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**PHYSICAL SCIENCES PAPER 1
TRIAL EXAMINATION 2021**

Time: 3 Hours + 10 min reading time
Examiner: K. Storm

Total: 200
Moderator: N. Lock

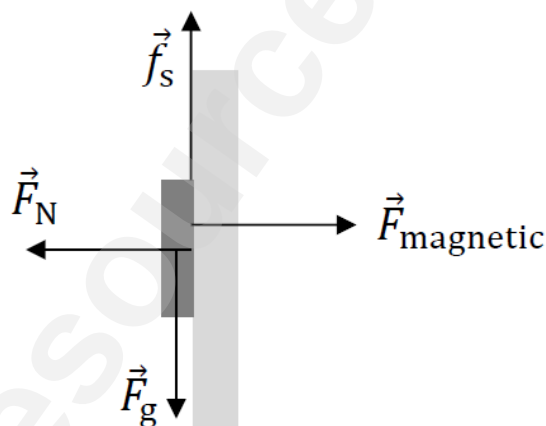
PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages, and a Data Sheet. Please check that your question paper is complete.
 2. Read the questions carefully.
 3. Answer ALL the questions.
 4. Start each question on a new page.
 5. Number your answers as the questions are numbered.
 6. Use the data and formulae whenever necessary.
 7. Show your working in all calculations.
 8. Units need not be included in the working calculations, but appropriate units should be shown in the answer.
 9. Answers must be expressed in decimal format, not left as proper fractions.
 10. Where appropriate, express answers to TWO decimal places.
 11. It is in your own interest to write legibly and to present your work neatly.
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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice grid on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

- 1.1 An object is falling at a constant speed near the surface of the earth. Which ONE of the following statements regarding this situation is TRUE?
- A The direction of the resultant force acting on the object is upward.
- B The direction of the resultant force acting on the object is downward.
- C There are no forces acting on the object.
- D The resultant force acting on the object is zero. (2)
- 1.2 A magnet is stuck on a fridge. The following force diagram shows all four forces acting on the magnet.



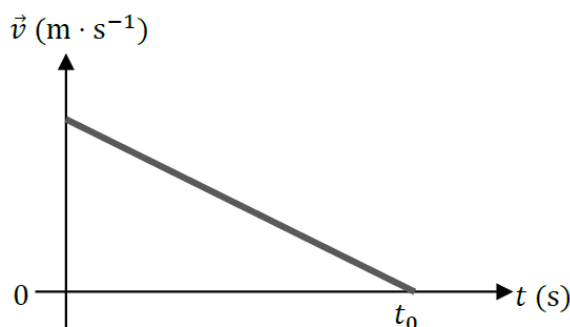
Consider the following two pairs of forces:

- (i) the normal force ($\vec{F}_N$) and the force of magnetic attraction ($\vec{F}_{\text{magnetic}}$)
- (ii) the gravitational force ($\vec{F}_g$) and the static frictional force ($\vec{f}_s$)

Which of the above pair(s) make up a Newton's third law action-reaction pair of forces?

- A (i) only
- B (ii) only
- C both (i) and (ii)
- D neither (i) nor (ii) (2)

- 1.3 The following velocity-time graph represents the motion of an object moving vertically through the air near the Earth's surface.



Use the graph to identify the positive direction of motion as well as the significance of time t_0 .

	Positive direction	At time t_0 the object...
A	up	... hits the ground
B	down	... hits the ground
C	up	... reaches a maximum height
D	down	... reaches a maximum height

(2)

- 1.4 Which ONE of the following statements is equivalent to Newton's Second Law of Motion? The net force experienced by an object is equal to...

- A the rate of change of momentum of that object
- B the change in momentum of that object.
- C the impulse experienced by the object.
- D the momentum of that object.

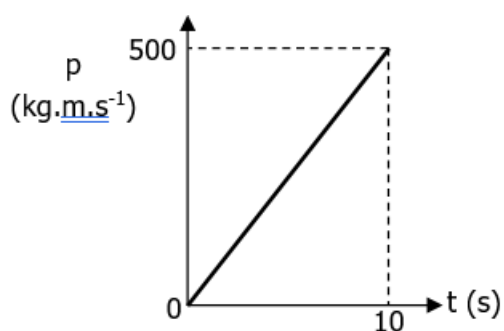
(2)

- 1.5 A book is pushed across a rough surface by a force of magnitude F while experiencing a frictional force of magnitude f . The average constant speed of the book is v . Which ONE of the following expressions gives the **rate at which the kinetic energy** of the book changes?

- A. $(F + f)v$
- B. $(F - f)v$
- C. $(-F - f)v$
- D. $(Fxf)v$

(2)

1.6 The graph shows how the momentum of a motorcycle changes with time.



What is the resultant force on the motorcycle?

- A 50 N B 500 N C 2500 N D 5000 N (2)

1.7 In the diagram below, Q is a negatively charged object.



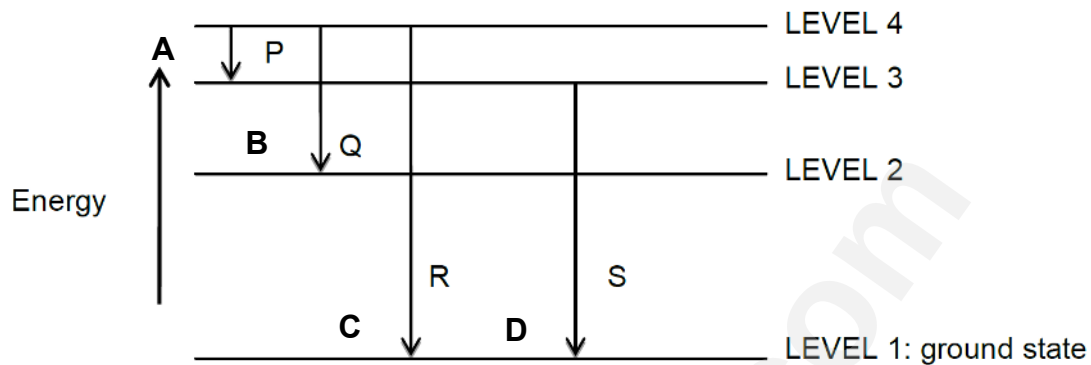
The direction of the electric field line at Point X is:

- A to the left
B up
C to the right
D down (2)

1.8 Two charges experience a force F when held a distance r apart. How would this force be affected if one charge is doubled, the other charge is tripled and the distance is halved?

- A 12 F
B 24 F
C 20 F
D 10 F (2)

- 1.9 The possible atomic transitions in an excited atom of an element are shown below. Which transition (A, B, C or D) will produce the spectral line with the longest wavelength?



(2)

- 1.10 A girl stands on a scale in a lift. When the lift is stationary, the scale reads 450 N. Later when the lift is in motion, the scale reading is 400 N at some stage. During this stage the lift could be moving ...

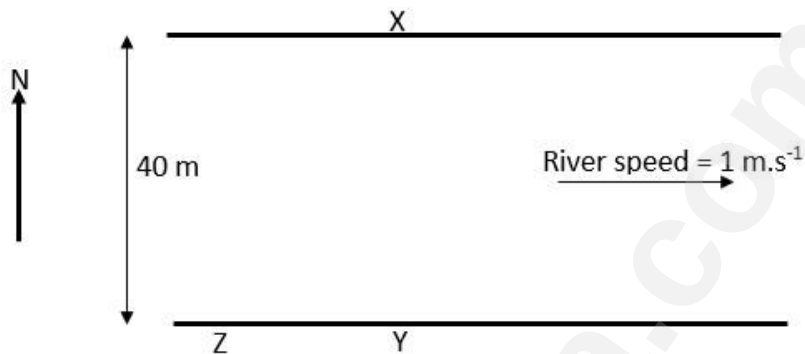
- A upwards with an increasing speed.
- B downwards with an increasing speed.
- C upwards with a constant speed.
- D downwards with a constant speed.

(2)

[2 x 10 = 20]

QUESTION 2

- 2.1 A river is flowing due East at 1 m.s^{-1} . Sam is practising river crossings in his canoe. His paddling speed in the canoe is 2 m.s^{-1} .



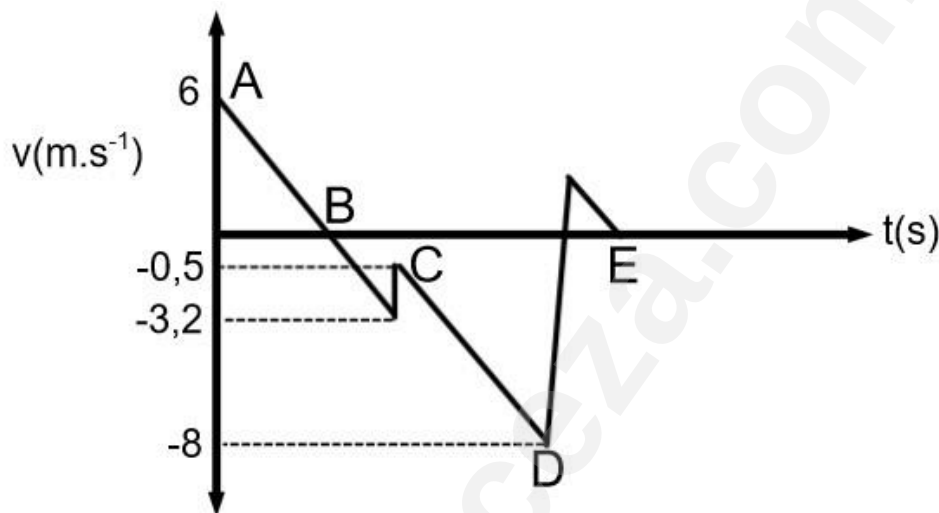
Sam wants to get from point X on the North bank to point Y which is 40 m directly opposite X on the South bank. In order to accomplish this, he paddles upstream towards point Z at 2 m.s^{-1} . Assume that the river banks are parallel in this section as shown.

- 2.1.1 Calculate the magnitude of his resultant velocity straight across the river. (2)
- 2.1.2 Calculate the **bearing** he must aim in, in order to end up at Y. (3)
- 2.1.3 Calculate the time taken for this journey. (3)
- 2.1.4 Calculate the distance between Z and Y. (3)
- 2.1.5 **TRUE or FALSE** : If the river was flowing East at 3 m.s^{-1} , then Sam (paddling at 2 m.s^{-1}) would be able to get from point X to point Y by aiming further upstream. (1)

- 2.2 A ball of mass **160 g** is thrown vertically upwards with a velocity of **6 m.s⁻¹** from a certain height above the ground.

On the way down the ball crashes through a thin horizontal glass pane and then continues downward, eventually bouncing on the ground.

The velocity-time sketch graph for the motion of the ball is shown below.

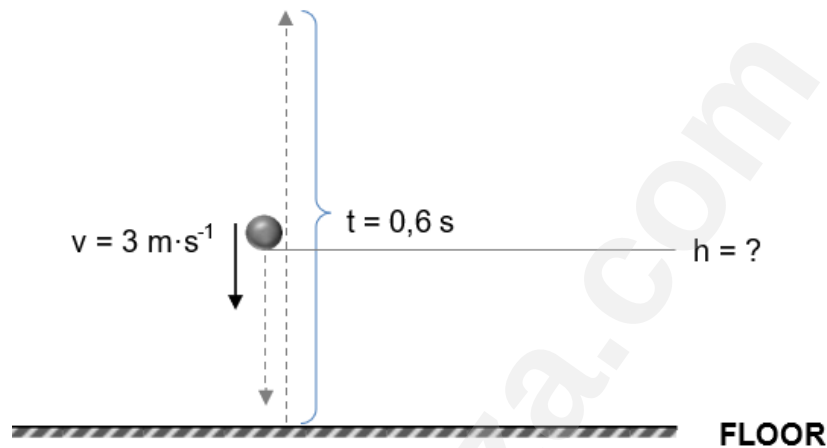


- 2.2.1 Write down the magnitude and direction of the acceleration of the ball when it reaches position B as indicated on the graph. (2)
- 2.2.2 Using equations of motion and the supplied information, calculate the distance between the pane of glass and the initial position from which the ball was thrown. (4)
- 2.2.3 Using equations of motion and the supplied information, calculate the time taken for the ball to travel from position C to position D. (4)
- 2.2.4 State the *work-energy theorem*. (2)
- 2.2.5 Calculate the net work done on the ball by the pane of glass. (4)

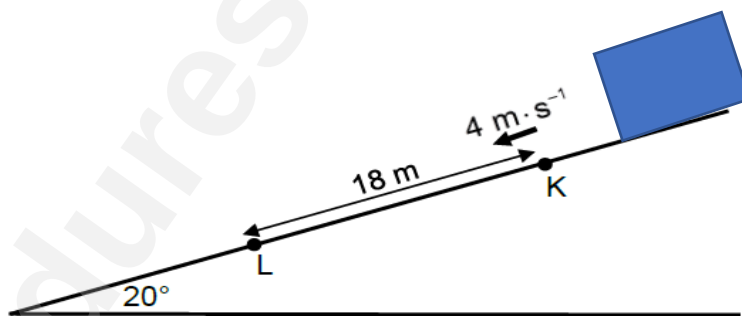
[28]

QUESTION 3

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



- 3.1.1 Calculate the speed with which the ball leaves the floor after bouncing. (3)
- 3.1.2 If the ball loses 5% of its kinetic energy during the bounce, use your answer from 3.1.1 to calculate the kinetic energy of the ball just before it hit the ground. (4)
- 3.1.3 Using energy principles, determine the height from which the girl threw the ball. (4)
- 3.2 A crate of mass 70 kg slides down a rough incline which is at an angle of 20° to the horizontal. The crate experiences a constant frictional force of 190 N.



The crate passes point K on the incline at a speed of $4 \text{ m} \cdot \text{s}^{-1}$ before passing point L 18 m lower down the incline

- 3.2.1 Draw a labelled free-body diagram of all the forces acting on the crate. (3)
- 3.2.2 Calculate the magnitude of the resultant force acting on the crate between point K and point L. (3)
- 3.2.3 Calculate the speed of the crate as it passes point L. (5)

[22]

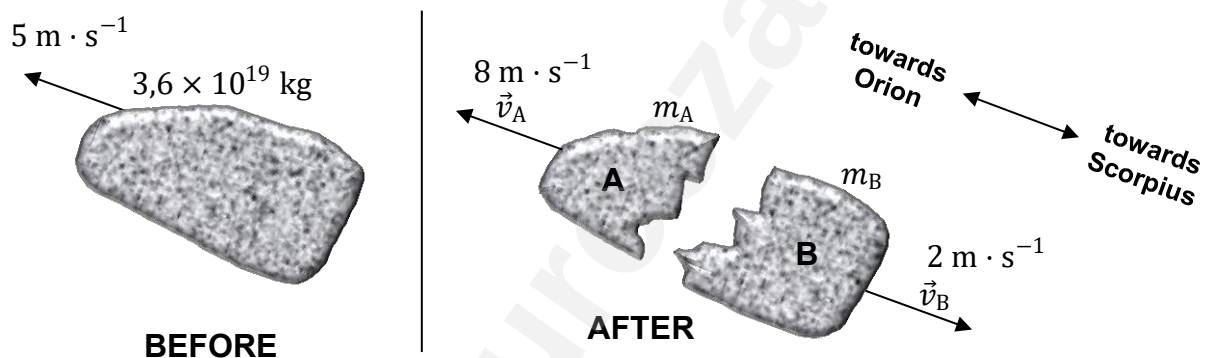
QUESTION 4

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

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

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

NB. All speeds are measured relative to the spaceship.



- 4.1 State, in words, the *principle of conservation of linear momentum*. (2)
- 4.2 Show that fragment A has a mass of $2,52 \times 10^{19} \text{ kg}$. (4)
- 4.3 Hence determine the impulse experienced by asteroid fragment A. (4)
- 4.4 The two fragments move apart from each other and after some time their centres of mass are 150 km apart. Calculate the magnitude of the gravitational force that the two asteroid fragments exert on each other. (4)

[14]

QUESTION 5

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

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



- 5.1 Calculate the skateboarder's gravitational potential energy at **A**. (3)
- 5.2 Calculate the work done by the frictional force exerted on the skateboarder as he moves from Point A to Point B. (4)
- 5.3 Calculate the work done by the gravitational force on the skateboarder as he moves from Point A to Point B. (3)
- 5.4 The skateboarder thinks about constructing an inclined plane to join Points A and B to provide an alternative route between these two points.



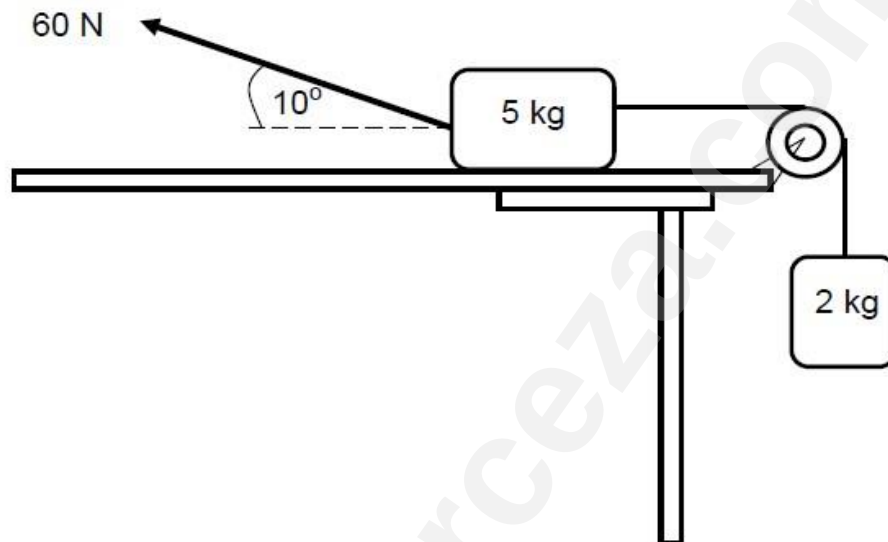
- 5.4.1 How would the work done by the gravitational force change if he were to roll from Point A to Point B along the inclined plane instead of following the curved track? Answer only INCREASES, DECREASES or REMAINS THE SAME. (1)
- 5.4.2 Explain your answer to QUESTION 5.4.1. (2)

[13]

QUESTION 6

A 5 kg block, resting on a rough horizontal table, is connected by a light inextensible string passing over a light frictionless pulley to another block of mass 2 kg. The 2 kg block hangs vertically as shown in the diagram below.

A force of **60 N** is applied to the 5 kg block at an angle of **10°** to the horizontal, causing the 5 kg block to accelerate to the **left**



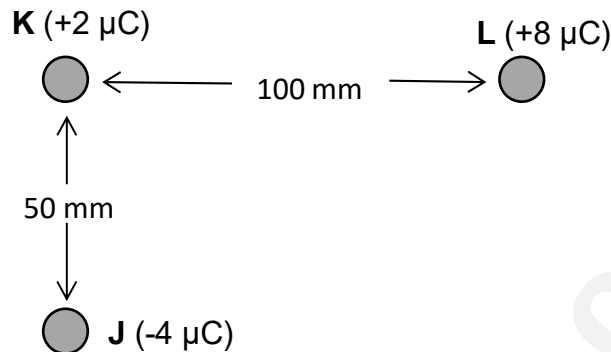
The coefficient of kinetic friction between the 5 kg block and the surface of the table is **0,5**. Ignore the effects of air resistance.

- 6.1 Draw a labelled free-body diagram showing ALL the forces acting on the 5 kg block. (5)
- 6.2 Calculate the magnitude of:
- 6.2.1 the vertical component of the 60 N force. (2)
- 6.2.2 the horizontal component of the 60 N force. (2)
- 6.3 State *Newton's Second Law of Motion* in words. (3)
- 6.4 Calculate the magnitude of the normal force acting on the 5 kg block. (3)
- 6.5 Calculate the magnitude of the force of friction acting on the 5 kg block. (3)
- 6.6 Calculate the acceleration of the system and the tension in the string connecting the two blocks. (6)

[24]

QUESTION 7

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

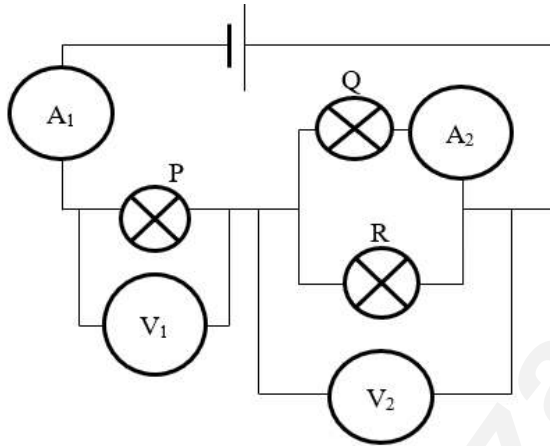


- 7.1.1 State *Coulomb's Law* in words. (2)
- 7.1.2 Calculate the magnitude of the electrostatic force between charges J and K. (4)
- 7.1.3 Draw a free-body diagram showing the electrostatic forces exerted on K due to charges J and L. Include F_{net} on your diagram. (3)
- 7.1.4 Calculate the magnitude and direction of the net electrostatic force exerted on K due to charges J and L. (6)
- 7.2 *Mars One* is an organisation based in the Netherlands that has put forward plans to land the first humans on Mars. They aim to establish a permanent human colony there by 2027, with no plan of returning to earth. The centre of Mars is an average distance of $2,25 \times 10^8$ km from the centre of Earth. Mars has a mass of $6,42 \times 10^{23}$ kg, and a radius of 3380 km. Earth has a mass of $5,98 \times 10^{24}$ and a radius of 6380 km.
- 7.2.1 State, in words, *Newton's Universal Law of Gravitation*. (2)
- 7.2.2 Calculate the magnitude of the gravitational force of attraction between Earth and Mars. (4)
- 7.2.3 Calculate the magnitude of the acceleration due to gravity on the surface of Mars. (4)
- 7.2.4 Calculate the magnitude of the gravitational force of Mars (weight) on a 500 kg spaceship when docked on the surface of Mars. (3)

[28]

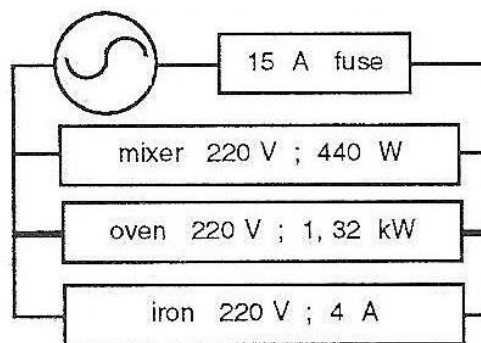
QUESTION 8

- 8.1 Define *resistance*. (2)
- 8.2 Three identical light bulbs are connected as shown. The internal resistance of the battery is negligible.



Give the ratio of...

- 8.2.1 voltage $V_1:V_2$ (2)
- 8.2.2 current $A_1:A_2$ (2)
- 8.2.3 power $P_P:P_Q$ (2)
- 8.3 In the photo, the mixer, the microwave and the iron are all connected to the same multi-plug. Next to the photo is a circuit diagram of the situation.

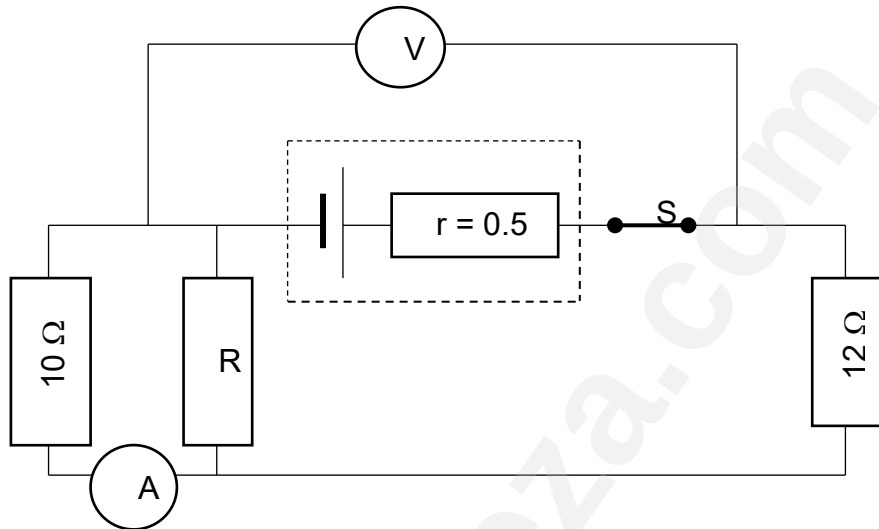


The fuse “blows” when the current exceeds 15 A.

- 8.3.1 Calculate the current in the mixer. (3)
- 8.3.2 Can all three items be used simultaneously?
Use applicable calculations to motivate your answer. (4)
- 8.3.3 The iron is used for 2 hours. What is the cost of the electricity used if the average cost per kWh-unit is 116,630 c/unit? (4)

- 8.4 A circuit is connected as shown in the diagram below. The resistance of R , which is connected in parallel with the $10\ \Omega$ resistor, is unknown. The internal resistance of the battery is $0.5\ \Omega$.

When switch S is closed, the reading on voltmeter V decreases from $45\ \text{V}$ to $43.5\ \text{V}$.



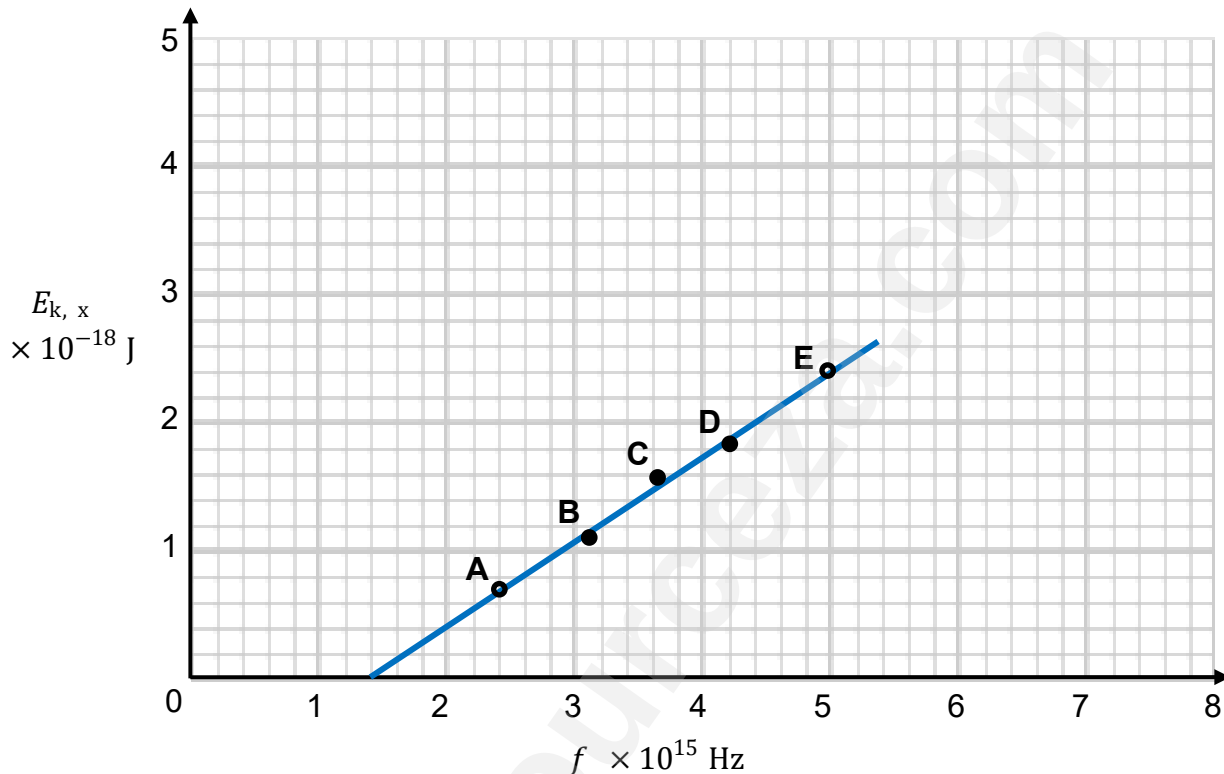
- 8.4.1 Calculate the lost volts. (1)
- 8.4.2 Calculate the current in the battery. (2)
- 8.4.3 Calculate the reading on ammeter A . Show all your calculations. (5)
- 8.4.4 Determine the resistance of resistor R . (3)
- 8.4.5 How will the reading on voltmeter V change if the resistor R burns out?
Explain your answer with the aid of an equation. (4)
- 8.5 Calculate the potential difference across a $20\ \Omega$ resistor through which 10^{18} electrons flow every $10\ \text{s}$. (5)

[39]

QUESTION 9

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

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



- 9.1 What does the gradient of the above graph represent? (1)
- 9.2 Define the term *threshold frequency*. (2)
- 9.3 Use the x -intercept of the graph in order to calculate the work function of the metal. (3)
- 9.4 In one of the experiments the brightness of one of the light sources was increased. How would this affect... (Answer only INCREASES, DECREASES or REMAINS THE SAME for both of the following sub questions.)
- 9.4.1 the number of electrons ejected per second? (1)
- 9.4.2 the kinetic energy of the ejected electrons? (1)
- 9.5 Calculate the speed of an ejected electron when light source E is used. (4)

[12]**TOTAL: 200**