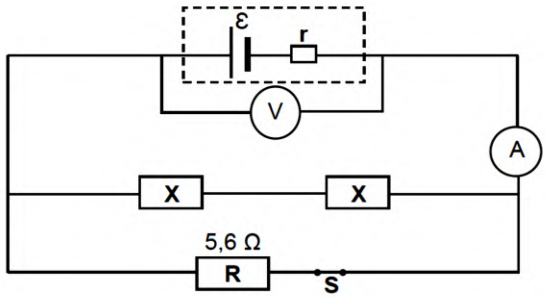
16.3 When switch **S** is CLOSED, calculate the:

16.3.1 Current through resistor **R** (3)

16.3.2 Power dissipated in resistor **R** (3)

16.3.3 Internal resistance, r, of the battery (3)

16.4 Two IDENTICAL resistors, each with resistance **X**, are now connected in the same circuit with switch **S** closed, as shown below.



The ammeter reading now increases to 4 A.

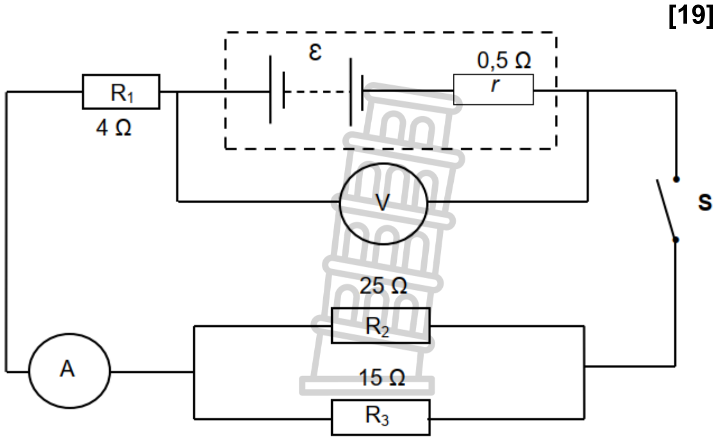
16.4.1 How would the voltmeter reading change? Choose from INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer by referring to $V_{\text{internal resistance}}$. (2)

16.4.2 Calculate resistance **X**. (5)

[19]

QUESTION 17

A battery with an internal resistance of 0,5 Ω and an unknown emf (ε) is connected to three resistors, a high resistance voltmeter and an ammeter of negligible resistance, as shown in the circuit diagram. The resistance of the connecting wires must be ignored.



17.1 Define the term *emf* of a battery. (2)

The reading on the voltmeter DECREASES by 1,5 V when switch **S** is closed.

17.2 Give a reason why the voltmeter reading decreases. (2)

17.3 Calculate the following when switch **S** is closed:

17.3.1 Reading on the ammeter (3)

17.3.2 Total external resistance of the circuit (4)

17.3.3 Emf of the battery (3)

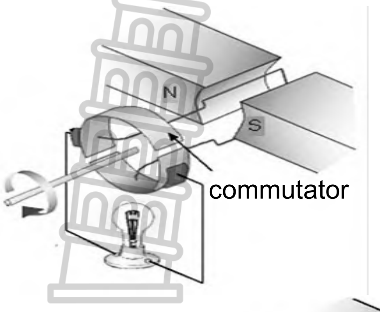
17.4 A learner makes the following statement: *The current through resistor R_3 is larger than the current through resistor R_2.* Is this statement CORRECT? Choose from YES or NO. Explain the answer. (3)

17.5 The 4 Ω resistor is now removed from the circuit. How will this affect the emf of the battery? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

[18]

ELECTRICAL MACHINES

QUESTION 1

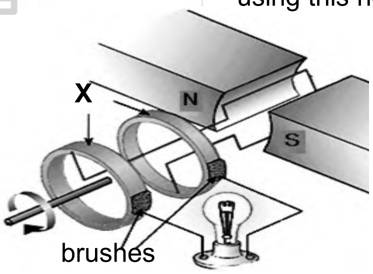


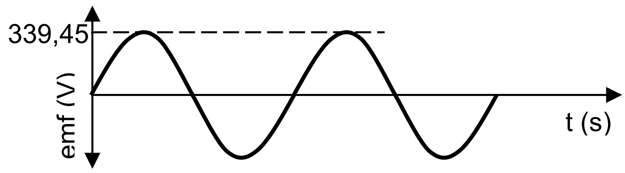
The diagram represents a simplified version of an electrical machine used to light up a bulb.

1.1 Name the principle on which the machine operates. (1)

1.2 State ONE way in which to make this bulb burn brighter. (1)

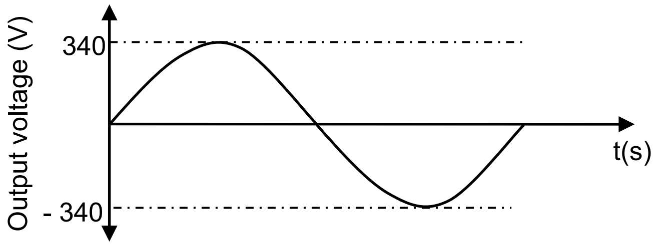
Some changes have been made to the machine and a new device is obtained. The new device as well as the graph of output emf versus time using this new device is shown below.





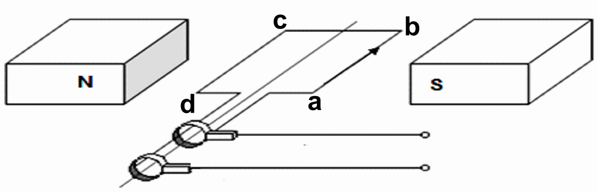
1.3 Name part **X** in the new device. (1)
1.4 Define the term *root mean square value of an AC voltage*. (2)
1.5 Calculate the rms voltage. (3)
[8]

QUESTION 2
The graph below shows the output voltage from a household AC generator for one cycle of rotation of the coils.



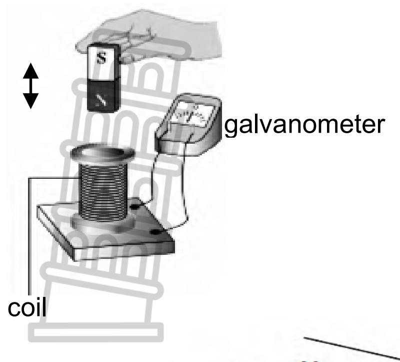
2.1 A 100 W light bulb is connected to this generator and it glows at its maximum brightness. Use the information from the graph to calculate the:
2.1.1 Resistance of the bulb (5)
2.1.2 rms current through the bulb (3)
2.2 Give ONE reason why AC voltage is preferred to DC voltage for everyday use. (1)
[9]

QUESTION 3
3.1 The output potential difference of an AC generator is 100 V at 20 Hz. A simplified diagram of the generator is shown below. The direction of the current in the coil is from **a** to **b**.



3.1.1 In which direction is the coil rotating? Write only CLOCKWISE or ANTICLOCKWISE. (1)
3.1.2 Starting from the position shown in the diagram, sketch a graph of the output potential difference versus time when the coil completes TWO full cycles. On the graph, clearly indicate the maximum potential difference (100 V) and the time taken to complete the twocycles. (3)
3.1.3 State ONE way in which this AC generator can be used to produce a lower output potential difference. (1)
3.2 An electrical device is rated 220 V, 1 500 W. Calculate the maximum current output for the device when it is connected to a 220 V alternating current source. (5)
[10]

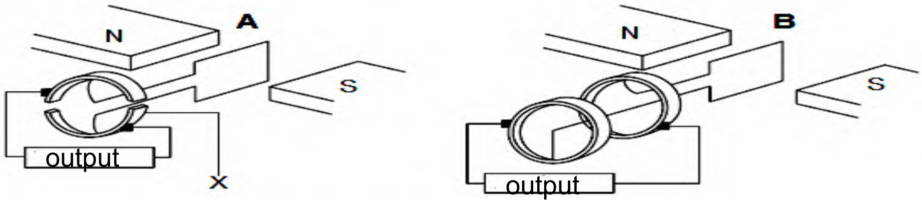
QUESTION 4



4.1 A teacher demonstrates how current can be obtained using a bar magnet, a coil and a galvanometer. The teacher moves the bar magnet up and down, as shown by the arrow in the diagram.

4.1.1 Briefly describe how the magnet must be moved in order to obtain a LARGE deflection on thegalvanometer. (2)

The two devices, **A** and **B**, below operate on the principle described in QUESTION 4.1.1 above.

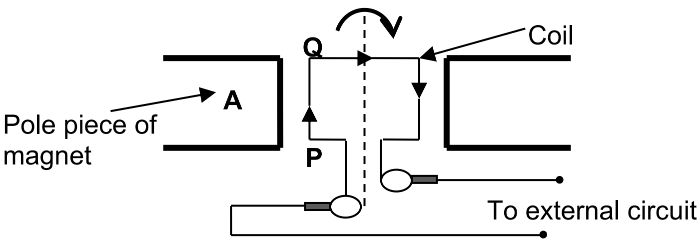


4.1.2 Write down the name of the principle. (1)
4.1.3 Write down the name of part **X** in device **A**. (1)

4.2 A 220 V, AC voltage is supplied from a wall socket to an electric kettle of resistance 40,33 Ω. Wall sockets provide rms voltages and currents.
Calculate the:
4.2.1 Electrical energy consumed by the kettle per second (4)
4.2.2 Maximum (peak) current through the kettle (3)
[11]

QUESTION 5

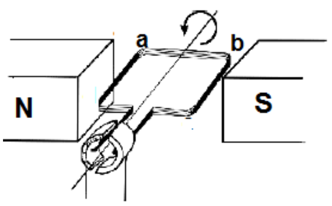
5.1 A simplified sketch of an AC generator is shown. The coil of the generator rotates clockwise between the pole pieces of two magnets. At a particular instant, the current in the segment **PQ** has the direction shown.



5.1.1 Identify the magnetic pole **A**.
Only write NORTH POLE or SOUTH POLE. (1)
5.1.2 The coil is rotated through 180°. Will the direction of the current in segment **PQ** be from **P to Q** or **Q to P**? (1)

5.2 An electrical device is connected to a generator which produces an rms potential difference of 220 V. The maximum current passing through the device is 8 A.
Calculate the:
5.2.1 Resistance of the device (5)
5.2.2 Energy the device consumes in two hours (5)
[12]

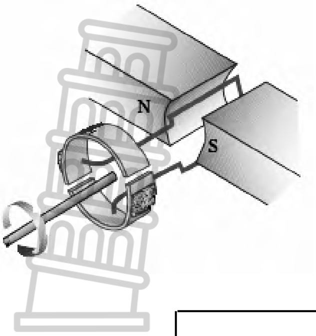
QUESTION 6



6.1 A part of a simplified DC motor is shown in the sketch.
6.1.1 In which direction (**a to b** OR **b to a**) is the current flowing through the coil if the coil rotates anticlockwise as indicated in the diagram? (1)
6.1.2 Name the rule you used to answer QUESTION 6.1.1. (1)
6.1.3 Which component in the diagram must be replaced in order for the device to operate as an AC generator? (1)

6.2 An electrical device of resistance 400 Ω is connected across an AC generator that produces a maximum emf of 430 V. The resistance of the coils of the generator can be ignored.
6.2.1 State the energy conversion that takes place when the AC generator is in operation. (2)
6.2.2 Calculate the root mean square value of the current passing through the resistor. (5)
[10]

QUESTION 7

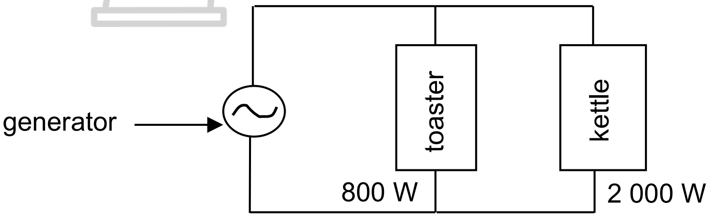


7.1 A generator is shown below. Assume that the coil is in a vertical position.

7.1.1 Is the generator above AC or DC? Give a reason for the answer. (2)

7.1.2 Sketch an induced emf versus time graph for ONE complete rotation of the coil. (The coil starts turning from the vertical position.) (2)

7.2 An AC generator is operating at a maximum emf of 340 V. It is connected across a toaster and a kettle, as shown in the diagram below. The toaster is rated at 800 W, while the kettle is rated at 2 000 W. Both are working under optimal conditions.

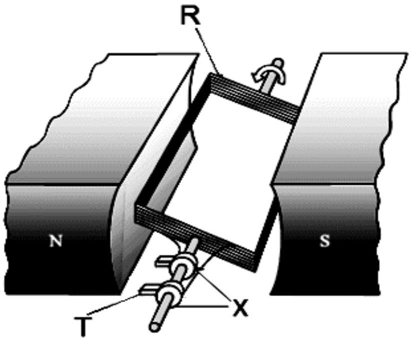


7.2.1 Calculate the rms current passing through the toaster. (3)

7.2.2 Calculate the total rms current delivered by the generator. (4)

[11]

QUESTION 8



8.1 The diagram shows a simplified version of a generator.

8.1.1 Write down the name of EACH part, **R**, **T** and **X**. (3)

8.1.2 Give the NAME of the law upon which the operation of the generator is based. (1)

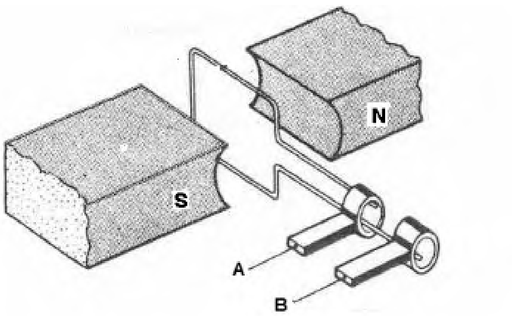
8.2 An AC supply is connected to a light bulb. The light bulb lights up with the same brightness as it does when connected to a 15 V battery.

8.2.1 Write down the rms value of the potential difference of the AC supply. (1)

8.2.2 If the resistance of the light bulb is 45 Ω, calculate the maximum current delivered to the light bulb. (4)

[9]

QUESTION 9



The diagram shows a simplified version of an AC generator.

9.1 Name the component in this arrangement that makes it different from a DC generator. (1)

9.2 Sketch a graph of induced emf versus time for TWO complete rotations of the coil. (2)

A practical version of the generator above has a large number of turns of the coil and it produces an rms potential difference of 240 V.

9.3 State TWO ways in which the induced emf can be increased. (2)

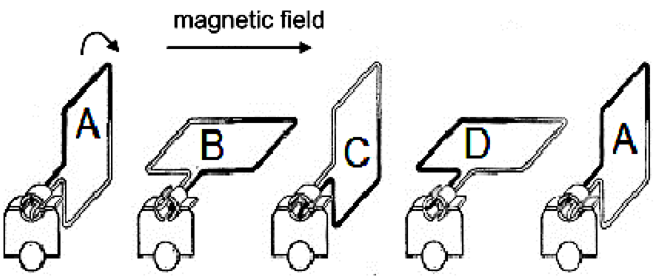
9.4 Define the term root mean square (rms) value of an AC potential difference. (2)

9.5 The practical version of the generator above is connected across an appliance rated at 1 500 W. Calculate the rms current passing through the appliance. (3)

[10]

QUESTION 10

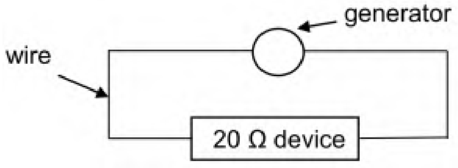
10.1 The diagram shows different positions (**ABCDA**) of the coil in a DC generator for a complete revolution. The coil is rotated clockwise at a constant speed in a uniform magnetic field. The direction of the magnetic field is shown in the diagram.



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

10.1.2 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)

10.2 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.



10.2.1 Write down the total resistance of the circuit. (1)

10.2.2 Calculate the average power delivered to the device. (5)

[9]

QUESTION 11

11.1 Learners want to build a small DC motor as a project. Write down THREE essential components that are needed for the building of the motor. (3)

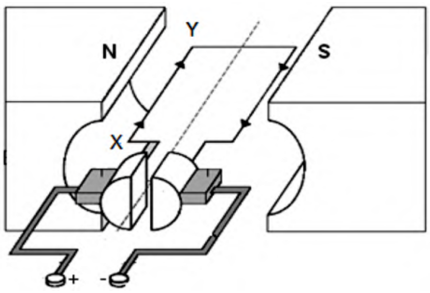
11.2 An electrical device with a resistance of 11 Ω is connected to an AC source with an rms voltage of 240 V.

11.2.1 Define the term rms voltage. (2)

11.2.2 Calculate the maximum (peak) current passing through the device. (4)

[9]

QUESTION 12



12.1 The diagram is a simplified representation of a DC motor. The current in the coil is in the direction **XY**.

12.1.1 Name the component that ensures that the coil rotates continuously in ONE DIRECTION. (1)

12.1.2 In which direction will the coil rotate? Write down only CLOCKWISE or ANTICLOCK-WISE. (2)

12.1.3 Write down the energy conversion which takes place while the motor is working. (2)

12.2 An AC generator, producing a maximum voltage of 320 V, is connected to a heater of resistance 35 Ω.

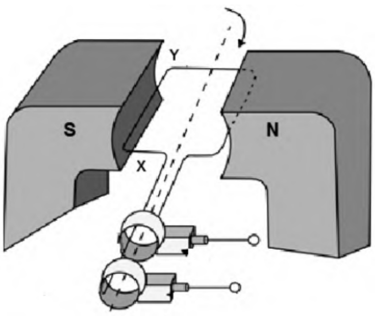
12.2.1 Write down the structural difference between an AC generator and a DC generator. (1)

12.2.2 Calculate the root mean square (rms) value of the voltage. (3)

12.2.3 Calculate the root mean square (rms) value of the current in the heater. (4)

[13]

QUESTION 13



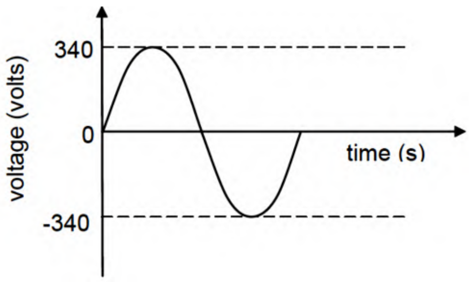
13.1 In the simplified AC generator, the coil is rotated clockwise

13.1.1 In which direction does the induced current flow in the coil? Choose from: **X to Y** or **Y to X** (1)

13.1.2 On which principle or law is the working of the generator based? (1)

13.1.3 State the energy conversion that takes place while the generator is in operation. (2)

13.2 The voltage output for an AC generator is shown below.



13.2.1 Write down the maximum (peak) output voltage of the generator. (1)

A stove is connected to the generator above, and delivers an average power of 1 600 W.

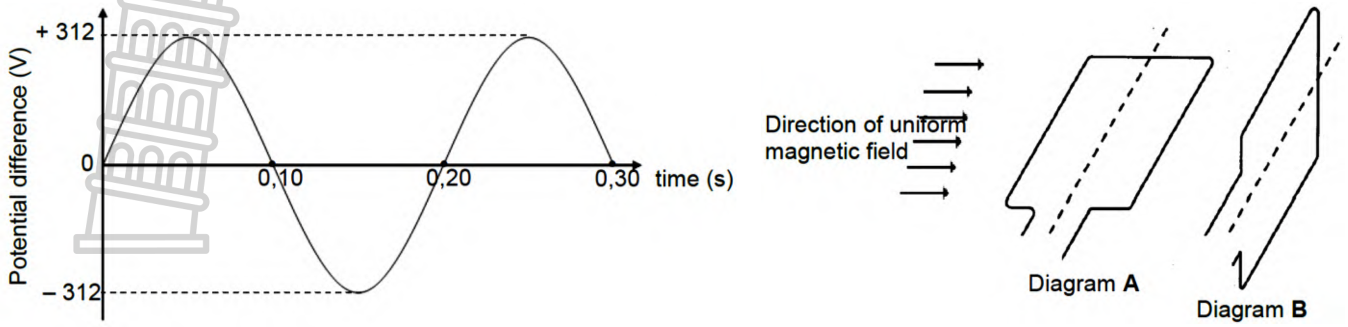
13.2.2 Calculate the rms voltage delivered to the stove. (3)

13.2.3 Calculate the resistance of the stove. (3)

[11]

QUESTION 14

The graph shows the voltage output of a generator. Diagrams **A** and **B** show the position of the generator at different times.



14.1 Does this generator have split rings or slip rings? (1)

14.2 Which ONE of the diagrams below, **A** or **B**, shows the position of the generator's coil at time = 0,10 s? (1)

14.3 Calculate the root mean square (rms) voltage for this generator. (3)

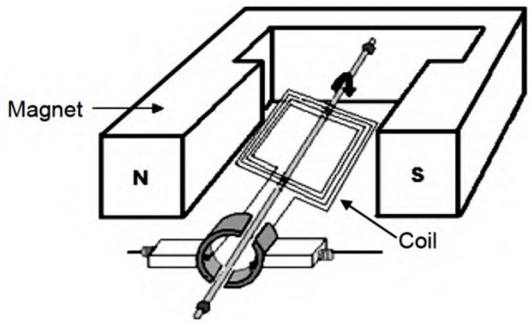
14.4 A device with a resistance of 40 Ω is connected to this generator.Calculate the:

14.4.1 Average power delivered by the generator to the device (3)

14.4.2 Maximum current delivered by the generator to the device (4)

[12]

QUESTION 15



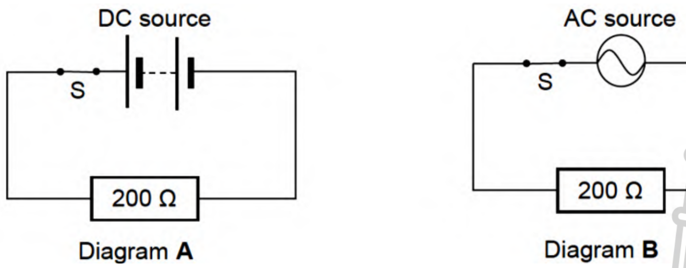
15.1 A simplified diagram of an electric generator is shown. When the coil is rotated with a constant speed, an emf is induced in the coil.

15.1.1 Is this an AC generator or a DC generator? (1)

15.1.2 Briefly explain how an emf is generated in the coil when the coil is rotated by referring to the principle of electromagnetic induction. (2)

15.1.3 Draw a sketch graph of the output voltage versus time for this generator. Show ONE complete cycle. (2)

15.2 A 200 Ω resistor is connected to a DC voltage supply, as shown in diagram **A**. The energy dissipated in the resistor in 10 s is 500 J. The same resistor is now connected to an AC source (diagram **B**) and 500 J of energy is also dissipated in the resistor in 10 s.



15.2.1 Define the term *rms voltage* of an AC source. (2)

15.2.2 Calculate the maximum (peak) voltage of the AC source. (5)

[12]

QUESTION 16

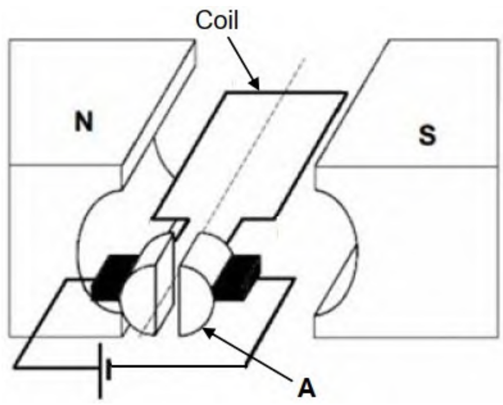
16.1 A simplified diagram of an electrical machine is shown.

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

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

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

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



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

16.2.1 Define the term *rms voltage*. (2)

16.2.2 Calculate the resistance of the device. (3)

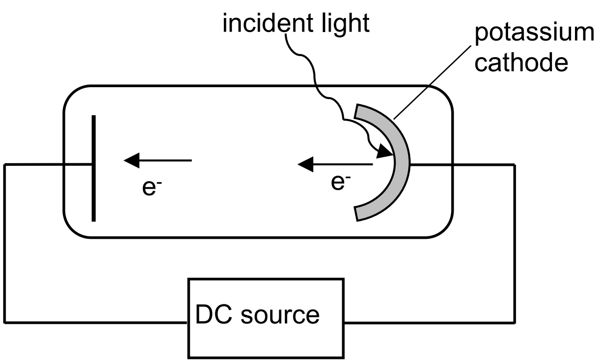
This device is now connected to a 150 V AC source.

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

[16]

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS

QUESTION 1



Ultraviolet light is incident onto a photocell with a potassium cathode as shown.

The threshold frequency of potassium is 5,548 x 10^{14} Hz.

1.1 Define the term threshold frequency (cut-off frequency). (2)

The maximum speed of an ejected photoelectron is 5,33 x 10^5 m·s^{-1}.

1.2 Calculate the wavelength of the ultraviolet light used. (5)

The photocell is now replaced by another photocell with a rubidium cathode. The maximum speed of the ejected photoelectron is 6,10 x 10^5 m·s^{-1} when the same ultraviolet light source is used.

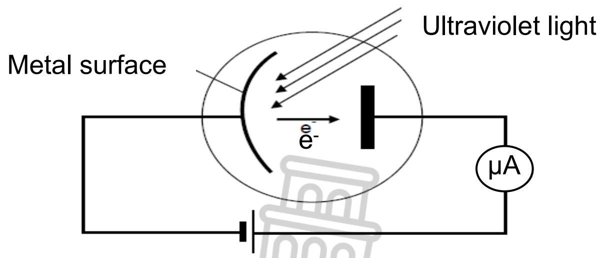
1.3 How does the work function of rubidium compare to that of potassium? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

1.4 Explain the answer to QUESTION 1.3. (3)

[11]

QUESTION 2

A learner uses photocells to determine the maximum kinetic energy of ejected photoelectrons. One photocell has a caesium cathode and the other has a sodium cathode. Each photocell is radiated by ultraviolet light from the same source as shown below.



The incomplete results obtained are shown in the table below.

NAME OF THE METAL	WORK FUNCTION OF THE METAL (J)	MAXIMUM KINETIC ENERGY OF PHOTOELECTRONS (J)
Caesium	3,36 x 10^{-19}	2,32 x 10^{-19}
Sodium	3,65 x 10^{-19}	E_K

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

2.2 Use the information in the table to calculate the wavelength of the ultraviolet light used in the experiment. (4)

2.3 Calculate the maximum kinetic energy, E_K, of an electron ejected from the sodium metal. (4)

2.4 The intensity of the incident ultraviolet light was then increased.

2.4.1 Give a reason why this change does NOT affect the maximum kinetic energy of the ejected photoelectrons. (1)

2.4.2 How does the increased intensity affect the reading on the ammeter? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

2.4.3 Explain the answer to QUESTION 2.4.2. (2)

[14]

QUESTION 3

3.1 In the diagram below, green and blue light are successively shone on a metal surface. In each case, electrons are ejected from the surface.

3.1.1 What property of light is illustrated by the photoelectric effect? (1)

3.1.2 Without any calculation, give a reason why the maximum kinetic energy of an ejected electron, using blue light, is GREATER THAN that obtained using green light, for the same metal surface. (2)

3.2 The wavelength associated with the cut-off (threshold) frequency of a certain metal is 330 nm. Calculate:

3.2.1 The work function of the metal (4)

3.2.2 The maximum speed of an electron ejected from the surface of the metal when light of frequency $1,2 \times 10^{15}$ Hz is shone on the metal (5)

[12]

QUESTION 4

In an experiment to demonstrate the photoelectric effect, light of different wavelengths was shone onto a metal surface of a photoelectric cell. The maximum kinetic energy of the emitted electrons was determined for the various wavelengths and recorded in the table below.

INVERSE OF WAVELENGTH $\frac{1}{\lambda}$ ($\times 10^{6}$ m^{-1})	MAXIMUM KINETIC ENERGY $E_{k(max)}$ ($\times 10^{-19}$ J)
5,00	6,60
3,30	3,30
2,50	1,70
2,00	0,70

4.1 What is meant by the term *photoelectric effect*? (2)

4.2 Draw a graph of $E_{k(max)}$ (y-axis) versus $\frac{1}{\lambda}$ (x-axis) on a graph paper. (3)

4.3 USE THE GRAPH to determine:

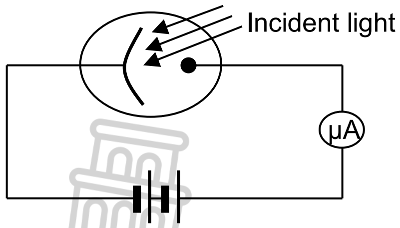
4.3.1 The threshold frequency of the metal in the photoelectric cell (4)

4.3.2 Planck's constant (4)

[13]

QUESTION 5

An investigation was conducted to determine the effects of changes in frequency AND intensity on the current generated in a photoelectric cell when light is incident on it. The apparatus used in the investigation is shown in the simplified diagram.



The results of the experiment are shown in the table below.

EXPERIMENT	FREQUENCY (Hz)	INTENSITY (Cd)	CURRENT (μA)
A	$4,00 \times 10^{14}$	10	0
B	$4,50 \times 10^{14}$	10	0
C	$5,00 \times 10^{14}$	10	0
D	$5,01 \times 10^{14}$	10	20
E	$5,01 \times 10^{14}$	20	40
F	$6,50 \times 10^{14}$	10	30

5.1 Define the term *work function*. (2)

5.2 Identify an independent variable. (1)

The threshold frequency for the metal used in the photocell is $5,001 \times 10^{14}$ Hz.

5.3 Define the term *threshold frequency*. (2)

5.4 Calculate the maximum speed of an emitted electron in experiment **F**. (5)

In experiments **D** and **E**, the current doubled when the intensity was doubled at the same frequency.

5.5 What conclusion can be made from this observation? (2)

[12]

QUESTION 6

6.1 In an experiment on the photoelectric effect, light is incident on the surface of a metal and electrons are ejected.

6.1.1 What does the photoelectric effect indicate about the nature of light? (1)

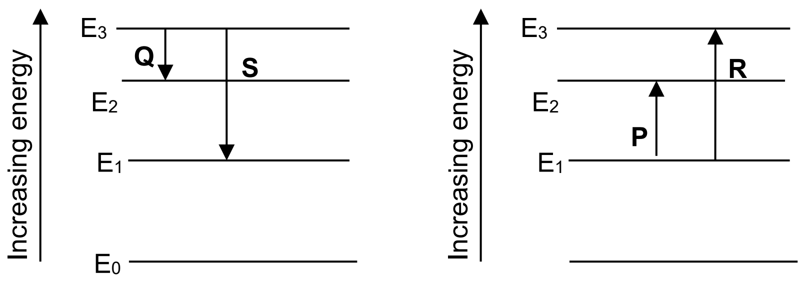
6.1.2 The intensity of the light is increased. Will the maximum speed of the ejected electrons INCREASE, DECREASE or REMAIN THE SAME? Give a reason for the answer. (2)

The wavelength corresponding with the threshold frequency is referred to as threshold wavelength. The table below gives the values of threshold wavelengths for three different metals.

METAL	THRESHOLD WAVELENGTH (λ_0) IN METRES
Silver	$2,88 \times 10^{-7}$
Calcium	$4,32 \times 10^{-7}$
Sodium	$5,37 \times 10^{-7}$

In the experiment using one of the metals above, the maximum speed of the ejected electrons was recorded as $4,76 \times 10^5$ m·s^{-1} for light of wavelength 420 nm.

6.1.3 Identify the metal used in the experiment by means of suitable calculations. (5)



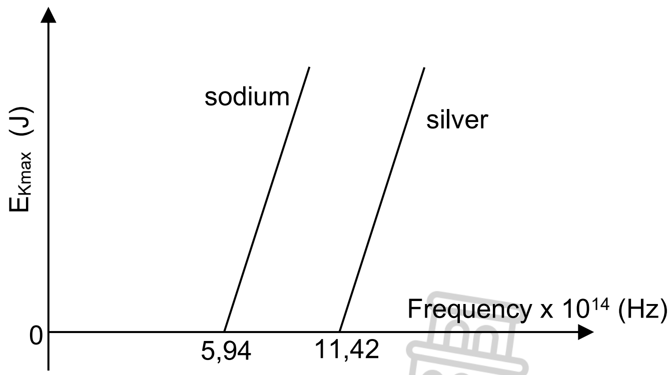
6.2 The simplified energy diagrams showing the possible electron transitions in an atom are shown alongside.

Using the letters **P**, **Q**, **R** and **S**, identify the lines that CORRECTLY show transitions that will result in the atom giving off an EMISSION SPECTRUM. Give a reason for the answer. (4)

[12]

QUESTION 7

7.1 A learner is investigating the photoelectric effect for two different metals, silver and sodium, using light of different frequencies. The maximum kinetic energy of the emitted photoelectrons is plotted against the frequency of the light for each of the metals, as shown in the graphs below.



7.1.1 Define the term *threshold frequency*. (2)

7.1.2 Which metal, sodium or silver, has the larger work function? Explain the answer. (3)

7.1.3 Name the physical constant represented by the slopes of the graphs. (1)

7.1.4 If light of the same frequency is shone on each of the metals, in which metal will the ejected photoelectrons have a larger maximum kinetic energy? (1)

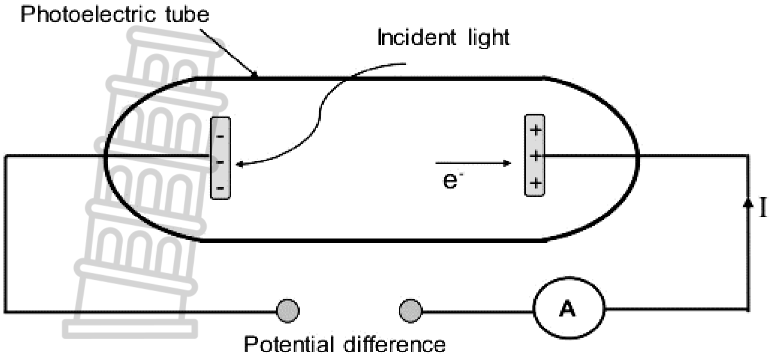
7.2 In a different photoelectric experiment blue light obtained from a light bulb is shone onto a metal plate and electrons are released. The wavelength of the blue light is 470×10^{-9} m and the bulb is rated at 60 mW. The bulb is only 5% efficient.

7.2.1 Calculate the number of photons that will be incident on the metal plate per second, assuming all the light from the bulb is incident on the metal plate. (5)

7.2.2 Without any further calculation, write down the number of electrons emitted per second from the metal. (1)

[13]

QUESTION 8



A simplified diagram of an apparatus for an experiment to investigate the photo-electric effect is shown alongside. Light of fixed frequency is incident on the cathode of a photoelectric tube.
During the experiment the ammeter (A) registers the photocurrent.

8.1 Define the term *photoelectric effect*. (2)

The intensity of the incident light is now increased.

8.2 State how this increase in intensity will affect the reading on the ammeter. Choose from INCREASE, DECREASE or REMAIN THE SAME. Give a reason for the answer. (3)

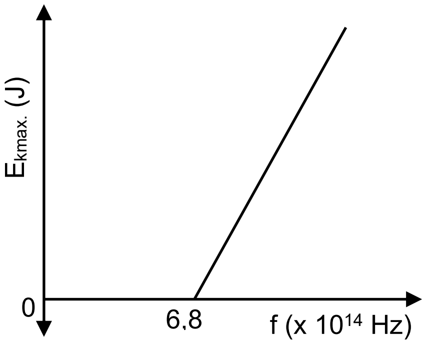
When the frequency of the incident light is $5,9 \times 10^{14}$ Hz, the maximum recorded kinetic energy of photoelectrons is $2,9 \times 10^{-19}$ J.

8.3 Calculate the maximum wavelength (threshold wavelength) of the incident light that will emit an electron from the cathode of the photo-electric tube. (5)

The maximum kinetic energy of the photoelectrons ejected increases when light of a higher frequency is used.

8.4 Use the photoelectric equation to explain this observation. (2)
[12]

QUESTION 9



The graph is obtained for an experiment on the photoelectric effect using different frequencies of light and a given metal plate.
The threshold frequency for the metal is $6,8 \times 10^{14}$ Hz.

9.1 Define the term *threshold frequency*. (2)

In the experiment, the brightness of the light incident on the metal surface is increased.

9.2 State how this change will influence the speed of the photoelectrons emitted. Choose from INCREASES, DECREASES or REMAINS UNCHANGED. (1)

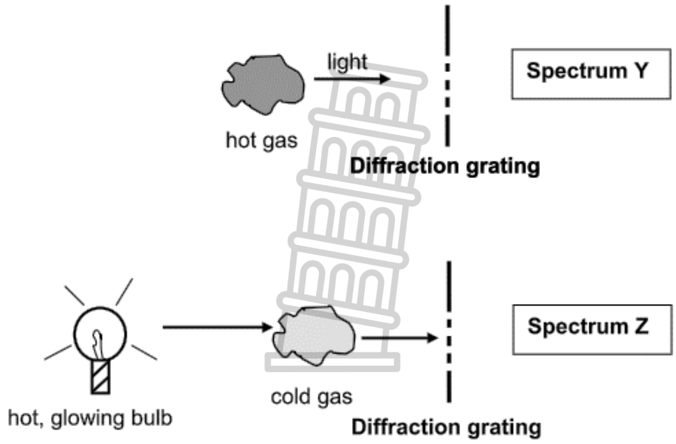
9.3 Show by means of a calculation whether the photoelectric effect will be OBSERVED or NOT OBSERVED, if monochromatic light with a wavelength of 6×10^{-7} m is used in this experiment. (5)

One of the radiations used in this experiment has a frequency of $7,8 \times 10^{14}$ Hz.

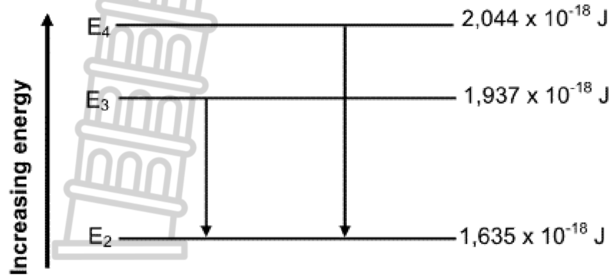
9.4 Calculate the maximum speed of an ejected photoelectron. (5)
[13]

QUESTION 10

10.1 A teacher in a science class explains how different types of spectra are obtained. The teacher uses the simplified diagrams shown alongside for the explanation.
Name the type of spectrum of:
10.1.1 **Y** (1)
10.1.2 **Z** (1)



10.2 In an excited atom, electrons can 'jump' from lower energy levels to higher energy levels. They can also 'drop' from higher energy levels to lower energy levels. The diagram (not drawn to scale) shows some of the transitions for electrons in an excited atom.



10.2.1 Do the transitions indicated in the diagram lead to ABSORPTION or EMISSION spectra? (1)

10.2.2 Calculate the frequency of the photon produced when an electron in an excited atom makes a transition from E_4 to E_2, as shown in the diagram. (4)

The threshold frequency of a metal, **Q**, is $4,4 \times 10^{14}$ Hz.

10.2.3 Calculate the kinetic energy of the most energetic electron ejected when the photon produced in QUESTION 10.2.2 is incident on the surface of metal **Q**. (4)

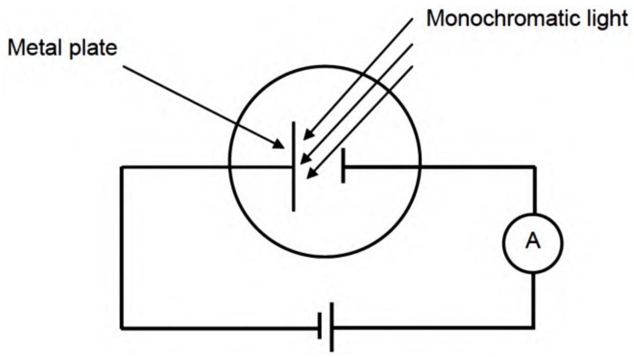
Another metal, **R**, has a threshold frequency of $7,5 \times 10^{14}$ Hz.

10.2.4 Will the photon produced in QUESTION 10.2.2 be able to eject electrons from the surface of metal **R**? Write down only YES or NO. Give a reason for the answer. (2)

[13]

QUESTION 11

11.1 In the diagram, monochromatic light is incident on the metal plate of a photocell. A sensitive ammeter shows a reading.



11.1.1 How does the energy of the photons of the incident light compare to the work function of the metal plate? Choose from GREATER THAN, LESS THAN or EQUAL TO. Give a reason for the answer. (2)

11.1.2 When a change is made to the monochromatic light, the reading on the ammeter increases. A learner makes the following statement with regard to this change:
The increase in the ammeter reading is due to an increase in the energy of the incident photons. Give a reason why this statement is INCORRECT. (2)

11.1.3 What does the photoelectric effect tell us about the nature of light? (1)

11.2 Ultraviolet radiation is incident on the surface of sodium metal. The threshold frequency (f_0) for sodium is $5,73 \times 10^{14}$ Hz. The maximum speed of an electron emitted from the metal surface is $4,19 \times 10^5$ m·s^{-1}.

11.2.1 Define or explain the term *threshold frequency*. (2)

11.2.2 Calculate the work function of sodium. (3)

11.2.3 Calculate the frequency of the incident photon. (3)

[13]

QUESTION 12

A group of students investigates the relationship between the work function of different metals and the maximum kinetic energy of the ejected electrons when the metals are irradiated with light of suitable frequency.

12.1 Define the term *work function*. (2)

During the investigation ultraviolet rays of wavelength 2×10^{-8} m are allowed to fall on different metal plates. The corresponding maximum kinetic energies of ejected electrons are measured. The data obtained is displayed in the table below.

METAL PLATE USED	**MAXIMUM KINETIC ENERGY ($E_{k(max)}$) ($\times 10^{-18}$ J)**
Lead	9,28
Potassium	9,58
Silver	9,19

12.2 Write down the dependent variable for this investigation. (1)

12.3 Write down ONE control variable for this investigation. (1)

12.4 Using the information in the table, and without any calculation, identify the metal with the largest work function. Explain the answer. (3)

12.5 Use information in the table to calculate the work function of potassium. (4)

12.6 State how an increase in the intensity of the ultraviolet light affects the maximum kinetic energy of the photoelectrons. Choose from INCREASES, DECREASES, REMAINS THE SAME. Explain the answer.(3)
[14]

QUESTION 13

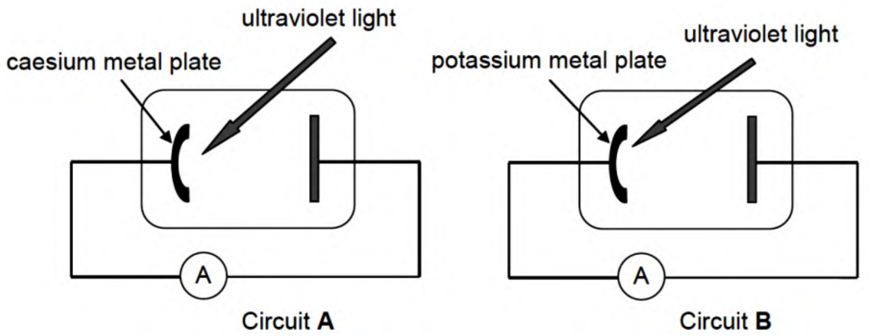
The threshold frequencies of caesium and potassium metals are given in the table below.

METAL	THRESHOLD FREQUENCY
Caesium	$5,07 \times 10^{14}$ Hz
Potassium	$5,55 \times 10^{14}$ Hz

13.1 Define the term *work function* in words. (2)

13.2 Which ONE of the two metals in the table has the higher work function? Give a reason for the answer by referring to the information in the table. (2)

The simplified diagrams below show two circuits, **A** and **B**, containing photocells. The photocell in circuit **A** contains a caesium metal plate, while the photocell in circuit **B** contains a potassium metal plate. Ultraviolet light with the same intensity and wavelength of $5,5 \times 10^{-7}$ m is incident on the metal plate in EACH of the photocells and the ammeter in circuit **A** registers a current.



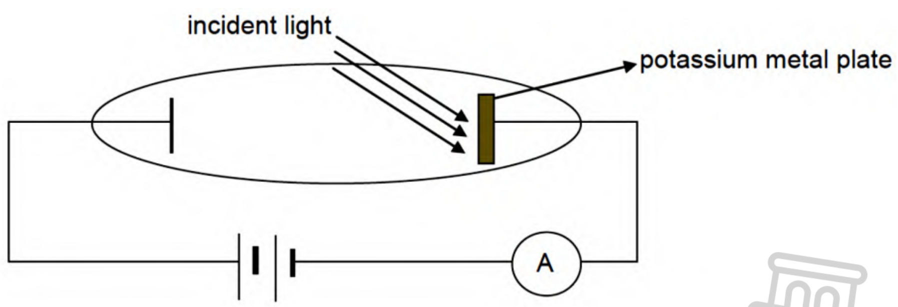
13.3 By means of a calculation, determine whether the ammeter in circuit **B** will also register a current. (3)

13.4 Calculate the maximum kinetic energy of an ejected electron in circuit **A**. (5)

13.5 How will the maximum kinetic energy of the ejected electron, calculated in QUESTION13.4, change when the intensity of the incident light increases? Choose from: INCREASES, DECREASES or REMAINS THE SAME. (1)
[13]

QUESTION 14

A potassium metal plate is irradiated with light of wavelength 5×10^{-7} m in an arrangement, as shown below. The threshold frequency of potassium is $5,55 \times 10^{14}$ Hz.



14.1 Define the term threshold frequency. (2)

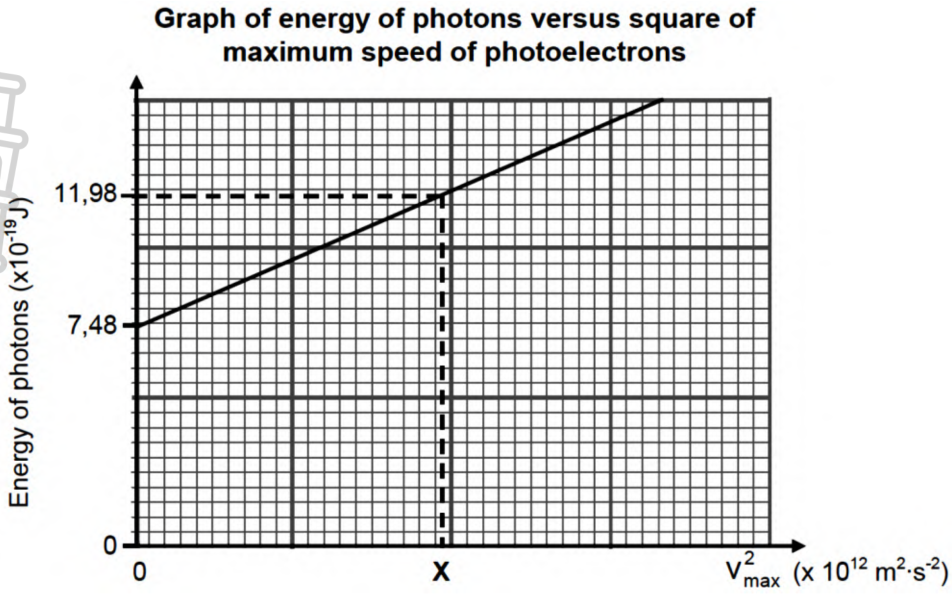
14.2 Calculate the energy of a photon incident on the metal plate. (3)

14.3 Using a suitable calculation, prove that the ammeter will show a reading. (4)

14.4 The intensity of the light is now increased. Explain why this change causes an increase in the ammeter reading. (3)
[12]

QUESTION 15

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.



15.1 Define the term *photoelectric effect*. (2)

Use the graph to answer the following questions.

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

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

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

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

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

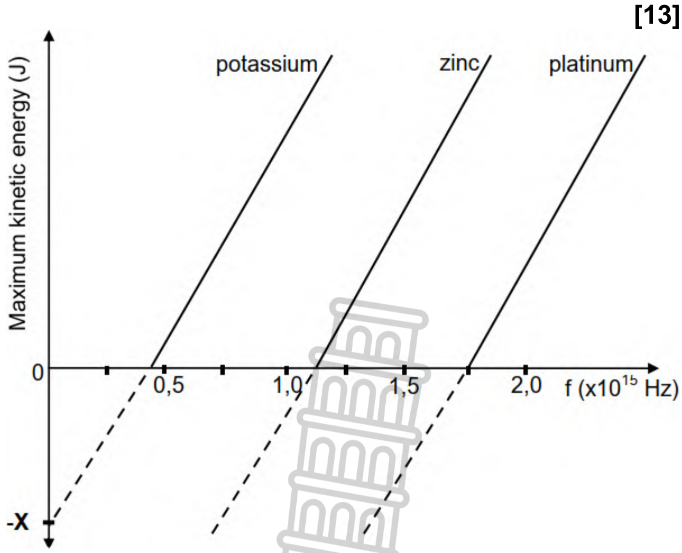
15.5.1 The gradient of the graph (1)

15.5.2 The number of photoelectrons emitted per unit time (1)

[13]

QUESTION 16

An experiment is conducted to investigate the relationship between the frequency of light incident on a metal and the maximum kinetic energy of the emitted electrons from the surface of the metal. This experiment is conducted for three different metals. The graph represents the results obtained.



16.1 Name the phenomenon on which this experiment is based. (1)

16.2 Name the physical quantity represented by **X** on the graph. (1)

16.3 Which ONE of the three metals needs incident light with the *largest wavelength* for the emission of electrons? Give a reason for the answer. (2)

16.4 Define the term *work function* in words. (2)

16.5 Calculate the:

16.5.1 Work function of **platinum** (3)

16.5.2 Frequency of the incident light that will emit electrons from the surface of **platinum** with a maximum velocity of $5{,}60 \times 10^5$ m·s^{-1} (4)

[13]

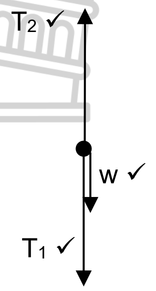
ANSWERS TO QUESTIONS

NEWTON'S LAWS

QUESTION 1

1.1 When a resultant (net) force acts on an object, the object will accelerate in the direction of the force with an acceleration which is directly proportional to the force ✓ and inversely proportional to the mass of the object.✓ (2)

1.2



Accepted labels	
w	F_g / F_w/ force of earth on block / weight / 49 N / mg / gravitational force
T_2	Tension 2 / F_Q / 250 N / F_{T2} / F_{app}
T_1	Tension 1 / F_{T1} / F_P

(3)

1.3 $F_{net} = ma$ ✓

For 5 kg block:

$T_2 + (-mg) + (-T_1) = ma$

$250 - (5)(9,8) - T_1$ ✓ $= 5a$

$201 - T_1 = 5a$

$T_1 = 201 - 5a$...... .(1)

✓for either 5a or 20a

For 20 kg block:

$T_1 + (-mg) = ma$.......(2)

$T_1 + [-20(9,8)]$ ✓ $= 20a$

$5 = 25a$ $\therefore$ $a = 0,2\ m\cdot s^{-2}$ upwards

$\therefore$ $T_1 = 201 - 5(0,2)$ ✓ $= 200$ N ✓ **OR** $T_1 = 20(9,8) + 20(0,2)$ ✓ $= 200$ N ✓ (6)

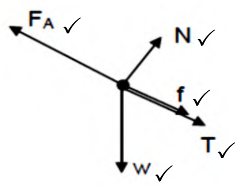
1.4 **Q** ✓ (1)

[12]

QUESTION 2

2.1 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)

2.2



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)

2.3.1 **OPTION 1/*OPSIE 1***

For the 1 kg block/*Vir die 1 kg blok*;

$f_k = \mu_k N$

$= \mu_k\ mg\cos\theta$✓

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

$= 2,46$ N✓

OPTION 2/*OPSIE 2*

BY PROPORTION:/*DEUR EWEREDIGHEID*

The smaller mass = ¼ of the larger mass✓

Die kleiner massa = ¼ die groter massa

$\therefore$frictional force/*wrywingskrag* = ¼ (10) ✓

= 2,5 N✓

(3)

2.3.2 $F_{net} = ma$✓

For 1 kg block/*Vir 1 kg blok*

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

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

$40 - T - 7,36 = a$

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

For 4 kg block/*Vir 4 kg blok*

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

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

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

From (1) and (2)/*Vanaf (1) en (2)*

$a = 0,61\ m\cdot s^{-2}$

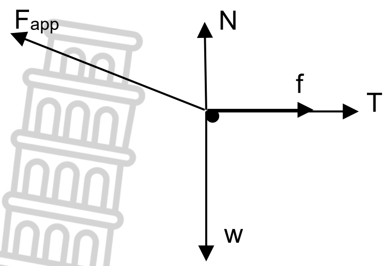
$T = 29,6 + (4(0,61)$ ✓ (6)

$T = 32,04$ N✓

[16]

QUESTION 3

3.1



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)

3.2.1 $F_{60y} = F_{60}\sin\theta$, $F_{60y} = 60\sin 10°$ ✓ **OR** $F_{60Y} = F_{60}\cos\theta$, $F_{60y} = 60\cos 80°$ ✓

$= 10,42$ N ✓ (2)

3.2.2 $F_{60x} = F_{60}\cos\theta$, $F_{60x} = 60\cos 10°$ ✓ **OR** $F_{60x} = F_{60}\sin\theta$, $F_{60x} = 60\sin 80°$ ✓

$= 59,09$ N ✓ (2)

3.3 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. ✓ (2)

3.4

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

(2)

3.5

$F_{net} = ma$ ✓ **OR** $T - m_2g = m_2a$ **OR** $T - 2(9,8) = 2a$

$T - 19,6$ ✓ $= 2a$……………………..(1)

$F_{60x} - (f + T) = m_8a$

$60\cos 10° - (f + T) = 5a$. ✓ **OR** $60\sin 80° - [f + T] = 5a$

$60\cos 10° - [(\mu_kN)$ ✓ $+ T)] = 5a$

$59,09 - (0,5 \times 38,58) - T$ ✓ $= 5a$

$39,8 - T = 5a$.......................(2)

$a = 2,886$ m·s^{-2}

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

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

$7T - 177,6 = 0$ ✓ $\therefore T = 25,37$ N ✓ (7)

[20]

QUESTION 4

4.1.1 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)

4.1.2

For 2,5 kg block $T = mg$ ✓ $\therefore T = (2,5)(9,8)$ ✓ $= 24,5$ N ✓	**OR** $F_{net} = ma$ $T - mg = (2,5)(0)$ ✓ $T - (2,5)(9,8)$ ✓ $= 0$ $T = 24,5$ N ✓	**OR** $F_{net} = ma$ $mg - T = (2,5)(0)$ ✓ $(2,5)(9,8) - T$ ✓ $= 0$ $T = 24,5$ N ✓

(3)

4.1.3

For mass M: $f_s = \mu_sN$ ✓ $\therefore N = \frac{24,5 ✓}{0,2 ✓} = 122,5$ N $N = Mg = 122,5$ N $\therefore$ $M(9,8) = 122,5$ N ✓ $\therefore M = 12,5$ kg ✓	**OR** μ_sN ✓ $= \mu_sMg$ $24,5$ ✓$= (0,2)$ ✓$M(9,8)$ ✓ $M = 12,5$ kg ✓

(5)

4.1.4 For the 5 kg block:

$f_k = \mu_kN$

$f_k = (0,15)(5)(9,8)$ ✓$= 7,35$ N

$F_{net} = ma$, $T - f_k = ma$ ✓

$\therefore T - 7,35 = 5a$ ✓

For the 2,5 kg block:

$w - T = ma$

$(2,5)(9,8) - T = 2,5a$ ✓ $\therefore 17,15 = 7,5$

$\therefore a = 2,29$ m·s^{-2} ✓

(5)

4.2

$F = G\frac{m_1m_2}{r^2}$ ✓

$F = \frac{(6,67\times10^{-11})(6,5\times10^{20})(90)}{(550\times10^3)^2}$ ✓ ✓ $= 12,90\ N$ ✓ (12,899 N)

OR

$g = \frac{Gm}{r^2}$ ✓

$g = \frac{(6,67\times10^{-11})(6,5\times10^{20})}{(550\times10^3)^2}$ ✓

$= 0,143...m\cdot s^{-2}$

Any one

$w = mg$

$= (90)(0,143..)$ ✓ $= 12,89\ N$ ✓ (downwards) (Accept 12,6 N - 12,90 N) (4)

[19]

QUESTION 5

5.1.1 **For the 5 kg mass/*Vir die 5 kg massa*:**

$T - f = ma$

$T - \mu_k(mg) = ma$✓

$T - (0,4)(5)(9,8)$✓ $= 5a$✓.........(1)

For the 20 kg mass/*Vir die 20 kg massa*

$mg - T = ma$

$20(9,8) - T = 20a$✓..........(2)

$176,4 = 25a$ (1) + (2)

$\therefore a = 7,06\ (7,056)\ m\cdot s^{-2}$✓ (5)

5.1.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$v_f^2 = v_i^2 + 2a\Delta y$✓ $= 0$✓ $+ (2)(7,056)(6)$✓ $v_f = 9,20\ m\cdot s^{-1}$✓	The 5 kg mass travels as fast as the 20 kg mass *Die 5 kg massa beweeg net so vinnig soos die 20 kg massa* $W_{net} = \Delta K$✓ $(5)(7,056)(6\cos0^{\circ})$✓ $= ½(5)(v_f^2 - 0)$✓ $v_f = 9,20\ m\cdot s^{-1}$✓

(4)

5.1.3 6 m ✓ (1)

5.2.1 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. ✓ (2)

5.2.2

$F = \frac{Gm_1m_2}{r^2}$ ✓

On the mountain/*Op die berg*

$F_g = \frac{(6,67\times10^{-11})(5,98\times10^{24})(65)}{(6,38\times10^6 + 6\times10^3)^2}$ ✓ ✓

$= 627,2\ N$

On the ground/*Op die grond*

$F_g = W = mg$

$= (65 \times 9,8)$✓

$= 637\ N$

$F_g = \frac{(6,67\times10^{-11})(5,98\times10^{24})(65)}{(6,38\times10^6)^2}$

$= 636,94\ N$

Difference/*Verskil* $= (637 - 627,2)$✓

$= 9,8\ N$✓ (6)

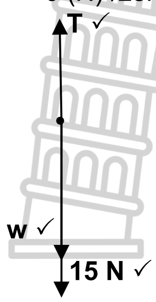
[18]

QUESTION 6

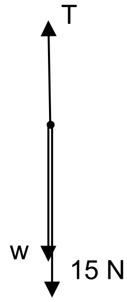
6.1 A body will <u>remain in its state of rest or motion at constant velocity</u> ✓ <u>unless a resultant/net force</u> ✓ acts on it. (2)

6.2 0 (N) /zero (newton) ✓ (2)

6.3



OR



Accepted labels	
w	F_g / F_w / weight / mg / gravitational force
T	F_T / tension
15 N	F_a / F_{15N} / $F_{applied}$ / F_t / / F

(3)

6.4 **<u>2 kg block</u>**

$F_{net} = ma$
$F_a + F_g + (-T) = ma$
$F_a + mg + (-T) = ma$ } ✓
$\underline{[15 + (2)(9,8) - T]}$ ✓ = $\underline{(2)(1,2)}$ ✓
T = 32,2 N

<u>10 kg block</u>

$T + (-f_k) = ma$
$T - \mu_k N = ma$
$T - \mu_k mg = ma$ } ✓
$32,2 - \underline{(\mu_k)(10)(9,8)}$ ✓ = (10)(1,2) ✓
$\therefore \mu_k = 0,21$ ✓ (7)

6.5 Smaller than ✓ (1)

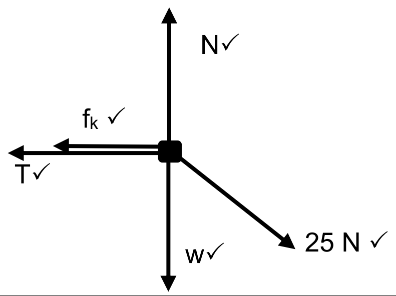
6.6 Remains the same ✓
The coefficient of kinetic friction is independent of the surface areas in contact. ✓
OR: The coefficient of kinetic friction depends only on type of materials used. ✓ (2)

QUESTION 7

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

7.2 $f_k = \mu_k N$ ✓ $= \mu_k mg = \underline{(0,15)(3)(9,8)}$ ✓ = 4,41 N ✓ (3)

7.3



Accepted Labels	
w	F_g/ F_w/force of earth on block / weight /14,7 N / mg /gravitational force
N	F_N / F_{normal} / normal force
T	Tension/F_T
f_k	$f_{kinetic\ friction}$ / f / F_f / kinetic friction
25 N	$F_{applied}$ / F_A / F

(5)

7.4.1

<u>OPTION 1</u>	**<u>OPTION 2</u>**
$f_k = \mu_k N = \mu_k(25\sin 30° + mg)$ $= 0,15[\underline{(25\sin30°)}$ ✓ + $\underline{(1,5)(9,8)}$ ✓] = 4,08 N ✓	$f_k = \mu_k N = \mu_k(25\cos 60° + mg)$ $= 0,15[(25\cos60°)$ ✓ + (1,5)(9,8) ✓] = 4,08 N ✓

(3)

7.4.2 For the 1,5 kg block
$F_{net} = ma$
$F_x + (-T) + (-f_k) = ma$ } ✓
$25\cos 30° - T - f_k = 1,5a$
$\underline{(25\cos 30° - T) - 4,08}$ ✓ = 1,5a
17,571 – T = 1,5a ……….(1)

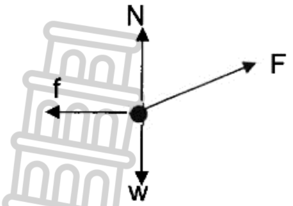
✓either one

For the 3 kg block
$T - f_k = 3a$
$\underline{T - 4,41}$ ✓ = 3a …………..(2)
13,161 = 4,5 a ∴ a = 2,925 m·s^{-2} and T = 13,19 N ✓ (13,17 N – 13,19 N) (5)

[18]

QUESTION 8

8.1.1



Accepted labels/*Aanvaarde benoemings*		
w	F_g/F_w/weight/mg/gravitational force *F_g/F_w/gewig/mg/gravitasiekrag*	✓
f	Friction/F_f/f_k/3 N/*wrywing/F_w*	✓
N	Normal (force)/$F_{normal}/F_N/F_{normaal}/F_{reaction/reaksie}$	✓
F	$F_A/F_{applied/toegepas}$	✓

(4)

8.1.2 $f_k = \mu_k N$ ✓
$3 = (0,2)N$ ✓
$N = 15$ N ✓ (3)

8.1.3
$$\left.\begin{array}{l} F_{net} = ma \\ N + F_{vert} - w = 0 \\ N + F_{vert} = w \end{array}\right\}$$ ✓ Any one

$\underline{F\sin 20^o}$ ✓= $\underline{(2)(9,8) - 15}$ ✓
$F = 13.45$ N✓ (4)

8.1.4
$$\left.\begin{array}{l} F_{net} = ma \\ F\cos 20^o - f = ma \end{array}\right\}$$ ✓ Any one

$\underline{13.45\cos 20^o - 3 = 2a}$✓
$a = 4,82$ m.s^{-2} ✓ (3)

8.2.1 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. ✓ (2)

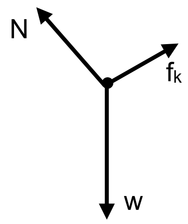
8.2.2 Increases ✓
Gravitational force is inverely proportional to the square of the distance between the centres of the objects. ✓ OR $F\alpha\dfrac{1}{r^2}$ (2)

[18]

QUESTION 9

9.1 0 N/zero ✓ (1)

9.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/N/19,6 N
f	$F_{friction}/F_f$/friction/f_k
N	F_N/F_{normal}/normal force
	Deduct 1 mark for any additional force.
	Mark is given for both arrow and label

(3)

9.3.1
$$\left.\begin{array}{l} F_{net} = ma \\ \underline{f_k - mg\sin\theta} = 0 \\ \underline{f_k = mg\sin\theta} \end{array}\right\}$$ ✓ 1 mark for any of these

f_k = $\underline{(2)(9,8)\sin 7^\circ}$ ✓ ∴ $f_k = 2,39$ N ✓ (2,389) N (3)

9.3.2
$$\left.\begin{array}{l} f_k = \mu_k N \\ \quad = \mu_k mg\cos 7^\circ \end{array}\right\}$$✓ any one

$2,389 = \underline{\mu_k(2)(9,8)\cos 7^\circ}$ ✓ ∴ $\mu_k = 0,12$ ✓ (3)

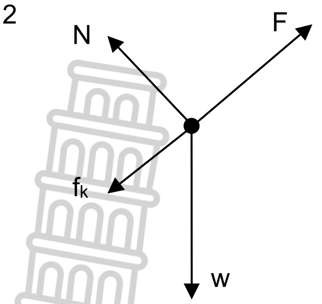
9.3.3 $F_{net} = ma$ OR $-f_k = ma$ OR $\mu_k N = ma$ ✓
$-\mu_k(mg) = ma$
$\underline{-(0,12)(2)(9,8)}$ ✓$\underline{= 2a}$ ✓ ∴ $a = -1,176$ m.s^{-2} (-1,18)
$v_f^2 = v_i^2 + 2a\Delta x$
$\underline{0 = (1,5)^2 + 2(-1,176)\Delta x}$✓ ∴ $\Delta x = 0,96$ m ∴ Distance = 0,96 m✓ (5)

[15]

QUESTION 10

10.1.1 An object continues in its state of <u>rest</u> or <u>uniform motion</u> (moving with constant velocity) <u>unless</u> it is acted upon by an <u>unbalanced (resultant/net)</u> force.✓✓ (2)

10.1.2



Accepted labels	
w	F_g / F_w/weight/mg /78,4 N/gravitational force
F	F_{app}/F_A / applied force (Accept T / tension)
f_k	(kinetic) friction/F_f/f/F_w
N	F_N/Normal (force)/ 67,9 N

(4)

10.1.3 $F_{net} = ma$
$F_{net} = 0$
$F+(-f_k) + (-F_{g||}) = ma$
$F- (f_k + F_{g||}) = ma$ } ✓Any one
F - 20,37✓ - (8)(9,8)sin30°✓ = 0 ✓ ∴ F = 59,57 N ✓
OR
F - 20,37✓- (8)(9,8)cos60°✓ = 0 ✓ ∴ F = 59,57 N ✓

OR
F - 20,37✓ - 39,2✓ = 0 ✓
F = 59,57 N ✓
OR
F = {20,37 ✓ + (8)(9,8)sin30°✓}✓

(5)

10.1.4

OPTION 1	**OPTION 2**
$F_{net} = ma$ $(F_{g\|\|} - f_k) = ma$ } ✓ (8)(9,8)sin30° - 20,37✓ = 8a ✓ ∴magnitude a = 2,35 m·s^{-2}✓	$F_{net} = ma$ $(f_k - F_{g\|\|}) = ma$ } ✓ 20,37 + [-(8)(9,8)sin30°]✓ = 8a ✓ ∴ a = -2,35 m·s^{-2} ∴ magnitude a = 2,35 m·s^{-2}✓

(4)

MOTION OF BLOCK MOVING UP PLANE IMMEDIATELY AFTER FORCE IS REMOVED:

OPTION 1 **Downward positive**	**OPTION 2** **Upwards positive**
$F_{net} = ma$ $(F_{g\|\|} + f_k) = ma$ } ✓ (8)(9,8)sin30° + 20,37✓ = 8a ✓ ∴magnitude a = 7,45 m·s^{-2}✓	$F_{net} = ma$ $(F_{g\|\|} + f_k) = ma$ } ✓ -(8)(9,8)sin30° – 20,37 ✓ = 8a ✓ ∴ a = -7,45 m·s^{-2} ∴ magnitude a = 7,45 m·s^{-2} ✓

(4)

10.2.1 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. ✓ (2)

10.2.2

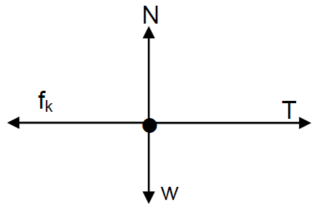
OPTION 1	**OPTION 2**
$g = \frac{GM}{r^2}$ ✓ ✓ $6 = \frac{(6{,}67\times10^{-11})M}{(700\times10^3)^2}$ ✓ M = 4,41 x 10^{22} kg ✓	$F = G\frac{m_1 m_2}{r^2}$ $mg = \frac{GmM}{r^2}$ } ✓Any one $(200)(6)$✓ $= \frac{(6{,}67\times10^{-11})(200)M}{(700\times10^3)^2}$✓ ∴ M = 4,41 x 10^{22} kg ✓

(4)
[21]

QUESTION 11

11.1 An object continues in its state of rest or uniform motion (moving with constant velocity) unless it is acted upon by a resultant/net force.✓✓ (2)

11.2



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f/f_k /27 N	✓
N	Normal (force)/F_{normal}/F_N /$F_{reaction}$	✓
T	F_T/tension	✓

(4)

11.3

Object Q:	Object P:
$F_{net} = ma$ $F_{net} = 0$ } ✓ $T + (f_k) = ma$ T – 3 ✓ = 0 ✓ T = 3 N	$F_{net} = ma$ $F_{hor} – (f_k + T) = ma$✓ (Fcos 30°) – 5 – 3 = 0 ✓ F = 9,24 N✓ (9,238 N)

(6)

11.4 3 s ✓ (1)

11.5 Y ✓
Graph Y represents motion of Q after the string breaks and shows a decreasing velocity ✓with a negative acceleration, ✓ because the net force (friction) on Q is in opposite direction to its motion.✓ (4)
[17]

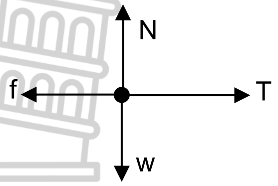
QUESTION 12

12.1 The rate of change of velocity. ✓✓ (2)

12.2 $\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
$0,5 = (0)(3) + \frac{1}{2}(a)(3^2)$ ✓ $\therefore a = 0,11\ m\cdot s^{-2}$ ✓ (3)

12.3 For the 3 kg mass:
$F_{net} = ma$ OR $(mg - T) / (mg + T) = ma$ ✓ $\therefore$ $(3)(9,8) - T = (3)(0,11)$ ✓ $\therefore T = 29,07\ N$ ✓ (3)

12.4



Accepted labels		
w	F_g / F_w / weight / mg / gravitational force	✓
f	Friction/ F_f / f_k / 27 N	✓
N	Normal (force) / F_{normaL} / F_N / /$F_{reaction}$	✓
T	F_T/tension	✓

(4)

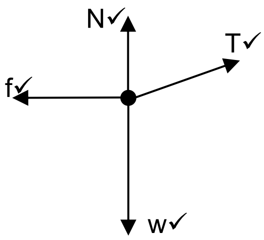
12.5

For P:	OR For P:
$F_{net} = ma$ / T- f = ma ✓	$F_{net} = ma$ / T- f = ma ✓
$29,07 - 27 = m(0,11)$ ✓	$29,72 - 27 = m(0,11)$ ✓ $\therefore m = 24,73\ kg$ ✓
m = 18,82 kg ✓ (Range: 18,60 – 18,82)	

QUESTION 13

13.1 When a (non-zero) resultant/net force acts on an object, the object will accelerate in the direction of the force with an acceleration that is directly proportional to the force and inversely proportional to the mass of the object. ✓✓ (2)

13.2



Accepted labels		
N	F_N; Normal, normal force	✓
f	F_f / f_k / frictional force/kinetic frictional force	✓
w	F_g; mg; weight;$F_{Earth\ on\ block}$;Fw / 78,4 N	✓
T	Tension; F_T /F_A, F /16,96 N	✓

(4)

13.3.1 The 2/8 kg block /system is accelerating. ✓ (1)

13.3.2 **For 2 kg:**
$F_{net} = ma$
mg -T= ma ✓ Any one
$(2)(9,8) - T = 2(1,32)$ ✓ $\therefore T = 16,96\ N$ ✓

OR

$F_{net} = ma \therefore mg + T = ma$
$(2)(-9,8) + T = 2(-1,32)$ ✓ $\therefore T = 16,96\ N$ ✓ (3)

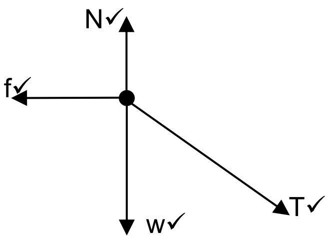
13.3.3 $F_{net} = ma$
$T\cos 15° - f = ma$
$T_x = T\cos 15°$ ✓any one
$= 16,96 \cos 15° = 16,38\ N\ (16,382\ N)$
$16,382 - f$ ✓ $= (8)(1,32)$ ✓ $\therefore f = 5,82\ N$ (to the left) ✓ (4)

13.4 **ANY ONE**
Normal force changes/decreases ✓
The angle (between string and horizontal) changes/increases.
The vertical component of the tension changes/increases. (1)

13.5 Yes ✓
The frictional force (coefficient of friction) depends on the nature of the surfaces in contact. ✓ (2)
[17]

QUESTION 14

14.1.1



Accepted labels		
N	F_N/Normal/normal force	✓
f	F_f/f_k/frictional force/kinetic frictional force	✓
w	F_g/mg/weight;F_w/gravitational force	✓
F	F_A/90 N/F_{90}	✓

(4)

14.1.2 Since it is moving at constant speed, the acceleration is zero/ the net force acting on it is zero. ✓ (1)

14.1.3

$F_{net} = ma$ $F_{net} = 0$ $F_x = f$ $F_x - f = 0$ $F\cos 40° - f = 0$ ✓ any one <u>90 cos 40°</u> <u>– *f* = 0</u> ✓ *f* = 68,94 N ✓	**OR**	$F_{net} = ma$ $F_{net} = 0$ $F_x = f$ $F_x - f = 0$ $F\cos 320° - f = 0$ ✓ any one <u>90 cos 320°</u> <u>– *f* = 0</u> ✓ *f* = 68,94 N ✓

(3)

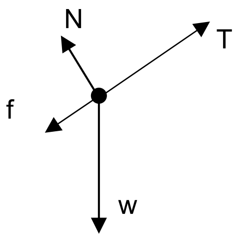
	OPTION 1	**OPTION 2**	
14.1.4	$v_f = v_i + a\Delta t$ <u>2 = 0</u> ✓+ <u>a(3)</u> ✓ a = 0,67 m·s^{-2} $F_{net} = ma$ ✓ <u>Fcos40°</u> ✓<u>– 68,94</u> ✓ = 15 (0,67) F = 103,11 N ✓ (103,05 N – 103,11N)	$F_{net}.\Delta t = \Delta p$ ✓ <u>Fcos 40º</u> ✓- <u>(68,94)</u> ✓<u>(3)</u> ✓= <u>15(2 – 0)</u> ✓ F = 103,11 N ✓	(6)
14.2	**OPTION 1** $F = G\frac{m_1 m_2}{r^2}$ ✓ 20✓$= (6{,}67\times10^{-11})\frac{m_{planet}(10)}{(6\times10^5)^2}$ ✓ m_{planet} = 1,08 x 10^{22} kg ✓	**OPTION 2** w = mg <u>20 = (10)(g)</u>✓ ✓ Any one g = 2 m·s^{-2} $g = \frac{GM}{R^2}$ $2 = \frac{(6{,}67\times10^{-11})M}{(6\times10^5)^2}$ ✓ M = 1,08 x 10^{22} kg✓	(4)

[18]

QUESTION 15

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

15.2



	Accept the following symbols
N ✓	F_N/Normal/Normal force
F ✓	F_f /f_k /frictional force/kinetic frictional force
w ✓	F_g,/mg/weight/$F_{\text{Earth on block}}$/19,6 N/gravitational force
T ✓	Tension/F_T /F_A/F

(4)

15.3 For the 2 kg block:
<u>F_{net} = ma</u>
<u>T +(- w_{II})+(- f_k)</u> = ma ✓Any one
<u>T – (w_{II} + f_k)</u> = ma
<u>T – (2)(9,8)sin30°</u>✓ <u>– 2,5</u>✓ = 2a ✓
T – 9,8 – 2,5 = 2a
T – 12,3 = 2a ……….(1)

For the 3 kg block:
<u>F_x + (-T) +(- w_{II})</u> = ma
F_x – (T + w_{II}) = ma
<u>[40 cos 25°</u>✓ <u>– T – (3)(9,8)sin30°</u>✓] ✓ = 3a
36,25 – T – 14,7 = 3a
21,55 – T = 3a …………(2)
9,25 = 5 a ∴ a = 1,85 m·s^{-2}✓ (8)

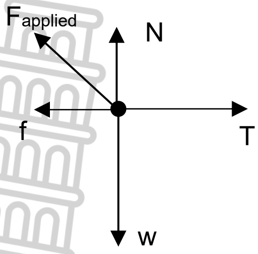
15.4 Greater than ✓
F_{net} increases. ✓ (2)

[16]

QUESTION 16

16.1 The <u>perpendicular force exerted by a surface on an object</u> in contact with the surface. ✓✓ (2)

16.2



(5)

16.3

For the 20 kg:

$F_{net} = ma$
$T – f – F_{Ax} = ma$ } ✓
$T – 5 – 35 \cos 40°$ ✓ $= 0$ ✓
$T = 31,81$ N

For m:

$F_{net} = ma$
$mg – T = ma$
$m(9,8) – 31,81$ ✓ $= 0$
$m = 3,25$ kg ✓

(5)

16.4.1 Decreases ✓ (1)

16.4.2 Velocity decreases ✓
Accelerates/Net force to left ✓✓
OR
As the tension decreases, the net force/acceleration acts in the opposite direction of motion /to the left. ✓✓ (3)

[16]

VERTICAL PROJECTILE MOTION

QUESTION 1

1.1 Motion <u>under the influence of the gravitational force/weight ONLY.</u> ✓✓ (2)

1.2

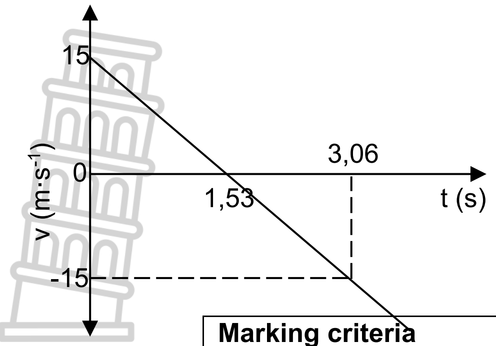
<u>OPTION 1</u> **Upwards positive:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ 0 ✓ = <u>$15 \Delta t + ½ (-9,8) \Delta t^2$</u> ✓ $\Delta t = 3,06$ s ∴ It takes 3,06 s ✓	**Downwards positive:** $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ 0 ✓ = <u>$-15 \Delta t + ½ (9,8) \Delta t^2$</u> ✓ $\Delta t = 3,06$ s ∴It takes 3,06 s ✓
<u>OPTION 2</u> **Upwards positive:** $v_f = v_i + a\Delta t$ ✓ 0 ✓ = <u>$15 +(-9,8)\Delta t$</u> ✓ $\Delta t = 1,53$ s It takes (2)(1,53) = 3,06 s ✓	**Downwards positive:** $v_f = v_i + a\Delta t$ ✓ 0✓ = <u>$-15 +(9,8)\Delta t$</u> ✓ $\Delta t = 1,53$ s It takes (2)(1,53) = 3,06 s ✓

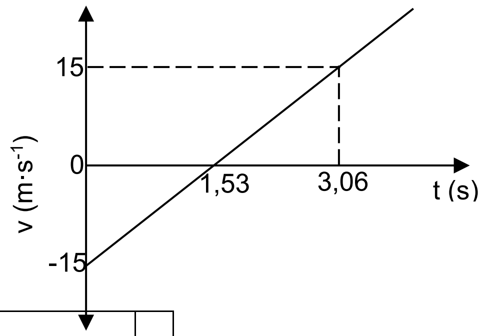
(4)

1.3

Upwards positive: $v_f^2 = v_i^2 + 2a\Delta y$ ✓ For ball A $0 = (15)^2$✓ + 2 (-9,8)Δy ✓ ∴ $\Delta y_A = 11,48$ m <u>When A is at highest point:</u> $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ = 0 + <u>½ (-9,8) (1,53)²</u> ✓✓ $\Delta y_B = -11,47$ m ∴ $\Delta y_B = 11,47$ m downward Distance = $y_A + y_B$ = 11,47 + 11,48 ✓ = 22,95 m ✓	**Downwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ For ball A $0 = (-15)^2$✓ + 2 (9,8)Δy✓ ∴ $\Delta y_A = -11,48$ m <u>When A is at highest point:</u> $\Delta y_B = v_i\Delta t + ½ a\Delta t^2$ = 0 + <u>½ (9,8) (1,53)²</u> ✓✓ $\Delta y_B = 11,47$ m ∴ $\Delta y_B = 11,47$ m downward Distance = $y_A + y_B$ = 11,48 + 11,47 ✓ = 22,95 m ✓

1.4 **UPWARD AS POSITIVE** **DOWNWARD POSITIVE**





Marking criteria	
Graph starts at correct initial velocity shown.	✓
Time for maximum height shown (1,53 s).	✓
Time for return shown (3,06 s)	✓
Shape: Straight line extending beyond 3,06 s	✓

(4)
[17]

QUESTION 2

2.1 Free fall ✓ (1)

2.2.1

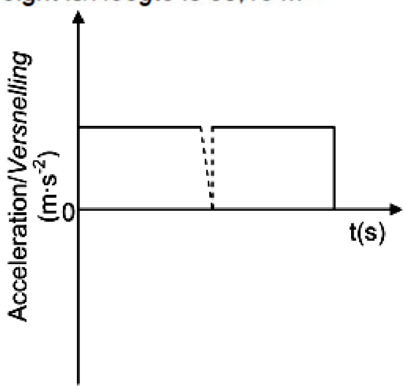
Upward positive:	**Downward positive:**
$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓	$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓
-30✓ = $\underline{v_i (1,5) + ½ (-9,8)(1,5)^2}$ ✓	30✓ = $\underline{v_i (1,5) + ½ (9,8)(1,5)^2}$ ✓
v_i = 12,65 m·s⁻¹✓	v_i = 12,65 m·s⁻¹✓

(4)

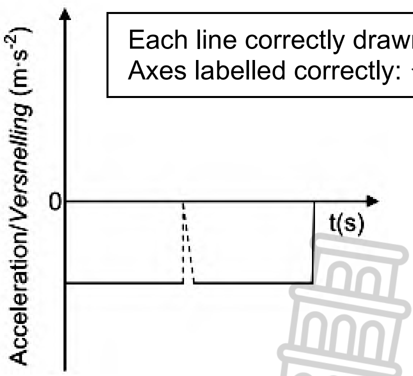
2.2.2 **POSITIVE MARKING FROM QUESTION 2.2.1.**
Downwards as positive

$v_f^2 = v_i^2 + 2a\Delta y$✓
$12,65^2$ ✓= $\underline{0 + 2(9,8)\,\Delta y}$✓
Δy = 8,16 m✓
Height/*Hoogte* **XC = XB + BC**
(30 + 8,16) = 38,16 m
Height is/*Hoogte is* 38,16 m✓ (5)

2.3



OR



Each line correctly drawn: ✓✓
Axes labelled correctly: ✓

(3)
[13]

QUESTION 3

3.1 5,88 m·s⁻¹✓ (1)

3.2

OPTION 1	**OPTION 2**
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{(-19,6)^2 = (5,88)^2 + 2(-9,8)\,\Delta y}$ ✓ Δy = - 17,84m Height above ground = 17,84 m ✓	Area between graph and t-axis for 2,6 s Δy = ½ bh + ½ bh = ½ (0,6)(5,88)✓+ ½(2,6 – 0,6)(-19,6)✓ = - 17,84 m ∴Height above ground = 17,84 m ✓
OPTION 3	**OPTION 4**
By symmetry ball returns to A at 1,2 s downward and v = -5,88 m·s⁻¹ Δy = Area of trapezium = ½(sum of parallel sides)(h) ✓ = ½{(-5,88) +(-19,6)} (2,6 - 1,2) ✓ = - 17,84m ∴Height above ground = 17,84 m ✓	$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{5,88 + (-19,6)}{2}\right)2,6$ ✓ = - 17,836 m ∴Height above ground =17,84 m ✓

(3)

3.3

OPTION 1	**OPTION 2**

$t_p = \left(\dfrac{3,2-2,6}{2}\right) + 2,6$ ✓ Time at P (tp) = 2,9 s ✓	$v_f = v_i + a\Delta t$ $0 = 2,94 + (-9,8)\Delta t$ ✓ $\Delta t = 0,3\text{s}$ ∴ $t_p = 2,6 + 0,3 = 2,9\text{s}$ ✓
OPTION 3 Gradient = -9,8 $\dfrac{\Delta y}{\Delta t} = -9,8$ ∴ $\dfrac{0-2,94}{\Delta t} = -9,8$ ✓ ∴ $\Delta t = 0,3$ s Time at P (tp) = $\underline{(2,6 + 0,3)}$ = 2,9 s ✓	

(2)

3.4

OPTION 1	**OPTION 2**	**OPTION 3**
Δy = area under graph ✓ $= \frac{1}{2}(0,3)(2,94)$ ✓ $= 0,44$ m✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ $= (2,94)(0,3) + \frac{1}{2}(-9,8)(0,3)^2$ ✓ $= 0,44$ m ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = 2,94^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = 0,44$m ✓

(3)

3.5 For t =2,9 s t_p = 2,9 s
Distance travelled by balloon since ball was dropped
$\Delta y = v\Delta t = (5,88)(2,9)$ ✓ = 17,05 m
Height of balloon when ball was dropped = 17,84 m
Height of balloon after 2,9 s = (17,05 + 17,84) ✓ = 34,89 m
Maximum height of ball above ground = 0,44 m
∴distance between balloon and ball = (34,89 – 0,44) ✓ = 34,45 m ✓ (4)

[13]

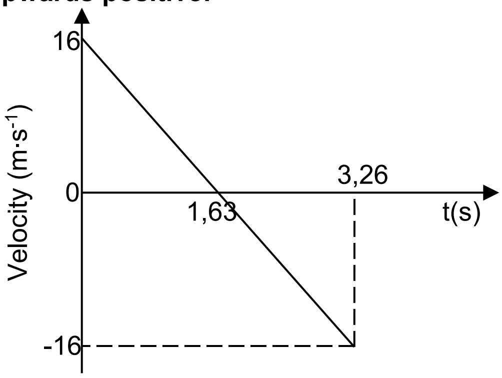
QUESTION 4

4.1

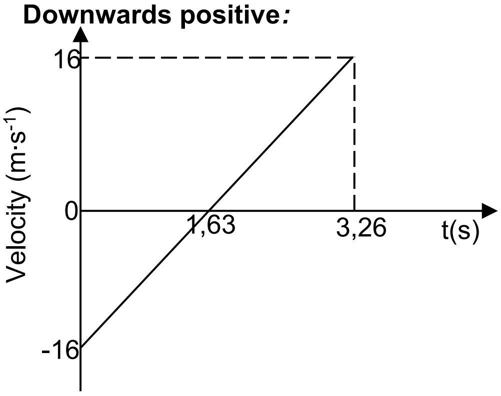
Upwards positive	**Downwards positive**
$v_f = v_i + a\Delta t$ ✓ -16✓ $= \underline{16 - 9,8(\Delta t)}$ ✓ $\Delta t = 3,27$s ✓	$v_f = v_i + a\Delta t$ ✓ 16 ✓ $= \underline{-16 + 9,8(\Delta t)}$ ✓ $\Delta t = 3,27$s ✓

(4)

4.2 **Upwards positive:**



Downwards positive*:*



Criteria for graph	
Correct shape for line extending beyond t = 1,63 s.	✓
Initial velocity correctly indicated as shown.	✓
Time to reach maximum height and time to return to the ground correctly shown.	✓

(3)

4.3

Marking criteria:
- Both equations ✓
- Equation for distance/displacement covered by A. ✓
- Equation for distance/displacement covered by B. ✓
- One of equations to have time as ($\Delta t + 1$) or ($\Delta t - 1$). ✓
- Solution for t = 2,24 s. ✓
- Final answer: 11,25 m ✓

Upwards positive:	**Downwards positive:**
Take y_A as height of ball A from the ground: $\Delta y_A = v_i\Delta t + \frac{1}{2} a\Delta t^2$ $y_A - 0 = 16\Delta t + \frac{1}{2}(-9,8)\Delta t^2 = 16\Delta t - 4,9\Delta t^2$ ✓ Take y_B as height of ball B from the ground: $\Delta y_B = v_i\Delta t + \frac{1}{2} a\Delta t^2$ $y_B - 30 = (v_i\Delta t + \frac{1}{2} a\Delta t^2)$ $y_B = 30 - [-9(\Delta t - 1) + \frac{1}{2}(-9,8)(\Delta t - 1)^2$ ✓ $= 34,1 + 0,8\Delta t - 4,9\Delta t^2$ ✓ $y_A = y_B$ $\therefore 16\Delta t - 4,9\Delta t^2 = 34,1 + 0,8\Delta t - 4,9\Delta t^2$ $15,2\Delta t = 34,1 \therefore \Delta t = 2,24$ s ✓ $y_A = 16(2,24) - 4,9(2,24)^2 = 11,25$ m ✓	Take y_A as height of ball A from the ground. $\Delta y_A = v_i\Delta t + \frac{1}{2} a\Delta t^2$ $y_A - 0 = -16\Delta t + \frac{1}{2}(9,8)\Delta t^2$ $= -16\Delta t + 4,9\Delta t^2$ ✓ Take y_B as height of ball B from the ground. ✓Both $\Delta y_B = v_i\Delta t + \frac{1}{2} a\Delta t^2$ $y_B - 30 = -(v_i\Delta t + \frac{1}{2} a\Delta t^2)$ $y_B = 30 - [9(\Delta t - 1) + \frac{1}{2}(9,8)(\Delta t - 1)^2$ ✓ $= 34,1 + 0,8\Delta t - 4,9\Delta t^2$ ✓ $y_A = y_B \therefore 16\Delta t - 4,9\Delta t^2 = 34,1 + 0,8\Delta t - 4,9\Delta t^2$ $\therefore 15,2\Delta t = 34,1 \therefore \Delta t = 2,24$ s ✓ $\Delta y_A = (-16(2,24) + 4,9(2,24)^2) = 11,25$ m ✓

(6)
[13]

QUESTION 5

5.1.1

OPTION 1/*OPSIE 1* **Upwards positive/*Opwaarts positief*:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $v_f^2 = (-2)^2 + 2(-9,8)(-45)$ ✓ $v_f = 29,76$ m·s^{-1} ✓	**Downwards positive/*Afwaarts positief*:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $v_f^2 = (2)^2 + 2(9,8)(45)$ ✓ $v_f = 29,76$ m·s^{-1} ✓ (29,77 m·s^{-1})
OPTION 2/*OPSIE 2* **Upwards positive/*Opwaarts positief*:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ for either equation/*vir beide vergelykings* $-45 = -2\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ $-4,9\Delta t^2 - 2\Delta t + 45 = 0$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ ✓ $\Delta t = 2,83$ $v_f = v_i + a\Delta t$ $v_f = 0 + (-9,8)(2,83)$ $v_f = -29,73$ m s^{-1} ✓	**Downwards positive/*Afwaarts positief*:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ for either equation/*vir beide vergelykings* $45 = 2\Delta t + \frac{1}{2}(9,8)\Delta t^2$ $4,9\Delta t^2 + 2\Delta t - 45 = 0$ ✓ $\Delta t = 2,83$ $v_f = v_i + a\Delta t$ $v_f = 0 + (9,8)(2,83)$ $v_f = 29,73$ m s^{-1} ✓

(4)

5.1.2

| **OPTION 1/*OPSIE 1***
Upwards positive/*Opwaarts positief*:
The balls hit the water at the same instant./*Die balle tref die water gelyktydig*
$v_f = v_i + a\Delta t$ ✓
Ball/*Bal* **A**
$-29,76 = -2 + (-9,8)\Delta t$
$\Delta t = 2,83$ s ✓
∴ for ball/*vir bal* **B**
$\Delta t_B = 2,83 - 1 = 1,83$ s
∴ for ball/*vir bal* **B**
$\Delta t_B = 2,83 - 1 = 1,83$ s ✓ | **Downwards positive/*Afwaarts positief***
The balls hit the water at the same instant./*Die balle tref die water gelyktydig*
$v_f = v_i + a\Delta t$ ✓
Ball/*Bal* **A**
$29,76 = 2 + (9,8)\Delta t$
$\Delta t = 2,83$ s ✓
∴ for ball/*vir bal* **B**
$\Delta t_B = 2,83 - 1 = 1,83$ s
∴ for ball/*vir bal* **B**
$\Delta t_B = 2,83 - 1 = 1,83$ s ✓ |

OPTION 2 **Upwards positive/*Opwaarts positief*:** Ball/*Bal* A $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $-45 = -2\Delta t + ½(-9,8)\Delta t^2$ $-4,9\ \Delta t^2 - 2\Delta t + 45 = 0$ $4,9\ \Delta t^2 + 2\Delta t - 45 = 0$ $\Delta t = 2,83$ ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓	**Downwards positive/*Afwaarts positief:*** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $45 = 2\Delta t + ½(9,8)\Delta t^2$ $4,9\ \Delta t^2 + 2\Delta t - 45 = 0$ $\Delta t = 2,83$ ✓ ∴ for ball/*vir bal* **B** $\Delta t_B = 2,83 - 1 = 1,83$ s ✓

(4)

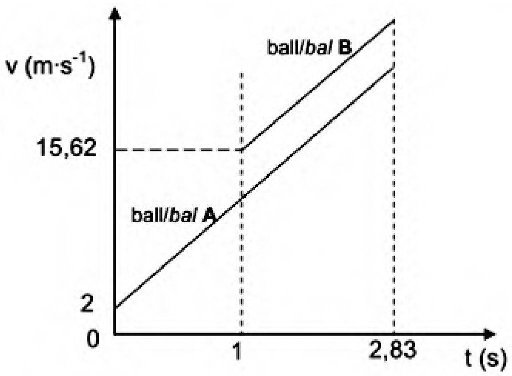
5.1.3

Upwards positive/*Opwaarts positief*: $\Delta t_B = 1.83$s ✓ $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ -45 ✓ $= v_i\ (1,83) + ½\ (-9.8)(1,83)^2$ ✓ $v_i = -15,62\ m\cdot s^{-1}$ ✓	**Downwards positive:** $\Delta t_B = 1,83$ s $\Delta y = v_i\Delta t + ½a\Delta t^2$ $45 = v_i(1,83) + ½(9,8)(1,83)^2$ $v_i = 15,62\ m\cdot s^{-1}$

(4)

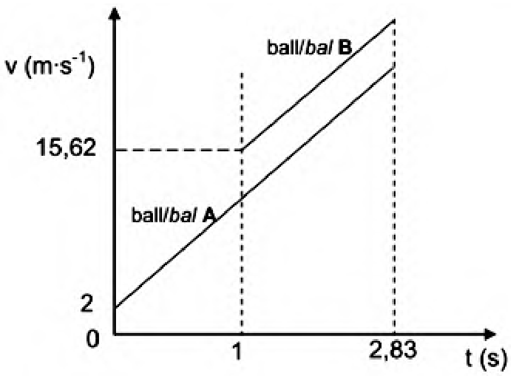
5.2

Upward positive



Marking criteria	
One mark for each intial velocity 2 $m\cdot s^{-1}$ & 15,62 $m\cdot s^{-1}$	✓✓
Release time of ball B: t = 1 s	✓
Flight time for both balls indicated as the same on time axis. (2,83 s)	✓
Shape – parallel lines	✓

Downward positive



Marking criteria	
One mark for each intial velocity - 2 $m\cdot s^{-1}$ & - 15,62 $m\cdot s^{-1}$	✓✓
Release time of ball B: t = 1 s	✓
Flight time for both balls indicated as the same on time axis.	✓
Shape – parallel lines	✓

(4)
[16]

QUESTION 6

6.1 An object which has been given an intial velocity ✓ and then moves under the influence of the force of gravity only. ✓ (2)

6.2

OPTION 1	
Upward positive $v_f = v_i + a\Delta t$ ✓ $\underline{-30 = 30}$✓ $+ (-9,8)\Delta t$ ✓ $\Delta t = 6,12$ s ✓	**Downward positive** $v_f = v_i + a\Delta t$ ✓ $\underline{30 = -30}$✓ $+ (9,8)\Delta t$ ✓ $\Delta t = 6,12$ s ✓
OPTION 2	
Upward positive $v_f = v_i + a\Delta t$ ✓ ∴ $\underline{0 = 30}$ ✓ $+ (-9,8)\Delta t$ ✓ $\Delta t = 3,06$ s ∴ total time = (2)(3,06) = 6,12 s ✓	**Downward positive** $v_f = v_i + a\Delta t$ ✓ ∴ $\underline{0 = -30}$ ✓ $+ (9,8)\Delta t$ ✓ ∴ $\Delta t = 3,06$ s ∴ total time = (2)(3,06) = 6,12 s ✓

(4)

6.3 **Upward positive**

$\left.\begin{array}{l}\Delta y = v_i\Delta t + ½\ a\Delta t^2 \\ \Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}\end{array}\right\}$ ✓

$= \{30(6,12) + ½\ (-9,8)(6,12)^2\}$✓ $- \{30\underline{(5,12) + ½\ (-9,8)(5,12)^2}\}$✓

$= -25,076$

Distance = $|\Delta y|$ = 25,08 m ✓

Downward positive

$\left.\begin{array}{l}\Delta y = v_i\Delta t + ½\ a\Delta t^2 \\ \Delta y_{last} = \Delta y_{(6,12)} - \Delta y_{(5,12)}\end{array}\right\}$ ✓

$= \{-30(6,12) + ½\ (9,8)(6,12)^2\}$✓ $- \{-30(5,12) + ½\ (9,8)(5,12)^2\}$ ✓

$= 25,076$

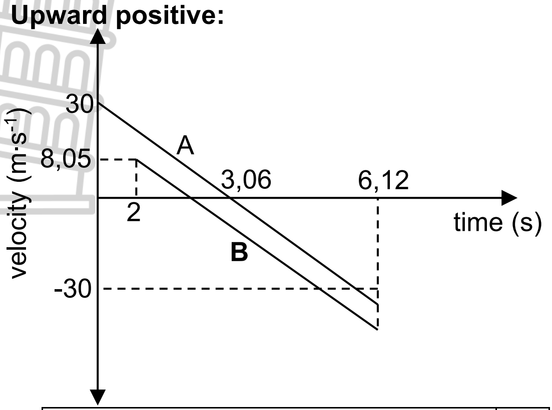
Distance = $|\Delta y|$ = 25,08 m ✓ (4)

.6.4

Upward positive	Downward positive
$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ -50✓ $= \underline{[v_i (4,12)] + [½ (-9,8)(4,12)^2]}$ ✓ $v_i = 8,05 \text{ m·s}^{-1}$ speed $= 8,05 \text{ m·s}^{-1}$ ✓	$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ 50✓ $= \underline{v_i (4,12) + [½ (9,8)(4,12)^2]}$ ✓ $v_i = - 8,05 \text{ m·s}^{-1}$ speed $= 8,05 \text{ m·s}^{-1}$ ✓

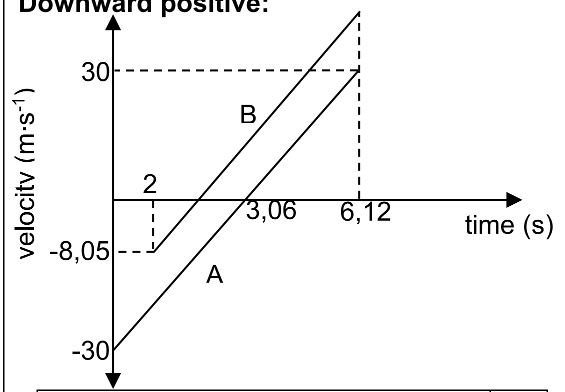
6.5

Upward positive:



Marking criteria	
Correct shape of A.	✓
Correct shape of Graph B parallel to A below A.	✓
Time at which both A and B reach the ground (6,12 s).	✓
Time for A to reach the maximum height (3,06 s) shown.	✓

Downward positive:



Marking criteria	
Correct shape of A.	✓
Correct shape of Graph B parallel to A above A.	✓
Time at which both A and B reach the ground (6,12 s).	✓
Time for A to reach the maximum height (3,06 s) shown.	✓

(4)
[18]

QUESTION 7

7.1 The motion of an <u>object under the influence of weight/ gravitational force only</u> / Motion in which the only force acting is the gravitational force. ✓✓ (2)

7.2

OPTION 1: Upwards positive	OPTION 1: Downwards positive
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0^2 + (2)(-9,8)$ ✓ (-20) ✓ $v_f = 19,80 \text{ m·s}^{-1}$ ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $= 0^2 + (2)(9,8)$ ✓ (20) ✓ $v_f = 19,80 \text{ m·s}^{-1}$ ✓
OPTION 2: Upwards positive	**OPTION 2: Downwards positive**
$\Delta y = v_i\Delta t + ½ a\Delta t^2$ $-20 = 0 + ½ (-9,8) \Delta t^2$✓ $\Delta t = 2,02$ s $v_f = v_i + a\Delta t$ ✓either one $= 0 + (-9,8)(2,02)$ ✓ $= -19,80 \text{ m·s}^{-1}$ ∴ $v_f = 19,80 \text{ m·s}^{-1}$ ✓	$\Delta y = v_i\Delta t + ½ a\Delta t^2$ $20 = 0 + ½ (9,8) \Delta t^2$✓ $\Delta t = 2,02$ s $v_f = v_i + a\Delta t$ ✓either one $= 0 + (9,8)(2,02)$ ✓ $= 19,80 \text{ m·s}^{-1}$ ✓

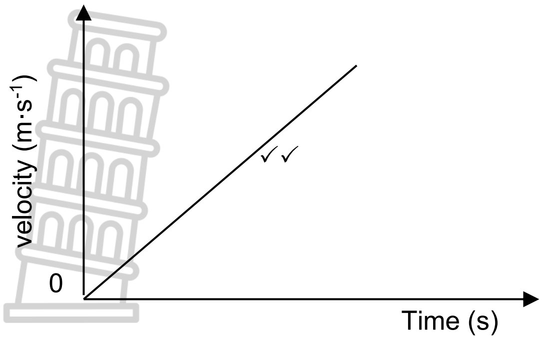
(4)

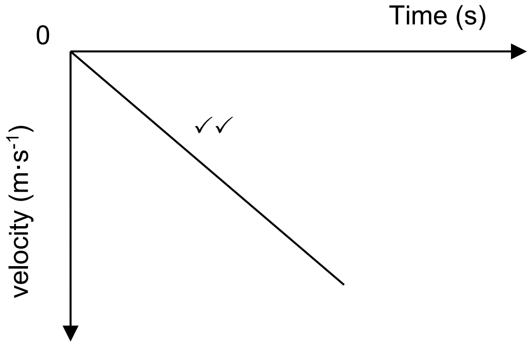
7.3

OPTION 1: Upwards positive	OPTION 1: Downwards positive
$v_f = v_i + a\Delta t$ ✓ $\underline{-19,80 = 0 + (-9,8)\Delta t}$ ✓ ∴ $\Delta t = 2,02$ s ✓	$v_f = v_i + a\Delta t$ ✓ $\underline{19,80 = 0 + (9,8)\Delta t}$ ✓ ∴ $\Delta t = 2,02$ s ✓
OPTION 2: Upwards positive:	**OPTION 2: Downwards positive:**
$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\underline{-20 = 0 + ½ (-9,8) \Delta t^2}$✓ ∴ $\Delta t = 2,02$ s ✓	$\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\underline{20 = 0 + ½ (9,8) \Delta t^2}$✓ ∴ $\Delta t = 2,02$ s ✓

(3)

7.4 **Downward positive** **Upward positive**





✓✓	Straight line through the origin.
	Deduct 1 mark if axes are not labelled correctly.

(2)
[11]

QUESTION 8

8.1 The only force acting on the ball is the gravitational force. ✓✓

8.2.1

OPTION 1	
Upwards as positive $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(10)(3) + \frac{1}{2}(-9,8)(3^2)}$ ✓ $= -14,10$ Height of building = 14,10 m ✓	**Downwards as positive** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-10)(3) + \frac{1}{2}(9,8)(3^2)}$ ✓ $= 14,10$ Height of building = 14,10 m ✓
OPTION 2	
Upward as positive For maximum height: $v_f = v_i + a\Delta t$ $0 = 10 + (-9,8)\Delta t \quad \therefore \quad \Delta t = 1,02$ s Time taken from point A to ground: 3 - 2(1,02) = 0,96 s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-10)(0,96) + \frac{1}{2}(-9,8)(0,96)^2}$ ✓ $= -14,1184$ ∴ Height = 14,12 m ✓	**Downwards as positive** For maximum height: $v_f = v_i + a\Delta t$ $0 = -10 + (9,8)\Delta t \quad \therefore \quad \Delta t = 1,02$ s Time taken from point A to ground: 3 - 2(1,02) = 0,96 s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(10)(0,96) + \frac{1}{2}(9,8)(0,96)^2}$ ✓ $= 14,1184$ ∴ Height = 14,12 m ✓

(3)

8.2.2

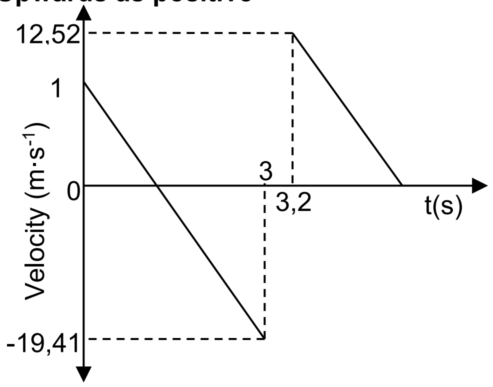
Upwards as positive: $v_f = v_i + a\Delta t$ ✓ $= \underline{(10) + (-9,8)(3)}$ ✓ $= -19,41$ Speed = 19,41 m·s^{-1} ✓	**Downwards as positive:** $v_f = v_i + a\Delta t$ ✓ $= \underline{(-10) + (9,8)(3)}$ ✓ $= 19,41$ Speed = 19,41 m·s^{-1} ✓

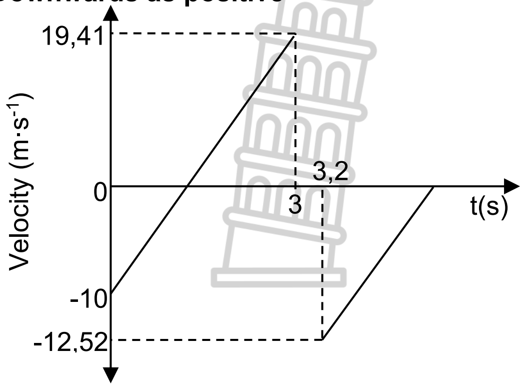
8.2.3

Upwards as positive: $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(-9,8)(8)}$ ✓ ∴ $v_i = 12,52$ m·s^{-1} Speed = 12,52 m·s^{-1} ✓	**Downwards as positive:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(9,8)(-8)}$ ∴ $v_i = -12,52$ Speed = 12,52 m·s^{-1} ✓

(3)

8.3 **Upwards as positive** **Downwards as positive**





Marking criteria	
Two parallel lines correctly drawn.	✓✓
Mark for velocity calculated in Q8.2.2. Mark for velocity calculated in Q8.2.3.	✓
Times 3 s and 3,2 s correctly shown.	✓

(4)
[15]

QUESTION 9

9.1 (Motion of) an object which has been given an initial velocity and then moves under the influence of the gravitational force/weight only. ✓✓ (2)

9.2 No ✓ The balloon is <u>not accelerating</u>./The balloon is <u>moving with constant velocity</u>./The net force acting on the balloon is zero.✓ (2)

9.3

<u>OPTION 1</u> Upward positive: $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ -22✓ = <u>(-1,2) Δt + ½ (-9,8)Δt²</u> ✓ ∴ Δt = 2 s ✓	**Downward positive:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ 22✓ = <u>(1,2) Δt + ½ (9,8)Δt²</u> ✓ ∴ Δt = 2 s ✓
<u>OPTION 2</u> **Upward positive:** $v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = (-1{,}2)^2 + (2)(-9{,}8)(-22)$ ✓ v_f = -20,8 m·s⁻¹ ✓Both $v_f = v_i + a\Delta t$ <u>-20,8 = -1,2 + -9,8Δt</u> ✓ ∴ Δt = 2 s ✓	**Downward positive:** $v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = (1{,}2)^2 + (2)(9{,}8)(22)$ ✓ v_f = 20,8 m·s⁻¹ ✓Both $v_f = v_i + a\Delta t$ <u>20,8 = 1,2 + 9,8Δt</u> ✓ ∴ Δt = 2 s ✓

(4)

9.4

Upward positive: $v_f = v_i + a\Delta t$ ✓ ∴ 0 = 15 + (-9,8)Δt ✓ ∴ Δt = 1,53 s Total time elapsed = <u>2 + 1,53 + 0,3</u> ✓ = 3,83 s Displacement of the balloon: $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ = -(1,2)(3,83) ✓= - 4,6 m Height = <u>22 - 4,6</u> ✓ = 17,4m ✓ **OR** $y_f = y_i + \Delta y$ = [22 – (1,2)(3,83)] ✓✓ = 17,4 m ∴ Height = 17,4 m✓	**Downward Positive:** $v_f = v_i + a\Delta t$ ✓ ∴ 0 = -15 + (9,8)Δt ✓ ∴ Δt = 1,53 s Total time elapsed = <u>2 + 1,53 + 0,3</u>✓ = 3,83 s Displacement of the balloon: $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ = (1,2)(3,83) ✓ = 4,6 m Height = <u>22 - 4,6</u> ✓ = 17,4m ✓ **OR** $y_f = y_i + \Delta y$ = [-22 + (1,2)(3,83)] ✓✓ = -17,4 m ∴ Height = 17,4 m ✓

(6)
[14]

QUESTION 10

10.1

<u>OPTION 1</u> **Upwards positive:** $v_f = v_i + a\Delta t$✓ ∴ 0 = (12) + (-9,8)(Δt) ✓ ∴ Δt = 1,22 s✓	**Downwards positive:** $v_f = v_i + a\Delta t$✓ ∴ 0 = (-12) + (9,8)(Δt) ✓ ∴ Δt = 1,22 s✓
<u>OPTION 2</u> **Upwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ 0 = 12² + 2(-9,8)Δy✓ ∴ Δy = 7,35 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ 7,35 =12Δt + ½ (-9,8)Δt² ∴ Δt = 1,22 s✓	**Downwards positive:** $v_f^2 = v_i^2 + 2a\Delta y$ 0 = (-12)² + 2(9,8)Δy✓ ∴ Δy = -7,35 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ -7,35 = -12Δt + ½ (9,8) Δt² ∴ Δt = 1,22 s✓

(3)

10.2

<u>OPTION 1</u> **Upwards positive:** $v_f = v_i + a\Delta t$ ✓ ∴ <u>-3v = -v</u> ✓ + <u>(-9,8)(1,22)</u> ✓ v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)	**Downwards positive:** $v_f = v_i + a\Delta t$ ✓ ∴ <u>3v = v</u> ✓ <u>+ (9,8)(1,22)</u> ✓ v = 5,98 m·s⁻¹ ✓ (5,978 to 6,03 m·s⁻¹)
<u>OPTION 2</u> **Upwards positive:** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ (-9,8)(1,2245) ✓ = <u>-3v – (-v)</u> ✓ ∴ v = 6,00 m·s⁻¹ ✓	**Downwards positive:** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ (9,8)(1,2245) ✓ = 3v - v✓ v = 6,00 m·s⁻¹ ✓

(4)

10.3

<u>OPTION 1</u> **Upwards positive:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ = <u>(-5,98)(2,44) + ½(-9,8)(2,44)²</u>✓ = - 43,764 ∴h = 43,76 m✓ (43,764 to 44,08 m)	**Downwards positive:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ = <u>(5,98)(2,44) + ½(9,8)(2,44)²</u> ✓ = 43,764 ∴h = 43,76 m✓(43,764 to 44,08)
<u>OPTION 2</u> **Upwards positive:** $v_f = v_i + a\Delta t$ v_f = - 5,98 + (-9,8)(2,44) = - 29,892 m·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>(-29,892)² = (- 5,98)² + 2(-9,8)Δy</u> ✓ Δy = - 43, 763 m ∴ h = 43,76 m✓(43,764 to 44,08)	**Downwards positive:** $v_f = v_i + a\Delta t$ v_f = 5,98 + 9,8(2,44) = 29,892 m·s⁻¹ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>(29,892)² = (5,98)² + 2(9,8)Δy</u> ✓ Δy = 43,76 m ∴ h = 43,76 m✓(43,764 to 44,08)

OPTION 3

Upwards positive:

For A: $v_f = v_i + a\Delta t$

$-12 = 12 + (-9,8)\Delta t$ ∴ $\Delta t = 2,45$ s

For B: $\Delta x = v_i\Delta t + ½ a\Delta t^2$ ✓

$= \underline{(-5,98)(2,45) + ½ (-9,8)(2,45)^2}$ ✓

$= - 44,06$ m ∴ h = 44,06 m ✓

Downwards positive:

For A: $v_f = v_i + a\Delta t$ ∴ $12 = -12 + (9,8)\Delta t$

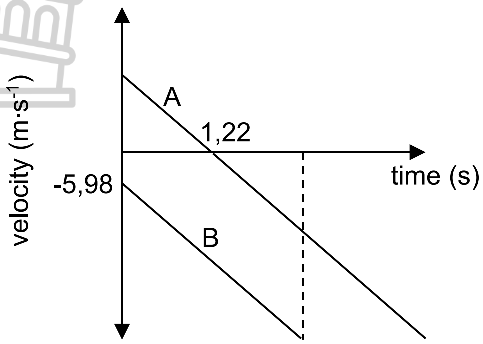
∴ $\Delta t = 2,45$ s

For B: $\Delta x = v_i\Delta t + ½ a\Delta t^2$ ✓

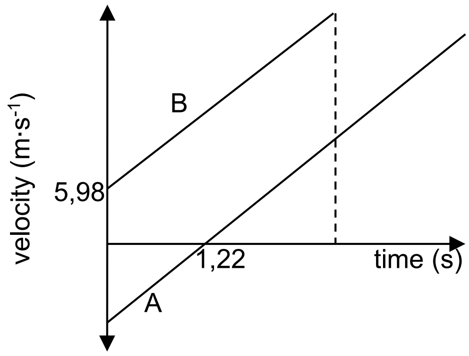
$= \underline{(5,98)(2,45) + ½ (9,8)(2,45)^2}$ ✓

$= 44,06$ m ∴ h = 44,06 m ✓ (3)

10.4 **Upwards as positive**



Downwards as positive



Criteria for graph	
Time 1,22 s shown **correctly**	✓
Initial velocity for stone B at time t = 0 correctly shown with correct signs	✓
Two sloping parallel lines with A **crossing** the time axis	✓
Straight line graph for A parallel to graph B, extending beyond the time when B hits ground	✓

(4)
[14]

QUESTION 11

11.1 10 $m{\cdot}s^{-1}$ ✓ (1)

11.2 The gradient represents the acceleration due to gravity (g) ✓ which is constant for free fall. ✓ (1)

11.3 **OPTION 1**

$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓

$= (10)(2) + ½ (9,8)(2^2)$ ✓

$= 39,6$ m

Height/*Hoogte* = 39,6 m ✓

$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓

$= (-10)(2) + ½ (-9,8)(2^2)$ ✓

$= -39,6$ m

Height/*Hoogte* = 39,6 m ✓

OPTION 2/*OPSIE 2*

$$\Delta x = \frac{(v_i + v_f)}{2}\Delta t \quad ✓$$

$$\Delta x = \left(\frac{10 + 29,6}{2}\right)(2) \quad ✓$$

$$\Delta x = 39,6\ m \quad ✓$$

OPTION 3/*OPSIE 3*

$$v_f^2 = v_i^2 + 2a\Delta x \quad ✓$$

$$(29,6)^2 = (10)^2 + 2(9,8)a\Delta x \quad ✓$$

$$\Delta x = 39,6\ m \quad ✓$$

(3)

11.4 **OPTION 1**

$v_f = v_i + a\Delta t$ ✓

$0 = -25 + (9,8)(\Delta t)$ ✓

$\Delta t = 2,55$ s

Total time T/*Totale tyd* = 8 +2,55 ✓

= 10,55 s ✓

OPTION 2

$v_f = v_i + a\Delta t$ ✓

$0 = 25 + (-9,8)(\Delta t)$ ✓

$\Delta t = 2,55$ s

Total time T/*Totale tyd* = 8 +2,55 ✓

= 10,55 s ✓ (4)

11.5.1 0,2 s ✓ (1)

11.5.2 4,955 s ✓✓ (2)

11.5.3 - 27 $m{\cdot}s^{-1}$ ✓ (1)

11.6 Inelastic ✓ The speeds at which it strikes and leaves the ground are not the same/The kinetic energies will not be the same. ✓ (2)

[16]

QUESTION 12

12.1 Motion under the influence of gravity/weight/gravitational force only. ✓✓ (2)

12.2 **OPTION 1**

UPWARDS AS POSITIVE

$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ $= \underline{(0)(1) + ½ (-9,8)(1^2)}$ ✓

$= - 4,9$ m

Height = $2\Delta y$ = (2)(4,9)

= 9,8 m ✓

DOWNWARDS AS POSITIVE

$\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ $= \underline{(0)(1) + ½ (9,8)(1^2)}$ ✓

$= 4,9$ m

Height = $2\Delta y$ = (2)(4,9)

= 9,8 m ✓

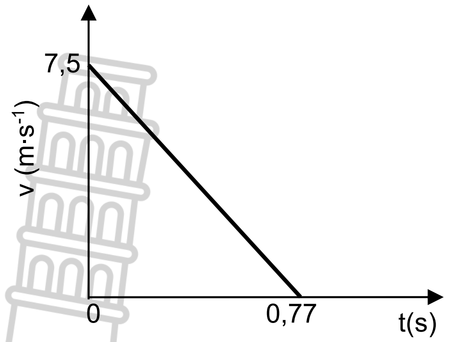
	OPTION 2 **UPWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (-9,8)(1) = -9,8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$✓ $\underline{(-9,8)^2 = 0 + (2)(-9,8)\Delta y}$ ✓ $\Delta y = -4,9$ m Height/*hoogte* = $2\Delta y = (2)(4,9)$ = 9,8 m✓	**DOWNWARD POSITIVE** $v_f = v_i + a\Delta t = 0 + (9,8)(1) = 9,8\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$✓ $\underline{(9,8)^2 = 0 + (2)(9,8)\Delta y}$ ✓ $\Delta y = 4,9$ m Height/*hoogte* = $2\Delta y = (2)(4,9)$ = 9,8 m✓	(3)
12.3	**UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$✓ $= \underline{0 + (2)(-9,8)(-9,8)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$✓ $= \underline{0 + (2)(9,8)(9,8)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓	
	OR **FROM POINT B** **UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$✓ $= \underline{(-9,8)^2 + (2)(-9,8)(-4,9)}$ ✓ $v_f = -13,86\ m\cdot s^{-1}$ Magnitude = $13,86 m\cdot s^{-1}$✓	**OR** **FROM POINT B** **DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$✓ $= \underline{(9,8)^2 + (2)(9,8)(4,9)}$ ✓ $v_f = 13,86\ m\cdot s^{-1}$ ✓	(3)
12.4	**UPWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 \underline{+ (2)(-9,8)(4,9)}$ ✓ ∴ $v_i = 9,8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓1 mark for any $\underline{F_{net}(0,2)}$ ✓ = $\underline{0,4[9,8 - (-13,86)]}$ ✓ $F_{net} = 47,32$ N ✓	**DOWNWARDS AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$✓ $0 = v_i^2 \underline{+ (2)(9,8)(-4,9)}$ ✓ ∴ $v_i = -9,8\ m\cdot s^{-1}$ $F_{net}\Delta t = m\Delta v$ $F_{net}\Delta t = m(v_f - v_i)$ } ✓1 mark for any $\underline{F_{net}(0,2)}$ ✓= $\underline{0,4[-9,8 - (13,86)]}$✓ $F_{net} = -47,32$ N ∴ $F_{net} = 47,32$ N ✓	(6) **[14]**

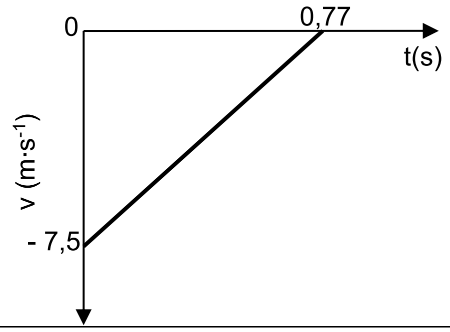
QUESTION 13

13.1 Downwards ✓
The only force acting on the object is the gravitational force/weight which acts downwards.✓ (2)

13.2	**OPTION 1** **Upward positive** $v_f = v_i + a\Delta t$ ✓ $\underline{0 = 7,5 + (-9,8)\Delta t}$ ✓ $\Delta t = 0,77$ s ✓	**Downward positive** $v_f = v_i + a\Delta t$ ✓ $\underline{0 = -7,5 + (9,8)\Delta t}$ ✓ $\Delta t = 0,77$ s ✓	
	OPTION 2 **Upward positive** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $\underline{(-9,8)\Delta t = 0 - 7,5}$ ✓ ∴ $\Delta t = 0,76531$ s (0,77 s) ✓	**Downward positive** $F_{net}\Delta t = m(v_f - v_i)$ ✓ $mg\Delta t = m(v_f - v_i)$ $\underline{(9,8)\Delta t = 0 - (-7,5)}$ ✓ ∴ $\Delta t = 0,76531$ s (0,77 s) ✓	(3)
13.3	**OPTION 1** **Upward positive -** At highest point $v_f = 0$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ 0 ✓ = $\underline{(7,5)^2 + (2)(-9,8)\Delta y}$ ✓ $\Delta y = 2,87$ (2,869) m✓ It is higher than height needed to reach point **T** (2,1 m) ✓ <u>therefore ball will pass point **T**.</u> ✓	**Downward positive -** At highest point $v_f = 0$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ 0✓ = $\underline{(-7,5)^2 + (2)(9,8)\Delta y}$✓ $\Delta y = -2,87$ (-2,869) m✓ It is higher than height needed to reach point **T** (2,1 m) ✓ <u>therefore ball will pass point **T**.</u> ✓	
	OPTION 2 **Upward positive** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\Delta y = (7,5)(0,77)$ ✓ + ½ $(-9,8)(0,77)^2$✓ $\Delta y = 2,87$ m (2,86 m)✓ It is higher than height needed to reach point **T** (2,1 m) ✓ <u>therefore ball will pass point **T**.</u> ✓	**Downward positive** $\Delta y = v_i\Delta t + ½ a\Delta t^2$✓ $\Delta y = (-7,5)(0,77)$ ✓ + ½ $(9,8)(0,77)^2$✓ $\Delta y = -2,87$ m (2,869 m)✓ It is higher than height needed to reach point **T** (2,1 m) ✓ <u>therefore ball will pass point **T**.</u> ✓	(6)

13.4





Marking criteria
Initial velocity and time for final velocity shown. ✓
Correct straight line (including orientation) drawn. ✓

(2)
[13]

QUESTION 14

14.1 (Motion during which) the only force acting is the force of gravity. ✓✓ (2)

14.2.1

<u>OPTION 1/</u> **UPWARDS AS POSITIVE:** $v_f = v_i + a\Delta t$ ✓ $0 = \underline{v_i + (-9,8)(1,53)}$ ✓ $\therefore v_i = 14,99\ m\cdot s^{-1}$ ($15\ m\cdot s^{-1}$) ✓ **DOWNWARDS AS POSITIVE:** $v_f = v_i + a\Delta t$ ✓ $0 = \underline{v_i + (9,8)(1,53)}$ ✓ $\therefore v_i = -14,99\ m\cdot s^{-1}$ $\therefore v_i = 14,99\ m\cdot s^{-1}$ ($15\ m\cdot s^{-1}$) ✓	**<u>OPTION 2</u>** $F_{net} = ma$ $= 9,8(m)$ $F_{net}\Delta t = m\Delta v$ ✓ $\underline{(9,8)(m)(1,53) = (m)(v_f - 0)}$ ✓ $v_f = 14,99\ m\cdot s^{-1}$ ($15\ m\cdot s^{-1}$) ✓

(3)

14.2.2

<u>OPTION 1/</u> **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{14,99(1,53) + \frac{1}{2}(-9,8)(1,53)^2}$ ✓ $= 11,47\ m$ ✓ (11,46-11,48) Maximum height is 11,47 m	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{-14,99(1,53) + \frac{1}{2}(9,8)(1,53)^2}$ ✓ $= -11,47\ m$ (11,46-11,48) Maximum height is 11,47 m ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (14,99)^2 + 2(-9,8)(\Delta y)}$ ✓ $\Delta y = 11,47\ m$ ✓ (11,46-11,48) Maximum height reached is 11,47 m	**DOWNWARDS AS POSITIVE:** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (-14,99)^2 + 2(9,8)(\Delta y)}$ ✓ $\Delta y = -11,47\ m$ (11,46-11,48) Maximum height reached is 11,47 m ✓

(3)

14.2.3

<u>OPTION 1</u> **UPWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (14,99)(4) + \frac{1}{2}(-9,8)(4)^2$ ✓ $= -18,4\ m$ Position is 18,4 m downwards (below the edge of the roof) ✓	**DOWNWARDS AS POSITIVE:** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-14,99)(4) + \frac{1}{2}(9,8)(4)^2$ ✓ $= 18,4\ m$ Position is 18,4 m downwards (below the edge of the roof) ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE:** $v_f = v_i + a\Delta t = (14,99) + (-9,8)(4) = -24,2\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{(-24,2)^2 = (14,99)^2 + 2(-9,8)(\Delta y)}$ ✓ $\Delta y = -18,4\ m$ Ball is 18,4 m downwards (below the edge of the roof) ✓	**DOWNWARDS AS POSITIVE:** $v_f = v_i + a\Delta t = (-14,99) + (9,8)(4) = 24,2\ m\cdot s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(24,2)^2 = (-14,99)^2 + 2(9,8)(\Delta y)$ ✓ $\Delta y = 18,4\ m$ Ball is 18,4 m downwards (below the edge of the roof) ✓

(3)

14.3 No ✓
The motion of the ball is only dependent on its initial velocity. ✓✓
OR: The initial velocity depends on the time taken to reach maximum height. (3)
[14]

QUESTION 15

15.1 (Motion during which) the only force acting is the force of gravity. ✓✓ (2)

15.2

<u>OPTION 1/</u> **UPWARDS AS POSITIVE*:*** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (10)^2 + (2)(-9{,}8)\Delta y}$ ✓ $\Delta y = 5{,}10$ m (5,102) Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE*:*** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = (-10)^2 + (2)(9{,}8)\Delta y}$ ✓ $\Delta y = -5{,}10$ m (5,102) Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE*:*** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $0 = (10)\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ $\Delta t = 2{,}04$ s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (10)(1{,}02) + \frac{1}{2}(-9{,}8)(1{,}02)^2$ ✓ $= 5{,}103$ Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓	**DOWNWARDS AS POSITIVE*:*** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $0 = (-10)\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$ $\Delta t = 2{,}04$ s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-10)(1{,}02) + \frac{1}{2}(9{,}8)(1{,}02)^2$ ✓ $= -5{,}103$ Height = $\underline{40 +}$ 5,10 ✓ = 45,10 m ✓

(4)

15.3 9,8 $m\cdot s^{-2}$ ✓ downwards ✓ (2)

15.4

<u>OPTION 1/</u> **UPWARDS AS POSITIVE*:*** Displacement from roof to meeting point $= -40 + 29{,}74 = -10{,}26$ m ✓ **Stone A** $\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $-10{,}26 = 10\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓ $\Delta t = 2{,}79$ s **Stone B** $\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $-10{,}26 = 0 + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓	**DOWNWARDS AS POSITIVE*:*** Displacement from roof to meeting point $= 40 - 29{,}74 = 10{,}26$ m ✓ **Stone A** $\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $10{,}26 = -10\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$ ✓ $\Delta t = 2{,}79$ s **Stone B** $\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $10{,}26 = 0 + \frac{1}{2}(9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓
<u>OPTION 2</u> **UPWARDS AS POSITIVE*:*** Displacement from roof to meeting point $= -40 + 29{,}74 = -10{,}26$ m ✓ Displacement of ball A from max height to meeting point = -15,36 m **Stone A** $v_f = v_i + a\Delta t$ $0 = 10 + (-9{,}8)\Delta t$ $\Delta t = 1{,}02$ s $\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $-15{,}36 = 0 + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}77$ s $\Delta t_{tot} = 1{,}77 + 1{,}02 = 2{,}79$s **StoneB** $\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $-10{,}26 = 0 + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}45$ s (1,447 s) x = 2,79 – 1,45✓ = 1,34 (s) ✓	**DOWNWARDS AS POSITIVE*:*** Displacement from roof to meeting point $= 40 - 29{,}74 = 10{,}26$ m ✓ Displacement of ball A from max height to meeting point = 15,36 m **Stone A** $v_f = v_i + a\Delta t$ $0 = -10 + (9{,}8)\Delta t$ $\Delta t = 1{,}02$ s $\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $15{,}36 = 0 + \frac{1}{2}(9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}77$ s $\Delta t_{tot} = 1{,}77 + 1{,}02 = 2{,}79$s **StoneB** $\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $10{,}26 = 0 + \frac{1}{2}(9{,}8)\Delta t^2$ ✓ $\Delta t = 1{,}45$ s (1,447 s) x = 2,79 – 1,45 ✓ = 1,34 (s) ✓

(6)

15.5.1 d ✓ (1)

15.5.2 a ✓ (1)

15.5.3 f ✓ (1)

15.5.4 c ✓ (1)

[18]

QUESTION 16

16.1 (Motion of an object) under the influence of <u>gravity (weight) only</u>. ✓✓ (2)

16.2.1 Δt = 0,67 – 0,64 = 0,03 s ✓✓ (2)

16.2.2

<u>OPTION 1</u> $\Delta t = \frac{1,90 - 0,67}{2}$ ✓ $= 0,62\ s$ ✓ $(0,615\ s)$	**<u>OPTION 2</u>** $\Delta x = v_i\Delta t + ½ a\Delta t^2$ $(-1,8) = 0 + ½ (-9,8)\Delta t^2$ ✓ Δt = 0,61 s ✓ (0,606 s)
<u>OPTION 3</u> $\Delta t = \frac{1,90 + 0,67}{2} = 1,285\ s$ Δt = 1,285 – 0,67 ✓ = 0,62 s ✓ (0,615 s)	**<u>OPTION 4</u>** $v_f^2 = v_i^2 + 2a\Delta x$ $0 = v_i^2 + 2(-9,8)(1,8)$ v_i = 5,94 m·s⁻¹ $v_f = v_i + a\Delta t$ 0 = 5,94 + (-9,8)Δt ✓ Δt = 0,61 s ✓

(2)

16.2.3

<u>OPTION 1</u> Upwards positive $v_f = v_i + a\Delta t$ ✓ <u>$0 = v_i + (-9,8)(0,62)$</u> ✓ v_i = 6,08 m·s^{-1} (6,076 m·s^{-1}) ✓	**<u>OPTION 2</u>** Upwards positive $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ <u>$1,8 = v_i (0,62) + ½ (-9,8) (0,62)^2$</u> ✓ v_i = 5,94 m·s^{-1} (5,9412 m·s^{-1}) ✓
Downwards positive $v_f = v_i + a\Delta t$ ✓ <u>$0 = v_i + (9,8)(0,62)$</u> ✓ v_i = -6,08 ∴v_i = 6,08 m·s^{-1} (6,076 m·s^{-1}) ✓	Downwards positive $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ <u>$1,8 = v_i (0,62) + ½ (9,8) (0,62)^2$</u> ✓ v_i = -5,94 ∴v_i = 5,94 m·s^{-1} (5,9412 m·s^{-1}) ✓

<u>OPTION 3</u> **Motion from top to bottom** Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ v_f^2 = <u>0 + 2(9,8)(1,8)</u> ✓ v_f = 5,94 m·s^{-1} ✓ initial velocity =5,94 m·s^{-1} Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ v_f^2 = <u>0 + 2(-9,8)(-1,8)</u> ✓ v_f = 5,94 m·s^{-1} ✓ initial velocity =5,94 m·s^{-1} **Motion from bottom to top** Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0^2 = v_i^2 + 2(9,8)(-1,8)$</u> ✓ v_i = 5,94 m·s^{-1} ✓ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ <u>$0 = v_i^2 + 2(-9,8)(1,8)$</u> ✓ v_i = 5,94 m·s^{-1} ✓	**<u>OPTION 4</u>** Upwards positive $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ <u>$0 = v_i(1,23) + ½ (-9,8)(1,23)^2$</u> ✓ v_i = 6,03 m·s^{-1} ✓ Downwards positive $\Delta y = v_i\Delta t + ½ a\Delta t^2$ ✓ <u>$0 = v_i(1,23) + ½ (9,8)(1,23)^2$</u> ✓ v_i = - 6,03 m·s^{-1} speed = 6,03 m·s^{-1} ✓ **<u>OPTION 5</u>** $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ ✓ $1,8 = \left(\frac{0 + v_i}{2}\right)(0,62)$ ✓ $v_i = 5,81\ m \cdot s^{-1}$ ✓ **<u>OPTION 6</u>** $\left.\begin{array}{l}F_{net}\Delta t = m\Delta v \\ F_{net}\Delta t = m(v_f - v_i)\end{array}\right\}$ ✓ <u>$m(9,8)(0,62) = m(0 - v_i)$</u> ✓ v_i = 5,94 m·s^{-1} ✓
<u>OPTION 7</u> $(E_p + E_k)_{floor} = (E_p + E_k)_{top}$ ✓ $(mgh + ½ mv^2)_{floor} = (mgh + ½ mv^2)_{top}$ <u>$0 + ½ v^2 = (9,8)(1,8) + 0$</u> ✓ v = 5,94 m·s^{-1} ✓	

(3)

16.2.4

Calculate initial velocity:	**Calculate time Δt**
OPTION 1 Downwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + 2(9,8)(-1,2)$ ✓ $v_i = -4,85\ m\cdot s^{-1}$ Upwards positive $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = v_i^2 + 2(-9,8)(1,2)$ ✓ $v_i = 4,85\ m\cdot s^{-1}$ **OPTION 2** $(E_{mech})_{top} = (E_{mech})_{bot}$ $(E_p + E_k)_{top} = (E_p + E_k)_{Bot}$ } ✓Any one/ $(mgh + ½mv^2)_{top} = (mgh + ½mv^2)_{Bot}$ $(9,8)(1,2) + 0 = 0 + (½)v^2$ ✓ $v_i = 4,85\ m\cdot s^{-1}$ upwards **OPTION 3** $W_{nc} = \Delta E_p + \Delta E_k$ $0 = (0 - mgh) + ½m(v_f^2 - v_i^2)$ } ✓Any one/ $0 = -(9,8)(1,2) + ½v_i^2$ ✓ $v_i = 4,85\ m\cdot s^{-1}$ upwards **OPTION 4** $W_{net} = \Delta E_k$ $w\Delta x\cos180° = ½m((v_f^2 - v_i^2)$ } ✓Any one/ $(9,8)(1,2)\cos180° = ½v_i^2$ ✓ $v_i = -4,85\ m\cdot s^{-1}$	Upwards positive $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $1,2 = (4,85)\Delta t + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 0,4898$ s / 0,5 s t = 1,97 + 2(0,4898) ✓ = 2,95 s / 2,97 s ✓ **OR** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $0 = (4,85)\Delta t + ½(-9,8)\Delta t^2$ ✓ $\Delta t = 0,9898$ s (or $\Delta t = 0$) t = 1,97 + 0,9898 ✓ = 2,96 s ✓ Downwards positive $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $1,2 = (-4,85)\Delta t + ½(9,8)\Delta t^2$ ✓ $\Delta t = 0,4898$ s / 0,5 s t = 1,97 + 2(0,4898) ✓ = 2,95 s / 2,97 s ✓ **OR** $\Delta y = v_i\Delta t + ½a\Delta t^2$ ✓ $0 = (4,85)\Delta t + ½(9,8)\Delta t^2$ ✓ $\Delta t = 0,9898$ s (or $\Delta t = 0$) t = 1,97 + 0,9898 ✓ = 2,96 s ✓ **OR** $v_f = v_i + a\Delta t$ ✓ $-4,85 = 4,85 + (-9,8)\Delta t$ ✓ $\Delta t = 0,9898$ s Δt = 1,97 + 0,9898 ✓ = 2,96 s ✓ **OR** Upwards positive $v_f = v_i + a\Delta t$ ✓ $0 = 4,85 + (-9,8)\Delta t$ ✓ $\Delta t = 0,4949$ s Δt = 1,97 + (2)(0,4949) ✓ = 2,96 s ✓ **OR** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $1,2 = \left(\frac{0 + 4,85}{2}\right)\Delta t$ ✓ $\Delta t = 0,4948$ s $\Delta t_{total} = 2(0,4948) = 0,99$ s Δt = 1,97 + 0,99 ✓ = 2,96 s ✓

OPTION 5
Downwards positive
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
$\underline{1,2}$ ✓ $= \underline{0 + \frac{1}{2}(9,8)\,\Delta t^2}$ ✓
$\Delta t = 0,49$ s
t = 1,97 + ✓ 2(0,49) ✓
= 2,96 s ✓
Upwards positive
$\Delta y = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓
$\underline{-1,2}$ ✓ $= \underline{0 + \frac{1}{2}(-9,8)\Delta t^2}$ ✓
$\Delta t = 0,49$ s
t = 1,97 + ✓ 2(0,49) ✓
= 2,96 s ✓

(6)
[15]

MOMENTUM AND IMPULSE

QUESTION 1

1.1

p = mv ✓ = 50(5) ✓ = 250 kg·m·s^{-1} ✓ (downward)	**OR**	p = mv ✓ = 50(-5) ✓ = - 250 kg·m·s^{-1} ∴ 250 kg·m·s^{-1} ✓ (downward)

(3)

1.2 The product of the net force and the time interval during which the force acts. ✓✓ (2)

1.3

$\Delta p = F_{net}\Delta t$ ✓ 0 - 250 ✓ = $F_{net}(0,2)$ F_{net} = -1 250 N ∴ F_{net} = 1 250 N ✓	$\Delta p = F_{net}\Delta t$ ✓ 250 - 0 ✓= $F_{net}(0,2)$ F_{net} = 1 250 N ✓	$\Delta p = F_{net}\Delta t$ ✓ 50(0 – (-5)) ✓= $F_{net}(0,2)$ F_{net} = 1 250 N ✓

(3)

1.4 Greater than ✓ (1)

1.5 <u>For the same momentum change</u>, ✓
the <u>stopping time</u> <u>(contact time)</u> ✓<u>will be smaller (less)</u>, ✓
∴ the (upward) force exerted (on her) is greater. (3)
[12]

QUESTION 2

2.1 Momentum is the product of an object's mass and its velocity. ✓✓ (2)

2.2

<u>Direction of motion positive:</u> $\Delta p = mv_f - mv_i$ ✓ = (175)(0 - (+20)) ✓= -3 500 kg·m·s^{-1} ✓ ∴ Δp = 3 500 kg·m·s^{-1} opposite to direction of motion ✓	**<u>Direction of motion negative:</u>** $\Delta p = mv_f - mv_i$ ✓ = (175)(0 - (-20)) ✓= 3 500 kg·m·s^{-1} ✓ ∴ Δp = 3 500 kg·m·s^{-1} opposite to direction of motion ✓

(4)

2.3

<u>Direction of motion positive:</u> $F_{net}\Delta t = \Delta p$ ✓ f(8) = -3 500 ✓ f = -437,5 N ✓ ∴ f = 437,5 N opposite to direction motion✓	**<u>Direction of motion negative:</u>** $F_{net}\Delta t = \Delta p$ ✓ f(8) = 3 500 ✓ f = 437,5 N ✓ ∴ f = 437,5 Nopposite to direction of motion ✓

(4)
[10]

QUESTION 3

3.1 A collision in which both total momentum and total kinetic energy are conserved. ✓✓ (2)

3.2 **<u>OPTION 1</u>**
For ball A

$\left.\begin{array}{l}(E_{mech})_{top} = (E_{mech})_{bottom} \\ (E_K + E_P)_{top} = (E_K + E_P)_{bottom} \\ (\frac{1}{2}mv^2 + mgh)_{top} = (\frac{1}{2}mv^2 + mgh)_{bottom}\end{array}\right\}$ Any one ✓

$\frac{1}{2}(0,2)(0)^2 + (0,2)(9,8)(0,2)_{top} = E_k + m(9,8)(0)_{bottom}$ ✓
$E_k = 0,39$ J ✓

<u>OPTION 2</u>
$W_{nc} = \Delta E_p + \Delta E_k$ ✓ ∴ $0 = mg(h_f – h_i) + \frac{1}{2}m(v_f^2 – v_i^2)$
$0 = (0,2)(9,8)(0,2 – 0) + \frac{1}{2}mv_f^2 – \frac{1}{2}(0,2)(0)^2$ ✓ ∴ $E_k = 0,39$ J ✓ (3)

3.3

$\left.\begin{array}{l}\Sigma E_{Kbefore} = \Sigma E_{Kafter} \\ E_{KiA} + E_{KiB} = E_{KfA} + E_{KfB} \\ E_{KiA} + E_{KiB} = \frac{1}{2} m_A v_{fA}^2 + E_{KfB}\end{array}\right\}$ ✓Any one

$\underline{0,39 + 0}$✓ $= \frac{1}{2}\underline{(0.2)v_{fA}^2 + 0,12}$ ✓ ∴ $v_{fA} = 1,64$ m·s^{-1} ✓ (4)

3.4

$E_{K before} = ½ m_A v_{iA}^2$ ∴ $0{,}39 = ½ (0{,}2) v_{iA}^2$ ✓ ∴ $v_{iA} = 1{,}98 \text{ m·s}^{-1}$

Impulse = $m(v_f - v_i)$ } ✓Any one
Impulse = $m(v_{iA} - v_{fA})$

$= 0{,}2(-1{,}64)$ ✓ $- (0{,}2)(1{,}98)$ ✓ $= 0{,}72 \text{ N·s}$ ✓ (5)

[14]

QUESTION 4

4.1

OPTION 1	OPTION 2
Take motion to the right as positive. $\Sigma p_i = \Sigma p_f$ } ✓ Any one $(m_1 + m_2)v_i = m_1v_{f1} + m_2v_{f2}$ $(3 + 0{,}02)(0)$ ✓ $= (3)(-1{,}4) + (0{,}02) v_{f2}$ ✓ $v_{f2} = 210 \text{ m·s}^{-1}$ ✓	Take motion to the left as positive. $\Sigma p_i = \Sigma p_f$ } ✓ Any one $(m_1 + m_2)v_i = m_1v_{f1} + m_2v_{f2}$ $(3 + 0{,}02)(0)$ ✓ $= (3)(1{,}4) + (0{,}02) v_{f2}$ ✓ $v_{f2} = -210 \text{ m·s}^{-1}$ ∴ speed $= 210 \text{ m·s}^{-1}$ ✓

(4)

4.2

OPTION 1	OPTION 2
$v_f^2 = v_i^2 + 2a\Delta x$ ✓ $0 = 210^2 + 2a(0{,}4)$ ✓ $a = -55\,125 \text{ m·s}^{-2}$ $F_{net} = ma$ ✓ $= (0{,}02)(-55\,125)$ ✓ $= -1\,102{,}5 \text{ N}$ Magnitude of force = 1 102,5 N ✓	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ ∴ $0{,}4 = \left(\frac{210 + 0}{2}\right)\Delta t$ ✓ ∴ $\Delta t = 0{,}004 \text{ s } (0{,}00381 \text{ s})$ $F_{net}\Delta t = \Delta p = m\Delta v$ ✓ ∴ $F_{net} = \frac{(0{,}02)(0 - 210)}{0{,}004}$ ✓ $= -1\,050 \text{ N}$ Magnitude of force = 1 050 N ✓

(5)

4.3 The same as/equal ✓ (1)

[10]

QUESTION 5

5.1 The total (linear) momentum of an isolated/(closed system ✓ is constant/conserved. ✓ (2)

5.2.1 $\sum p_i = \sum p_f$ ✓

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$(m_1 + m_2)v_i = m_1v_{1f} + m_2v_{2f}$

0 ✓ $= (0{,}4)v_{1f} + 0{,}6\,(4)$ ✓

$v_{1f} = -6 \text{ m·s}^{-1}$

$= 6 \text{ m·s}^{-1}$ to the left/*na links* ✓

(4)

5.2.2

OPTION 1	OPTION 2	OPTION 3
$\Delta p = F_{net}\Delta t$ ✓ $[(0{,}6)(4) - 0]$ ✓ $= F_{net}\,(0{,}3)$ ✓ $F_{net} = 8 \text{ N}$ ✓ **OR/OF** $m(v_f - v_i) = F_{net}\Delta t$ ✓ $0{,}6(4 - 0)$ ✓ $= F_{net}(0{,}3)$ ✓ $F_{net} = 8 \text{ N}$ ✓	$v_f = v_i + a\,\Delta t$ $4 = 0 + a(0{,}3)$ $a = 13{,}33 \text{ m·s}^{-2}$ $F_{net} = ma$ $= 0{,}6(13{,}33)$ $F_{net} = 8 \text{ N}$ ✓	$\Delta p = F_{net}\Delta t$ ✓ $[(0{,}4)(6) - 0]$ ✓ $= F_{net}\,(0{,}3)$ ✓ $F_{net} = 8 \text{ N}$ ✓ **OR/OF** $m(v_f - v_i) = F_{net}\Delta t$ ✓ $0{,}4(6 - 0)$ ✓ $= F_{net}(0{,}3)$ ✓ $F_{net} = 8 \text{ N}$ ✓

(4)

5.3 No ✓ (1)

[11]

QUESTION 6

6.1 The total (linear) momentum of an isolated/closed system ✓ is constant/conserved. ✓ (2)

6.2.1

OPTION 1	OPTION 2
$\sum p_i = \sum p_f$ } ✓ any one $m_1 v_{1i} + m_2v_{2i} = m_1 v_{1f} + m_2v_{2f}$ $m_1 v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ $(5)(4) + (3)(0)$ ✓ $= (5 + 3)v_f$ ✓ ∴ $v = 2{,}5 \text{ m·s}^{-1}$ ✓	$\Delta p_{5kg} = -\Delta p_{3kg}$ ✓ $mv_f - mv_i = mv_f - mv_i$ $5v_f - (5)(4)$ ✓ $= 3v_f - (3)(0)$ ✓ $v_f = 2{,}5 \text{ m·s}^{-1}$ ✓

(4)

6.2.2

OPTION 1 $F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$ ✓ ∴ $F_{net}(0{,}3)$ ✓ $= 8\,[(0 - (2{,}5)]$ ✓
∴ $F_{net} = -66{,}67 \text{ N}$ ∴ $F_{net} = 66{,}67 \text{ N}$ ✓

OPTION 2	OPTION 3
$F_{net} = ma$ ✓ $= \frac{m(v_f - v_i)}{\Delta t} = \frac{8(0 - 2{,}5)}{0{,}3}$ ✓ ✓ $= -66{,}67 \text{ N}$ ∴ $F_{net} = 66{,}67 \text{ N}$ ✓	$v_f = v_i + a\Delta t$ ∴ $0 = 2{,}5 + a(0{,}3)$ ✓ ∴ $a = -8{,}333 \text{ m·s}^{-2}$ $F_{net} = ma$ ✓ $= 8\,(-8{,}333)$ ✓ $= -66{,}67 \text{ N}$ ∴ $F_{net} = 66{,}67 \text{ N}$ ✓

(4)

[10]

QUESTION 7

7.1 A system on which the resultant/net external force is zero. ✓ (2)

7.2.1

OPTION 1	OPTION 2
$p = mv$✓ ∴ $\underline{30\ 000 = (1\ 500)v}$ ✓ ∴$v = 20\ m{\cdot}s^{-1}$✓	$\Delta p = mv_f - mv_i$ ✓ ∴ $\underline{0 = (1\ 500)v_f - 30\ 000}$ ✓ ∴ $v = 20\ m{\cdot}s^{-1}$✓

(3)

7.2.2

OPTION 1	OPTION 2
$\left.\begin{array}{l}\sum p_i = \sum p_f \\ m_1 v_{1i} + m_2v_{2i} = m_1 v_{1f} + m_2v_{2f}\end{array}\right\}$ ✓ for any $\underline{30\ 000 + (900)(-15)}$ ✓ = $\underline{14\ 000 + 900v_B}$✓ ∴ $v_B = 2{,}78\ m{\cdot}s^{-1}$ ✓east ✓	$\left.\begin{array}{l}\Delta p_A = -\Delta p_B \\ p_f - p_i = -(mv_f - mv_i)\end{array}\right\}$ ✓ for any $\underline{14\ 000 - 30\ 000}$ ✓= $\underline{900v_f - 900(-15)}$ ✓ $v_f = 2{,}78\ m{\cdot}s^{-1}$✓ east

7.2.3

OPTION 1	OPTION 2
$\text{Slope} = \frac{\Delta p}{\Delta t} = F_{net}$✓ $= \frac{(14\ 000 - 30\ 000)}{20{,}2 - 20{,}1}$ ✓ $= -160\ 000$ ∴ $F_{net} = 160\ 000\ N$ ✓	$F_{net}\Delta t = \Delta p$ ✓ $F_{net}(0{,}1)$ ✓ = $\underline{14\ 000 - 30\ 000}$ ✓ $F_{net} = -160\ 000\ N$ $F_{net} = 160\ 000\ N$ ✓

OPTION 3
$F_{net}\Delta t = \Delta p$ ✓ ∴ $F_{net}(0{,}1)$ ✓ = $\underline{900[(2{,}78) - (-15)]}$ ✓ ∴ $F_{net} = -160\ 020\ N$ $F_A = -F_B$ ∴ $F_{net} = 160\ 020\ N$ ✓

(4)
[13]

QUESTION 8

8.1

$v = \frac{\Delta x}{\Delta t} = \frac{0{,}2}{0{,}4} = 0{,}5\ m{\cdot}s^{-1}$	$v = \frac{\Delta x}{\Delta t} = \frac{0{,}4}{0{,}8} = 0{,}5\ m{\cdot}s^{-1}$	$v = \frac{\Delta x}{\Delta t} = \frac{0{,}6}{1{,}2} = 0{,}5\ m{\cdot}s^{-1}$
✓ Formula ✓ Correct substitution in all three equations. ✓ Arriving at correct answer.		

(3)

8.2 The total linear momentum of a closed/isolated system is constant/is conserved. (2)

8.3
$\left.\begin{array}{l}\sum p_i = \sum p_f \\ m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}\end{array}\right\}$ ✓ Any one
$\underline{(3{,}5)(0{,}5)}$ ✓ = $\underline{(3{,}5 + 6)v_f}$ ✓
$v_f = v_{6kg} = 0{,}184\ m{\cdot}s^{-1}$

For trolley B:
$F_{net}\Delta t = \Delta p = m\Delta v$✓
$\underline{F_{net}(0{,}5) = 6(0{,}184 - 0)}$ ✓ ∴ $F_{net} = 2{,}21\ N$✓
∴ Magnitude of the average net force experienced by trolley B = 2,21 N·✓

For trolley A:
$F_{net}\Delta t = \Delta p = m\Delta v$✓
$\underline{F_{net}(0{,}5) = 3{,}5(0{,}184 - 0{,}5)}$ ✓ ∴ $F_{net} = -2{,}21\ N{\cdot}$
∴ Magnitude of the average net force experienced by trolley B = 2,21 N·✓

(6)
[11]

QUESTION 9

9.1 It is the product of the resultant/net force acting on an object✓ and the time the resultant/net force acts on the object. ✓ (2)

9.2.1 $p = mv$ ✓ $= (0{,}03)(700)$ ✓ $= 21\ kg{\cdot}m{\cdot}s^{-1}$ ✓ (3)

9.2.2 **OPTION 1**

Δt for a bullet $= \frac{60}{220}$ ✓$= 0{,}27\ s$

$F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i)$ **OR** $F_{ave\ gun\ on\ bullet} = \frac{\Delta p}{\Delta t} = \frac{21 - 0}{0{,}27}$ ✓ $= 77{,}01\ N$ ✓ $(77{,}78\ N)$

∴average force of bullet on gun = 77,01 N / 77,8 N to the west ✓

OPTION 2

$\left.\begin{array}{l}F_{net}\Delta t = \Delta p = (p_f - p_i) = (mv_f - mv_i) \\ F_{av} = \frac{\Delta p}{\Delta t}\end{array}\right\}$ ✓ Any one

$\Delta p_{tot} = (21)(220)$ ✓ $= 4\ 620\ kg{\cdot}m{\cdot}s^{-1}$

$F_{ave\ gun\ on\ bullet} = \frac{4\ 620 - 0}{60}$ ✓ $= 77{,}00\ N$ ✓

∴ average force of bullet on gun = 77,01 N / 77,78 N to the west ✓ (5)

9.3 77 N / 77,78 N ✓ to the east ✓ (2)
[12]

QUESTION 10

10.1 The total linear momentum of a closed/isolated system is constant/conserved. ✓✓ (2)

10.2
$\left.\begin{array}{l}\sum p_i = \sum p_f \\ m_Bv_{Bi} + m_bv_{bi} = m_Bv_{Bf} + m_bv_{bf} \\ \Delta p_{bullet} = -\Delta p_{block}\end{array}\right\}$ ✓ Any one
$\underline{(0{,}015)(400)}$ ✓ + 0 = $(0{,}015)v_{Bf}$ + $\underline{2(0{,}7)}$ ✓ ∴ $V_{Bf} = 306{,}67\ m{\cdot}s^{-1}$✓ (4)

10.3

OPTION 1

$F_{net}\Delta t = \Delta p$
$\Delta p = mv_f - mv_i$ } ✓ Any one

For bullet:
$\Delta p = (0{,}015)(306{,}666 - 400)$ ✓
$= -1{,}4\ kg\cdot m\cdot s^{-1}$
$F_{net}(0{,}002) = -1{,}4 \therefore F_{net} = -700\ N$

For block:
$\Delta p = (2)(0{,}7 - 0)$ ✓
$= 1{,}4\ kg\cdot m\cdot s^{-1}$
$F_{net}(0{,}002) = 1{,}4 \therefore F_{net} = 700\ N$

$W_{net} = \Delta E_k$
$F_{net}\Delta x\cos\theta = \frac{1}{2} m(v_f^2 - v_i^2)$
$(700)\Delta x\cos 180° = \underline{\frac{1}{2}(0{,}015)(306{,}67^2 - 400^2)}$ ✓
$\therefore \Delta x = 0{,}71\ m$ ✓

$F_{net} = ma$
$-700 = (0{,}015)a$ **OR** $700 = (0{,}015)a$
$a = -46\ 666{,}67$ **OR** $46\ 665\ m\cdot s^{-2}$

$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$
$= (400)(0{,}002)$ ✓ $+ \underline{\frac{1}{2}(-46666{,}67)(0{,}002)^2}$ ✓
$= 0{,}71\ m\ (0{,}70667)\ m$ ✓
OR
$v_f^2 = v_i^2 + 2a\Delta x$
$(306{,}67)^2$ ✓ $= \underline{(400)^2 + 2(-46\ 666{,}67)\Delta x}$ ✓
$\Delta x = 0{,}71\ m\ (0{,}70667\ m)$ ✓

OPTION 2

$v_f = v_i + a\Delta t$ ✓ $\therefore$ $\underline{306{,}666 = 400 + a(0{,}002)}$ ✓ $\therefore$ $a = -46\ 667\ m\cdot s^{-2}$

$v_f^2 = v_i^2 + 2a\Delta x$ $\therefore$ $\underline{(306{,}666)^2}$ ✓ $= \underline{400^2 + 2(-4667)\Delta x}$ ✓ $\therefore$ $\Delta x = 0{,}71\ m\ \ (0{,}706\ m)$ ✓ (5) **[11]**

QUESTION 11

11.1 The total linear momentum of a closed/isolated system remains constant/is conserved.✓✓ (2)

11.2 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ } ✓ any one
For the system cat-skate board **A**
$\underline{(3{,}5)(0) + (2{,}6)(0)}$ ✓ $= \underline{(3{,}5)v_{skateboard}} + (2{,}6)(3)$ ✓ $\therefore$ $v_{skateboard} = 2{,}23\ m\cdot s^{-1}$ ✓ to the left ✓ (5)

11.3

OPTION 1	**OPTION 2**
$F_{net}\Delta t = \Delta p = mv_f - mv_i$ ✓ $= (3{,}5)(1{,}28 - 0)$ ✓ $= 4{,}48\ N\cdot s$ ✓	$F_{net}\Delta t = \Delta p = mv_f - mv_i$ ✓ $= (2{,}6)(1{,}28 - 3)$ ✓ $= -4{,}48\ N\cdot s$ ✓

(3) **[10]**

QUESTION 12

12.1 $E_{(mech\ top)} = E_{(mech\ bottom)}$
$(E_p + E_k)_{top/bo} = (E_p + E_k)_{bottom}$
$(mgh + \frac{1}{2} mv^2)_{top} = (mgh + \frac{1}{2} mv^2)_{bottom}$ } ✓ for any
$\underline{(1{,}5)(9{,}8)(2) + 0}$ ✓ $= \underline{0 + \frac{1}{2}(1{,}5)v^2}$ ✓ $\therefore$ $v = 6{,}26\ m\cdot s^{-1}$ ✓ (4)

12.2 The total linear momentum of a closed/isolated system is constant/conserved. ✓✓ (2)

12.3 $\Sigma p_i = \Sigma p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v$ } ✓ for any
$\underline{(1{,}5)(6{,}26) + 0}$ ✓ $= \underline{(1{,}5 + 2)v_f}$ ✓ $\therefore$ $v_f = 2{,}68\ m\cdot s^{-1}$ ✓ (4)

12.4

OPTION 1	**OPTION 2**
$\Delta x = v\Delta t$ ✓ $= (2{,}68)(3)$ ✓ $= 8{,}04\ m$ ✓	$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ ✓ $= (2{,}68)(3) + \frac{1}{2}(0)(3)^2$ ✓ $= 8{,}04\ m$ ✓ (Range 8,04 – 8,05)

(3) **[13]**

QUESTION 13

13.1 Momentum is the product of the mass of an object and its velocity. ✓✓ (2)

13.2 To the left ✓ Newton's third law ✓ (2)

NOTE: For QUESTIONS 13.3 and 13.4 motion to the right has been taken as positive.

13.3

OPTION 1

$\sum p_i = \sum p_f$
$m_1v_{1i} + m_2v_{2i} = m_1v_{2f} + m_2v_{2f}$ } ✓
mass of girl is m
$\underline{\{(m + 2)(0)\} + \{8(0)\}}$ ✓ $= \{(m + 2)(-0{,}6)\}$ ✓ $+ (8)(4)$ ✓ $\therefore m = 51{,}33\ kg$ ✓

OPTION 2	**OPTION 3**
$\sum p_i = \sum p_f$ $m_1v_{1i} + m_2v_{2i} = m_1v_{2f} + m_2v_{2f}$ $0 = m_1v_{1f} + m_2v_{2f}$ } ✓ 0 ✓ $= (8)(4)$ ✓ $+ m_2(-0{,}6)$ ✓ $\therefore m_2 = 53{,}33\ kg \therefore m_{girl} = 53{,}33 - 2 = 51{,}33\ kg$ ✓	$\Delta p_{girl} = -\Delta p_{parcel}$ ✓ $m(v_f - v_i) = -m(v_f - v_i)$ $(m + 2)(-0{,}6 - 0)$ ✓ $= -8(4 - 0)$ ✓ $m = 51{,}33\ kg$ ✓

(5)

13.4 Impulse = $\Delta p = m(v_f - v_i)$ ✓ = $\underline{(51{,}33 + 2)(-0{,}6 - 0)}$ ✓ = $-32\ N{\cdot}s/kg{\cdot}m{\cdot}s^{-1}$
Magnitude of impulse is 32 $N{\cdot}s$ /32 $kg{\cdot}m{\cdot}s^{-1}$ ✓
OR
Impulse = $\Delta p_{parcel} = m(v_f - v_i)$ ✓ = $(8)(4 - 0)$ ✓ = 32 $kg\ m{\cdot}s^{-1}$ $\therefore \Delta p_{girl}$ = 32 $kg\ m{\cdot}s^{-1}$ ✓ (3)
13.5 32 $kg{\cdot}m{\cdot}s^{-1}$ ✓ to the right/opposite direction ✓ (2)
[14]

QUESTION 14
14.1 The total (linear) momentum in a isolated/closed system remains constant/is conserved. ✓✓ (2)
14.2 **OPTION 1**

$$\left.\begin{array}{l} \sum p_i = \sum p_f \\ m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f} \\ m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f \end{array}\right\}\checkmark \text{Any one}$$

$\{0{,}45(9) + 0{,}20(0)\}$ ✓ = $(0{,}45 + 0{,}20)v$ ✓ $\therefore$ $v = 6{,}23\ m{\cdot}s^{-1}$ ✓
OR
$\Delta p_{ball} = -\Delta p_{cont}$ ✓ $\therefore$ $0{,}45(v - 9)$ ✓ = $-0{,}2(v - 0)$ ✓ $\therefore$ $v = 6{,}23\ m{\cdot}s^{-1}$ ✓ (4)
14.3 $K = \frac{1}{2}mv^2$ ✓
Total kinetic energy before collision: $\underline{\frac{1}{2}(0{,}45)(9)^2 + 0}$ ✓ = 18,225 J
Total kinetic energy after collision: $\underline{\frac{1}{2}(0{,}45 + 0{,}20)(6{,}23)^2}$ ✓ = 12,614 J
$\sum K_{before} \neq \sum K_{after}$ $\therefore$ Collision is inelastic. ✓✓ (5)
[11]

QUESTION 15
15.1 Isolated system is a system on which the resultant/net external force is zero. ✓✓ (2)
15.2.1 $p = mv$ ✓
$24 = m(480)$ ✓
$m = 0{,}05$ kg ✓ (3)
15.2.2

OPTION 1	**OPTION 2**
$\left.\begin{array}{l} F_{net}\Delta t = \Delta p \\ F_{net}\Delta t = (p_{bullet})_f - (p_{bullet})_i \\ F_{net}\Delta t = (mv_{bullet})_f - (mv_{bullet})_i \end{array}\right\}\checkmark \text{Any one}$ $F_{net}(0{,}01)$ ✓ = $\underline{(0{,}05)(80) - 24}$ ✓ $F_{net} = -2\ 000$ N $F_{net} = 2\ 000$ N ✓ west ✓	$v_f = v_i + a\Delta t$ $\underline{80 = 480 + a(0{,}01)}$ ✓ $a = -40\ 000\ m{\cdot}s^{-2}$ $F_{net} = ma$ ✓ $= (0{,}05)(-40\ 000)$ ✓ $= -2\ 000$ N $F_{net} = 2\ 000$ N ✓ west ✓

(5)
[10]

QUESTION 16
16.1 (Linear) momentum (of an object) is the product of mass and velocity. ✓✓ (2)
16.2.1

OPTION 1 **East as positive** $\left.\begin{array}{l} \sum p_i = \sum p_f \\ m_pv_{pi} + m_Qv_{Qi} = m_pv_{pf} + m_Qv_{Qf} \end{array}\right\}\checkmark \text{Any one}$ $\underline{(0{,}16)(10) + (0{,}2)(-15)}$ ✓ = $\underline{(0{,}16)(-5) + (0{,}2)v_{Qf}}$ ✓ $v_{Qf} = -3\ m{\cdot}s^{-1}$ $v_{Qf} = 3\ m{\cdot}s^{-1}$ ✓ west ✓
OPTION 2 **West as positive** $\left.\begin{array}{l} \sum p_i = \sum p_f \\ m_pv_{pi} + m_Qv_{Qi} = m_pv_{pf} + m_Qv_{Qf} \end{array}\right\}\checkmark \text{Any one}$ $\underline{(0{,}16)(-10) + (0{,}2)(15)}$ ✓ = $\underline{(0{,}16)(5) + (0{,}2)Q_{Nf}}$ ✓ $v_{Qf} = 3\ m{\cdot}s^{-1}$ ✓ west ✓
OPTION 3 $\Delta p_p = -\Delta p_Q$ ✓ $\underline{(0{,}16)(-5 - 10)}$ ✓ = $\underline{-(0{,}2)(v - (-15))}$ ✓ $v = -3\ m{\cdot}s^{-1}$ $= 3\ m{\cdot}s^{-1}$ ✓ west ✓ **IF**: $\Delta p_p = \Delta p_Q$: $\frac{0}{5}$

(5)

16.2.2

For ball P
West as negative
Impulse = Δp
$F_{net}\Delta t = \Delta p$ } ✓Any one
$\Delta p = m(v_{Pf} - v_{Pi})$
$= 0{,}16(-5 - 10)$ ✓
$= -2{,}4$
$\therefore$ 2,4 N·s ✓ (2,4 kg·m·s^{-1})

OR
West as positive
Impulse = Δp
$F_{net}\Delta t = \Delta p$ } ✓Any one
$= m(v_{Pf} - v_{Pi})$
$= 0{,}16(5 - (-10))$ ✓
$= 2{,}4$ N·s ✓

For ball Q
West as negative
Impulse = Δp
$F_{net}\Delta t = \Delta p$ } ✓Any one
$= m(v_{Qf} - v_{Qi})$
$= 0{,}2[-3 - (-15)]$ ✓
$= 2{,}4$ N·s ✓ (2,4 kg·m·s^{-1})

OR
West as positive
Impulse = Δp
$F_{net}\Delta t = \Delta p$ } ✓Any one
$= m(v_{Qf} - v_{Qi})$
$= 0{,}16(3 - (15))$ ✓
$= -2{,}4$ N·s
$\therefore$ 2,4 N·s ✓ (2,4 kg·m·s^{-1}) (3)

[10]

WORK, ENERGY AND POWER

QUESTION 1

1.1.1 In an isolated/closed system, ✓ the total mechanical energy is conserved/remains constant. ✓ (2)

1.1.2 No ✓ (1)

1.1.3

OPTION 1
Along **AB**
$E_{mech\ at\ A} = E_{mech\ at\ B}$ } ✓Any one
$(E_p + E_k)_A = (E_p + E_k)_B$
$(mgh + ½ mv^2)_A = (mgh + ½ mv^2)_B$
$(10)(9{,}8)(4) + 0 = 0 + ½ (10) v_f^2$ ✓
$v_f = 8{,}85$ m·s^{-1}

OPTION 2
Along **AB**
$W_{net} = \Delta E_k$ ✓
$F_g\Delta h\cos\theta = ½ m(v_f^2 - v_i^2)$
$(10)(9{,}8)(4)\cos 0° = ½ (10)(v_f^2 - 0)$ ✓
$v_f = 8{,}85$ m·s^{-1}

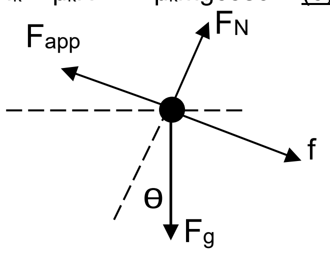
Substitute 8,85 m·s^{-1} in one of the following options

Along **BC** (Option 1)
$W_{net} = \Delta K$ ✓ $\therefore$ $f\Delta x \cos\theta = \Delta K$
$\underline{f(8)\cos 180°}$ ✓ $= \underline{½ (10)(0 - 8{,}85^2)}$ ✓
$f = 48{,}95$ N ✓

Along **BC** (Option 2)
$W_{nc} = \Delta K + \Delta U$ ✓ $\therefore$ $f\,\Delta x\cos\theta = \Delta K + \Delta U$
$\underline{f(8)\cos 180}$ ✓ $= \underline{½ (10)(0 - 8{,}85^2) + 0}$ ✓
$f = 48{,}95$ N ✓ (6)

1.2.1 $f_k = \mu_k N$ ✓ $= \mu_k mg\cos\theta = \underline{(0{,}19)(300)(9{,}8)\cos 25°}$ ✓ $= 506{,}26$ N ✓ (3)

1.2.2



$F_{net} = 0$ OR $\underline{F_{app} + (-F_g\sin\theta) + (-f) = 0}$ ✓
$F_{app} - (300)(9{,}8)\sin 25°$ ✓ $- 506{,}26$ ✓ $= 0$
$F_{app} = 1\,748{,}76$ N
$P_{ave} = Fv_{ave}$ ✓ $= 1748{,}76 \times 0{,}5$ ✓ $= 874{,}38$ W ✓ (6)

[18]

QUESTION 2

2.1 $\Delta U + \Delta K = 0$ ✓
$(5)(9{,}8)(5) + 0$ ✓ $+ (0 + ½ (5v_f^2)$ ✓ $= 0$
$v_f = \sqrt{2 \times 9{,}8 \times 5}$
$= 9{,}90$ m·s^{-1} ✓ (9,899 m·s^{-1}) (4)

2.2 No friction/zero resultant force ✓ and thus no loss in energy. ✓
OR Only conservative forces are present. **OR** Mechanical energy is conserved. (2)

2.3 The force for which the work done is path dependent. ✓✓ (2)

2.4

OPTION 1
$W_{nc} = \Delta U + \Delta K$ ✓
$F\,\Delta x\cos\theta = \Delta U + \Delta K$
$(18\,\Delta x\cos 180$ ✓$) = (5)(9{,}8)(3 - 0)$ ✓ $+ ½ (5)(0 - 9{,}90^2)$ ✓
$\Delta x = 5{,}4458$ m ✓
$\theta = \sin^{-1}\dfrac{3}{5{,}4458}$ ✓
$\theta = 33{,}43°$ ✓

OPTION 2

$W_{net} = W_f + W_G$ ✓

$W_{net} = f\,\Delta x\cos\theta + mg\sin\theta\Delta x\cos\theta$

$= [(18)\,\Delta x\cos 180^\circ) + 5\,(9{,}8)\dfrac{3}{\Delta x}(\Delta x)\cos 180^\circ]$ ✓

$= -18\Delta x - 147$

$W_{net} = \Delta K$ ✓

$\Delta K = \frac{1}{2}(5)(0 - 9{,}90^2)$ ✓

$= -245{,}025$

$-18\Delta x - 147 = -245{,}025$

$\Delta x = 5{,}4458$ m ✓

$\theta = \sin^{-1}\dfrac{3}{5{,}4458}$ ✓

$\theta = 39{,}43^\circ$ ✓ (7)

[15]

QUESTION 3

3.1 If the work done in moving an object between two points depends on the path taken (then the force applied is non-conservative). ✓✓ (2)

3.2.1 No ✓ (1)

3.2.2 <u>Since there is no acceleration, the net force is zero</u> ✓hence <u>net work done ($F_{net}\Delta x\cos\theta$) must be zero.</u> ✓ (2)

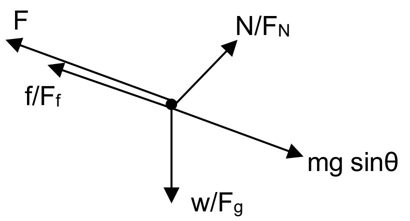
3.3 $F_{//} - (f + F) = 0$ ✓

OR $F = mg\sin\theta - f_k$

OR $F = mg\sin\theta - 266$

$F = [100(9{,}8)\sin 25^\circ]$ ✓ $- 266$ ✓

$F = 148{,}17$ N ✓



(4)

3.4

OPTION 1

$W = F\Delta x\cos\theta$ **OR** $W_{net} = W_f + W_g + W_N$ **OR** $W_{net} = f_k\Delta x\cos 180^\circ$ ✓ $+ mg\sin\theta\Delta x\cos 0^\circ + 0$

$= (266)(3)(-1)$ ✓$+ [100(9{,}8)\sin 25^\circ\,(3)(1)]$ ✓ $+ 0 = 444{,}5$ J

$W_{net} = \Delta E_K/\Delta K = \frac{1}{2}m(v_f^{\,2} - v_i^{\,2})$ ✓

$444{,}5 = \frac{1}{2}(100)(v_f^{\,2} - 0)$ ✓ $\therefore\ v_f = 2{,}98$ m·s^{-1} ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$ ✓

$f\Delta x\cos\theta$ ✓$= (mgh_f - mgh_i) + (\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2)$

$266\Delta x\cos 180^\circ$ ✓ $= (0 - mg\sin 25^\circ\ \Delta x\cos 0^\circ) + (\frac{1}{2}mv_f^2 - 0)$

$266(3)(-1) = [-100(9{,}8)\sin 25^\circ(3)(1)]$ ✓ $-\frac{1}{2}(100)(v_f^2 - 0)$✓ $\therefore\ v_f = 2{,}98$ m·s^{-1}✓

OPTION 3

$W_{net} = \Delta E_k$ ✓

$F_{net}\Delta x\cos\theta$ ✓$= \frac{1}{2}m(v_f^2 - v_i^2)$

$(148{,}17)$ ✓ $(3)\cos 0^\circ$✓ $= \frac{1}{2}(100)(v_f^2 - 0^2)$ $\therefore$ $444{,}51 = 50v_f^2$ ✓ $\therefore$ $v_f = 2{,}98$ m·s^{-1} ✓

OPTION 4

$F_{net} = ma$ ✓

$148{,}17$✓ $= 100a$ ✓

$a = 1{,}48$ m·s^{-2}

$v_f^2 = v_i^2 + 2a\Delta x$ ✓

$= 2(1{,}48)(3)$ ✓ $\therefore\ v_f = 2{,}98$ m·s^{-1} ✓ (6)

[15]

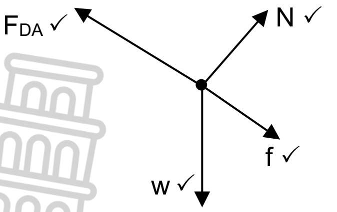
QUESTION 4

4.1

OPTION 1	**OPTION 2**
$v_{ave} = \dfrac{800}{75}$ ✓$= 10{,}67$m·s^{-1} $P_{ave} = Fv_{ave}$✓ $P_{ave} = (240)(10{,}67)$ $= 2\ 560{,}8$ W (2,56 kW) ✓	$v_{ave} = \dfrac{800}{75}$ ✓ $= 10{,}67$m·s^{-1} Distance covered in 1 s = 10,67m· $\therefore$ W(Work done in 1 s) = $F\Delta x\cos\theta$ ✓ $= (240)(10{,}67)(1)$ $= 2\ 560{,}8$ J s^{-1} $\therefore$ $P_{ave} = 2\ 560{,}8$ W (2,56 kW) ✓
OPTION 3	**OPTION 4**
$P = \dfrac{W}{\Delta t}$ ✓ $= \dfrac{F\Delta x\cos\theta}{\Delta t} = \dfrac{(240)(800)\cos 0^\circ}{75}$ ✓ $= 2\ 560$ W ✓	$P = \dfrac{W}{\Delta t}$ ✓ $= \dfrac{F\Delta x\cos\theta}{\Delta t} = \dfrac{(240)(800)\cos 0^\circ}{75}$ ✓ $= 2\ 560$ W ✓

(3)

4.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/2 940 N
f	$F_{friction}/F_f$/friction/294 N/f_k
N	F_N/F_{normal}/normal force
F_D	$F_{Applied}$/350 N/Average driving force/$F_{driving\ force}$

(4)

4.3 The net/total work done on an object is equal ✓ to the change in the object's kinetic energy.✓ (2)

4.4 **OPTION 1**

$W_{nc} = \Delta U + \Delta K$ ✓ $\therefore$ $W_f + W_D = \Delta U + \Delta K$

$(f\Delta x\cos\theta + F_D\Delta x \cos\theta = mg(h_f - h_i) + ½ m(v_f^2 - v_i^2)$

$(294)(450)(\cos180°)$ ✓ + $(350)(450)\cos0°$✓= $(300)(9,8)(5 - 0)$ ✓ + $½(300)(v_f^2 - 0)$ ✓ $\therefore v_f = 8{,}37\ m\cdot s^{-1}$ ✓

OPTION 2

$W_{net} = \Delta K$ ✓ $\therefore$ $W_{net} = W_D + W_g + W_f + W_N = (F_D\Delta x\cos\theta) + (mg\sin\alpha)\Delta x\cos\theta) + (f\Delta x\cos\theta) + 0$

$W_{net} = [350(450)](\cos0°)$✓+ $(300)(9,8)\left(\frac{5}{450}\right)(450)(\cos180°)$ ✓+ $294(450)(\cos180°)$✓

= 157 500 – 14 700 – 132 300 = 10 500 J

$W_{net} = \Delta K$ $\therefore$ $10\ 500 = ½ (300)(v_f^2 - 0)$ ✓ $\therefore v_f = 8{,}37\ m\cdot s^{-1}$ ✓ (6)

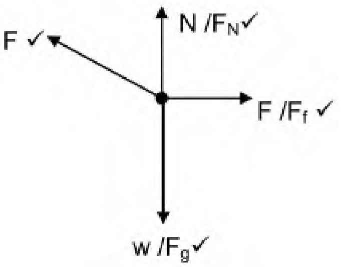
[15]

QUESTION 5

5.1 It is a ratio of two forces (hence units cancel). ✓ (1)

5.2 The net/total work done on an object is equal ✓ to the change in the object's kinetic energy.✓ (2)

5.3



(4)

5.4 $F\sin20° + N = mg$✓

$N = mg - F\sin20°$

$W_{fk} = f_k\Delta x\cos\theta = \mu_k N\Delta x\cos\theta$✓

$= \mu_k(mg - F\sin 20)(3)\cos\theta$

$= (0{,}2)[200(9{,}8) - F\sin 20](3)\cos180°$✓

$= (-1176 + 0{,}205\ F)$ J✓ (4)

5.5 $W_{tot} = [W_g] + W_f + W_F$ ✓

0 ✓ = [0] +[(-1176 + 0,205 F)] + [F (cos 20) (3) (cos 0)]✓ (4)

F = 388,88 N✓

[15]

QUESTION 6

6.1 The total mechanical energy in an isolated/closed system ✓remains constant/is conserved. ✓ (2)

6.2.1 $W = F\Delta x\cos\theta$ ✓ $= (30)\left(\frac{5}{\sin30°}\right)\cos\theta$ ✓ $= (30)(10)\cos180° = (30)(10)(-1) = -300$ J ✓ (3)

6.2.2 **OPTION 1**

$\left.\begin{array}{l} W_{nc} = \Delta E_P + \Delta E_K \\ W_{nc} = mg(h_f - h_i) + ½m(v_f^2 - v_i^2) \end{array}\right\}$ ✓Any one

-300 ✓= $(20)(9{,}8)(0 - 5)$ ✓+ $½ (20)(v_f^2 - 0)$ ✓ $\therefore$ $v = 8{,}25\ m\cdot s^{-1}$✓

OPTION 2

$\left.\begin{array}{l} W_{net} = \Delta E_K \\ W_g + W_f = ½m(v_f^2 - v_i^2) \end{array}\right\}$ ✓Any one

$W_g + (-300) = ½(20)(v_f^2 - 0)$ ✓

$[(20)(9{,}8)\sin30° \frac{5}{0{,}5}\cos0°]$ ✓ + (- 300) ✓ = $10v_f^2$ $\therefore$ $v_f = 8{,}25\ m\cdot s^{-1}$ ✓ (5)

6.3 $F = w_{//} + f = (100)(9{,}8)\sin30° + 25$ ✓ = 515 N

$P_{ave} = Fv_{ave}$ ✓ = (515)(2) ✓ = 1 030 W ✓ (4)

[14]

QUESTION 7

7.1 $E_k = \frac{1}{2} mv^2$ ✓ $= \frac{1}{2}(2)(4,95)^2$ ✓ $= 24,50$ J ✓ (3)

7.2 **OPTION 1**

$E_{mech\ before} = E_{mech\ after}$
$[(E_{mech})_{bob} + (E_{mech})_{block}]_{before} = [(E_{mech})_{Block} + (E_{mech})_{bob}]_{after}$ } Any one ✓
$(mgh + \frac{1}{2} mv^2)_{before} = (mgh + \frac{1}{2} mv^2)_{after}$

$\underline{(5)(9,8)h + 0 + 0}$ ✓ $= \underline{5(9,8)\frac{1}{4}h + 0 + 24,50}$ ✓ ∴ h = 0,67 m ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$
$0 = \Delta E_p + \Delta E_k$ } Any one ✓
$-\Delta E_p = \Delta E_k$

$-[\underline{(5)(9,8)(\frac{1}{4}h) - (5)(9,8)h}]$ ✓ $= 24,50$ ✓
∴ h = 0,67 m ✓

OPTION 3

Loss E_p bob = Gain in E_k of block ✓
$mg(\frac{3}{4}h) = 24,5$
$(5)(9,8)(\frac{3}{4}h)$ ✓ $= 24,5$ ✓
∴ h = 0,67 m ✓

(4)

7.3 The <u>net/total work done on an object is equal</u> ✓ to the <u>change in the object's kinetic energy.</u> ✓ (2

7.4 **OPTION 1**

$W_{net} = \Delta E_K$ ✓
$W_f + mg\Delta y\cos\theta = \frac{1}{2}m(v_f^2 - v_i^2)$
$W_f + \underline{(2)(9,8)(0,5)\cos180°}$ ✓ $= \underline{\frac{1}{2}(2)(2^2 - 4,95^2)}$ ✓
$= -10,7$ J ✓

OPTION 2

$W_{nc} = \Delta E_K + \Delta U$
$W_{nc} = \Delta E_K + \Delta E_P$ } ✓
$W_f = \underline{\frac{1}{2}(2)(2^2 - 4,95^2)}$ ✓ $+ \underline{(2)(9,8)(0,5-0)}$ ✓
∴ $W_f = -10,7$ J ✓

(4)
[13]

QUESTION 8

8.1 $W_{net} = \Delta K$ ✓
$W_{net} = \frac{1}{2}(M + m)(v_f^2 - v_i^2)$

$W_{fr} = f\Delta x\cos\theta$ ✓ $= \frac{1}{2}(M + m)(v_f^2 - v_i^2)$
$\underline{10 \times 2 \cos180}$ ✓ $= \underline{\frac{1}{2}(7,02)(0 - v_i^2)}$ ✓
$v_{bb} = 2,39$ m·s^{-1} ✓ (2,387) m·s^{-1} (5)

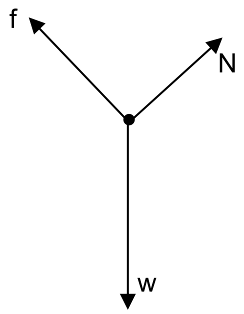
8.2 The <u>total (linear) momentum of an isolated/closed system</u> ✓ <u>is constant/conserved.</u> ✓ (2)

8.3 **POSITIVE MARKING FROM QUESTION 8.1.**

$\Sigma p_i = \Sigma p_f$ ✓
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$
$0,02v_i + (7)(0) = (7,02)(2,39)$
$0,02v_i$ ✓ $= 7,02\ (2,39)$ ✓
$v_i = 838,89$ m·s^{-1} ✓ (4)
[11]

QUESTION 9

9.1



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f/50 N	✓
N	Normal force/F_{NORMAL}/F_{NOR}	✓

(3)

9.2 The net/total work done on an object equals the change in the object's kinetic energy. ✓✓ (2)

9.3 **OPTION 1**

$W_{net} = \Delta E_K$
$f\Delta x\cos\theta + F_g\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ } ✓Any one
$(50)(25\cos180°)$ ✓ $+ (60)(9,8)(25\cos70°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\ 250 + 5\ 027,696 = 6\ 750 - 30v_i^2$ ∴ $v_i = 9,95(4)$ m.s^{-1} ✓

OPTION 2

$W_{net} = \Delta E_K$
$f\Delta x\cos\theta + F_{g||}\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ } ✓Any one
$(50)(25\cos180°)$ ✓ $+ (60)(9,8\sin20°)(25\cos0°)$ ✓ $= \frac{1}{2}(60)(15^2 - v_i^2)$ ✓
$-1\ 250 + 5\ 027,696 = 6\ 750 - 30v_i^2$ ∴ $v_i = 9,95(4)$ m.s^{-1} ✓

OPTION 3

$W_{nc} = \Delta E_K + \Delta E_P$
$f\Delta x\cos\theta = \frac{1}{2}(mv_f^2 - mv_i^2) + (mgh_Q - mgh_P)$ ✓Any one
$E_{mechP} + E_{mechQ} + W_{nc} = 0$

$(50)(25\cos 180^\circ)$ ✓= $\frac{1}{2}(60)(15^2 - v_i^2)$ ✓ + $(60)(9,8)(-25\sin 20^\circ)$ ✓

$-1\ 250 = 6\ 750 - 30\ v_i^2 - 5\ 027,696$ ∴ $v_i = 9,95(4)\ m.s^{-1}$✓ (5)

9.4 **OPTION 1**

$P_{ave} = Fv_{ave}$ ✓ $= 50$✓ $\frac{(9,95+15)}{2}$ ✓ $= 623,75\ W$ ✓

OPTION 2

$P = \frac{W}{\Delta t}$
$P = \frac{f\Delta x\cos\theta}{\Delta t}$ ✓Any one

$= \frac{[50(25\cos 180^\circ)]}{2,004}$ ✓ ✓ $= -623,75\ W$✓

$\Delta x = \frac{(v_i + v_f)}{2}\Delta t$

$25 = \frac{(9,954+15)}{2}\Delta t$ ✓

$\Delta t = 2,004\ s$ (4)

[14]

QUESTION 10

10.1 The rate at which work is done. / Rate at which energy is expended. ✓✓ (2)

10.2.1 **OPTION 1**

$W = F\Delta x\cos\theta$✓

$W_{gravity} = mg\Delta y\cos\theta = \underline{(1\ 200)(9,8)(55)\cos 180^\circ}$ ✓ $= -646\ 800\ J\ (6,47 \times 10^5\ J)$✓

OPTION 2

$W = -\Delta E_p$✓ $= -(1200)(9,8)(55 - 0)$ ✓ $= -646800\ J$ ✓ (3)

10.2.2 $W_{counterweight} = mg\Delta y\cos\theta = \underline{(950)(9,8)(55)\cos 0^\circ}$ ✓ $= 512\ 050\ J$ ✓ $(5,12 \times 10^5\ J)$ (2)

10.3 **OPTION 1**

$W_{net} = \Delta E_K$
$W_{gravity} + W_{countweight} + W_{motor} = 0$
$W_{motor} = -(W_{gravity} + W_{countweight})$ ✓Any one
$W_{nc} = \Delta E_K + \Delta E_p$

Substituting into any of the above equations will lead to:

-646800✓ $+ 512050$ ✓$+ W_{motor} = 0$

∴ $W_{motor} = 134\ 750\ J$ ∴ $P_{av\ motor} = \frac{W}{\Delta t}$ ✓ $= \frac{34750}{180}$ ✓ $= 748,61\ W$✓

OPTION 2

$F_{net} = 0$ ∴ $F_{gcage} + F_{gcount} + F_{motor} = F_{net}$ ✓

-117600✓ $+ 9310$✓ $+ F_{motor} = 0$ ∴ $F_{motor} = 2450\ N$

$P_{ave} = Fv_{ave}$ ✓ $= 2450\ \frac{55}{180}$ ✓ $= 748,61\ W$

OPTION 3

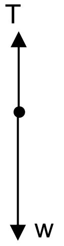
$P_{ave} = Fv_{ave}$ ✓✓ $= [1200(9,8)$ ✓ $- 950(9,8)]$ ✓ $\frac{55}{180}$ ✓ $= 748,61\ W$ ✓ (6)

[13]

QUESTION 11

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

11.2



Accepted labels	
w✓	F_g / F_w / weight / mg/ 58,8N / gravitational force / $F_{earth\ on\ block}$
T✓	F_T/ Tension

(2)

11.3

$W_w = w\Delta x\cos\theta$✓ $= mg\Delta x\cos\theta$ $= (6)(9,8)(1,6)\cos 0^\circ$✓ ∴ $W = 94,08\ J$ ✓	$W_w = -\Delta E_P$ ✓$= -mg(h_f - h_i)$ $= -(6)(9,8)(0 - 1,6)$ ✓ $= 94,08\ J$✓

(3)

11.4

OPTION 1

$W_{net} = \Delta E_K / \Delta K = ½m(v_f^{\,2} – v_i^{\,2})$
$W_{net} = F_{net}\Delta x\cos\theta$
$W_{net} = W_f + W_g + W_N$
$= \mu_k N\Delta x\cos\theta + W_g + W_N$
✓Any one

$W_{net} = \underline{(0,4)(4)(9,8)(1,6)\cos180°}$ ✓ + 94,08 + 0 = 68,992 J

$W_{net} = ½m(v_f^{\,2} – v_i^{\,2})$ ∴ $\underline{68,992}$✓= $\underline{½(4)(v_f^{\,2} – 0) + ½(6)(v_f^2 – 0)}$✓ ∴ v = 3,71 m·s^{-1} ✓

OPTION 2

$W_{nc} = \Delta E_p + \Delta E_k$
$f\Delta x\cos\theta = (m_1gh_f – m_1gh_i) + (½m_1v_f^2 - ½m_1v_i^2) + (½m_2v_f^2 - ½m_2v_i^2)$
✓Any one

$\underline{(0,4)(4)(9,8)\ (1,6)\cos 180°}$ ✓= [0 - (6)(9,8)(1,6)]✓+ (½(6)v_f^2 + ½(4)v_f^2 - 0)✓ ∴ v = 3,71 m·s^{-1} ✓

OPTION 3

$W_{net} = \Delta E_K$ ✓

For the 4 kg mass: $\underline{T(1,6)\cos0° + [(0,4)(9,8)(4)](1,6)\cos180°}$✓ = ½(4)$v^2$ – 0)

For the 6 kg mass: $\underline{(6)(9,8)(1,6)]\cos0°+ T(1,6)\cos180°}$✓ = ½(6)($v^2$ – 0)

Adding the two equations : 68,992 = $\underline{½\ (4)v^2 + ½\ (6)v^2}$ ✓ ∴ v = 3,71 m·s^{-1} ✓ (5)

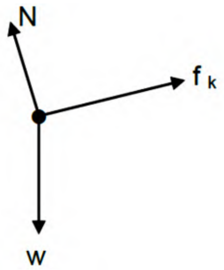
[12]

QUESTION 12

12.1 The total mechanical energy in a closed/isolated system is constant/conserved. ✓✓ (2)

12.2 $E_{mech\,P} = E_{mech\,Q}$ **OR** $(E_p + E_k)_{Pe} = (E_p + E_k)_Q$ **OR** $W_{net} = \Delta E_K$ OR $W_{con} = \Delta E_K$ **OR**
$(mgh + ½\ mv^2)_P = (mgh + ½\ mv^2)_Q$ ✓
$\underline{(50)(9,8)3 + 0}$ ✓= $\underline{0 + ½(50)v^2}$✓ ∴ v = 7,67 m·s ✓ (4)

12.3



Accepted labels		
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f	✓
N	Normal force/F_{NORMAL}/F_N	✓

(3)

12.4 $f_k = \mu_k N$ **OR** $f_k = \mu_k mg\cos\theta$ ✓
$f_k = (0,08)(50)(9,8)\cos30°$ ✓= 33,95 N ✓ (3)

12.5 **POSITIVE MARKING FROM QUESTION 5.4/*POSITIEWE NASIEN VANAF VRAAG 5.4***

$W = F_{net}\Delta x\cos\theta$

$W_{net} = W_f + W_w + W_N$
$W_{net} = W_f + (-\Delta E_P) + W_N$
$W_{net} = f_k\ \Delta x\cos180° + mg\sin\theta\ \Delta x\cos0 + 0$

$W_{net} = \Delta E_K/\Delta K$

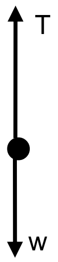
✓1 mark for any one/
1 punt vir enige van die drie

W_{net} = [33,948)(5)(-1)] ✓+ [(50)(9,8) (5)sin 30° + 0]✓
= 1055, 26 (1055,259)
$\underline{1055,259 = ½\ (50)\ (v_f^{\,2} – 7,668^2)}$ ✓
v_f = 10,05 m·s^{-1}✓ (5)

[17]

QUESTION 13

13.1



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force/N/19,6 N
T	Tension/F_T/ F_A/

(2)

13.2 Tension ✓ **OR** $F_{applied}$ (1)

13.3 $W = F\Delta x\cos\theta$ / $W_w = mg\Delta x\cos\theta$ } ✓any one

$= \underline{75(9,8)\ (12)\cos 180°}$✓ $= -\ 8\ 820$ J ✓

OR $W_w = -\Delta E_p$ ✓ $= -\ (mgh - 0) = -(75)(9,8)(12)$ ✓ $= -\ 8\ 820$ J ✓ (3)

13.4 The net work done on an object is equal to the change in the object's kinetic energy. ✓✓ (2)

13.5 **OPTION 1**

$W_{net} = \Delta K$ / $F_{net}\Delta x\cos\theta = (½\ mv_f^2 - ½\ mv_i^2)$ } ✓any one

$\underline{(75)(0,65)(12)}$ ✓$\cos 0°$ ✓ $= ½(75)(v_f^2 - 0)$ ✓

$\therefore v_f = 3{,}95\ m{\cdot}s^{-1}$ ✓

OPTION 2

$W_{net} = \Delta K$ / $W_{nc} = \Delta K + \Delta U$ / $W_T + W_g = \Delta K$ } ✓any one

$T - mg = ma$

$T - 75(9,8) = 75(0,65)$✓ $\therefore$ $T = 783{,}75$ N

$W_T = 783{,}75\ (12)\cos 0°$✓ $= 9405$ J

$9405 - (8820) = ½\ (75)(v_f^2 - 0)$ ✓ $\therefore$ $v_f = 3{,}95\ m{\cdot}s^{-1}$ ✓

$W_{nc} = (½\ mv_f^2 - ½\ mv_i^2) + (mgh_f - mgh_i)$
9405 ✓$= (½\ (75)v_f^2 - 0)$ ✓$+ (75)(9,8)(12 - 0)$ ✓
$v_f = 3{,}95\ m{\cdot}s^{-1}$ ✓ (5)

[13]

QUESTION 14

14.1 A force for which the work done in moving an object between two points depends on the path taken. ✓✓ (2)

14.2 No ✓ (1)

14.3

OPTION 1	**OPTION 2**
$P = \frac{W}{\Delta t}$ ✓ $= \frac{4{,}8\times10^6}{(90)}$ ✓ $= 53\ 333{,}33$ W $= 5{,}33 \times 10^4$ W (53,33 kW) ✓	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ $= \left(\frac{0 + 25}{2}\right)(90) = 1\ 125$ m $W_F = F\Delta x\cos\theta$ $4{,}80 \times 10^6 = F(1\ 125)\cos 0°$ $\therefore$ $F = 4\ 266{,}667$ N $P_{ave} = Fv_{ave}$ ✓ $= (4\ 266{,}667)(12{,}5)$ ✓ $= 53\ 333,\ 33$ W ✓

(3)

14.4 The net/total work done on an object is equal to the change in the object's kinetic energy✓✓ (2)

14.5 **OPTION 1**

$W_{net} = \Delta K$ ✓ **OR** $W_w + W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2$ **OR**

$mg\Delta x\cos\theta + W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2$

$\therefore$ $\underline{(1\ 500)(9,8)200\cos 180°}$✓ $+ \underline{W_f + 4{,}8 \times 10^6}$ ✓$= \underline{½\ (1\ 500)(25^2 - 0)}$ ✓

$-2\ 940\ 000 + W_f + 4{,}8 \times 10^6 = 468\ 750$ $\therefore$ $W_f = -1\ 391\ 250$ J $= -1{,}39 \times 10^6$ J ✓

OR

$W_{net} = \Delta K$✓ OR $W_w + W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2$ OR $-\Delta E_p + W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2$

$\therefore$ $\underline{-(1\ 500)(9,8)(200 - 0)}$✓ $+ \underline{W_f + 4{,}8 \times 10^6}$ ✓$= \underline{½\ (1\ 500)(25^2 - 0)}$ ✓

$-2\ 940\ 000 + W_f + 4{,}8 \times 10^6 = 468\ 750$ $\therefore$ $W_f = -1\ 391\ 250$ J $= -1{,}39 \times 10^6$ J ✓ (5)

OPTION 2

$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = ½\ mv_f^2 - ½\ mv_i^2 + mgh_f - mgh_i = ½\ m\ (v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**

$W_{nc} = ½\ mv_f^2 + mgh_f - ½\ mv_i^2 - mgh_i$ **OR** $W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2 + mgh_f - mgh_i$ ✓

$\therefore$ $\underline{W_f + 4{,}8 \times 10^6}$ ✓$= \underline{[½\ (1\ 500)(25)^2 + -0]}$ ✓$+\underline{[(1\ 500)(9,8)(200) - 0]}$✓

$\therefore$ $W_f = -\ 1{,}39 \times 10^6$ J ($-1{,}40 \times 10^6$J)✓

OR

$W_{nc} = \Delta K + \Delta U$ ✓ **OR** $W_{nc} = ½\ mv_f^2 - ½\ mv_i^2 + mgh_f - mgh_i = ½\ m\ (v_f^2 - v_i^2) + mg(h_f - h_i)$ **OR**

$W_{nc} = ½\ mv_f^2 + mgh_f - ½\ mv_i^2 - mgh_i$

$\therefore$ $\underline{W_f + 4{,}8 \times 10^6}$ ✓$= [\underline{½\ (1500)(25)^2}$ ✓$+ \underline{(1500)(9,8)(200)}$ ✓$] - [0 + 0]$ (5)

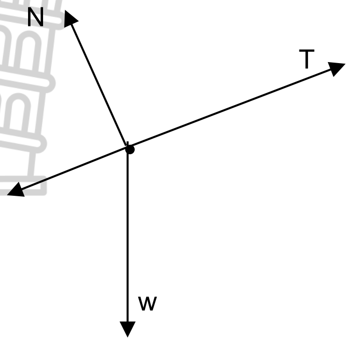
$\therefore$ $W_f = -\ 4{,}8 \times 10^6 + 3{,}4 \times 10^6 = -\ 1{,}39 \times 10^6$ J ($-1{,}40 \times 10^6$ J)✓ **[13]**

QUESTION 15

15.1 Tension ✓

15.2 There is friction/tension in the system. ✓
OR Friction/tension is a non-conservative force/ The system is not isolated because there is friction/tension. (1)

15.3



Accepted labels		✓
w	F_g/F_w/weight/mg/gravitational force	✓
f	Friction/F_f/f_k/178,22 N	✓
N	Normal (force)/F_{normal}/F_N/$F_{reaction}$	✓
T	F_T/F_A/$F_{applied}$/700 N/Tension	✓

(4)

15.4 $W = F\Delta x\cos\theta$ ✓
$W_f = [178,22(4)\cos 180°]$ ✓
$= -712,88$ J ✓ (3)

15.5

OPTION 1
$W_{net} = \Delta E_K$
$W_f + W_g + W_T = \Delta K$
$W_f + mg\sin\theta\Delta x\cos\theta + W_T = \Delta K$
$-712,88 + \underline{(70)(9,8)(\sin 30°)(4)\cos 180°}$ ✓ + $\underline{(700 \times 4 \times \cos 0°)}$✓ = $\underline{½\, 70(v_f^2 - 0)}$✓
$v_f = 4,52\ m\cdot s^{-1}$✓

OPTION 2
$W_{nc} = \Delta E_K + \Delta E_p$ ✓
$W_T + W_f = \Delta E_K + \Delta E_p$
$(700)(4)\cos 0°)$ ✓ + $(-712,88) = [(70)(9,8)\, 4(\sin 30°). - 0\,]$ ✓+ $\underline{½\, 70(v_f^2 - 0)}$ ✓
$v_f = 4,52\ m\cdot s^{-1}$ ✓

OPTION 3
$F_{net} = F_T - [mg\sin\theta + f_k]$
$= \underline{700 - [(70)(9,8\sin 30°) + 178,22]}$ ✓
$= 178,78$ N
$W_{net} = \Delta E_K$ ✓
$F_{net}\,.\,\Delta x\cos\theta = \Delta E_K$
$\underline{(178,78)(4)\cos 0°}$ ✓ = $\underline{½\, 70(v_f^2 - 0)}$✓ $\therefore v_f = 4,52\ m\cdot s^{-1}$ ✓ (5)

15.6 $2(-712,88) = -1425,76$ J ✓ (1)

[15]

QUESTION 16

16.1 A *conservative force* is a force for which the <u>work done</u> in <u>moving an object between two points is independent of the path taken.</u> ✓✓ (2)

16.2 Gravitational (force) ✓ (1)

16.3 No ✓ There is friction ✓ (between the object and the track). (2)

16.4 $E_P = mgh$ ✓ = $\underline{(1,8)(9,8)(1,5)}$ ✓ = 26,46 J ✓ (3)

16.5

OPTION 1	**OPTION 2**
$W_{nc} = \Delta K + \Delta U$ ✓Any one $W_f = ½m(v_f^2 - v_i^2) + mg(h_f - h_i)$ $= \underline{½(1,8)(4^2 - 0,95^2)}$ ✓+ $\underline{(0 - 26,46)}$ ✓ $= -12,87$ J ✓	$W_{net} = \Delta K$ $W_f + W_g = ½mv_f^2 - ½mv_i^2$ ✓Any one $W_f + mgh = ½m(v_f^2 - v_i^2)$ $W_f + mgh = ½mv_f^2 - ½mv_i^2$ $W_f + 26,46$ ✓= $\underline{½(1,8)[(4)^2 - (0,95)^2]}$ ✓ $W_f = -12,87$ J (- 12,872 J) ✓

(4)

16.6 (W_{net} =) 0 J / zero ✓ (1)

[13]

QUESTION 17

17.1 A force is non-conservative if the <u>work it does</u> on an object (which is moving between two points) <u>depends on the path taken</u>. ✓✓ **OR** A force is non-conservative if the <u>work</u> it does on an object <u>depends on the path taken.</u> **OR** A force is non-conservative if the <u>work</u> it does <u>in moving</u> an object around a <u>closed path is non-zero.</u> (2)

17.2

$K = \frac{1}{2}mv^2$ / $E_k = \frac{1}{2}mv^2$
$\Delta K = K_f - K_i$
$\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$= \frac{1}{2}m(v_f^2 - v_i^2)$ } ✓Any one
$= \frac{1}{2}(200)(2^2 - 4^2)$ ✓
$\Delta K = -1\,200$ J ✓

(3)

17.3

OPTION 1

$W_{nc} = \Delta K + \Delta U$
$W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$ } ✓Any one
$= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$
$\underline{-3{,}40 \times 10^3}$ ✓ = $\underline{-1\,200 + 200(9{,}8)(h_f - 10)}$ ✓
h = 8,88 m ✓ (8,87765 m)

OPTION 2

$E_{(mech/meg)A} + W_f = E_{(mech)B}$
$(E_p + E_k)_A + W_f = (E_p + E_k)_B$ } ✓Any one
$(mgh + \frac{1}{2}mv^2)_A + W_f = (mgh + \frac{1}{2}mv^2)_B$
$\underline{200(9{,}8)(10) + \frac{1}{2}(200)(4^2) - 3{,}40 \times 10^3}$ ✓ = $\underline{200(9{,}8)(h) + \frac{1}{2}(200)(2)^2}$ ✓
h = 8,88 m ✓ (8,87755)

OPTION 3

$W_{net} = \Delta K$
$W_f + W_w = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$W_f - \Delta E_p = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ } ✓Any one
$W_f - mg(h_f - h_i) = \frac{1}{2}m(v_f^2 - v_i^2)$
$\underline{-3{,}40 \times 10^3 - 200(9{,}8)(h-10)}$ ✓ = $-1\,200$ ✓
h = 8,88 m ✓ (8,87755 m)

(4)

17.4

OPTION 1

$W_{nc} = \Delta K + \Delta U$
$W_{engine} + W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_f - mgh_i$ } ✓Any one
$= \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$
$W_{engine} + \underline{(50)(2)(15)\cos 180°}$ ✓ = $0 + \underline{200(9{,}8)}(22 - 8{,}88)$ ✓
$W_{engine} = 27\,215{,}20$ J

$$P_{engine} = \frac{W_{engine}}{\Delta t} \checkmark$$
$$= \frac{27\,215{,}20}{15}$$
$$= 1\,814{,}35\ W \checkmark$$

OPTION 2

$W_{net} = \Delta K$
$W_N + W_{engine} + W_w + W_f = 0$ } ✓ Any one
$W_N + W_{engine} - \Delta E_p + W_f = 0$
$\underline{0 + W_{engine} - (200)(9{,}8)(13{,}12)}$ ✓ + $\underline{(50)(2)(15)\cos 180° = 0}$ ✓
$W_{engine} = 27\,215{,}20$ J

OR

$W_{net} = \Delta K$
$W_N + W_{engine} + W_{w||} + W_f = 0$ } ✓ Any one
$W_N + W_{engine} + mg\sin\theta\Delta x\cos 180° + W_f = 0$
$\underline{0 + W_{engine} - (200)(9{,}8)}\left(\frac{13{,}12}{\Delta x}\right)(\Delta x)\underline{(-1)}$ ✓ + $\underline{(50)(2)(15)\cos 180° = 0}$ ✓
$W_{engine} = 27\,215{,}20$ J

$$P_{engine} = \frac{W_{engine}}{\Delta t} \checkmark$$
$$= \frac{27\,215{,}20}{15}$$
$$= 1\,814{,}35\ W \checkmark$$

OPTION 3

$F_{net} = ma$ } ✓ *Enige een*

$F_{engine} + F_{friction} + F_{g//} = 0$

$F_{engine} + (\underline{-50})$ ✓ $- \frac{(200)(9,8)(13,12)}{30}$ ✓ $= 0$

$F_{engine} = 907,17$ N

$P_{ave} = Fv_{ave}$ ✓

$P_{ave} = (907,17)(2)$

$= 1\ 814,35$ W ✓

OR

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

$= (907,17)(30)\cos 0^o$

$= 27\ 215,10$ J

$P_{engine} = \frac{W_{engine}}{\Delta t}$ ✓

$= \frac{27\ 215,10}{15}$

$= 1\ 814,34\ W$ ✓

(5)

[14]

DOPPLER EFFECT

QUESTION 1

1.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

1.1.2 Towards ✓

Observed/detected frequency is greater than the actual frequency. ✓ (2)

1.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$\therefore 1\ 200$ ✓ $= \frac{343}{343 - v_s}$ ✓ (1130) ✓ $\therefore v_s = 20,01\ m\cdot s^{-1}$ ✓ (5)

1.2 The star is approaching the earth./The earth and the star are approaching (moving towards) each other ✓

The spectral lines in diagram 2 are shifted towards the blue end/are blue shifted. ✓ (2)

[11]

QUESTION 2

2.1.1 $v = f\lambda$ ✓

$\lambda = \frac{340}{520}$

$= 0,65$ m✓ v = f (2)

2.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{340 ✓}{(340 - 15) ✓}(520)$ ✓

$f_L = 544$ Hz

$v = f\lambda$

$\lambda = \frac{340}{544}$ ✓

$= 0,63$m✓ (6)

2.2 The wavelength in QUESTION 2.1.2 is shorter because the waves are compressed as they approach the observer. ✓✓ (2)

2.3 The red shift occurs when the spectrum of a distant star moving away from the earth is shifted toward the red end of the spectrum. ✓✓ (2)

[12]

QUESTION 3

3.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

3.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓ The following values are obtained using other points:

825 ✓ $= \frac{v}{v - v_s}(800)$ ✓

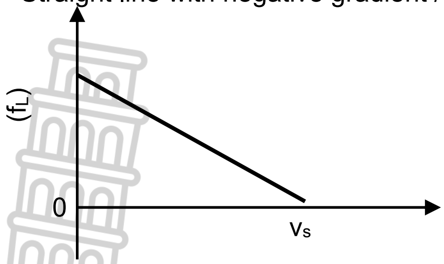
$(1,03125)(v - 10)$ ✓$= v$

$v = 330\ m\cdot s^{-1}$ ✓

v_s ($m\cdot s^{-1}$)	Frequencies	v ($m\cdot s^{-1}$)
v_s = 20	850	310
v_s = 20	845	375,56
vs =30	880	330
40	910	331

(5)

3.3 Straight line with negative gradient / frequency decreases (linearly). ✓✓



(2)
[9]

QUESTION 4

4.1.1 Frequency (of sound detected by the listener (observer). ✓ (1)

4.1.2 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓

4.1.3 Away ✓ Detected frequency of source decreases. ✓ (2)

4.1.4

EXPERIMENT 2	**EXPERIMENT 3**
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 874 ✓ $= \frac{v✓}{v + 10}(900)$ ✓ $\therefore v = 336{,}15\ m \cdot s^{-1}$ ✓	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 850 ✓ $= \frac{v✓}{v + 20}(900)$ ✓ $\therefore v = 340\ m \cdot s^{-1}$ ✓
EXPERIMENT 4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓ 827 ✓ $= \frac{v✓}{v + 30}(900)$ ✓ $\therefore v = 339{,}86\ m \cdot s^{-1}$ ✓	

(5)

4.2 Away from the earth. ✓ (1)
[11]

QUESTION 5

5.1 $v = f\lambda$ ✓
$= (222 \times 10^3)(1{,}5 \times 10^{-3})$ ✓
$= 333\ m.s^{-1}$ ✓ (3)

5.2.1 Towards the bat. ✓ (1)

5.2.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR/OF** $f_L = \frac{v}{v - v_s} f_s$ ✓

$230{,}3$ ✓ $= \frac{333\ ✓}{333 - v_s ✓}(222)$ ✓

$76689{,}9 - 230{,}3\ v_s = 73\ 926$

$v = 12\ m.s^{-1}$ ✓ (towards bat/*na die vlermuis toe*) (6)
[10]

QUESTION 6

6.1 **X** ✓ (1)

6.2 As ambulance approaches the hospital the waves are compressed ✓ or wavelengths are shorter. Since the speed of sound is constant ✓ the observed frequency must increase. ✓ Therefore the hospital must be located on the side of X (from $v = f\lambda$)
OR: The number of wave fronts per second reaching the observer are more at X. ✓✓.
For the same constant speed, this means that the observed frequency increases ✓ therefore the hospital must be located on the side of X. (from $v = f\lambda$) (3)

6.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓ $\therefore$ $f_L = \frac{340\ ✓}{340 - 30\ ✓}(400)$ ✓ $\therefore f_L = 438{,}71$ Hz ✓ (5)

6.4 $v = f\lambda$ ✓ $\therefore$ $340 = 400\lambda$ ✓ $\therefore$ $\lambda = 0{,}85$ m ✓ (3)
[12]

QUESTION 7

7.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

7.1.2 $v = f\lambda$ ✓ $\therefore$ $340 = f(0{,}28)$ ✓ $\therefore$ $f_s = 1\ 214{,}29$ Hz ✓ (3)

7.1.3

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v \pm v_L}{v \pm v_s} \times \frac{v}{\lambda_s}$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$f_L = \left(\frac{340\ ✓}{340 - 30\ ✓}\right)1214{,}29$ ✓ **OR** $f_L = \left(\frac{340}{340 - 30}\right) \times \frac{340}{0{,}28}$ $\therefore f_L = 1\ 331{,}80$ Hz ✓ (5)

7.1.4 Decreases ✓ (1)

7.2 The spectral lines of the star are/should be shifted towards the lower frequency end, ✓ which is the red end (red shift) of the spectrum. ✓ (2)

[13]

QUESTION 8

8.1 Speed ✓ (1)

8.2 3 m·s⁻¹ ✓ (1)

8.3.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

8.3.2 345 m·s⁻¹ ✓ (1)

8.3.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ $= \left(\frac{345+0}{345 - 57{,}5}\right)$ ✓ ✓ $\left(\frac{1000}{1}\right) = 1\,200$ Hz ✓ (4)

8.3.4 295 ✓ (K) (1)

8.4.1 Diagram 3 ✓ (1)

8.4.2 1 ✓ The source is stationary. ✓ (2)

[13]

QUESTION 9

9.1.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

9.1.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ ✓

$365 = \frac{(340+0)}{(340 - v_s)} \times 330$ ✓ ✓ ✓ $\therefore v_s = 32{,}60$ m·s⁻¹ ✓ (5)

9.2 According to the Doppler Effect if the star moves away ✓ from the observer a lower frequency/longer wavelength ✓ is detected. This lower frequency/ longer wavelength corresponds to the the red end ✓ of the spectrum. (3)

[10]

QUESTION 10

10.1.1 Doppler effect ✓ (1)

10.1.2 Measuring the rate of blood flow. ✓ **OR:** Ultrasound (scanning) (1)

10.1.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ **OR** $f_L = \frac{v}{v - v_s} f_s$ **OR** $f_L = \frac{v}{v + v_s} f_s$ ✓

$2600 = \frac{340}{(340 - v_s)} f_s$ ✓ ✓

$1750 = \frac{340}{(340 + v_s)} f_s$ ✓ ∴ 2600(340-v_s) = 1750(340 + v_s) ✓ ∴ $v_s = 66{,}44$ m·s⁻¹ ✓ (6)

10.1.4 (a) Increase ✓ (1)

(b) Decrease ✓ (1)

10.2.1 The spectral lines (light) from the star are shifted towards longer wavelengths. ✓✓ (2)

10.2.2 Decrease ✓ (1)

[13]

QUESTION 11

11.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

11.2.1 170 Hz ✓ (1)

11.2.2 130 Hz ✓ (1)

11.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$170 = \frac{(340+0)}{(340 - v_s)} \times f_s$ ✓ ✓ ------------ 1

$130 = \frac{(340-0)}{340 + v_s} \times f_s$ ✓ ✓ ------------ 2

$v_s = 45{,}33$ m·s⁻¹ ✓ (45,33 – 45,45 m·s⁻¹) (6)

[10]

QUESTION 12

12.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

12.2 Towards A ✓ Recorded frequency higher. ✓ (2)

12.3
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

FOR A:
$690 ✓ = \frac{340}{340 - v_s} f_s$ ✓ (1)

FOR B:
$610 ✓ = \frac{340}{340 + v_s} f_s$ ✓ (2)

$\frac{690}{610} = \frac{340 + v_s}{340 - v_s}$

$1{,}131\ (340 - v_s) = 340 + v_s$

$v_s = 20{,}90\ m.s^{-1}$ ✓ $(20.90 \text{ to } 20.92\ m.s^{-1})$ (6)

12.4 Doppler flow meter/Measuring foetal heartbeat/Ultra sound/Sonar/Radar (for speeding) ✓ (1)

[11]

QUESTION 13

13.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

13.2

OPTION 1	**OPTION 2**
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s} f_s$	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s}\left(\frac{v}{\lambda_s}\right)$
(5100) ✓ $= \frac{340}{340 - 240}$ ✓ f_s ✓	(5100) ✓ $= \left(\frac{340}{340 - 240}\right)$ ✓ ✓ $\left(\frac{340}{\lambda_s}\right)$ ✓✓
f_s = 1 500 Hz	
$v = f\lambda$ ✓ ∴ $340 = (1\ 500)\lambda$ ✓ ∴ $\lambda = 0{,}23$ m ✓	$\lambda = 0{,}23$ m ✓

(7)

13.3 Greater than ✓ (1)

[10]

QUESTION 14

14.1 An apparent change in observed/detected frequency/pitch/wavelength ✓ as a result of the relative motion between a source and an observer/listener. ✓ (2)

14.2 Away from ✓ Observed frequency lower ✓ (2)

14.3 $v = f\lambda$ ✓ ∴ $340 = f\ (0{,}34)$ ✓ ∴ $f = 1\ 000$ Hz ✓ (3)

14.4

OPTION 1	**OPTION 2**
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s} f_s$	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s}\left(\frac{v}{\lambda_s}\right)$
950 ✓ $= \frac{340 - v_L}{340 + 0}$ ✓ $1\ 000$ ✓ ∴ $v_L = 17\ m \cdot s^{-1}$	950 ✓ $= \frac{340 - x/10}{340 + 0}$ ✓ (1000) ✓
Distance $x = v\Delta t = (17)(10)$ ✓ = 170 m ✓	Distance x = 170 m ✓

(6)

[13]

QUESTION 15

15.1 $\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ **OR** $v = \frac{d}{t} = \frac{300}{10}$ ✓ $= 30 m \cdot s^{-1}$ ✓

$300 = v_i\ (10)$ ✓

$v_i = 30\ m \cdot s^{-1}$ ✓ (2)

15.1.2 The change in frequency (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of sound propagation. ✓✓ (2)

15.1.3 Car/source (just) passes observer. ✓✓ (2)

15.1.4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v - v_s} f_s$

932 ✓ $= \frac{340}{340 - 30}$ ✓ f_s ∴ $f_s = 849{,}76$ Hz ✓ (4)

15.2 **ANY TWO:**
Doppler / Blood flow meter/Measuring the heartbeat of a foetus/Radar/Sonar/Used to determine whether stars are receding or approaching earth. (2)

[12]

QUESTION 16

16.1 Doppler effect ✓ (1)

16.2 P registers a shorter period/higher frequency./Q registers a longer period/lower frequency. ✓ (1)

16.3 $f = \frac{1}{T}$ ✓ $= \frac{1}{17 \times 10^{-4}}$ ✓ $= 5{,}88 \times 10^{2} = 588{,}24$ Hz ✓ (3)

$f = \frac{1}{18 \times 10^{-4}}$ ✓ $= 5{,}56 \times 10^{2} = 555{,}56$ Hz

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ **OR** $f_L = \frac{v}{v + v_s} f_s$

$555{,}56$ ✓ $= \frac{340}{340 + v}$ ✓ $588{,}24$ ✓ $\therefore$ $v = 20 \text{ m·s}^{-1}$ ✓ (6)

[11]

QUESTION 17

17.1 The change in frequency✓ (or pitch) (of the sound) detected by a listener because the source and the listener have different velocities relative to the medium of propagation. ✓ **OR**
An (apparent) change in (observed/detected) frequency (pitch), as a result of the relative motion between a source and an observer (listener). (2)

17.2 Towards (1)

17.3

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$

$$3\,148 \checkmark = \frac{340 + 0}{340 - v_s} f_s \checkmark$$

$$2\,073 \checkmark = \frac{340 - 0}{340 + v_s} f_s \checkmark$$

Solve for v_s: $\therefore v_s = 70 \text{ m·s}^{-1}$ ✓

(6)

17.4

OPTION 1	**OPTION 2**	**OPTION 3**
$\Delta t = \frac{\Delta x}{v}$ $\Delta t = \frac{350}{70}$ ✓ $\Delta t = 5\ s$ ✓	$\Delta x = v_i\Delta t + ½ a\Delta t^2$ $350 = 70\Delta t + 0$ ✓ $\Delta t = 5$ s ✓	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ $350 = \left(\frac{70 + 70}{2}\right)\Delta t$ ✓ $\Delta t = 5\ s$ ✓

(2)

[11]

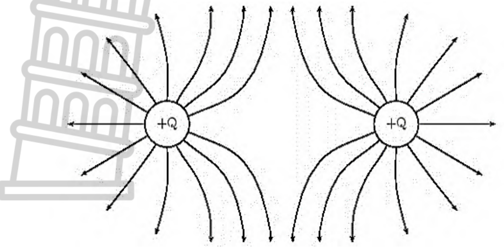
ELECTROSTATICS

QUESTION 1

1.1 To ensure that charge does not leak to the ground/is insulated. ✓ (1)

1.2 Net charge = $\frac{Q_R + Q_S}{2} = \frac{+8 + (-4)}{2}$ ✓= 2 μC ✓ (2)

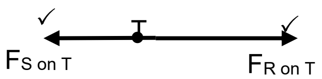
1.3



Criteria for sketch:	
Correct direction of field lines	✓
Shape of the electric field	✓
No field line crossing each other / No field lines inside the spheres.	✓

(3)

1.4



(2)

1.5

$F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{ST} = \frac{(9\times10^9)(1\times10^{-6})(2\times10^{-6})}{(0,2)^2}$ ✓ ✓ = 0,45 N left **OR** $F_{TS} = \frac{1}{4}F_{RT} = \frac{1}{4}(1,8)$ = 0,45 N left

$F_{RT} = \frac{(9\times10^9)(1\times10^{-6})(2\times10^{-6})}{(0,1)^2}$ ✓ = 1,8 N right **OR** $F_{RT} = 4F_{ST}$ = 4(0,45) = 1,8 N right *regs*

$F_{net} = F_{ST} + F_{RT}$ = 1,8 + (-0,45) ✓ = 1,35 N or towards sphere S or right *S* ✓ (6)

1.6 Force experienced ✓per unit positive charge ✓placed at that point. (2)

1.7

OPTION 1

$E = \frac{F}{q}$ ✓ = $\frac{1,35}{1\times10^{-6}}$ = 1,35 x 10^6 N·C^{-1} ✓

OPTION 2

$E_R = \frac{kQ}{r^2}$ ✓ = $\frac{(9\times10^9)(2\times10^{-6})}{(0,1)^2}$ ✓= 1,8 x 10^6 N·C^{-1} right

$E_S = \frac{kQ}{r^2} = \frac{(9\times10^9)(2\times10^{-6})}{(0,2)^2}$ = 4,5 x 10^5 N·C^{-1} left

E_{net} = 1,8 x 10^6 - 4,5 x 10^5 = 1,35 x 10^6 N·C^{-1} ✓ (3)

[19]

QUESTION 2

2.1 The (magnitude of the) electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges✓ and inversely proportional to the square of the distance between them.✓ (2)

2.2.1 $F = \frac{KQ_1Q_2}{r^2}$

$1,44\times10^{-1}$ ✓ $= \frac{(9\times10^9)Q^2}{(0,5)^2}$ ✓

Q = 2 x10^{-6} C✓ (4)

2.2.2 Q = ne✓

2 x10^{-6} = n(1,6x10^{-19}) ✓

n = 1,25 x10^{13} electrons/*elektrone*✓ (3)

2.3.1 Left / West ✓ (1)

2.3.2 Take right as positive/*Neem regs as positief*

$E_{net} = E_A + E_B$ ✓

$(3\times10^4) = -\frac{(9\times10^9)(2\times10^{-6})}{(1,5)^2}$ ✓ $+ \frac{(9\times10^9)Q_{final}}{(1)^2}$ ✓

$Q_{final} = 4,22 \times 10^{-6}$ C ✓

Q = ne

$4,22 \times 10^{-6} = n(1,6\times10^{-19})$ ✓

$n_f = 2,64 \times 10^{13}$ electrons/*elektrone* ✓

electrons removed/*elektrone verwyder*

$= (2,64 \times 10^{13} + 1,25 \times 10^{13})$ ✓

$= 3,89 \times 10^{13}$ electrons/*elektrone* ✓ (8)

[18]

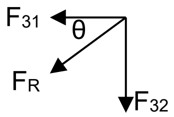
QUESTION 3

3.1 The (magnitude of the) electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

3.2 $F = k\frac{Q_1Q_2}{r^2}$ ✓

$F_{31} = \frac{(9\times10^9)(5\times10^{-6})(6\times10^{-6})}{(0,3)^2}$ ✓ = 3 N to the left

$F_{32} = \frac{(9\times10^9)(5\times10^{-6})(3\times10^{-6})}{(0,1)^2}$ ✓ = 13,5 N downwards



$\mathbf{F_R} = \mathbf{F_{31}} + \mathbf{F_{32}}$ ∴ $F_R = \sqrt{(3)^2 + (13,5)^2}$ ✓ = 13,83 N

Can use any trigonometric ratio

$\theta = \tan^{-1}\frac{13,5}{3}$ ✓ = 77,47°

OR $\theta = \tan^{-1}\frac{3}{13,5}$ ✓ = 12,53° ∴ Net force = 13,83 N in direction192,53° / 77,47° ✓ (7)

[9]

QUESTION 4

4.1 For object N: $n = \frac{Q}{q_e}$ ✓ ∴ $Q = (5 \times 10^6)(-1,6 \times 10^{-19})$ ✓ $= -8 \times 10^{-13}$ C ✓ (3)

4.2 Charge on M (Q_M) is $+8 \times 10^{-13}$ C ✓✓ (2)

4.3 The electrostatic force experienced per unit positive charge placed at that point. ✓✓ (2)

4.4 $E = \frac{kQ}{r^2}$ ✓

$E_{PM} = \frac{(9\times10^9)(8\times10^{-13})}{(0,25)^2}$ ✓✓ $= 0,12$ N·C^{-1} to the right

$E_{PN} = \frac{(9\times10^9)(8\times10^{-13})}{(0,1)^2}$ ✓ $= 0,72$ N·C^{-1} to the left

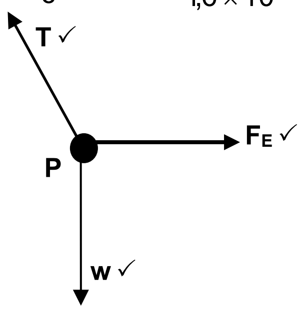
$E_{net} = E_{PM} - E_{PN}$ ✓ $= 0,12 - 0,72 = -0,60$ N·C^{-1} ∴ E_{net} = 0,60 N·C^{-1} to the left ✓ (6)

[13]

QUESTION 5

5.1 $n = \frac{Q}{e}$ ✓ ∴ $n = \frac{0,5\times10^{-6}}{1,6\times10^{-19}}$ ✓ $= 3,13 \times 10^{12}$ elektrone ✓ ....(3)

5.2



Accepted labels	
w	F_g / F_w / weight / mg / gravitational force
T	F_T / tension
F_E	Electrostatic force/F_C/ Coulombic force/F_Q /*$F_{RP/PR}$*

(3)

5.3 The (magnitude) of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product (of the magnitudes) of the charges ✓ and inversely proportional to the square of the distance between them.✓ (2)

5.4 $F_E = k\dfrac{Q_1Q_2}{r^2}$ ✓

$$\frac{T\sin\theta}{T\cos\theta} = F_E$$

$$\therefore \frac{T\sin 7^\circ}{T\cos 83^\circ} ✓ = \frac{(9\times10^9)(0{,}5\times10^{-6})(0{,}9\times10^{-6})}{(0{,}2)^2} ✓✓ \quad \therefore T = 0{,}83\ N ✓$$ (5)

[13]

QUESTION 6

6.1 $E_X = E_2 + E_{(-8)}$ ✓ $= \dfrac{kQ_2}{r^2} + \dfrac{kQ_{-8}}{r^2}$ ✓ correct equation

$$= \frac{(9\times10^9)(2\times10^{-5})}{(0{,}25)^2} ✓ + \frac{(9\times10^9)(8\times10^{-6})}{(0{,}15)^2} ✓$$

$= 2{,}88 \times 10^6 + 3{,}2 \times 10^6 = 6{,}08 \times 10^6\ N{\cdot}C^{-1}$ ✓ to the east/right ✓

OR

$E = \dfrac{kQ}{r^2}$ ✓

$E_2 = \dfrac{(9\times10^9)(2\times10^{-5})}{(0{,}25)^2} = 2{,}88\times 10^6\ NC^{-1}$ to the east/right

$E_{-8} = \dfrac{(9\times10^9)(8\times10^{-6})}{(0{,}15)^2} = 3{,}2 \times 10^6\ N{\cdot}C^{-1}$ to the east/right

$E_X = E_2 + E_{(-8)} = (2{,}88 \times 10^6 + 3{,}2 \times 10^6)$ ✓ $=$ $6{,}08 \times 10^6\ N{\cdot}C^{-1}$ ✓ to the east/right ✓ (6)

6.2

OPTION 1	OPTION 2
$F_E = QE$ ✓ $= (-2 \times 10^{-9})(6{,}08 \times 10^6)$ ✓ $= -12{,}16 \times 10^{-3}\ N$ $F_E = 1{,}22 \times 10^{-2}\ N$ ✓ to the west/left ✓	$F_{(-2)Q1} = qE_{(2)}$ ✓ $= (2 \times 10^{-9})(2{,}88 \times 10^6)$ $= 5{,}76 \times 10^{-3}\ N$ to the west/left $F_{(-2)Q2} = qE_{(8)}$ $= (2 \times 10^{-9})(3{,}2 \times 10^6)$ $= 6{,}4 \times 10^{-3}\ N$ to the west/left $F_{net} = 5{,}76 \times 10^{-3} + 6{,}4 \times 10^{-3}$ ✓ $= 1{,}22 \times 10^{-2}\ N$ ✓to the west/left

(4)

6.3 $2{,}44 \times 10^{-2}\ N$ ✓ / twice / double (1)

[11]

QUESTION 7

7.1 The magnitude of the charges is equal. ✓ (1)

7.2 The (magnitude) of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product (of the magnitudes) of the charges ✓ and inversely proportional to the square of the distance between them.✓ (2)

7.3.1 $T\cos 20^\circ = w$✓

$= mg$

$= (0{,}1)(9{,}8)$✓ $= 0{,}98\ N$

$\therefore T = 1{,}04\ N$✓ (3)

7.3.2

$F_{electrostatic/elektrostaties} = T\sin 20^\circ$✓

$\dfrac{kQ_1Q_2}{r^2}$ ✓$= (1{,}04)\sin 20^\circ$

$\dfrac{kQ_1Q_2}{r^2} = 0{,}356$

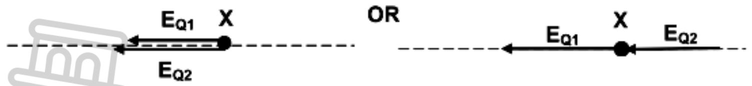
$\dfrac{(9\times10^9)(250\times10^{-9})(250\times10^{-9})}{r^2}$ ✓$= 0{,}356$✓

$\therefore r = 0{,}0397\ m$ ✓ (5)

[11]

QUESTION 8

8.1



Vectors E_{Q1} and E_{Q2} in the same direction. ✓✓
Correct drawing of vectors E_{Q1} and E_{Q2}. ✓✓ The fields due to the two charges add up because they come from the same direction. Hence the field cannot be zero. (4)

8.2 $E = k\frac{Q}{r^2}$ ✓

$E_{2,5\mu C} = k\frac{Q}{r^2} = \frac{(9\times10^9)(2,5\times10^{-6})}{(0,3)^2}$ ✓ $= 250\ 000\ N.C^{-1}$ to the left/*na links*

$E_{6\ \mu C} = k\frac{Q}{r^2} = \frac{(9\times10^9)(6\times10^{-6})}{(1,3)^2}$ ✓ $= 31\ 952,66\ N.C^{-1}$ to the left/*na links*

$E_P = E_{6\mu C} + E_{2,5\mu C}$ ✓
$= 31\ 952,66 + 250\ 000$
$= 281\ 952,66\ N.C^{-1}$ ✓to the left/*na links* ✓ (6)

[10]

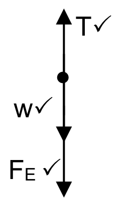
QUESTION 9

9.1

$n = \frac{Q}{e}$ ✓ $= \frac{-32\times10^{-9}}{-1,6\times10^{-19}}$ ✓ $= 2 \times 10^{11}$ ✓electrons	$n = \frac{Q}{e}$ ✓ $= \frac{32\times10^{-9}}{1,6\times10^{-19}}$ ✓ $= 2 \times 10^{11}$ ✓ electrons

(3)

9.2



Accepted labels	
w	F_g/F_w/weight/mg/gravitational force
T	F_T/tension
F_E	$F_{electrostatic}$/F_{Q1Q2} /Coulomb force/F

(3)

.3 $F_{net} = mg + F_E - T = 0 \therefore mg + k\frac{Q_1Q_2}{r^2} - T = 0$ ✓ ✓

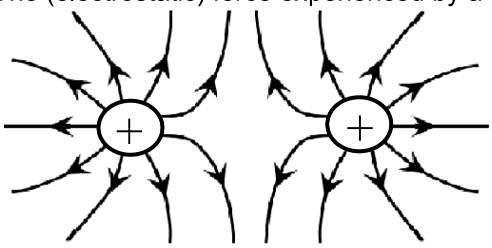
$\therefore (0,007)(9,8)$ ✓ $+ (9 \times 10^9)\frac{(32\times10^{-9})(55\times10^{-9})}{(0,025)^2}$ ✓ $= T$ $\therefore$ $T = 9,39(4) \times 10^{-2}$ N ✓ (5)

[11]

QUESTION 10

10.1 The (electrostatic) force experienced by a unit positive charge (placed at that point). ✓✓ (2)

10.2



Marking guidelines	
Lines must not cross / Lines must touch the spheres but not enter spheres	✓
Arrows point outwards	✓
Correct shape	✓

(3)

10.3 $E = \frac{kQ}{r^2}$ ✓

$E_{Q1x} = \frac{(9\times10^9)(30\times10^{-6})}{(x)^2}$ ✓ & $E_{Q2x} = \frac{(9\times10^9)(45\times10^{-6})}{(0,15+x)^2}$ ✓

$E_{net} = 0 \quad \therefore E_{Q1x} = E_{Q2x} \therefore \frac{(9\times10^9)(30\times10^{-6})}{(x)^2} = \frac{(9\times10^9)(45\times10^{-6})}{(0,15+x)^2}$ ✓

$\therefore x = 0,67$ m ✓ (0,667 m) (5)

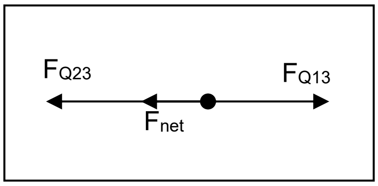
[10]

QUESTION 11

11.1 The magnitude of the electrostatic force exerted by one point charge on another point charge <u>is directly proportional to the product of the (magnitudes of the) charges</u> ✓ and <u>inversely proportional to the square of the distance between them.</u> ✓ (2)

11.2.1 Negative ✓✓ (2)

11.2.2 $F = k\dfrac{Q_1Q_3}{r^2}$ ✓



$0{,}012 = \dfrac{(9\times10^9)Q_1(2\times10^{-6})}{(2{,}5)^2}$ ✓ $\therefore Q_1 = 4{,}17 \times 10^{-6}$ C ✓

$F_{net} = F_{Q13} + F_{Q23}$ ✓

$-0{,}3$ ✓ $= 0{,}012 - \dfrac{(9\times10^9)(Q_2)(2\times10^{-6})}{1^2}$ ✓ **OR** $0{,}3 = -0{,}012 + \dfrac{(9\times10^9)(Q_2)(2\times10^{-6})}{1^2}$

$\therefore Q_2 = 1{,}6 \times 10^{-5}$ C ✓ (7)

[11]

QUESTION 12

12.1.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

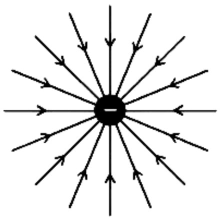
12.1.2 F_E/Electrostatic force ✓ (1)

12.1.3 The electrostatic force is inversely proportional to the square of the distance between the charges. ✓ (1)

12.1.4 Slope $= \dfrac{\Delta F_E}{\Delta \frac{1}{r^2}}$ ✓ $= \dfrac{0{,}027 - 0}{5{,}6 - 0}$ ✓ $= 4{,}82 \times 10^{-3}$ N·m²

Slope $= F_E r^2 = kQ_1Q_2 = kQ^2$ ✓ $\therefore 4{,}82 \times 10^{-3}$ ✓ $= \underline{9 \times 10^9\ Q^2}$ ✓ $\therefore Q = 7{,}32 \times 10^{-7}$C ✓ (6)

12.2.1



Criteria for drawing electric field:	
Direction	✓
Field lines radially inward	✓

(2)

12.2.2 $E = \dfrac{kQ}{r^2}$ ✓

Right as positive:

$E_{PA} = \dfrac{(9\times10^9)(0{,}75\times10^{-6})}{(0{,}09)^2}$ ✓ $= 8{,}33 \times 10^5$ N·C⁻¹ to the left

$E_{PB} = \dfrac{(9\times10^9)(0{,}8\times10^{-6})}{(0{,}03)^2}$ ✓ $= 8 \times 10^6$ N·C⁻¹ to the left

$E_{net} = E_{PA} + E_{PC} = [-8{,}33 \times 10^5 + (-8 \times 10^6)]$ ✓✓ $= -8{,}83 \times 10^6 = 8{,}83 \times 10^6$ N·C⁻¹ ✓

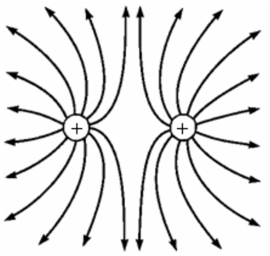
Left as positive: $E_{net} = E_{PA} + E_{PC} = \underline{(8{,}33 \times 10^5 + 8 \times 10^6)}$ ✓✓ $= 8{,}83 \times 10^6$ N·C⁻¹ ✓ (5)

[17]

QUESTION 13

13.1 Electric field is a region of space in which an electric charge experiences a force. ✓✓ (2)

13.2



Marking criteria	
Correct shape as shown.	✓
Direction away from positive	✓
Field lines start on spheres and do not cross.	✓

(3)

13.3 $E_{PA} = \frac{kQ}{r^2}$ ✓ $= \frac{(9\times10^9)(5\times10^{-6})}{(1,25)^2}$ ✓ $= 2,88 \times 10^4$ N·C^{-1} to the right

$E_{PB} = \frac{kQ}{r^2} = \frac{(9\times10^9)(5\times10^{-6})}{(0,75)^2}$ ✓ $= 8,00 \times 10^4$ N·C^{-1} to the left

$E_{net} = E_{PA} + E_{PB} = 2,88 \times 10^4 + (-8,00 \times 10^4) = 5,12 \times 10^4$ N·C^{-1} ✓ (5)

[10]

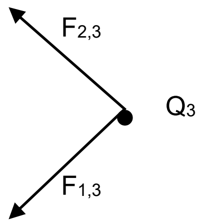
QUESTION 14

14.1.1 Removed ✓ (1)

14.1.2 $n = \frac{Q}{e}$ ✓ $= \frac{6\times10^{-6}}{1,6\times10^{-19}}$ ✓ $= 3,75 \times 10^{13}$ ✓electrons (3)

14.2.1 Negative ✓ (1)

14.2.2



(2)

14.2.3 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_{1,3x} = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{r^2}(\cos 45°)$ ✓ $= \frac{(0,0764)}{r^2}$ ✓ *(3)*

14.2.4 $F = \frac{kQ_1Q_2}{r^2}$

$F_{2,3x} = \frac{(9\times10^9)(2\times10^{-6})(6\times10^{-6})}{r^2}$ ✓$(\cos 45°) = \frac{0,0764}{r^2}$

$\left.\begin{array}{l} F_x = F_{1,3x} + F_{2,3x} \\ F_x = \frac{0,0764}{r^2} + \frac{0,0764}{r^2} = 2\frac{0,0764}{r^2} \end{array}\right\}$ ✓ Addition

NOTE: $F_{y\ net} = 0$

$(0,12)$ ✓ $= \frac{0,1528}{r^2}$ $\therefore r = 1,128$ m ✓ (4)

14.3.1 The electric field at a point is the <u>(electrostatic) force experienced</u> ✓<u>per unit positive charge</u> ✓ placed at that point. (2)

14.3.2 $E = \frac{kQ}{r^2}$ ✓ $\therefore\ 100 = \frac{(9\times10^9)Q}{(0,6)^2}$ ✓ $\therefore$ Q = 4 x 10^{-9} C

When the electric field strength 50 is N·C^{-1}:

$E = \frac{kQ}{r^2}$ $\therefore\ 50 = \frac{(9\times10^9)(4\times10^{-9})}{r^2}$ ✓ ✓ equation

$\therefore$ r = 0,85 m ✓ (0,845) m (5)

[21]

QUESTION 15

15.1 The magnitude of the electrostatic force exerted by one point charge on another point charge <u>is directly proportional to the product of the (magnitudes of the) charges</u> ✓ and <u>inversely proportional to the square of the distance between them.</u> ✓ (2)

15.2 **OPTION 1**

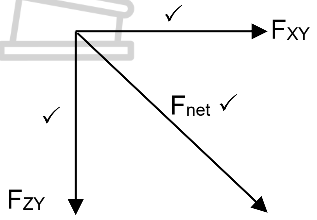
$F = \frac{kQ_1Q_2}{r^2}$ ✓ $= \frac{(9\times10^9)(6\times10^{-6})(8\times10^{-6})}{(0,2)^2}$ ✓ ✓ $= 10,8$ N ✓

OPTION 2

Both ✓ $\left\{ \begin{array}{l} E = \frac{kQ}{r^2} = \frac{(9\times10^9)(8\times10^{-6})}{(0,2)^2} ✓ = 1,8 \times 10^4\ \text{N·C}^{-1} \\ F = Eq = (1,8 \times 10^4)(6 \times 10^{-6}) ✓ = 10,8\ \text{N} ✓ \end{array} \right.$

(4)

15.3



Marking criteria	
$F_{Z\ op\ Y}$ if correct direction	✓
$F_{X\ op\ Y}$ if correct direction	✓
Resultant vector	✓

(3)

15.4 **OPTION 1**

$\left. \begin{array}{l} F_{net}^2 = F_{XY}^2 + F_{ZY}^2 \\ 15,20^2 = 10,8^2 + F_{ZY}^2 \end{array} \right\}$ ✓Any one

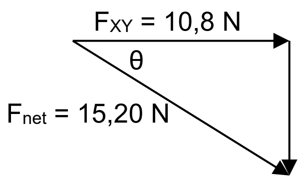
$F_{ZY} = 10,696$ N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}$ $\therefore$ $10,696$✓ $= 9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0,30)^2}$ ✓ $\therefore$ $Q_Z = 1,34 \times 10^{-5}$ C✓

OPTION 2

$\cos\theta = \frac{10,8}{15,2}$ $\therefore$ $\theta = 44,72^\circ$

$\sin 44,72 = \frac{F_{ZY}}{15,2}$ ✓ **OR** $\tan 44,72 = \frac{F_{ZY}}{F_{XY}}$



$\therefore$ $F_{ZY} = 10,696$ N

$F_{ZY} = k\frac{Q_ZQ_Y}{r^2}$

$\therefore 10,696$ ✓ $= 9\times10^9 \times \frac{8\times10^{-6}\times Q_Z}{(0,30)^2}$ ✓

$\therefore$ $Q_Z = 1,34 \times 10^{-5}$ C ✓

(4)
[13]

QUESTION 16

16.1 Electric field at a point is the force per unit positive charge placed at that point. ✓✓ (2)

16.2 $E = \frac{kQ}{r^2}$ ✓

$E_{net} = (E_A + E_B)$

$= 9\times10^9\frac{(1,5\times10^{-6})}{(0,4)^2} + 9\times10^9\frac{(2,0\times10^{-6})}{(0,3)^2}$ ✓ ✓

$= 2,84 \times 10^5$ N·C^{-1} ✓

(4)

16.3 $F_E = qE$ ✓

$= (3,0 \times 10^{-9})(2,84 \times 10^5)$ ✓

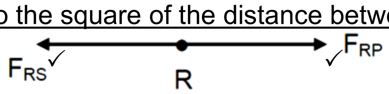
$= 8,52 \times 10^{-4}$ N ✓

(3)
[9]

QUESTION 17

17.1 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes of the) charges ✓ and inversely proportional to the square of the distance between them. ✓ (2)

17.2



(2)

17.3 To the right as positive:

$F = k\dfrac{Q_1Q_2}{r^2}$ ✓

$F_{netR} = F_{PR} + F_{SR}$

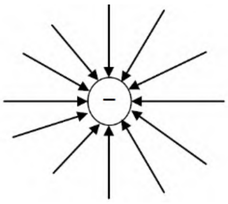
$F_{net} = \dfrac{kQ_1Q_2}{r^2} + \dfrac{kQ_1Q_2}{r^2}$

$-1{,}27\times10^{-6} = \left\{\dfrac{(9\times10^9)(1{,}5\times10^{-9})(Q)}{(0{,}3)^2} - \dfrac{(9\times10^9)(2\times10^{-9})(Q)}{(0{,}2)^2}\right\}$ ✓ ✓ ✓

$-1{,}27 \times 10^{-6} = 150Q - 450Q$ ✓ ∴ $4{,}23 \times 10^{-9}$ C ✓ (7)
[11]

QUESTION 18

18.1



Marking criteria:
Shape (radial) ✓
Polarity of A ✓

(2)

18.2 $E = \dfrac{kQ}{r^2}$ ✓

$3 \times 10^7 = \dfrac{(9\times10^9)(Q)}{(0{,}5)^2}$ ✓

$Q = 8{,}33 \times 10^{-4}$ C ✓ (3)

18.3 $Q = ne$ ✓

$= (10^5)(1{,}6\times10^{-19})$ ✓

$= 1{,}6 \times 10^{-14}$ C

$E = \dfrac{F}{Q}$ ✓

$3 \times 10^7 = \dfrac{F}{1{,}6\times10^{-14}}$ ✓

$F = 4{,}8 \times 10^{-7}$ N ✓ Right/*Regs* ✓

Positive marking from Q8.2 for this option.

$F = k\dfrac{Q_1Q_2}{r^2}$ ✓

$F = (9\times10^9)\dfrac{(8{,}33\times10^{-4})(1{,}6\times10^{-14})}{(0{,}5)^2}$ ✓

$= 4{,}8 \times 10^{-7}$ N ✓ Right/*Regs* ✓ (6)
[11]

QUESTION 19

19.1 The two forces must be equal in magnitude ✓ but in opposite directions. ✓ (2)

19.2 The magnitude of the electrostatic force exerted by one point charge on another point charge <u>is directly proportional to the product of the (magnitudes of the) charges</u> ✓ and <u>inversely proportional to the square of the distance between them.</u> ✓ (2)

19.3 $F = k\dfrac{Q_1Q_2}{r^2}$ ✓

$F_{PQ} = \dfrac{(9\times10^9)(Q)(5\times10^{-6})}{(x)^2}$ ✓ $= \dfrac{45\times10^3Q}{x^2}$

$F_{VQ} = \dfrac{(9\times10^9)(Q)(7\times10^{-6})}{(1-x)^2}$ ✓ $= \dfrac{63\times10^3Q}{(1-x)^2}$

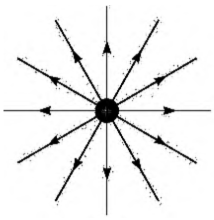
$(F_{net} = F_{PQ} - F_{VQ} = 0)$

$\dfrac{45\times10^3Q}{x^2} = \dfrac{63\times10^3Q}{(1-x)^2}$ ✓ ∴ $6{,}708(1 - x) = 7{,}937x$ ∴ $x = 0{,}46$ m away from P (5)

[9]

QUESTION 20

20.1



Criteria for sketch	
Lines are directed away from the charge.	✓
Lines are radial, start on sphere and do not cross.	✓

(2)

20.2 $Q = ne$ ✓ $= (8 \times 10^{13})(-1{,}6 \times 10^{-19})$ ✓ or $(8 \times 10^{13})(1{,}6 \times 10^{-19}) = -12{,}8 \times 10^{-6}$ C

Net charge on the sphere $Q_{net} = (+6 \times 10^{-6}) + (-12{,}8 \times 10^{-6})$ ✓ $= -6{,}8 \times 10^{-6}$ C

$E = \frac{kQ}{r^2}$ ✓

$E = \frac{(9 \times 10^9)(6{,}8 \times 10^{-6})}{(0{,}5)^2}$ ✓

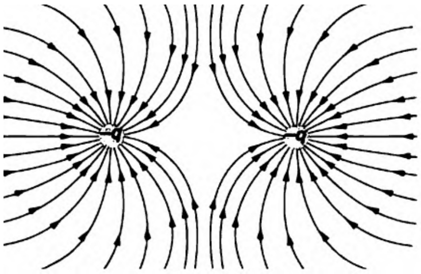
$= 2{,}45 \times 10^5$ N·C^{-1} ✓ towards sphere ✓ (7)

[9]

QUESTION 21

21.1 $Q_{net} = \frac{Q_1 + Q_2 + Q_3}{3}$ ∴ $-3 \times 10^{-9} = \frac{-15 \times 10^{-9} + Q + 2 \times 10^{-9}}{3}$ ✓ ∴ $Q = +4 \times 10^{-9}$ C ✓ (2)

21.2



Correct shape ✓
Correct direction ✓
Lines must not cross and must touch spheres ✓

(3)

21.3 The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes) of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

21.4

OPTION 1

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$F_{SP} = \frac{(9 \times 10^9)(3 \times 10^{-9})(3 \times 10^{-9})}{(0{,}1)^2}$ ✓

$= 8{,}1 \times 10^{-6}$ N downwards

$F_{TP} = \frac{(9 \times 10^9)(3 \times 10^{-9})(3 \times 10^{-9})}{(0{,}3)^2}$ ✓

$= 9 \times 10^{-7}$ N left

$F_{net}^2 = (F_{SP})^2 + (F_{TP})^2$

$F_{net} = \sqrt{(F_{SP})^2 + (F_{TP})^2}$ ✓ for any

$F_{net} = \sqrt{(8{,}1 \times 10^{-6})^2 + (0{,}9 \times 10^{-6})^2}$

$F_{net} = 8{,}15 \times 10^{-6}$ N ✓

OPTION 2

$E_s = \frac{kQ}{r^2} = \frac{(9 \times 10^9)(3 \times 10^{-9})}{(0{,}1)^2}$

$= 2\ 700$ N.C^{-1} ✓

$E_T = \frac{kQ}{r^2} = \frac{(9 \times 10^9)(3 \times 10^{-9})}{(0{,}3)^2}$

$= 300$ N.C^{-1}

$E_{net} = \sqrt{E_S^2 + E_T^2} = \sqrt{(2700)^2 + (30)^2}$ ✓

$= 2\ 716{,}62$ N.C^{-1}

$F = Eq = (2\ 716{,}62)(3 \times 10^{-9})$ ✓

$= 8{,}15 \times 10^{-6}$ N ✓

(5)

21.5 $E = \frac{F}{q}$ ✓ $= \frac{8{,}15 \times 10^{-6}}{3 \times 10^{-9}}$ ✓

$= 2{,}72 \times 10^3$ N·C^{-1} ✓ (3)

21.6.1 Sphere P or T ✓ (1)

21.6.2 **SPHERE P:** $n_e = \frac{Q}{q_e}$ or $n_e = \frac{Q}{e} = \frac{-15 \times 10^{-9}}{-1{,}6 \times 10^{-19}}$ ✓ $= 9{,}38 \times 10^{10}$

mass gained $= n_e m_e = (9{,}38 \times 10^{10})(9{,}11 \times 10^{-31})$ ✓ $= 8{,}55 \times 10^{-20}$ kg ✓

SPHERE T:

$n_e = \frac{Q}{q_e}$ or $n_e = \frac{Q}{e} = \frac{-5 \times 10^{-9}}{-1{,}6 \times 10^{-19}}$ ✓ $= 3{,}125 \times 10^{10}$

mass gained $= n_e m_e = (3{,}125 \times 10^{10})(9{,}11 \times 10^{-31})$ ✓ $= 2{,}85 \times 10^{-20}$ kg ✓ (3)

[19]

QUESTION 22

22.1 The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. ✓✓ (2)

22.2 q_2 is positive ✓
The electric field due to q_1 points to the right because q_1 is negative. ✓ Since the net field is zero, the field due to q_2 must point to the left away from q_2, ✓ hence q_2 is positive.
OR Since E_{net} is zero, E_1 and E_2 are in opposite directions therefore q_1 and q_2 are oppositely charged. (3)

22.3 $E = k\frac{Q}{r^2}$ ✓

$E_{net} = 0$

$\therefore k\frac{q_1}{r_1^2} = k\frac{q_2}{r_2^2}$ **OR** $\frac{q_1}{r_1^2} = \frac{q_2}{r_2^2}$

$\frac{(9\times10^9)(3\times10^{-9})}{(0,1)^2} = \frac{(9\times10^9)q_2}{(0,4)^2}$ ✓✓

$q_2 = +4,8 \times 10^{-8}$ C ✓ (4)

22.4 The electrostatic force (of attraction/repulsion) between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. ✓✓ (2)

22.5 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F = \frac{(9\times10^9)(3\times10^{-9})(4,8\times10^{-8})}{(0,3)^2}$ ✓

$= 1,44 \times 10^{-5}$ N ✓ (3)

22.6 Yes ✓
Both charges are equal and positive ✓ (2)
[16]

QUESTION 23

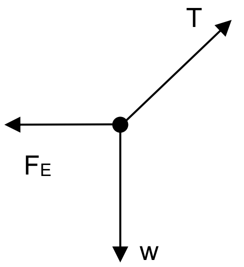
23.1.1 Positive ✓ (1)

23.1.2 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$3,05 = \frac{(9\times10^9)(6\times10^{-6})Q}{0,2^2}$ ✓

$Q = 2,259 \times 10^{-6}$ C ✓ ($2,26 \times 10^{-6}$ C) (3)

23.1.3



Accepted labels	
w✓	F_g / F_w / weight / mg / gravitational force
T✓	F_T / tension
F_E✓	Electrostatic force/ Coulomb force/ $F_{E\ Field}$

(3)

23.1.4

OPTION 1	**OPTION 2**
$F_{net} = 0$ $F_E = T\sin10°$ $F_E = T\cos80°$ } ✓Any one $3,05 = T\sin10°$ $= T\cos80°$ } ✓Any one $T = 17,56$ N ✓ (17,564 N)	$\frac{T}{\sin 90°} = \frac{F_E}{\sin 10°}$ ✓ $\frac{T}{1} = \frac{3,05}{\sin 10°}$ ✓ $T = 17,56$ N ✓

(3)

23.2.1 The electric field at a point is the (electrostatic) force ✓ experienced per unit positive charge placed at that point. ✓ (2)

23.2.2 Electric field at **M** due to **A** (+2 x10^{-5} C):

$E_A = \frac{kQ}{r^2}$ ✓ $= 9\times10^9\frac{(2\times10^{-5})}{(0,2)^2}$ ✓ $= 4,5 \times 10^6$ N·C^{-1} (to the right)

Electric field at **M** due to **B** (-4 x10^{-5} C):

$E_B = \frac{kQ}{r^2}$

$= 9\times10^9\frac{(4\times10^{-5})}{(0,2)^2}$ ✓

$= 9 \times 10^6$ N·C^{-1} (to the right)

OR $q_B = 2x\ q_A$

$E_B = 2x\ E_A$✓

$= 9 \times 10^6$ N·C^{-1} (to the right)

E_{net} at **M** = $E_A + E_B$ = ($4,5 \times 10^6 + 9 \times 10^6$) ✓ = $1,35 \times 10^7$ N·C^{-1} ✓ to the right ✓ (6)
[18]

QUESTION 24

24.1

$n = \frac{Q}{e}$ ✓

$= \frac{-4x10^{-6}}{-1,6x10^{-19}}$ ✓

$= 2,5x10^{13}$ ✓

A negative answer not accepted; substitute so that a positive answer is obtained. (3)

24.2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-6})(3x10^{-6})}{0,2^2}$ ✓

$= 2,7\ N$ ✓ (3)

24.3 Electric field is a <u>region</u> (in space) where (in which) an <u>(electric) charge experiences a (electric) force</u>. ✓✓ (2)

24.4

OPTION 1

Electric field at M due to: -4 x 10^{-6} C

$E_{AM} = \frac{kQ}{r^2}$ ✓

$= \frac{(9x10^9)(4x10^{-6})}{0,3^2}$ ✓

$= 4x10^5\ N \cdot C^{-1}\ (to\ left)$

Electric field at M due to: +3 x 10^{-6} C

$E_{BM} = \frac{kQ}{r^2}$

$= \frac{(9x10^9)(3x10^{-6})}{0,1^2}$ ✓

$= 2,7x10^6\ N \cdot C^{-1}\ (to\ right)$

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

= 4,0 x10^5 – 2,7 x10^6 ✓

= 2,3 x10^6 N·C^{-1} ✓(right)

OR

Net electric field at M

$E_{net} = E_{BM} + E_{AM}$

= -4,0 x10^5 + 2,7 x10^6 ✓

= - 2,3 x10^6 N·C^{-1}

= 2,3 x10^6 N·C^{-1} ✓ (right)

OPTION 2

$F_{AM} = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9x10^9)(4x10^{-6})Q}{0,3^2}$ ✓

$= (4x10^5)(Q)$

$F_{BM} = \frac{kQ_1Q_2}{r^2}$

$= \frac{(9x10^9)(3x10^{-6})Q}{0,1^2}$ ✓

$= (2,7x10^6)(Q)$

F_{net} = 2,7 x 10^6Q + (-4 x 10^5Q)✓ = 2,3 x 10^6Q

$E = \frac{F}{Q}$ ✓

$= \frac{2,3x10^6Q}{Q}$

$= 2,3x10^6\ N \cdot C^{-1}$ ✓ $(right)$ (5)

24.5 Positive (1)

24.6

$(F_{net})^2 = (F_{AD})^2 + (F_{AB})^2$ $(7{,}69)^2 = (F_{AD})^2 + (2{,}7)^2$ ✓ $F_{AD} = 7{,}2$ N $F_{AD} = \frac{kQ_1Q_2}{r^2}$ $7{,}2 = \frac{(9x10^9)(4x10^{-6})Q}{0{,}15^2}$ ✓ $Q_D = 4{,}5x10^{-6}\ C$ ✓	**OR** $F_{AD} = \frac{kQ_1Q_2}{r^2}$ $= \frac{(9x10^9)(4x10^{-6})Q}{0{,}15^2}$ ✓ $= 1{,}6x10^6\ Q$ $F_{net} = \sqrt{(F_{AB}^2 + F_{AD}^2)}$ $7{,}69 = \sqrt{2{,}7^2 + (1{,}6x10^6 Q)^2}$ ✓ $Q = 4{,}50x10^{-6}\ C$ ✓

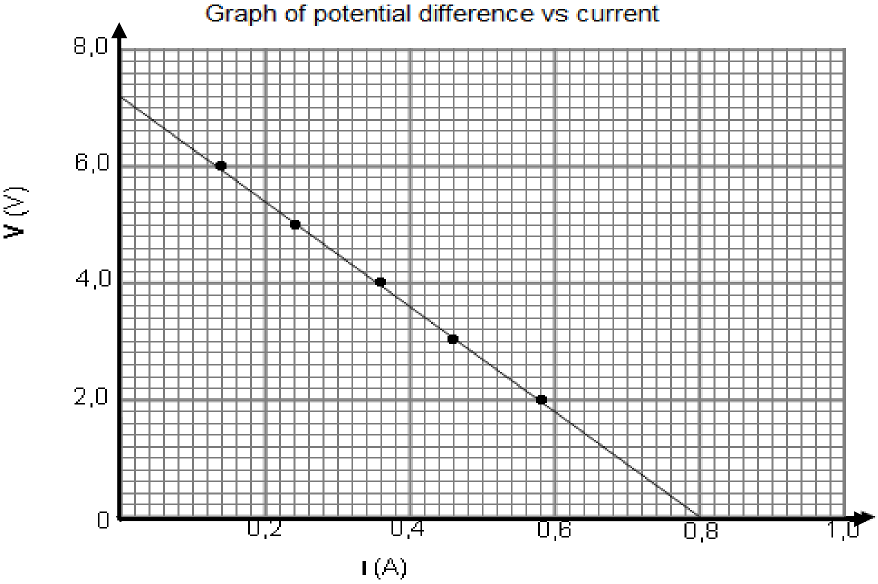
(3)
[17]

ELECTRIC CIRCUITS

QUESTION 1

1.1.1 Keep the temperature (of battery) constant. ✓ (1)

1.1.2



Criteria for drawing line of best fit:	
ALL points correctly plotted (at least 4 points)	✓✓
Correct line of best fit if 3 plotted points are used.	✓

(3)

1.1.3 7,2 V✓
(Accept any readings between 7,0 V and 7,4 V or the value of the y-intercept.) (1)

1.1.4 Slope = $\frac{\Delta V}{\Delta I} = \frac{0 - 7{,}2}{0{,}8 - 0}$ ✓✓ = - 9 ∴ r = 9 Ω ✓ (3)

1.2.1 P = VI ✓ ∴ 100 = 20(I) ✓ ∴ I = 5 A ✓ (3)

1.2.2 $P = \frac{V^2}{R}$ ✓ ∴ $R = \frac{(20)^2}{150}$ ✓ = 2,67 Ω ✓ (3)

1.2.3 P = VI **OR** P = I²R

∴ $I_{150W} = \frac{150}{20}$ ✓ = 7,5 A **OR** ∴ $I_{150W} = \sqrt{\frac{150}{2{,}67}}$ ✓ = 7,5 A

I_{tot} = (5 + 7,5) ✓
ε = I(R + r) ✓ ∴ 24 = 12,5(R + r)
24 = V_{ext} + V_{ir} ∴ 24 = 20 + 12,5(r) ✓ ∴ r = 0,32 Ω ✓ (5)

1.2.4 Device Z is a voltmeter. ✓ (1)

1.2.5 Device **Z** should be a voltmeter (or a device with very high resistance) because it has a very high resistance✓ and will draw very little current. ✓ The current through **X** and **Y** will remain the same hence the device can operate as rated. (2)
[22]

QUESTION 2

2.1.1 Same length of wires.✓
Same thickness/cross-sectional area of wires. ✓ (2)

2.1.2 Wire A (Resistor A)/*Draad A* ✓

$R = \frac{\Delta V}{\Delta I}$ ✓

$R_A = \frac{4,4}{0,4}$ ✓ $= 11\ \Omega$✓

$R_B = \frac{2,2}{0,4}$✓ $= 5,5\ \Omega$✓

$E = I^2 R\Delta t$✓

For the same time and current, the heating in A will be higher because its resistance is higher than that of B. ✓ (8)

Accept any correct coordinates chosen from the graph *Aanvaar enige korrekte koördinate van die grafiek gekies.*

2.2.1

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$I_{5,5\Omega} : I_{11\Omega}$ 2 : 1 $I_{5,5\Omega} = (0,2)(2)$ ✓✓ $= 0,4$ A✓	$V = IR$ $V_{11\ \Omega} = 0,2 \times 11$ $= 2,2$ V✓ $V_{5,5} = V_{11} = 2,2$ V✓ $I_{5,5} = \frac{2,2}{5,5}$ $= 0,4$ A✓

(3)

2.2.2

OPTION 1/OPSIE 1	**OPTION 2/*OPSIE 2***
$V = IR$ $I_{tot} = (0,4 + 0,2)$ ✓ $= 0,6$ A $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + ...$✓ $\frac{1}{Rp} = \frac{1}{11} + \frac{1}{5,5}$ ✓ $R_P = 3,67\ \Omega$ $R_T = R_P + R_A$ $= 3,67 + 11$✓ $= 14,67\Omega$ $\varepsilon = I(R + r)$ ✓ $9 = 0,6(14,67 + r)$ ✓ $r = 0,33\ \Omega$ ✓	$I_{tot} = (0,4 + 0,2)$ ✓ $= 0,6$ A $V_{ext} = V_{11\ \Omega} + V_{//}$ ✓ $= [I_{tot}(R_{11}) + 2,2]$ $= 0,6\ (11)$ ✓ $+ 2,2$ $= 8,8$V✓ $\varepsilon = V_{ext} + I_{tot}(r)$ ✓ $9 = 8,8 + 0,6r$✓ $r = 0,33\ \Omega$✓

(7)

2.2.3 Decrease ✓
The total resistance increases. ✓ (2)
[22]

QUESTION 3

3.1 Negative ✓ (1)

3.2 $I_{2\Omega} = \frac{V}{R}$ ✓ $= \frac{1,36}{(4+2)}$ ✓ $= 0,23$ A ✓ (3)

3.3

OPTION 1	**OPTION 2**
$I_{3\Omega} = \frac{V}{R} = \frac{1,36}{3}$ ✓ $= 0,45$ A $I_T = I_2 + I_3 = 0,23 + 0,45$ ✓ $= 0,68$ A $V_{int/\text{"lost"}} = \varepsilon - V_{ext}$✓ $= 1,5 - 1,36$ ✓ $= 0,14$ V $V_{int/\text{"lost"}} = Ir$ ✓ $0,14 = (0,68)r$ ✓ $\therefore\ r = 0,21\ \Omega$ ✓	$I_3 = \frac{V}{R} = \frac{1,36}{3}$ ✓ $= 0,45$ A $I_T = I_2 + I_3 = 0,23 + 0,45$ ✓ $= 0,68$ A $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\therefore \frac{1}{R_p} = \frac{1}{6} + \frac{1}{3}$ ✓ $\therefore\ R_P = 2\ \Omega$ $\varepsilon = I(R + r)$ ✓ $\therefore 1,5 = 0,68(2 + r)$ ✓ $\therefore\ r = 0,21\ \Omega$ ✓

(7)

3.4 Decreases ✓ Effective resistance across parallele circuit decreases. ✓ Terminal poetantial difference decreases. ✓ Resistance in ammeter branch remains constant. ✓ (4)
[15]

QUESTION 4

4.1 The <u>potential difference across a conductor is directly proportional to the current</u> ✓in the conductor <u>at constant temperature</u>. ✓ (2)

4.2

OPTION 1	OPTION 2
$V_8 = IR$ ✓ = (0,5)(8) = 4 V = V_{16} $I_{16} = \frac{V}{R} = \frac{4}{16}$ = 0,25 A $I_{tot//} = I_{A1}$ = (0,5 + 0,25) ✓ = 0,75 A ✓	$V_8 = IR$ ✓ = (0,5)(8) ✓ = 4 V $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{8} + \frac{1}{16}$ ✓ ∴ R = 5,33 Ω $I_{tot//} = \frac{4}{5,33} = I_{A1}$ = 0,75 A ✓

(4)

4.3

OPTION 1	OPTION 2

$V_{20\Omega}$ = IR =(0,75) (20) ✓ = 15 V
$V_{//tot}$ = (15 + 4) ✓ = 19 V
V_R = 19 V
P = VI ✓
∴ 12 = (19)I_R ✓
∴ $I_R = I_{A2}$ = 0,63 A ✓
	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{8} + \frac{1}{16}$ ✓ ∴ R = 5,33 Ω
	$R_{//} + R_{20}$ = (5,33 + 20) ✓ = 25,33 Ω
	$V_{//tot} = I(R_{//} + R_{20})$ = (0,75)(25,33) = 19 V
	P = VI ✓ ∴ 12 = (19)I_R ✓
	∴ $I_R = I_{A2}$ = 0,63 A ✓

(5)

4.4

OPTION 1	OPTION 2
ε = I(R + r) ✓ = $V_{//tot} + V_{int}$ = 19 + (0,75 + 0,63)(1) ✓ = 20,38 V ✓	V_{int} = Ir = (0,75 + 0,63)(1) ✓ = 1,38 V ε = $V_{//tot} + V_{int}$ ✓ = 19 + 1,38 = 20,38 V ✓

(3)

[14]

QUESTION 5

5.1.1 V = IR✓

= (0,2)(4+8)✓

= 2,4 V✓ (3)

5.1.2

V = IR 2,4 =I_2(2) ✓ $I_{2\Omega}$ = 1,2 A✓ $I_T = I_2$ + 0,2 A✓ = 1,4 A✓	OR I_2= 6 x 0,2 ✓ I_2 = 1,2 A✓ $I_T = I_2$ + 0,2 ✓ = 1,4 A✓

(4)

5.1.3

OPTION 1	OPTION 2
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{R_p} = \frac{1}{12} + \frac{1}{2}$ R_P = 1,72 Ω✓ ε = I(R+r) ✓ = 1,4(1,72+ 0,5) ✓ = 3,11 V✓	V_{int} = Ir✓ =(1,4)(0,5) = 0,7 V✓ ε = $V_{ext/eks} + V_{int}$✓ = 2,4 +0,7✓ = 3,1 V✓

(5)

5.2 Removing the 2 Ω resistor increases the total resistance of the circuit. ✓ Thus otal current decreases, decreasing the V_{int} (V_{lost}). ✓ Therefore the voltmeter reading V increases. ✓ (3)

[15]

QUESTION 6

6.1.1

OPTION 1	OPTION 2	OPTION 3
$P = \frac{V^2}{R}$ ✓ $4 = \frac{V^2}{R} = \frac{(12)^2}{R}$ ✓R = 36 Ω ✓	P = VI 4 = I(12) I = 0,33...A V = IR ✓ 12 = 0,33R ✓ ∴R = 36,36 Ω ✓	P = V I 4 = I(12) ∴ I = 0,33 ..A P = I^2 R ✓ 4 = (0,33^2)R ✓ ∴R = 36,73 Ω ✓

(3)

6.1.2 Increase (1)

6.1.3 No change ✓ Same potential difference ✓ (and resistance) (2)

6.1.4 V = IR ✓ ∴ 5 = I(6) ✓ ∴ I = 0,83 A

$V_{\text{"lost"}}$ = Ir **OR** ε = I(R + r)

1 = (0,83)r ✓ 6 = (0,83)(6 + r) ✓

r = 1,20 Ω✓ r = 1,23 Ω ✓ (4)

6.2.2 <u>Maximum work done (or energy provided)</u> ✓ by a cell per <u>unit charge</u> passing through it. ✓ (2)

6.2.3

OPTION 1	**OPTION 2**

$V_{\text{"lost"}} = Ir$
$1{,}5$ ✓ $= I(1{,}2)$
$I = 1{,}25$ A
 	
$V_{\parallel} = I_6R_6$
$4{,}5 = I_6(6)$
$I_6 = 0{,}75$ A
 	
$V_x = IR_x$ ✓
$4{,}5 = (1{,}25 - 0{,}75)R_x$ ✓
$R_x = 9\ \Omega$ ✓
	$V_{\text{"lost"}} = Ir$
	$1{,}5$ ✓ $= I(1{,}2)$ $\therefore$ $I = 1{,}25$ A
	$V_{\parallel} = I_pR_p$
	$4{,}5 = (1{,}25)R_p$ ✓
	$R_p = 3{,}6\ \Omega$
	$\frac{1}{R_{//}} = \frac{1}{Rx} + \frac{1}{R_6}$ ✓
	$\frac{1}{R_{//}} = \frac{1}{Rx} + \frac{1}{6}$ ✓
	$\therefore R_{//} = \frac{6R_x}{R_x + 6} = 3{,}6$ $\therefore R_x = 9\ \Omega$ ✓

(5)
[17]

QUESTION 7

7.1.1 Maximum work done (or energy transferred) by a battery per unit charge passing through it. ✓✓ (2)

7.1.2 12 V ✓ (1)

7.1.3 0 V / Zero ✓ (1)

7.1.4

OPTION 1	**OPTION 2**
$\varepsilon = I(R + r)$ **OR** $\varepsilon = V_{ext} + V_{int}$ ✓ $12 = 11{,}7 + Ir$ <u>$0{,}3 = I_{tot}(0{,}2)$</u> ✓ $\therefore I_{tot} = 1{,}5$ A ✓	$V = IR$ ✓ <u>$0{,}3 = I_{tot}(0{,}2)$</u> ✓ $I_{tot} = 1{,}5$ A ✓

(3)

7.1.5 $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10} + \frac{1}{15}$ ✓ $\therefore R = 6\ \Omega$ ✓ (2)

7.1.6

OPTION 1	**OPTION 2**
$V = IR$ ✓ $11{,}7$✓ $=$ <u>$1{,}5(6 + R)$</u> ✓ $R = 1{,}8\ \Omega$ ✓	$V = IR$ ✓ <u>$11{,}7 = 1{,}5R$</u> ✓ $R = 7{,}8\ \Omega$ and $R_R = 7{,}8 - 6$ ✓✓ $= 1{,}8\ \Omega$ ✓

(4)

7.2.1

OPTION 1	**OPTION 2**	**OPTION 3**
$P_{ave} = Fv_{ave}$ ✓ $= mg(v_{ave})$ $= (0{,}35)(9{,}8)(0{,}4)$ ✓ $= 1{,}37$ W ✓	$P = \frac{W_{nc}}{\Delta t}$ ✓ $= \frac{\Delta E_k + \Delta E_p}{\Delta t}$ $= \frac{0 + (0{,}35)(9{,}8)(0{,}4 - 0)}{1}$ ✓ $= 1{,}37$ W ✓	$P = \frac{W}{\Delta t}$ ✓ $= \frac{\Delta E_p}{\Delta t}$ $= \frac{(0{,}35)(9{,}8)(0{,}4)}{1}$ ✓ $= 1{,}37$ W ✓

(3)

7.2.2

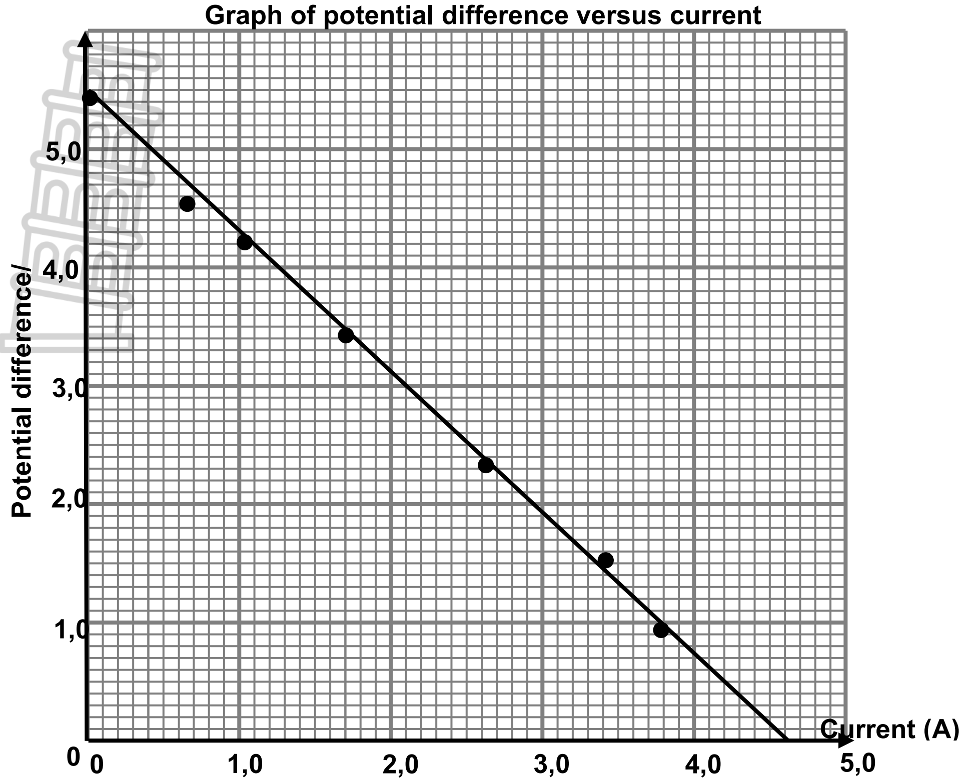
OPTION 1	**OPTION 2**
$P = VI$ <u>$1{,}37 = (3)I$</u> ✓ $I = 0{,}46$ A ✓Any one $\varepsilon = V_{ext} + V_{int}$ $= V_T + V_x + V_{int}$ <u>$12 = V_T + 3 + (0{,}2)(0{,}46)$</u> ✓ $V_T = 8{,}91$ V $V_T = IR_T$ <u>$8{,}91 = (0{,}46)R_T$</u> ✓ $\therefore R_T = 19{,}37\ \Omega$ ✓	$P = \frac{V^2}{R}$ ✓Any one $1{,}37 = \frac{3^2}{R}$ ✓ $R = 6{,}57\ \Omega$ $P = VI$ <u>$1{,}37 = (3)I$</u> ✓ $I = 0{,}46$ A $\varepsilon = I(R + r)$ <u>$12 = 0{,}46(6{,}57 + R_T + 0{,}2)$</u> ✓ $\therefore R_T = 19{,}38\ \Omega$ ✓

(5)
[21]

QUESTION 8

8.1.1 The <u>potential difference across a conductor is directly proportional to the current in the conductor</u> ✓ at <u>constant temperature.</u> ✓ (2)

8.1.2



Straight line passing through 4 or five points. ✓
Straight line with intercepts on both axes. ✓ (2)

8.1.3 5,5 V (Accept any value from 5,4 V to 5,6 V.) **NOTE:** The value must be the y-intercept. (1)

8.1.4 Slope = $\frac{\Delta V}{\Delta I}$ ✓ or $\frac{y_2 - y_1}{x_2 - x_1} = \frac{5,5 - 0}{0 - 4,6}$ ✓ = - 1,2 ∴ Internal resistance(r) = 1,2 Ω ✓

NOTE: Any correct pair of coordinates chosen from the line drawn (3)

8.2.1 V = IR ∴ 21,84 = I_{tot}(8) ✓ ∴ I_{tot} = 2,73 A ✓ (3)

8.2.2 $\frac{1}{R_{//}} = \frac{1}{R_{30}} + \frac{1}{R_{20}}$ ∴ $\frac{1}{R_{//}} = \frac{1}{30} + \frac{1}{20}$ ✓ ∴ $R_{//}$ = 12 Ω ✓ (2)

8.2.3

OPTION 1
R_{tot} = (8 + 12 + *r*) ✓ = (20 + *r*)
ε = I(R +r) ✓ ∴ 60 = 2,73(20 + *r*) ✓ ∴ *r* = 1,98 Ω✓

OPTION 2
$V_{//} = I_{tot} \times R_{//}$ = 2,73(12) ✓ = 32,76 V

$V_{terminal}$ = (32,76 + 21,84) ✓
= 54,6 V
"V_{lost}" = 60 - 54,6 = 5,4 V
V = IR ∴ 5,4 = 2,73 r ∴ r = 1,98 Ω ✓

OR

ε = $V_{lost} + V_{//} + V_8$
60 = (V_{lost} + 32,76 + 21,84) ✓
V_{lost} = 5,4 V
(4)

8.2.4

OPTION 1	OPTION 2	OPTION 3
W = $\frac{V^2}{R}\Delta t$ ✓ W = $\frac{(54,6)^2}{20}(0,2)$ ✓ = 29,81 J✓	W = $I^2R\Delta t$✓ = $(2,73)^2$ (20)(0,2) ✓ = 29,81 J✓	W = VIΔt✓ = (54,6)(2,73)(0,2) ✓ = 29,81 J ✓

(3)
[20]

QUESTION 9

9.1.1 <u>**P** and **Q** burn with the same brightness</u> ✓ same potential difference/same current. ✓ (2)

9.1.2 <u>**P** is dimmer (less bright) than **R**./**R** is brighter than **P**.</u>✓
<u>**R** is connected across the battery alone</u> <u>therefore the voltage (terminal pd) is the same as the emf source</u> (energy delivered by the source). ✓
OR: The potential difference across **R** is twice (larger/greater than) that of **P**./The current through **R** is twice (larger/greater than) that of **P.** (2)

9.1.3 **T** does not light up at all. ✓ **R** is brighter than **T**. ✓ **Reason:** The wire acts as a short circuit. ✓
OR: The potential difference across T / current in T is zero.✓ (2)

9.2.1 $\frac{1}{R_{//}} = \frac{1}{R_5} + \frac{1}{R_{10}}$ ✓ $= \frac{1}{5} + \frac{1}{10}$ ∴ $R_{//} = 3,33\ \Omega$ (3,333 Ω)

OR

$R_{//} = \frac{R_5 R_{10}}{R_5 + R_{10}}$ ✓ $= \frac{(5)(10)}{(5+10)}$ ✓ $= 3,33\ \Omega$ (3,333 Ω)

$R_{tot} = R_8 + R_{//} + r = (8 + 3,33 + 1)$ ✓
$= 12,33\ \Omega$

$I_{tot} = \frac{V}{R}$ ✓ $= \frac{20}{12,33}$ ✓ $= 1,62$ A

∴ $I_8 = 1,62$ A ✓

$R = R_8 + R_{//} = 8 + 3,33 = 11,33\ \Omega$

$\varepsilon = I(R + r)$✓
$20 = I[(11,33 + 1)$✓$]$ ✓
$I = 1,62$ A ✓

(6)

9.2.2

OPTION 1
$V = IR$
$V_5 = \mathcal{E} - (V_8 + V_1)$ } ✓Any one
$= 20$✓ $-$ [<u>1,62(8 + 1)</u>] ✓ = 5,42 V ✓

OPTION 2
$R_{//} = \frac{(5)(10)}{(5+10)} = 3,33\ \Omega$

$V_{R//} = \frac{R_{//}}{R_{tot}} \times V_{tot}$ ✓ ∴ $V_{R//} = \frac{(3,33)}{(12,33)}(20)$✓✓ = 5,41 V✓

$V_{||} = IR_{||}$ ✓
$= (1,62)(3,33)$ ✓✓
$= 5,39$ V ✓

9.2.3

OPTION 1
$P = IV$ ✓
$= (1,62)(20)$ ✓
$= 32,4$ W ✓

OPTION 2
$P = I^2R$ ✓
$P_{tot} = P_{8\Omega} + P_{//} + P_{1\Omega}$
$= I^2(R_8 + R_{//} + R_1)$
$= (1,62)^2[8 + 3,33 + 1)]$ ✓ $= 32,36$ W ✓

(3)
[19]

QUESTION 10

10.1.1 The potential difference (voltage) across a conductor is <u>directly</u> proportional to the current in the conductor at <u>constant temperature</u>. ✓✓ (1)

10.1.2 Equivalent resistance ✓ (1)

10.1.3 Gradient $= \frac{\Delta V}{\Delta I} = \frac{2-0}{0,5-0}$ ✓ $= 4\ (\Omega)$ ✓ **NOTE:** Any correctly chosen pair of coordinates. (2)

10.1.4

OPTION 1
In series $R_1 + R_2 = 4\ \Omega$ ✓................(1)
In parallel $\frac{R_1 R_2}{R_1 + R_2} = 1\ \Omega$ ✓✓ ....(2)
$R_1R_2 = 4\ \Omega$
∴ $R_1 = R_2 = 2\ \Omega$ ✓

OPTION 2
For graph X: $R_1 + R_2 = 4$ ✓ ....(1)
For graph Y: $\frac{1}{R_{//}} = \frac{1}{R_1} + \frac{1}{R_2}$
$\left\{\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \left(\frac{1}{1}\right)\right\}$ ✓✓...................(2)
$R_1^2 - 4R_1 + 4 = 0$ ∴ $R_1 = 2\ \Omega$✓

(4)

10.2.1 $I = \frac{V}{R}$ ✓ $= \frac{5}{(R_M + R_N)} = \frac{5}{(6)}$ ✓ = 0,83 A ✓ (3)

10.2.2

OPTION 1
$\mathcal{E} = I(R + r)$ ✓ $= 0,83[(6 + 1,5)$ ✓$+ 0,9$✓$]$
$= 6,997$ V = 7(,00) V ✓ (6,972 – 7,00 V)

OPTION 2
$\mathcal{E} = (V_s + V_{//} + V_r)$ ✓ / $V_{ext} + V_{int}$
$= [5 + (0,833 \times 1,5)$ ✓$+ (0,9 \times 0,833)]$ ✓✓
$= 6,999$ V = 7(,00) V ✓ (6,972 – 7,00 V)

(4)

10.2.3 The resistance R_N will be 3 Ω ✓
The voltage divides (proportionately) in a series circuit. <u>Since the voltage across **M** is half the total voltage, it means the resistances of **M** and **N** are equal.</u> ✓ (2)
[18]

QUESTION 11

11.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. (2)

11.1.2 Graph X. ✓ Graph X is a straight line (passing through the origin) therefore potential difference is directly proportional to current. ✓ (2)

11.2.1
$$\frac{1}{R_{//}} = \frac{1}{R_{10}} + \frac{1}{R_{15}}$$
$$\frac{1}{R_{//}} = \frac{1}{10} + \frac{1}{15} ✓$$
$R_{//} = 6\ \Omega$

$R = 10 + 6 + 2$ ✓
$= 18\ \Omega$

$R = \frac{V}{I}$ ✓

$I = \frac{6}{18}$ ✓
$= 0,33\ A$ ✓ (5)

11.2.2 Decrease ✓
The total resistance of the circuit increases. ✓ (2)

11.2.3 Increase ✓ (1)

11.2.4 The total resistance in the external circuit increases, ✓
Current decreases ✓
"Lost" volts decreases ✓ (3)

[15]

QUESTION 12

12.1.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
OR The ratio of potential difference across a conductor to the current in the conductor is constant, provided the temperature remains constant. (2)

12.1.2 $V_1 = IR$ ✓ $= (0,6)(4)$ ✓ $= 2,4\ V$ ✓ (3)

12.1.3

OPTION 1	**OPTION 2**	**OPTION 2**
$I_{6\Omega} = \frac{V}{R} = \frac{2,4}{6}$ ✓ $= 0,4\ A$ ✓	$\frac{6}{10}(I) = 0,6$ ✓ $\therefore I = 1\ A \quad \therefore I_{6\Omega} = 0,4\ A$ ✓	$V_{4\Omega} = V_{6\Omega} \therefore \quad I_{4\Omega}R_1 = I_{6\Omega}R_2$ $(0,6)(4) = I_{6\Omega}(6)$ ✓ $I_{6\Omega} = 0,4\ A$ ✓

(2)

12.1.4 $V_2 = IR = (0,4 + 0,6)(5,8)$ ✓ $= 5,8\ V$ ✓ (2)

12.1.5

OPTION 1	**OPTION 2**
$V_{ext} = (5,8 + 2,4)$ ✓ $= 8,2\ V$ $V_{int} = Ir$ $= (1)(0,8)$ ✓ $= 0,8\ V$ $Emf = 0,8 + 8,2 = 9\ V$✓	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{4} = \frac{5}{12} \quad \therefore R_p = 2,4\ \Omega$ $R_{ext} = (2,4 + 5,8)$ ✓ $= 8,2\ \Omega$ $Emf = I(R + r) = 1(8,2 + 0,8)$ ✓ $= 9\ V$ ✓

(3)

12.1.6

OPTION 1	**OPTION 2**	**OPTION 3**
$W = VI\Delta t$ ✓ $= (0,8)(1)(15)$ ✓ $= 12\ J$ ✓	$W = I^2R\Delta t$ ✓ $= (1)^2(0,8)(15)$ ✓ $= 12\ J$ ✓	$W = \frac{V^2\Delta t}{R}$ ✓ $= \frac{0,8^2(15)}{0,8}$ ✓ $= 12\ J$ ✓

(3)

12.2.1 $R = \frac{V}{I} = \frac{2,8}{0,7}$ ✓ $= 4\ \Omega$ ✓ (2)

12.2.2 Increases ✓
Total resistance decreases,✓ current/power increases, ✓ motor turns faster (3)

[20]

QUESTION 13

13.1 The battery supplies 12 J per coulomb/per unit charge. ✓✓
OR The potential difference of the battery in an open circuit is 12 V. (2)

13.2

OPTION 1	**OPTION 2**	**OPTION 3**
$V_{lost} = Ir$ ✓ $= (2)(0,5) = 1\ V$ $V_{ext} = Emf - V_{lost} = (12 - 1)$ ✓ $= 11\ V$✓	$\varepsilon = I(R + r)$ ✓ $12 = V_{ext/eks} + (2)(0,5)$ ✓ $V_{ext/eks} = 11\ V$✓	$\varepsilon = I(R + r)$ ✓✓ $12 = 2(R + 0,5)$ $R = 5,5\ \Omega$ $V = IR = 2(5,5)$ ✓ $= 11\ V$ ✓

(3)

13.3

OPTION 1	**OPTION 2**	**OPTION 3/*OPSIE 3***
$R = \frac{V}{I}$ ✓ $= \frac{11}{2} = 5,5\ \Omega$ ✓	$0,5 : R = 1:11$ ✓ $R = 5,5\ \Omega$ ✓	$\frac{1}{0,5} = \frac{11}{R}$ ✓ $R = 5,5\ \Omega$✓

OPTION 4	OPTION 5
$V_{total} = IR_{total}$ $12 = (2)R_{total}$ $R_{total} = 6\ \Omega$ $R = 6 – 0,5$ ✓ $= 5,5\ \Omega$ ✓	$\varepsilon = I(R + r)$ $12 = 2(R + 0,5)$ ✓ $R = 5,5\ \Omega$ ✓

(2)

13.4 Decreases ✓
Total resistance decreases. ✓
Current increases. ✓
"Lost volts" increases, ✓emf the same **OR** in $\varepsilon = V_{ext} + Ir$, Ir increases ✓, ε is constant
External potential difference decreases $\therefore V_{ext/eks}$ decreases (4)
[11]

QUESTION 14

14.1 Temperature ✓ (1)
14.2 $r = 3\ \Omega$ or $1,5\ \Omega$ ✓✓ (2)
14.3 **Any correct values from the graph**

OPTION 1	OPTION 2	OPTION 3
ε = slope (gradient) of the graph ✓ $\varepsilon = \frac{7,5-(-3)}{1,5-0}$ ✓ $= 7\ V$ ✓	$R = \frac{\varepsilon}{I} - r$ ✓ $7,5 = 1,5\varepsilon - 3$ ✓ $\varepsilon = 7\ V$ ✓	$\varepsilon = I(R + r)$ ✓ $= 0,5(11 + 3)$ ✓ $\varepsilon = 7\ V$ ✓

(3)
[6]

QUESTION 15

15.1.1 The rate at which (electrical) energy is converted (to other forms) (in a circuit). ✓✓
OR: The rate at which energy is used./Energy used per second.
OR: The rate at which work is done. (2)

15.1.2

$P = \frac{V^2}{R}$ ✓ $6 = \frac{(12)^2}{R}$ ✓ $R = 24\ \Omega$ ✓	$W = \frac{V^2\Delta t}{R}$ ✓ $6 = \frac{(12)^2(1)}{R}$ ✓ $R=24\ \Omega$ ✓	$P = VI$ $6 = (12)(I)$ $\therefore I = 0,5\ A$ $P = I^2R$ ✓ $6 = (0,5)^2 R$ ✓ $R = 24\ \Omega$ ✓	$P = VI$ ✓ $6 = (12)(I)$ $\therefore I = 0,5\ A$ $V = IR$ $12 = (0,5)R$ ✓ $R = 24\ \Omega$ ✓

(3)

15.1.3

OPTION 1	OPTION 2

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
$= \frac{1}{24} + \frac{1}{24}$ ✓
$R_{//} = 12\ \Omega$
$R_{ext} = (R_s + R_{//})$
$R_{ext} = (24 + 12)$ ✓
$= 36\ \Omega$
$V = IR$ **OR** $\varepsilon = I(R + r)$ ✓
$12 = I(36 + 2)$ ✓
$I = 0,32\ A$ ✓ (0,316 A)
	$R_{ext} = (R_s + R_{//})$
	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
	$= \frac{1}{24} + \frac{1}{24}$ ✓ $\therefore R_{//} = 12\ \Omega$
	$R_{ext} = (24 + 12)$ ✓ $= 36\ \Omega$
	$P = I^2R = \frac{V^2}{R}$ ✓
	$I^2(36+2) = \frac{(12)^2}{38}$ ✓
	$I = 0,32\ A$ ✓ (0,316)

(5)

15.1.4

OPTION 1	OPTION 2

$V = IR$
$V = I(R_A+r)$
$= 0,316(26)$ ✓
$= 8,216\ V$ (8,32 V)
 	
$V_{//} = (12 – 8,216)$ ✓
$= 3,784\ V$ (3,68 V)
$\therefore V_C = 3,78\ V$ (3,68 V) ✓
	$V = IR$
	For the parallel portion (or from 8.1.3):
	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ OR $R = \frac{R_1R_2}{(R_1+R_2)}$
	$R = \frac{(24)(24)}{48} = 12\ \Omega$
	$V_{//} = V_C$ ✓
	$V = IR_{//} = (0,316)(12)$ ✓ $= 3.79\ V$ (3,84 V)✓

OPTION 3 $I_A = I_B + I_C = 2\ I_B$ $0,316 = 2I_B$ ✓ $I_B = 0,158\ A$ $V = 0,158\ (24)$ ✓ $= 3,79\ V$✓	

(3)

15.1.5 **OPTION 1**

$P = \frac{V^2}{R}$ **OR** For a given resistance, power is directly proportional to V^2. ✓

Since the potential difference across light bulb C is less than the operating voltage, ✓ the output/power will be less. ✓

OPTION 2

$P = I^2 R$ OR For a given resistance, power is directly proportional to I^2. ✓

In the circuit, the current in light bulb C is less than the optimum current required (0,5 A). ✓ The output power will be less.✓

OPTION 3

P = IV **OR** Power is directly proportional/equal to product of V and I. ✓

The voltage across light bulb C, as well as the current in the bulb are less than the optimum values ✓ hence power is less ✓ and brightness is less. (3)

15.2.1 The total current passes through resistor A. ✓ For the parallel portion, the current branches, therefore only a portion of the total current passes through resistor C. ✓ (2)

15.2.2 The current in B is equal ✓ to the current in A. The circuit becomes a series circuit. ✓ (2)

[21]

QUESTION 16

16.1 Maximum work done (or energy provided) ✓ by a battery per unit charge passing through it. ✓ (2)

16.2 13 V ✓ (1)

16.3.1 $R = \frac{V}{I}$ ✓ $\therefore 5,6 = \frac{10,5}{I}$ ✓ $\therefore$ I = 1,88 A ✓ (1,875 A) (3)

16.3.2

OPTION 1	**OPTION 2**
P = VI ✓ = (10,5)(1,88) ✓ = 19,74 W ✓ (19,688 W)	$P = I^2R$ ✓ $= (1,88)^2(5,6)$ ✓ = 19,79 W ✓ (19,688 W)
OPTION 3 $P = \frac{V^2}{R}$ ✓ $= \frac{10,5^2}{5,6}$ ✓ = 19,79 W ✓ (19,688 W)	

(3)

16.3.3

OPTION 1	**OPTION 2**
Ɛ = I(R + r) ✓ 13 = 1,88 (5,6 + r) ✓ r = 1,31 Ω ✓	$r = \frac{V_{internal}}{I}$ ✓ $= \frac{2,5}{1,88}$ ✓ = 1,33 Ω ✓

(3)

16.4.1 Decreases ✓

$V_{internal\ resistance}$/Internal volts increase ✓ (2)

16.4.2

OPTION 1	**OPTION 2**
Ɛ = I(R + r) ✓ $13 = 4\,(R_{ext} + 1,31)$ ✓ R_{ext} = 1,94 Ω (1,92 Ω) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{1,94} = \frac{1}{5,6} + \frac{1}{R_2}$ ✓ R_2 = 2,97 Ω (2,92 Ω) $X = \frac{1}{2}(2,97)$ ✓ = 1, 49 Ω ✓ (1,46 – 1,49 Ω)	Ɛ = I(R + r) ✓ $13 = 4(R_{ext} + 1,31)$ ✓ R_{ext} = 1,94 Ω (1,92 Ω) $R_p = \frac{R_1 R_2}{R_1 + R_2}$ $1,94 = \frac{5,6 R_2}{5,6 + R_2}$ ✓ R_2 = 2,97 Ω (2,92 Ω) $X = \frac{1}{2}(2,97)$ ✓ = 1,49 Ω ✓ (1,46 – 1,49 Ω)

OPTION 3	OPTION 4
$\varepsilon = I(R + r)$ ✓ $\underline{13 = 4(R_{ext} + 1{,}31)}$ ✓ $R_{ext} = 1{,}94\ \Omega$ (1,92 Ω) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{1{,}94} = \frac{1}{5{,}6} + \frac{1}{2X}$ ✓ $2X = 2{,}97\ \Omega$ (2,92 Ω) $X = \frac{1}{2}(2{,}97)$ ✓ $= 1{,}49\ \Omega$ ✓ (1,46 – 1,49 Ω)	$\varepsilon = I(R + r)$ ✓ $\underline{13 = 4(R_{ext} + 1{,}31)}$ ✓ $R_{ext} = 1{,}94\ \Omega$ (1,92 Ω) $R_p = \frac{R_1 R_2}{R_1 + R_2}$ $1{,}94 = \frac{(5{,}6)(2X)}{5{,}6 + 2X}$ ✓✓ $(1{,}94)(5{,}6 + 2X) = 11{,}2X$ $X = 1{,}49\ \Omega$ ✓

(5)
[19]

QUESTION 17

17.1 (Maximum) <u>energy provided (work done)</u> by a battery <u>per coulomb/unit charge</u> passing through it. ✓✓
OR Work done by the battery to move <u>a unit coulomb of charge in the circuit</u>. (2)

17.2 Energy (per coulomb of charge) is converted to heat in the battery <u>due to the internal resistance</u>. ✓✓ (2)

17.3.1

$$I = \frac{V}{R} \checkmark$$
$$= \frac{1{,}5}{0{,}5} \checkmark$$
$$= 3\ A \checkmark$$

(3)

17.3.2

OPTION 1	OPTION 2
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{R_p} = \frac{1}{25} + \frac{1}{15}$ ✓ $R_p = 9{,}375\ \Omega$ $R_{ext} = 9{,}375 \underline{+ 4}$ ✓ $= 13{,}38\ \Omega$ ✓ (13,375 Ω)	$R_p = \frac{R_1 R_2}{R_1 + R_2}$ ✓ $R_p = \frac{(25)(15)}{25 + 15}$ ✓ $R_p = 9{,}375\ \Omega$ $R_{ext} = 9{,}375 \underline{+ 4}$ ✓ $= 13{,}38\ \Omega$ ✓ (13,375 Ω)

(4)

17.3.3

OPTION 1 $\varepsilon = I(R + r)$ ✓ $= 3(13{,}38 + 0{,}5)$ ✓ $= 41{,}64\ V$ ✓ (Range: 41,625 – 41,64)
OPTION 2 $\varepsilon = V_{ext} + V_{int}$ ✓ $= (3)(13{,}38) + 1{,}5$ ✓ $= 41{,}64\ V$ ✓ (Range: 41,625 – 41,64)

(3)

17.4

Yes. ✓
For the same voltage/potential difference, ✓
a larger current will flow through a smaller resistor ($I = \frac{V}{R}$) ✓
OR
$I \; \alpha \; \frac{1}{R}$ ✓, V = constant ✓
I is inversely proportional to R and V is constant.
OR
$V_{||} = IR$
$= (3)(9{,}38)$
$= 28{,}14$ V
$I_{R2} = \frac{V}{R} = \frac{28{,}14}{25} = 1{,}13\ A$ ✓
$I_{R3} = \frac{V}{R} = \frac{28{,}14}{15} = 1{,}88\ A$ ✓
OR
V is the same ✓
$\left.\begin{array}{l} I_{15\Omega} = \frac{25}{40} I \\ I_{25\Omega} = \frac{15}{40} I \end{array}\right\}$ ✓

(3)

17.5 Remains the same. (1)

[18]

ELECTRICAL MACHINES

QUESTION 1

1.1 Electromagnetic induction ✓ (1)

1.2 Rotate coil faster./Increase number of coils./Increase the strength of the magnetic field. ✓ (1)

1.3 Slip rings ✓ (1)

1.4 The <u>AC potential difference/voltage</u> ✓ that produces the <u>same amount of electrical energy as an equivalent DC potential difference/voltage</u>. ✓ (2)

1.5 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{339{,}45}{\sqrt{2}}$ ✓ $\therefore V_{rms} = 240{,}03$ V ✓ (3)

[8]

QUESTION 2

	OPTION 1	OPTION 2	
2.1.1	$P_{ave} = \frac{V_{rms}^2}{R}$ ✓ 100 ✓ $= \frac{(\frac{340}{\sqrt{2}})^2}{R}$ ✓ ✓ $R = 578\ \Omega$ ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}}$ ✓ $= 240{,}04$ $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ 100 ✓ $= \frac{(240{,}04)^2}{R}$ ✓ $\therefore R = 578\ \Omega$ ✓	(5)
2.1.2	$P_{ave} = I_{rms}V_{rms}$ ✓ $100 = I_{rms}\frac{340}{\sqrt{2}}$ ✓ $\therefore I_{rms} = 0{,}417$ A ✓	$V_{rms} = I_{rms}R$ ✓ $\frac{340}{\sqrt{2}} = I_{rms}(578)$ ✓ $\therefore I_{rms} = 0{,}417$ A ✓	(3)

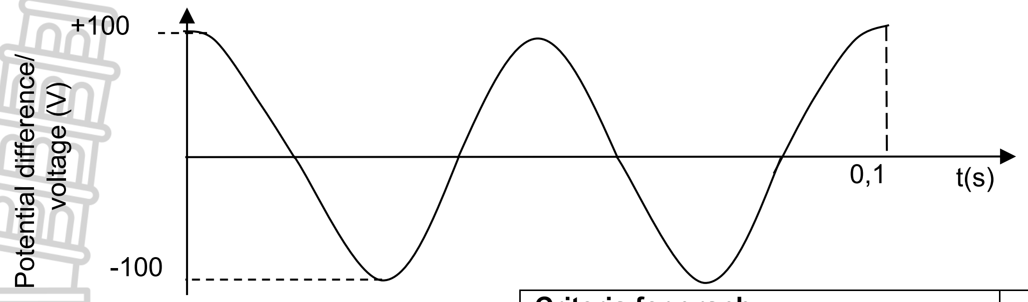
2.2 Can be stepped up or down. / Can be transmitted with less power loss. ✓ (1)

[9]

QUESTION 3

3.1.1 Anticlockwise ✓ (1)

3.1.2



Criteria for graph:	
Two full cycles with correct shape.	✓
Showing the maximum voltage.	✓
Showing the time 0,1s for two cycles.	✓

(3)

3.1.3 Decrease the frequency/ speed of rotation ✓(1)

3.2 $P_{ave} = V_{rms}I_{rms}$ ✓ ∴ $\underline{1\,500 = (220)(I_{rms})}$ ✓ ∴ $I_{rms} = 6{,}82$ A

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ ∴ $I_{max} = \sqrt{2}\,(6{,}82)$ ✓ $= 9{,}65$ A ✓ (5)

[10]

QUESTION 4

4.1.1 Move the bar magnet <u>very quickly</u>✓✓ **OR** up and down <u>inside the coil.</u> (2)

4.1.2 Electromagnetic induction ✓ (1)

4.1.3 Commutator ✓ (1)

4.2.1

<u>OPTION 1</u> $P_{ave} = \frac{V^2_{rms}}{R}$ ✓ $= \frac{(220)^2}{40{,}33}$ ✓ $= 1\,200{,}10$ W (J·s^{-1}) ✓	$W = \frac{V^2_{rms}}{R}\Delta t$ ✓ $= \frac{(220)^2}{40{,}33}$ ✓ (1) ✓ $= 1200{,}10$ J ✓
<u>OPTION 2</u> $I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{220}{40{,}33}$ ✓ $= 5{,}45$ A $P_{ave} = I^2_{rms}R = (5{,}45)^2\,40{,}33$ ✓ $= 1\,197{,}9$ W /1 200,10 W ✓	$I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{220}{40{,}33}$ ✓ $= 5{,}45$ A $W = I^2_{rms}R\Delta t = (5{,}45)^2(40{,}33)(1)$ ✓ $= 1\,197{,}9$ J / 1 200,10 J ✓

(4)

4.2.2

<u>OPTION 1</u> $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $220 = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = 311{,}13$ V ✓ any formula $I_{max} = \frac{V_{max}}{R} = \frac{331{,}13}{40{,}33}$ ✓ $= 7{,}71$ A ✓ **OR** $P_{ave} = \frac{V_{max}I_{max}}{2}$ $1200{,}1 = \frac{311{,}13 I_{max}}{2}$ ∴ $I_{max} = 7{,}71$ A	**<u>OPTION 2</u>** $P_{ave} = V_{rms}I_{rms}$ ✓ $\underline{1200{,}1 = (220)I_{rms}}$ ✓ $I_{rms} = 5{,}455$ A $I_{max} = \sqrt{2}\,(5{,}455)$ $= 7{,}71$ A✓ (7,715 A)

OPTION 3	OPTION 4	
$P_{ave} = I^2_{rms}R$ ✓ $1200,1 = I^2_{rms}(40,33)$ ✓ $I_{rms} = 5,455$ A $I_{max} = \sqrt{2}\, I_{rms} = \sqrt{2}\,(5,455) = 7,71$ A ✓	$V_{rms} = I_{rms}R$ ✓ $220 = I_{rms}(40,33)$ ✓ $I_{rms} = 5,455$ A $I_{max} = \sqrt{2}\, I_{rms} = \sqrt{2}\,(5,455) = 7,71$ A ✓	(3) **[11]**

QUESTION 5

5.1.1 North pole ✓ (1)
5.1.2 Q to P ✓ (1)

5.2.1

OPTION 1	OPTION 2	
$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{8}{\sqrt{2}}$ ✓ $= 5,66$ A $V_{rms} = I_{rms}R$ ✓ $220 = 5,66R$ ✓ $\therefore R = 38,87\ \Omega$ ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $\therefore 220 = \frac{V_{max}}{\sqrt{2}}$ ✓ $\therefore V_{max} = 311,12$ V $V_{max} = I_{max}R$ ✓ $311,12 = 8R$ ✓ $\therefore R = 38,89\ \Omega$ ✓	(5)

5.2.2

OPTION 1	OPTION 2	OPTION 3	
$P_{ave} = V_{rms}I_{rms}$ ✓ $= (220)(5,66)$ ✓ $= 1\ 245,2$ W $P = \frac{W}{\Delta t}$ ✓ $1\ 245,22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584$ J ✓	$P_{ave} = I^2_{rms}R$ ✓ $= (5,66)^2(38,87)$ ✓ $= 1\ 245,22$ W $P = \frac{W}{\Delta t}$ ✓ $1\ 245,22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584$ J ✓	$P_{ave} = \frac{V^2_{rms}}{R}$ ✓ $= \frac{(220)^2}{38,87}$ ✓ $= 1\ 245,18$ W $P = \frac{W}{\Delta t}$ ✓ $1\ 245,22 = \frac{W}{7200}$ ✓ $W = 8\ 965\ 584$ J ✓	(5) **[12]**

QUESTION 6

6.1.1 a to b ✓ (1)
6.1.2 Fleming's left hand rule /Left hand motor rule ✓ (1)
6.1.3 Split rings /commutator ✓ (1)
6.2.1 Mechanical/Kinetic energy to electrical energy ✓✓ (2)

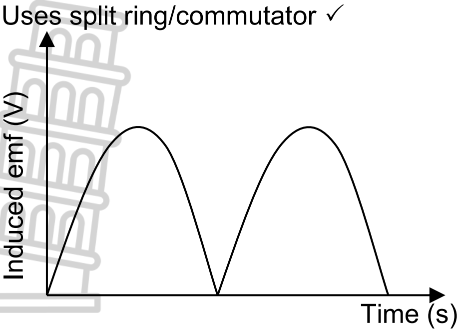
6.2.2

OPTION 1	OPTION 2	
$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V $I = \frac{V}{R}$ ✓ $= \frac{304,06}{400}$ ✓ $= 0,76$ A ✓	$V_{max} = I_{max}R$ ✓ $430 = I_{max}(400)$ ✓ $I_{max} = 1,075$ $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{1,075}{\sqrt{2}}$ ✓ $= 0,76$ A ✓	
OPTION 3	**OPTION 4**	
$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V $P_{ave} = \frac{V^2_{rms}}{R} = \frac{(304,06)^2}{400} = 231,13$ W $P_{ave} = I_{rms}V_{rms}$ ✓ $231,13 = I_{rms}(304,06)$ ✓ $\therefore I_{rms} = 0,76$ A ✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ $= 304,06$ V $P_{ave} = \frac{V^2_{rms}}{R} = \frac{(304,06)^2}{400} = 231,13$ W $P_{ave} = I^2_{rms}R$ ✓ $231,13 = I^2_{rms}(400)$ ✓ $\therefore I_{rms} = 0,76$ A ✓	(5) **[10]**

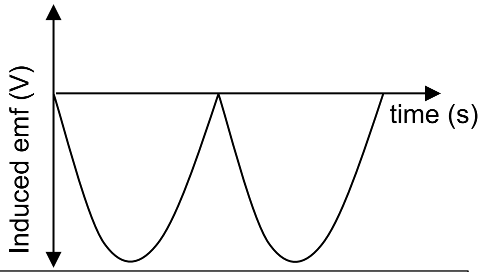
QUESTION 7

7.1.1 DC-generator ✓
Uses split ring/commutator ✓ (2)

7.1.2



OR



Curve starts at zero to first peak. ✓
Shape and one complete DC cycle. ✓

(2)

7.2.1

OPTION 1 $V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}} = 240{,}416$ V $P_{ave} = V_{rms}I_{rms}$ ✓ $800 = I_{rms}(240{,}416)$ ✓ $I_{rms} = 3{,}33$ A ✓	**OPTION 2** $V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{340}{\sqrt{2}}$ $P_{ave} = V_{rms}I_{rms}$ ✓ $800 = \frac{340}{\sqrt{2}} I_{rms}$ ✓ $\therefore I_{rms} = 3{,}33$ A ✓
OPTION 3 $P_{ave} = \frac{V_{rms}^2}{R} = \frac{V_{max}^2}{2R}$ $800 = \frac{(340)^2}{(\sqrt{2})^2 R}$ $\therefore R = 72{,}25\ \Omega$ $V_{rms} = I_{rms}R$ ✓ $I_{rms} = \frac{240{,}416}{72{,}25}$ ✓ $= 3{,}33$ A ✓	**OPTION 4** $P_{ave} = I_{rms}^2 R$ ✓ $800 = I_{rms}^2 (72{,}25)$ ✓ $I_{rms} = 3{,}33$ A ✓

(3)

7.2.2

OPTION 1 For the kettle: $P_{ave} = V_{rms}I_{rms}$ ✓ $2000 = \frac{340}{\sqrt{2}} I_{rms}$ ✓ $\therefore I_{rms} = 8{,}32$ A $I_{tot} = (8{,}32 + 3{,}33)$ ✓ $= 11{,}65$ A ✓	**OPTION 2** $P_{ave} = V_{rms}I_{rms}$ ✓ $= \frac{V_{max}I_{max}}{2}$ $2\ 800 = \frac{340}{2} I_{max}$ ✓ $\therefore I_{max} = 16{,}47$ A $I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{16{,}47}{\sqrt{2}}$ ✓ $\therefore I_{rms} = 11{,}65$ A ✓

(4)
[11]

QUESTION 8

8.1.1 **R:** armature/coil(s) ✓
T: Carbon brushes ✓
X: Slip rings ✓ (3)

8.1.2 Faraday's Law ✓ (1)

8.2.1 115 V ✓ (1)

8.2.2

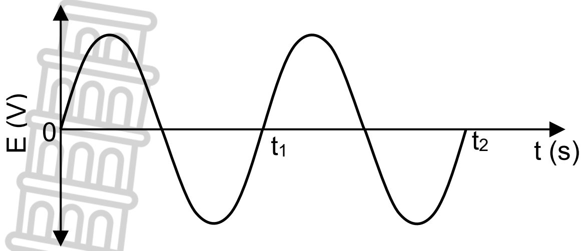
OPTION 1 $V_{rms} = I_{rms}R$ $I_{rms} = \frac{15}{45}$ ✓ $= 0{,}333$ A $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓any one $I_{max} = (0{,}333)\sqrt{2}$ ✓ $= 0{,}47$ A ✓	**OPTION 2** $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = (15)\sqrt{2}$ ✓ $= 21{,}213$ V ✓any one $V_{max} = I_{max}R$ $I_{max} = \frac{21{,}213}{45}$ ✓ $= 0{,}47$ A ✓

(4)
[9]

QUESTION 9

9.1 Slip rings ✓ (1)

9.2



Marking criteria	
Sine graph starts from 0.	✓
Two complete waves (between t_0 and t_2)	✓

(2)

9.3 **Any TWO:**
Increase the speed of rotation. ✓
Increase the number of coils (turns). ✓
Use stronger magnets. (2)

9.4 The <u>AC potential difference/voltage</u> ✓ that produces the <u>same amount of electrical energy as an equivalent DC potential difference/voltage</u>. ✓ (2)

9.5

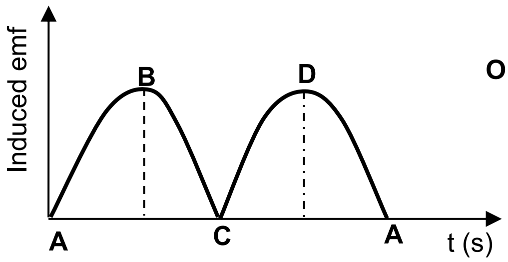
OPTION 1	**OPTION 2**
$P_{ave} = I_{rms}V_{rms}$ ✓ $\underline{1500 = I_{rms/wgk}(240)}$ ✓ $I_{rms} = \frac{1500}{240} = 6{,}25\ A$ ✓	$P_{ave} = \frac{V^2}{R}$ ✓ $\therefore\ 1500 = \frac{240^2}{R}$ $\therefore R = 38{,}4\ \Omega$ $I_{rms} = \frac{V}{R} = \frac{240}{38{,}4}$ ✓ $= 6{,}25\ A$ ✓

(3)
[10]

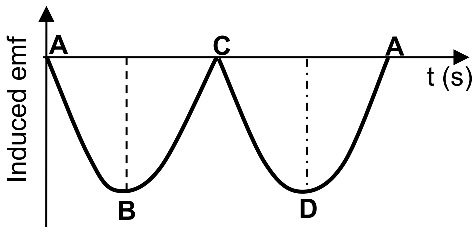
QUESTION 10

10.1.1 <u>Mechanical to electrical</u> ✓ (1)

10.1.2



OR



Criteria for graph	
Correct DC shape, starting from zero	✓
Positions ABCDA correctly indicated on the graph	✓

(2)

10.2.1 20,5 Ω ✓ (1)

10.2.2

<table>
<tr><td colspan="3"><u>OPTION 1</u>
$I_{rms} = \frac{V_{rms}}{R}$ ✓ $= \frac{25}{20{,}5}$ ✓ $= 1{,}22\ (1{,}2195)\ A$</td></tr>
<tr><td>$P_{ave} = I_{rms}^2 R$
$=(1{,}22)^2(0{,}5)$
$= 0{,}74\ W$
$P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(25)^2}{20{,}5}$ ✓
$= 30{,}49\ W$
Actual energy delivered per second(power) = (30,49– 0,74)
= 29,75 W ✓</td><td>$P_{ave} = I_{rms}^2 R$ ✓
$= (1{,}22)^2(20)$ ✓
$= 29{,}77\ W$ ✓
OR
$V_{rms\ device} = \frac{20}{20{,}5} \times 25$ ✓
$= 24{,}39\ V$
$P_{ave} = V_{rms}I_{rms}$ ✓
$= (24{,}39)(1{,}22)$
$= 29{,}76\ W$ ✓</td><td>$W = I_{rms}^2 R\Delta t$
$= (1{,}22)^2\ (0{,}5)(1)$
$= 0{,}74\ J$
$P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(25)^2}{20{,}5}$ ✓
$= 30{,}49\ W$
Actual energy delivered per second(power)
= (30,49 – 0,74) = 29,75 W ✓</td></tr>
<tr><td colspan="3"><u>OPTION 2</u>
$V_{rms\ device} = \frac{20}{20{,}5} \times 25$ ✓ $= 24{,}39\ V$ $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $= \frac{(24{,}39)^2}{20}$ ✓✓ $= 29{,}74\ W$ ✓</td></tr>
</table>

(5)
[9]

QUESTION 11

11.1.1 **ANY THREE**
Permanent magnets; coils (armature); commutator; brushes; power supply/battery (3)

11.2.1 The AC potential difference/voltage ✓ that produces the same amount of electrical energy as an equivalent DC potential difference/voltage. ✓ (2)

11.2.2

OPTION 1	**OPTION 2**
✓	✓
$V_{rms} = I_{rms}R$	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$
$I_{rms} = \frac{V_{rms}}{R}$	$V_{max} = (240)\sqrt{2}$ ✓
$I_{rms} = \frac{240}{11}$ ✓	$= 339{,}41$
$= 21{,}82$ A	$V_{max} = I_{max}R$
$I_{rms} = \frac{I_{max}}{\sqrt{2}}$	$I_{max} = \frac{339{,}41}{11}$ ✓
$I_{max} = (21{,}82)\sqrt{2}$ ✓	$I_{max} = 30{,}86$ A ✓
$I_{max} = 30{,}86$ A ✓	

(4)
[9]

QUESTION 12

12.1.1 Split ring/commutator ✓ (1)
12.1.2 Anticlockwise ✓✓ (2)
12.1.3 Electrical energy ✓to mechanical (kinetic) energy ✓ (2)
12.2.1 DC generator: split ring/commutator and AC generator has slip rings ✓ (1)
12.2.2 $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{320}{\sqrt{2}}$ ✓ $= 226{,}27$ V ✓ (3)
12.2.3 $I_{max} = \frac{V_{max}}{R} = \frac{320}{35}$ ✓ $= 9{,}14$ A $\therefore I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $= \frac{9{,}14}{\sqrt{2}}$ ✓ $= 6{,}46$ A ✓ (4)

[13]

QUESTION 13

13.1.1 Y to/*na* X ✓ (1)
13.1.2 Faraday's Law Electromagnetic Induction ✓
OR Electromagnetic induction/Faraday's Law ✓ (1)
13.1.3 Mechanical (kinetic) energy ✓to electrical energy ✓ (2)
13.2.1 340 V ✓ (1)
13.2.2 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{340}{\sqrt{2}}$ ✓ $\therefore V_{rms/wgk} = 240{,}42$ V ✓ (3)

13.2.3

OPTION 1	**OPTION 2**
$P_{ave/gemid} = \frac{V^2_{rms/wgk}}{R}$ ✓	$P_{ave/gemid} = \frac{V^2_{rms/wgk}}{R}$ ✓ $= \frac{\frac{V^2_{max/maks}}{2}}{R} = \frac{V^2_{max/maks}}{2R}$
$1\,600 = \frac{(240{,}42)^2}{R}$ ✓ $\therefore R = 36{,}13\ \Omega$ ✓	$\therefore 1\,600 = \frac{(340)^2}{2R}$ ✓ $\therefore R = 36{,}13\ \Omega$ ✓

(3)
[11]

QUESTION 14

14.1 Slip rings ✓ (1)
14.2 B ✓ (1)
14.3 $V_{rms/wgk} = \frac{V_{max/maks}}{\sqrt{2}}$ ✓ $= \frac{312}{\sqrt{2}}$ ✓ $= 220{,}62$ V ✓ (3)

14.4.1

OPTION 1
$P_{aver/gemid} = \frac{V^2_{rms/wgk}}{R}$ ✓ $= \frac{(220{,}62)^2}{40}$ ✓ $= 1216{,}83$ W ✓

OPTION 2

$I_{rms} = \frac{V_{rms/wgk}}{R}$ ✓ any one

$= \frac{(220,62)}{40}$

$= 5,515$

$P_{ave} = I^2_{rms}R$

$= (5,515)^2(40)$ ✓

$= 1216,61$ W ✓

OR

$P_{ave} = V_{rms}I_{rms} = (220,62)(5,515)$ ✓ $= 1216,72$ W✓ (3)

14.4.2

OPTION 1

$I_{max} = \frac{V_{max/maks}}{R}$ ✓

$= \frac{312}{40}$ ✓✓

$= 7,8$ A ✓

OPTION 2

$P_{ave} = V_{rms}I_{rms}$

$1\,216,83 = 220,62\ I_{rms}$ ✓ ✓ Any one

$I_{rms} = 5,515$ A

$I_{rms} = \frac{I_{max/maks}}{\sqrt{2}}$

$5,515 = \frac{I_{max/maks}}{\sqrt{2}}$ ✓ ∴ $I_{max} = 7,8$ A ✓

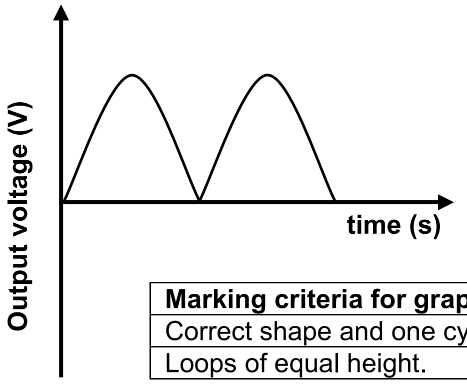
(4)
[12]

QUESTION 15

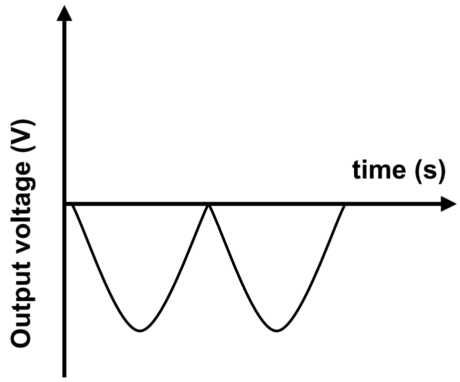
15.1.1 DC ✓ (1)

15.1.2 Emf is induced as a result of the rate of change of magnetic flux linked ✓✓ with the coil. (2)

15.1.3



OR



Marking criteria for graph:	
Correct shape and one cycle.	✓
Loops of equal height.	✓

(2)

15.2.1 The AC potential difference/voltage ✓ that produces the same amount of electrical energy as an equivalent DC potential difference/voltage. ✓ (2)

15.2.2

OPTION 1

$W = \frac{V^2}{R}\Delta t$ ✓

$500 = \frac{V^2}{200}(10)$ ✓

$V = V_{rms} = 100$ V

OPTION 2

$W = I^2R\Delta t$ ✓

$500 = I^2(200)(10)$

$I = I_{rms} = 0,5$ A

$P_{ave} = V_{rms}I_{rms}$

$\frac{500}{10} = V_{rms}(0,5)$✓

$V_{rms} = 100$ V

OPTION 3

$P_{ave} = I^2_{rms}R$ ✓

$\frac{500}{10} = I^2_{rms}(200)$

$I_{rms} = 0,5$ A

$P_{ave} = V_{rms}I_{rms}$

$\frac{500}{10} = V_{rms}(0,5)$ ✓ ∴ $V_{rms} = 100$ V

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ ∴ $100 = \frac{V_{max}}{\sqrt{2}}$ ✓ ∴ $V_{max} = 141,42$ V✓

(5)
[12]

QUESTION 16

16.1.1 (DC) motor ✓ (1)

16.1.2 Electrical to mechanical/kinetic (energy). (2)

16.1.3 Split ring/commutator (1)

16.1.4 Anticlockwise (2)

16.2.1 The AC voltage/potential difference which dissipates the same amount of energy/heat/power as an equivalent DC voltage/potential difference. ✓✓ (2)

16.2.2

OPTION 1

$$P_{ave} = \frac{V_{rms}^2}{R} ✓$$
$$200 = \frac{220^2}{R} ✓$$
$$R = 242\ \Omega ✓$$

OPTION 2

$$P_{ave} = V_{rms}I_{rms} ✓$$
$$200 = I_{rms}(220)$$
$$I_{rms} = 0{,}909\ A$$
$$R = \frac{V_{rms}}{I_{rms}}$$
$$= \frac{220}{0{,}909} ✓$$
$$= 242\ \Omega ✓$$

OPTION 3

$$P_{ave} = V_{rms}I_{rms} ✓$$
$$200 = I_{rms}(220)$$
$$I_{rms} = 0{,}909\ A$$
$$P_{ave} = I_{rms}^2 R$$
$$200 = (0{,}909)^2 R ✓$$
$$R = 242\ \Omega ✓$$

(3)

16.2.3

OPTION 1

$$W = \frac{V^2\Delta t}{R} ✓✓$$
$$= \frac{(150^2)(10x60) ✓}{242 ✓}$$
$$= 55\ 785{,}12\ J ✓$$

OPTION 5

$$P_{ave} = \frac{V_{rms}^2}{R} ✓$$
$$= \frac{150^2}{242} ✓$$
$$= 92{,}975\ W$$
$$P_{ave} = I_{rms}^2 R$$
$$92{,}975 = I_{rms}^2(242)$$
$$I_{rms} = 0{,}6198\ A$$
$$W = I^2R\Delta t ✓$$
$$= (0{,}6198)^2(242)(10)(60) ✓$$
$$= 55\ 778{,}88\ J ✓$$

OPTION 2

$$P_{ave} = \frac{V_{rms}^2}{R} ✓$$
$$= \frac{150^2}{242} ✓$$
$$= 92{,}975\ W$$
$$P = \frac{W}{\Delta t} ✓$$
$$92{,}975 = \frac{W}{(10)(60)} ✓$$
$$W = 55\ 785{,}12\ J ✓$$

OPTION 3

$$R = \frac{V_{rms}}{I_{rms}} ✓$$
$$242 = \frac{150}{I_{rms}} ✓$$
$$I_{rms} = 0{,}620\ A$$
$$P_{ave} = I_{rms}V_{rms}$$
$$= (0{,}62)(150)$$
$$= 92{,}97\ W$$
$$P = \frac{W}{\Delta t} ✓$$
$$92{,}975 = \frac{W}{(10)(60)} ✓$$
$$W = 55\ 785{,}12\ J ✓$$

OPTION 4

$$R = \frac{V_{rms}}{I_{rms}} ✓$$
$$242 = \frac{150}{I_{rms}} ✓$$
$$I_{rms} = 0{,}620\ A$$

W = $I^2R\Delta t$ ✓
= $(0{,}62)^2(242)(10)(60)$ ✓
= 55 814,88 J ✓
(55 785,12 – 55 896 J)
OR/*OF*
W = $VI\Delta t$
= (150)(0,62)(600)
= 55 800 J

(5)
[16]

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS

QUESTION 1

1.1 The minimum frequency of light needed to emit electrons ✓ from the surface of a metal. ✓ (2)

1.2

$$\left.\begin{aligned} &E = W_o + E_{k(max)} \\ &E = W_o + \frac{1}{2}mv_{max}^2 \\ &h\frac{c}{\lambda} = hf_o + \frac{1}{2}mv_{max}^2 \end{aligned}\right\} ✓\text{Any one}$$

$$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{\lambda} ✓ = (6{,}63 \times 10^{-34})(5{,}548 \times 10^{14}) ✓ + \frac{1}{2}(9{,}11\times10^{-31})(5{,}33\times10^{5})^2 ✓$$

$\lambda = 4 \times 10^{-7}$ m ✓ (5)

1.3 Smaller (less) than ✓ (1)

1.4 The wavelength/frequency/energy of the incident light/photon is constant. ✓
Since the speed is higher, the kinetic energy is higher ✓ and the work function / W_0 / threshold frequency smaller. ✓ (3)
[11]

QUESTION 2

2.1 The minimum energy needed to emit an electron ✓ from (the surface of) a metal. ✓ (2)

2.2
$$\left.\begin{array}{l} E = W_0 + \frac{1}{2}mv^2_{max} \\ h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv^2_{max} \end{array}\right\} \text{Any ONE OF/}\textit{ENIGE EEN van}✓$$

$$\frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{(\lambda)} = (3{,}36 \times 10^{-19})✓ + 2{,}32 \times 10^{-19}✓$$

$\lambda = 3{,}50 \times 10^{-7}$ m✓ (4)

2.3
$$\left.\begin{array}{l} E = W_0 + \frac{1}{2}mv^2_{max} \\ \textbf{OR/}\textit{\textbf{OF}} \\ h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv^2_{max} \end{array}\right\} ✓$$

$$\frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{(3{,}50 \times 10^{-7})}✓ = (3{,}65 \times 10^{-19})✓ + E_k$$

$E = 2{,}03 \times 10^{-19}$ J✓ (4)

2.4.1 Increasing the intensity does not change the energy / frequency / wavelength of the incident photons. ✓
OR: The energy of a photon remains unchanged (for the same frequency). (1)

2.4.2 Increases ✓ (1)

2.4.3 More photons/packets of energy strike the surface of the metal per unit time. ✓ Hence more (photo) electrons ejected per unit time ✓ leading to increased current. (2)

[14]

QUESTION 3

3.1.1 The particle nature of light. ✓ (1)

3.1.2 Shorter wavelength means higher photon energy. ✓

Photon energy is inversely proportional to wavelength ✓ ($E = \frac{hc}{\lambda}$).

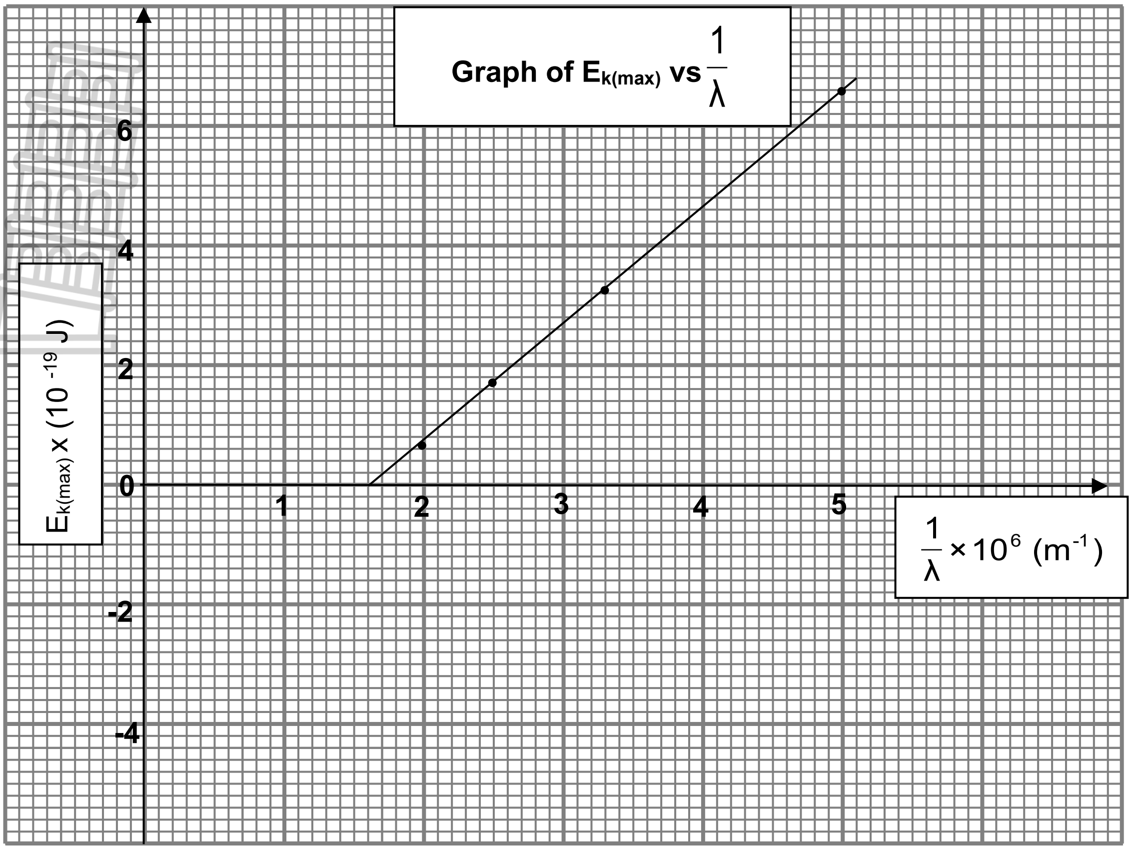
For the same metal, kinetic energy is proportional to photon energy. (2)

<table>
<tr><td>3.2.1</td><td><u>OPTION 1</u>
$W_o = h\frac{c}{\lambda}$ ✓ $= \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)✓}{330 \times 10^{-9}✓}$
∴ $W_o = 6{,}03 \times 10^{-19}$ J ✓</td><td><u>OPTION 2</u>
$c = f\lambda$ ∴ $3 \times 10^8 = f_o(330 \times 10^{-9})$ ✓
∴ $f_o = 9{,}09 \times 10^{14}$ Hz
$W_o = hf_o$ ✓ for both equations
$= (6{,}63 \times 10^{-34})(9{,}09 \times 10^7)$ ✓
$= 6{,}03 \times 10^{-19}$ J ✓</td><td>(4)</td></tr>
<tr><td>3.2.2</td><td colspan="2"><u>OPTION 1</u>
$\left.\begin{array}{l} E = W_o + E_k \\ hf = hf_o + E_k \\ hf = hf_o + \frac{1}{2}mv^2 \\ E = W_o + \frac{1}{2}mv^2 \end{array}\right\}$ ✓ Any one
$(6{,}63 \times 10^{-34})(1{,}2 \times 10^{15})$ ✓ $= (6{,}03 \times 10^{-19})$ ✓ $+ \frac{1}{2}(9{,}11 \times 10^{-31})v^2$ ✓ ∴ $v = 6{,}5 \times 10^5$ m·s^{-1} ✓</td><td></td></tr>
<tr><td></td><td colspan="2"><u>OPTION 2</u>
$\left.\begin{array}{l} E_K = E_{light} - W_o \\ \quad = hf_{light} - hf_o \end{array}\right\}$ ✓ Any one
$= (6{,}63 \times 10^{-34})(1{,}2 \times 10^{15})$ ✓ $- 6{,}03 \times 10^{-19}$ ✓ $= 1{,}926 \times 10^{-19}$ J
$E_K = \frac{1}{2}mv^2$ ∴ $1{,}926 \times 10^{-19} = \frac{1}{2}(9{,}11 \times 10^{-31})v^2$✓ ∴ $v = 6{,}5 \times 10^5$ m·s^{-1} ✓</td><td>(5)
[12]</td></tr>
</table>

QUESTION 4

4.1 It is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident/shines on it. ✓✓ (2)

4.2



Criteria for drawing line of best fit:	
ALL points correctly plotted (at least 3 points)	✓✓
Correct line of best fit if all plotted points are used.	✓

(3)

4.3.1

OPTION 1

$\frac{1}{\lambda} = 1{,}6 \times 10^6$ m^{-1} ✓ (**Accept** 1,6 x 10^6 m^{-1} to 1,7 x 10^6 m^{-1})

$f_o = c\frac{1}{\lambda}$ ✓ = (3 x 10^8)(1,6 x 10^6) ✓ = 4,8 x 10^{14} Hz ✓ (**Accept** 4,8 x 10^{14} Hz to 5,1 x 10^{14} Hz)

OPTION 2

By extrapolation: y-intercept = $-W_o$

$W_o = hf_o$ ✓

3,2 x 10^{-19}✓ = (6,63 x 10^{-34})f_o ✓

f_o = 4,8 x 10^{14} Hz ✓ (**Accept** 4,8 x 10^{14} Hz to 4,83 x 10^{14} Hz)

OPTION 3 **(**Points from the graph**)**

$E = W_o + E_{k(max)}$ ∴ $\frac{hc}{\lambda} = hf_0 + E_{k(max)}$ ✓

(6,63 x 10^{-34})(3 x 10^8)(1,6 x 10^6) ✓ = (6,63 x 10^{-34})f_0 + 0 ✓ ∴ f_o = 4,8 x 10^{14} Hz ✓

OR 6,63 x 10^{-34})(3 x 10^8)(5 x 10^6) ✓ = (6,63 x 10^{-34})f_0 + 6,6 x 10^{-19} ✓ ∴ f_o = 4,92 x 10^{14} Hz ✓

OR 6,63 x 10^{-34})(3 x 10^8)(3,3 x 10^6) ✓ = (6,63 x 10^{-34})f_0 + 3,3 x 10^{-19} ✓ ∴ f_o = 4,8 x 10^{14} Hz ✓

OR 6,63 x 10^{-34})(3 x 10^8)(2,5 x 10^6) ✓ = (6,63 x 10^{-34})f_0 + 1,7 x 10^{-19} ✓ ∴ f_o = 4,94 x 10^{14} Hz ✓

OR 6,63 x 10^{-34})(3 x 10^8)(2,2 x 10^6) ✓ = (6,63 x 10^{-34})f_0 + 0,7 x 10^{-19} ✓ ∴ f_o = 5,54 x 10^{14} Hz ✓ (4)

4.3.2

OPTION 1

hc = gradient ✓ = $\frac{\Delta y}{\Delta x} = \frac{6{,}6 \times 10^{-19}}{(5 - 1{,}6) \times 10^6}$ ✓

= 1,941 x10^{-25} (J·m)

$h = \frac{\text{gradient}}{c} = \frac{1{,}941 \times 10^{-25}}{3 \times 10^8}$ ✓

= 6,47 x10^{-34} J·s ✓

OPTION 2

$\left.\begin{aligned} W_0 &= \text{y intercept} \\ &= 3{,}2 \times 10^{-19}\ \text{J} \end{aligned}\right\}$ ✓

Accept: 3,2 x10^{-19} J to 3,4 x10^{-19}J

$W_o = hf_o$

3,2 x 10^{-19} ✓ = h(4,8 x 10^{14}) ✓

h = 6,66 x 10^{-34} J·s✓

Accept: 6,66 x10^{-34} J·s to 7,08 x10^{-34}J·s)

OPTION 3 (Points from the graph)

$\frac{hc}{\lambda} = W_0 + E_{k(max)}$ = 3,2 x 10^{-19} ✓+ 6,6 x 10^{-19} ✓

$h = \frac{9,8 \times 10^{-19}}{(3 \times 10^8)(5 \times 10^6)}$ ✓ = 6,53 x 10^{-34} J·s ✓

OR

$\frac{hc}{\lambda} = W_0 + E_{k(max)}$ = 3,2 x 10^{-19} ✓+ 3,3 x 10^{-19} ✓

$h = \frac{6,5 \times 10^{-19}}{(3 \times 10^8)(3,3 \times 10^6)}$ ✓ = 6,57 x 10^{-34} J·s ✓

OR

$\frac{hc}{\lambda} = W_0 + E_{k(max)}$ = 3,2 x 10^{-19} ✓+ 1,7 x 10^{-19} ✓

$h = \frac{4,7 \times 10^{-19}}{(3 \times 10^8)(2,5 \times 10^6)}$ ✓ = 6,27 x 10^{-34} J·s ✓

OPTION 4

$W_0 = \frac{hc}{\lambda}$ ✓

3,2 x 10^{-19} ✓= h(3 x 10^8)(1,6 x 10^6)✓

h = 6,66 x 10^{-34} J·s ✓

(4)
[13]

QUESTION 5

5.1 The minimum energy needed to emit electrons ✓ from the surface of a certain metal. ✓ (2)

5.2 Frequency/Intensity ✓ (1)

5.3 The minimum frequency (of a photon/light) needed to emit electrons ✓ from the surface of a certain metal. ✓ (2)

5.4 $E = W_0 + E_k$, $hf = hf_0 + E_k$ ✓ Any one/*Enige een*

$(6,63 \times 10^{-34})(6,50 \times 10^{14})$✓$=(6,63 \times 10^{-34})(5,001 \times 10^{14})$ ✓+ ½$(9,11 \times 10^{-31})v^2$✓

$\therefore$ v= 4,67 x 10^5 m·s^{-1}✓

OR/OF

$E_K = E_{light} - W_o$, $= hf_{light} - hf_o$ ✓ Any one/*Enige een*

= (6,63 x 10^{-34})(6,50 x 10^{14} - 5,001 x 10^{14}) ✓

= 9,94 x 10^{-20} J

E_K = ½ mv^2 ✓

$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{(2)(9,94 \times 10^{-20})}{9,11 \times 10^{-31}}}$✓

v = 4,67 x 10^5 m·s^{-1} ✓ (5)

5.5 The photocurrent is directly proportional to the intensity of the incident light. ✓✓ (2)
[12]

QUESTION 6

6.1.1 Light has a particle nature. ✓ (1)

6.1.2 Remains the same. ✓
For the same colour/ frequency/wavelength the energy of the photons will be the same. ✓
(The brightness causes more electrons to be released, but they will have the same maximum kinetic energy.)
OR Maximum kinetic energy of ejected photo-electrons is independent of intensity of radiation. (2)

6.1.3 $E = W_0 + E_k$ **OR** $hf = hf_0 + E_k$ **OR** $hf = hf_0 + ½ mv^2$ **OR** $E = W_0 + ½ mv^2$

$\frac{(6,63 \times 10^{-34})(3 \times 10^8)}{420 \times 10^{-9}}$ ✓$= \frac{(6,63 \times 10^{-34})(3 \times 10^8)}{\lambda_o}$ ✓ + $\frac{1}{2}(9,11 \times 10^{-31})(4,76 \times 10^5)^2$ ✓

$\therefore$ λ_o = 5,37 x 10^{-7} m $\therefore$ the metal is sodium ✓ (5)

6.2 **Q** ✓ and **S** ✓
Emission spectra occur when excited atoms /electrons drop from higher energy levels to lower energy levels. ✓✓ (Characteristic frequencies are emitted.) (4)
[12]

QUESTION 7

7.1.1 The minimum frequency of a photon/light needed ✓ to emit electrons from a certain metal surface. ✓ (2)

7.1. 2 Silver ✓
Threshold frequency / cut-off frequency (of Ag) is higher. ✓ and W_o α f_o / $W_o = hf_o$ ✓ (3)

7.1.3 Planck's constant ✓ (1)

7.1.4 Sodium ✓ (1)

7.2.1 Energy radiated per second by the blue light = $(\frac{5}{100})(60 \times 10^{-3})$ ✓ = 3×10^{-3} J·s^{-1}

$E_{photon} = \frac{hc}{\lambda}$ ✓ = $\frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{470 \times 10^{-9}}$ ✓ = $4{,}232 \times 10^{-19}$ J

Total number of photons incident per second = $\frac{3 \times 10^{-3}}{4{,}232 \times 10^{-19}}$ ✓ = $7{,}09 \times 10^{15}$ ✓ (5)

7.2.2 $7{,}09 \times 10^{15}$ (electrons per second) ✓
OR: Same number as that calculated in Question 7.2.1 above. (1)
[13]

QUESTION 8

8.1 It is the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident/shines on that surface. ✓✓ (2)

8.2 Increase ✓
Increase in intensity means that for the same frequency the number of photons incident per unit time increase. ✓ Therefore the number of electrons ejected per unit time increases. ✓ (3)

8.1.3

OPTION 1

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14})$ ✓ = $\frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{\lambda_0} + 2{,}9 \times 10^{-19}$

$39{,}117 \times 10^{-20} - 2{,}9 \times 10^{-19} = \frac{19{,}89 \times 10^{-26}}{\lambda_o}$ $\therefore \lambda_o = 1{,}97 \times 10^{-6}$ m ✓

OPTION 2

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$((6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14})$ ✓ = $(6{,}63 \times 10^{-34})f_0 + 2{,}9 \times 10^{-19}$ $\therefore f_o = 1{,}52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ $\therefore$ $3 \times 10^8 = (1{,}52 \times 10^{14})\lambda_0$ ✓ $\therefore$ $\lambda_o = 1{,}97 \times 10^{-6}$ m ✓

OPTION 3

$E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6{,}63 \times 10^{-34} \times 5{,}9 \times 10^{14})$ ✓ = $W_o + 2{,}9 \times 10^{-19}$ $\therefore W_o = 1{,}01 \times 10^{-19}$ J

$W_o = hf_o$ $\therefore$ $1{,}01 \times 10^{-19} = (6{,}63 \times 10^{-34})f_o$ $\therefore f_o = 1{,}52 \times 10^{14}$ Hz

$c = f_o\lambda_o$ $\therefore$ $3 \times 10^8 = (1{,}52 \times 10^{14})\lambda_0$ ✓ $\therefore$ $\lambda_o = 1{,}97 \times 10^{-6}$ m ✓ (5)

8.4 From the photo-electric equation, for a constant work function, ✓ the energy of the photons is proportional to the maximum kinetic energy of the photoelectrons. ✓ (2)
[12]

QUESTION 9

9.1 The minimum frequency of light ✓needed to emit electrons from the surface of a metal. ✓ (2)

9.2 The speed remains unchanged. ✓ (1)

9.3

OPTION 1

$c = f\lambda$ ✓

$\therefore$ $3 \times 10^8 = f(6 \times 10^{-7})$ ✓

$\therefore$ $f = 5 \times 10^{14}$ Hz ✓

The value of f is less than the threshold frequency of the metal, ✓ therefore photoelectric effect is not observed. ✓

OPTION 2

For the given metal: $W_0 = hf_0$ ✓ = $(6{,}63 \times 10^{-34})(6{,}8 \times 10^{14})$ ✓ = $4{,}51 \times 10^{-19}$ J

For the given wavelength:

$E_{photon} = \frac{hc}{\lambda} = \frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{6 \times 10^{-7}}$ ✓ **OR** $E_{photon} = hf = (6{,}63 \times 10^{-34})(5 \times 10^{14})$ ✓✓

$= 3{,}32 \times 10^{-19}$ J $= 3{,}32 \times 10^{-19}$ J

Energy is less than work function ✓ of metal, therefore photoelectric effect not observed.✓ (5)

9.4 $E = W_0 + E_{k(max)}$ **OR** $E = W_0 + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = hf_0 + \frac{1}{2}mv^2_{max}$ **OR** $hf = hf_0 + \frac{1}{2}mv^2_{max}$

$\underline{(6{,}63 \times 10^{-34})(7{,}8 \times 10^{14})}$ ✓ = $\underline{(6{,}63 \times 10^{-34})(6{,}8 \times 10^{14})}$ ✓ + $\frac{1}{2}mv^2_{max}$

$\frac{1}{2}mv^2_{max} = 6{,}63 \times 10^{-20}$ J thus $\frac{1}{2}(9{,}11 \times 10^{-31})v^2_{max}$ ✓ $= 6{,}63 \times 10^{-20}$ ∴ $v_{max} = 3{,}82 \times 10^5$ m·s^{-1} ✓ (5)

[13]

QUESTION 10

10.1.1 (Line) emission (spectrum) ✓ (1)

10.1.2 (Line) absorption (spectrum) ✓ (1)

10.2.1 Emission ✓ (1)

10.2.2 Energy released in the transition from E_4 to $E_2 = E_4 – E_2$

$E_4 – E_2 = (2{,}044 \times 10^{-18} – 1{,}635 \times 10^{-18})$ ✓ $= 4{,}09 \times 10^{-19}$ J

$E = hf$ ✓ ∴ $\underline{4{,}09 \times 10^{-19} = (6{,}63 \times 10^{-34})f}$ ✓ ∴ $f = 6{,}17 \times 10^{14}$ Hz ✓ (4)

10.2.3 $E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$4{,}09 \times 10^{-19}$ ✓ = $\underline{(6{,}63 \times 10^{-34})(4{,}4 \times 10^{14})}$ ✓ + $E_{k(max)}$ ∴ $E_{k(max)} = 1{,}17 \times 10^{-19}$ J ✓

OR

$\left.\begin{aligned} E_{k(max)} &= E_{light} – W_o \\ &= hf_{light} – hf_o \end{aligned}\right\}$ ✓ Any one

$= \underline{(6{,}63 \times 10^{-34})(6{,}17 \times 10^{14})}$ ✓ - $\underline{(6{,}63 \times 10^{-34})(4{,}4 \times 10^{14})}$ ✓ $= 1{,}17 \times 10^{-19}$ J ✓ (4)

10.2.4 No ✓

The threshold frequency is greater than the frequency of the photon. ✓

OR: The frequency of the photon is less than the threshold frequency.

OR: Energy of the photon is less than the work function of the metal. (2)

[13]

QUESTION 11

11.1.1 Greater than ✓

Electrons are ejected from the metal plate. ✓ (2)

11.1.2 Increase in intensity implies that, for the same frequency, the number of photons per second increases (ammeter reading increases), ✓ but the energy of the photons stays the same. ✓ Therefore the statement is incorrect.

OR An increase in energy of photons only increases kinetic energy of the photoelectrons and not the number of photoelectrons, thus the ammeter reading will not change. (2)

11.1.3 Light has a particle nature. ✓ (1)

11.2.1 The minimum frequency needed for the emission of electrons from the surafce of a metal. ✓✓ (2)

11.2.2 $W_o = hf_o$ ✓

$= (6{,}63 \times 10^{-34})(5{,}73 \times 10^{14})$ ✓

$= 3{,}8 \times 10^{-19}$ J ✓ (3)

11.2.3 $E = W_o + E_{k(max)}$ **OR** $hf = hf_o + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2$ **OR** $E = W_o + \frac{1}{2}mv^2$ ✓

$(6{,}63 \times 10^{-34})f = 3{,}8 \times 10^{-19} + [\frac{1}{2}(9{,}11\ 10^{-31})(4{,}19 \times 10^5)^2]$ ✓

$f = 9{,}94 \times 10^{14}$ Hz ✓ (3)

[13]

QUESTION 12

12.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

12.2 (Maximum) kinetic energy of the ejected electrons ✓ (1)

12.3 Wavelength/Frequency (of light) ✓ (1)

12.4 Silver✓

According to Photoelectric equation, $hf = W_o + \frac{1}{2}mv^2$

<u>(For a given constant frequency), as the work function increases the kinetic energy decreases.</u>✓

<u>Silver has the smallest kinetic energy</u>✓ and hence the highest work function. (3)

12.5 $hf = W_o + \frac{1}{2}mv^2_{max/maks}$ **OR** $h\frac{c}{\lambda} = W_o + E_{k(max/maks)}$ ✓

$\frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{2 \times 10^{-8}}$ ✓ $= W_o + 9{,}58 \times 10^{-18}$ ✓

$9{,}945 \times 10^{-18} = W_o + 9{,}58 \times 10^{-18}$

∴ $W_o = 3{,}65 \times 10^{-19}$ J ✓ (4)

12.6 Remains the same ✓

Increasing intensity increases number of photons (per unit time), but frequency stays constant ✓ and energy of photon is the same. ✓ Therefore the kinetic energy does not change. (3)

[14]

QUESTION 13

13.1 The minimum energy needed to eject electrons ✓ from the surface of a certain metal. ✓ (2)

13.2 Potassium / K ✓

f_o for potassium is greater than f_o for caesium ✓

OR

Work function is <u>directly proportional</u> to threshold frequency ✓ (2)

13.3

<u>OPTION 1</u>

$c = f\lambda$ ✓ ∴ $\underline{3 \times 10^8 = f(5{,}5 \times 10^{-7})}$ ✓ ∴ $f = 5{,}45 \times 10^{14}$ Hz ∴ $f_{uv} < f_{o \text{ of K(potassium)}}$

∴Ammeter in circuit **B** will not show a reading ✓

<u>OPTION 2</u>

$E = \frac{hc}{\lambda} = \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{5{,}5 \times 10^{-7}} = 3{,}6164 \times 10^{-19}$ J

$W_o = hf_o$ ✓ $= (6{,}63 \times 10^{-34})(5{,}55 \times 10^{14})$ ✓$= 3{,}68 \times 10^{-19}$ J

$W_o > E$ or $hf_o > hf$ ∴The ammeter will not register a current ✓

<u>OPTION 3</u>

$c = f_o\lambda_o$ ✓

$3 \times 10^8 = (5{,}55 \times 10^{14})\lambda$ ✓

$\lambda_o = 5{,}41 \times 10^{-7}$ m

λ_o(threshold) < λ(incident) ∴ the ammeter will not register a current ✓ (3)

13.4

<u>OPTION 1</u>

$E = W_0 + E_{k(max)}$ ✓ **OR** $hf = hf_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$ ✓

$\frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{5{,}5 \times 10^{-7}}$ ✓ $= \underline{(6{,}63 \times 10^{-34})(5{,}07 \times 10^{14}) + E_{k(max)}}$ ✓

$E_K = 2{,}55 \times 10^{-20}$ J ✓✓ (Range: $2{,}52 \times 10^{-20} – 2{,}6 \times 10^{-20}$ J)

<u>OPTION 2</u>

$E = W_0 + E_{k(max)}$ **OR** $hf = hf_o + \frac{1}{2}mv^2_{max}$ **OR** $h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$ ✓

$(6{,}63 \times 10^{-34})(5{,}45 \times 10^{14})$ ✓✓ $= \underline{(6{,}63 \times 10^{-34})(5{,}07 \times 10^{14}) + E_{k(max)}}$ ✓

$E_K = 2{,}52 \times 10^{-20}$ J ✓ (Range: $2{,}52 \times 10^{-20} – 2{,}6 \times 10^{-20}$ J) (5)

13.5 Remains the same ✓ (1)

[13]

QUESTION 14

14.1 The minimum frequency of light needed to eject electrons from a metal surface. ✓✓ (2)

14.2

<u>OPTION 1/</u>

$E = h\frac{c}{\lambda}$ ✓

$= \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{5 \times 10^{-7}}$ ✓

$= 3{,}98 \times 10^{-19}$ J✓

<u>OPTION 2</u>

$c = f\lambda$

$3 \times 10^8 = f(5 \times 10^{-7})$ ✓Both

$f = 6 \times 10^{14}$ Hz

$E = hf$

$= (6{,}63 \times 10^{-34})(6 \times 10^{14})$ ✓

$= 3{,}98 \times 10^{-19}$ J✓ (3)

14.3

<u>OPTION 1</u>

$E = W_0 + E_{kmax}$

$hf = W_0 + \frac{1}{2}mv^2_{max}$

$h\frac{c}{\lambda} = W_0 + E_{K(max/maks)}$

$h\frac{c}{\lambda} = hf_0 + E_{K(max/maks)}$

✓Any one

$\underline{3{,}98 \times 10^{-19} = (6{,}63 \times 10^{-34})(5{,}55 \times 10^{14}) + E_{K(max)}}$ ✓

$E_{K(max)} = 3{,}0 \times 10^{-20}$ J ✓

$E_{K(max} > 0$ ✓

(The electrons emitted from the metal plate have kinetic energy to move between the plates, hence the ammeter registers a reading.)

OPTION 2
$W_o = hf_o$ ✓ = (6,63 x 10^{-34})(5,55 x10^{14}) ✓ = 3,68 x 10^{-19} J
$E_{photon} > W_o$ ✓
(The energy of the incident photon is greater than the work function of potassium. From the equation $hf = W_0 + E_{Kmax}$, the ejected photoelectrons will move between the plates, ✓ hence the ammeter registers a reading.) (4)

14.4 The increase in intensity increases the *number* of photons per second.✓
Since each photon releases one electron ✓ the number of ejected electrons per second increases.✓ (3)
[12]

QUESTION 15

15.1 The process whereby electrons are ejected from a metal surface ✓ when light of suitable frequency is incident/shines on the surface. ✓ (2)

15.2 7,48 x 10^{-19} (J) ✓
$E = W_0 + E_{kmax}$ ($= W_0 + ½mv^2_{max}$) ✓
When $E_k = 0$, $E = W_0$ ✓ (3)

15.3 Mass (of photo-electron) ✓ (1)

15.4 **OPTION 1**
Gradient = ½m ✓
$$\frac{11{,}98 \times 10^{-19} - 7{,}48 \times 10^{-19}}{X - 0} = ½(9{,}11 \times 10^{-31})$$ ✓ ✓ ✓
X = 0,9868 ✓ (0,99 or 9,87)

OPTION 2
$E = W_0 + ½mv^2_{max}$ ✓
11,98 x 10^{-19} ✓ = 7,48 x 10^{-19}✓ + ½(9,11 x 10^{-31}) v^2✓ [or ½(9,11 x 10^{-31})X]
4,5 x 10^{-19} = 4,56 x $10^{-31}v^2$
v^2 = 0,9868 x 10^{12}
X = 0,9868 ✓ (0,99) (5)

15.5.1 Remains the same ✓ (1)
15.5.2 Increases ✓ (1)
[13]

QUESTION 16

16.1 Photoelectric effect ✓ (1)
16.2 Work function (of potassium) ✓ (1)
16.3 Potassium ✓ It has the lowest work function / threshold frequency / highest threshold wavelength. ✓ (2)
16.4 The work function of a metal is the minimum energy that an electron (in the metal) needs ✓ to be emitted/ejected from the metal / surface. ✓ (2)

16.5.1 $W_o = hf_o$ ✓
= (6,63 x 10^{-34})(1,75 x 10^{15}) ✓
= 1,160 x 10^{-18} J ✓
OR/*OF*
$\left.\begin{array}{l} E = W_o + E_{k(max)} \\ hf = W_o + E_{k(max)} \end{array}\right\}$ ✓ Any one
(6,63 x 10^{-34})(1,75 x 10^{15}) = W_o + 0 ✓
W_o = 1,160 x 10^{-18} J ✓ (3)

16.5.2 $\left.\begin{array}{l} E = W_o + E_{k(max)} \\ hf = hf_o + ½mv^2_{max} \end{array}\right\}$ ✓Any one/
(6,63 x 10^{-34})f ✓ = 1,160 x 10^{-18} + ½(9,11 x 10^{-31}) (5,60 x 10^5)^2 ✓
∴ f = 1,97 x 10^{15} Hz ✓ (4)
[13]

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