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PRELIMINARY EXAMINATION
24 AUGUST 2020

PHYSICAL SCIENCES: PAPER I

Time: 3 hours

200 marks

Name: _____

Exam Number:

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PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages and a green DATA SHEET of 2 pages (i–ii). Please check that your question paper is complete.
2. Remove the DATA SHEET from the middle of this question paper.
3. Read the questions carefully.
4. ALL the questions in this paper must be answered.
5. Question 1 consists of 10 multiple-choice questions that must be answered on the Answer Sheet provided on the inside cover of your Answer Book.
6. **START EACH QUESTION ON A NEW PAGE.**
7. Please ensure that you number your answers as the questions are numbered.
8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
8. Answers must be expressed in decimal format, not left as proper fractions.
9. Use the data and formulae whenever necessary.
10. Show all the necessary steps in calculations.
11. Where appropriate, take your answers to TWO decimal places.
12. It is in your interest to write legibly and to present your work neatly.

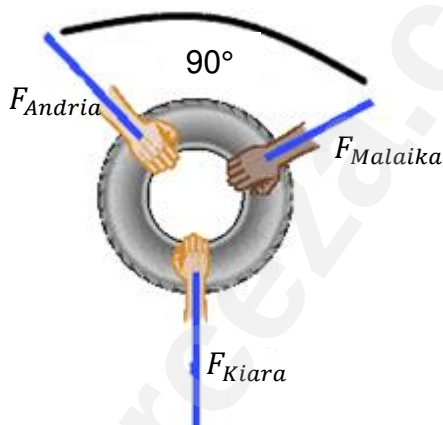
QUESTION 1 EENIE MEENIE MINY MO

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter of the option that you consider to be most correct. Every question has only one correct answer.

A	B	☒	D
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Here the answer C has been marked.

- 1.1 In a tug-of-war, Andria, Kiara, and Malaika pull horizontally on a car tyre as shown in the diagram. The tyre remains stationary despite the three pulls. Which one of the following correctly shows how to find the force that Kiara pulls with?

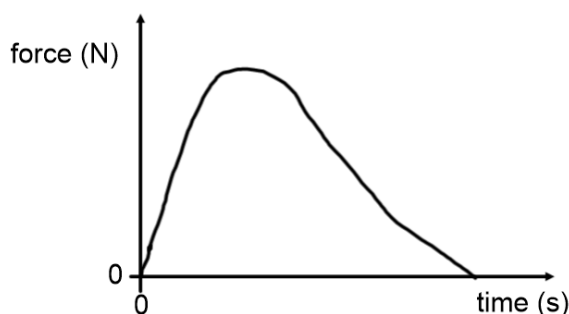


- A $F_{Kiara} = F_{Andria} + F_{Malaika}$
 B $\vec{F}_{Kiara} = \vec{F}_{Andria} + \vec{F}_{Malaika}$
 C $F_{Kiara} = F_{Andria}^2 + F_{Malaika}^2$
 D $\vec{F}_{Kiara} = \vec{F}_{Andria} - \vec{F}_{Malaika}$
- 1.2 A person throws an object of mass M straight up with an initial speed v . The object rises to a maximum height H above the launch point. The person now throws an object of mass $\frac{1}{2}M$ straight up with a speed of $2v$. In terms of H , to what maximum height does the object of mass $\frac{1}{2}M$ rise above the launch point? Ignore air resistance.
- A $4H$
 B $2H$
 C $\sqrt{2}H$
 D H

- 1.3 A fisherman hangs a fish on a scale which reads the weight of the fish in newtons. He climbs into a lift to go and hand his catch in for payment. While travelling in the lift, he notices that the scale reads less than its weight. This will happen when:

A the lift is at rest
 B the lift is moving downwards at a constant velocity
 C the lift has a constant acceleration upwards
 D the lift has a constant acceleration downwards

- 1.4 The graph shows how the force acting on a rocket varies with time.



What does the area under the graph represent?

A distance
 B change in kinetic energy
 C change in velocity
 D change in momentum

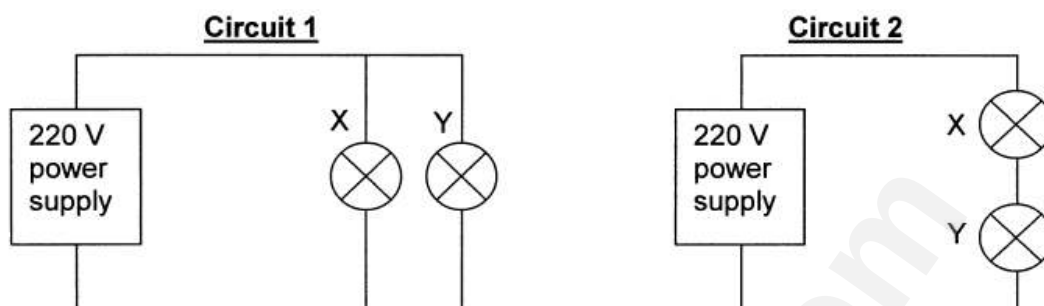
- 1.5 A gas molecule of mass m moving at velocity u collides at right angles with the side of a container and rebounds elastically. Which one of the following statements concerning the motion of the molecule is **incorrect**?

A The magnitude of the change in momentum of the molecule is zero.
 B The magnitude of the change in momentum of the molecule is $2mu$.
 C The force exerted by the molecule on the side of the container is equal to the force exerted by the container on the molecule.
 D The change in kinetic energy of the molecule is zero.

- 1.6 The magnitude of the gravitational force exerted by one body on another body is F when the distance between the centres of the two bodies is r . If the position of the object changes, the magnitude of the gravitational force becomes $\frac{9}{4}F$. What will the new distance between the centre of the bodies now be in terms of r ?

A $\frac{9}{4}r$
 B $\frac{4}{9}r$
 C $\frac{3}{2}r$
 D $\frac{2}{3}r$

- 1.7 Hanna has two light bulbs, **X** and **Y**, marked 100 W and 60 W respectively. She first connects them in parallel (circuit 1) and then in series (circuit 2) in order to compare their brightness in each circuit.



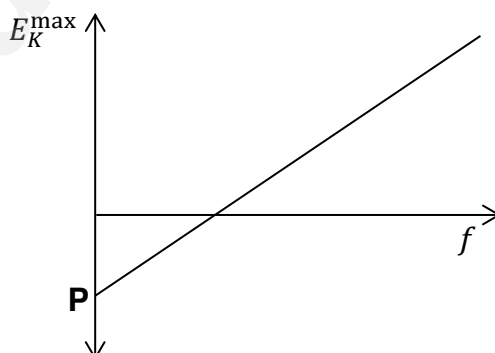
Which bulb, **X** or **Y**, glows brighter in each circuit?

	Circuit 1	Circuit 2
A	X	Y
B	Y	X
C	X	X
D	Y	Y

- 1.8 The device that converts electrical energy into mechanical energy is called a:

- A transformer
- B generator
- C motor
- D rectifier

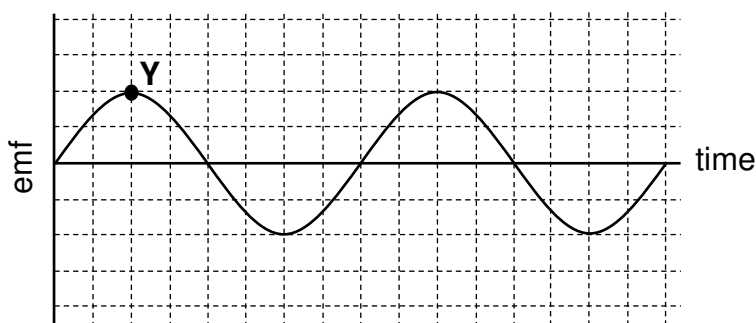
- 1.9 The graph below shows the relationship between **maximum kinetic energy** ($E_K^{\max}$) of the photoelectrons and frequency of incident photons during an experiment on the photoelectric effect.



What quantity does the point **P** represent?

- A negative maximum kinetic energy of photoelectron
- B negative work function
- C negative maximum frequency
- D negative threshold frequency

- 1.10 The induced emf produced by a generator vs. time for TWO full rotations of the armature is shown in the graph below.



Which one of the following combinations correctly shows the corresponding graph of magnetic flux vs. time as well as the position of the armature (as viewed from the slip rings) when the emf is at Y?

A

B

C

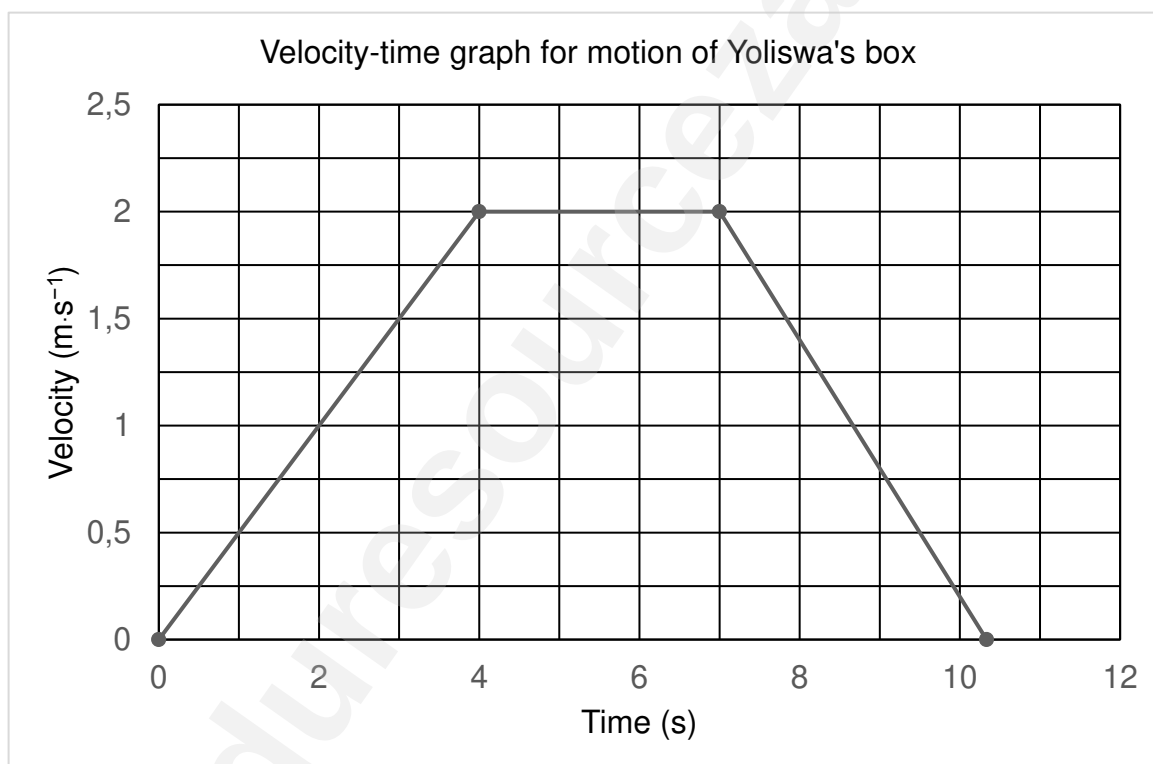
D

QUESTION 2 HOME IS WHERE YOUR POSITION IS ZERO

Yoliswa is pushing a box (mass 25 kg) in a straight line across the school hall floor applying a constant force **F** at an angle of 30° to the horizontal. She pushes the box across the frictionless floor from **W** to **X**, after which she stops pushing, and the box continues moving to **Y**. Then, at **Y**, the box moves onto a rough carpet.



The velocity-time graph below represents the motion from **W** to **Z**.



- 2.1 2.1.1 Define *acceleration*. (2)
- 2.1.2 Calculate the magnitude and direction of the acceleration during the first 4 seconds. (4)
- 2.1.3 Calculate the magnitude of the force **F**, applied by Yoliswa during the first 4 seconds. (4)
- 2.2 2.2.1 Define *distance*. (2)
- 2.2.2 Use the graph to calculate the length of the frictionless section. (4)

- 2.3 Sketch a position vs time graph of the motion of Yoliswa's box as it moves from **W** to **Z**. You do not need to include any calculated values on your graph but you must label positions **W** to **Z**. Choose point **Y** as your reference point. (4)
- 2.4 Arya and Jemma are also pushing boxes across the hall. Arya is pushing her box at a constant speed of $3 \text{ m} \cdot \text{s}^{-1}$ toward Jemma. When Arya is 15 m away from Jemma, Jemma accelerates at $0,22 \text{ m} \cdot \text{s}^{-1}$ from rest toward Arya. Calculate the time it takes Arya and Jemma to pass each other. (6)
- [26]**

QUESTION 3 AIR RESISTANCE IS A DRAG

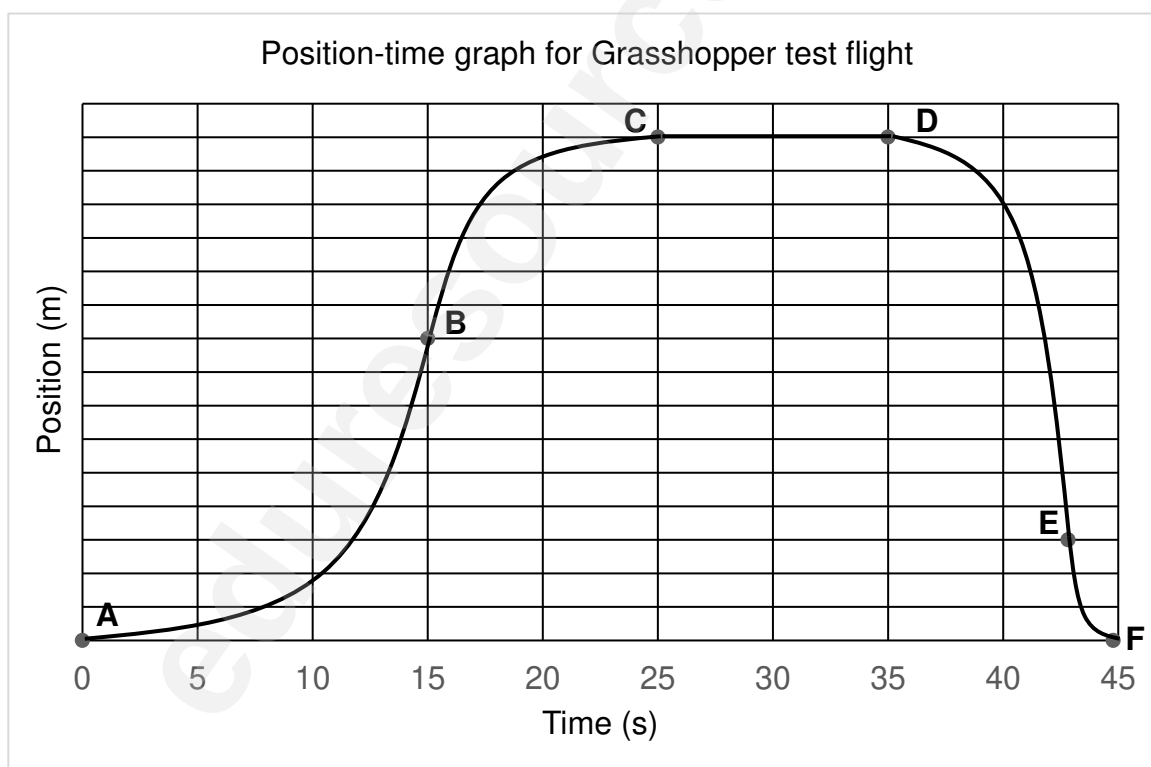
On 30th May 2020, Space X launched their first manned flight using the Falcon 9 reusable rocket to launch the Dragon crew capsule, sending two NASA astronauts to the International Space Station. The Falcon 9 is able to land its rocket boosters to be re-used in future missions.

Getting to this point of reusability required a long series of practice flights. In 2011, Space X's first **VTVL** (vertical take-off, vertical landing) flight test vehicle, *the Grasshopper*, made eight test flights between September 2012 and October 2013.

During one test flight, Grasshopper makes the following motion:

- A to B:** Grasshopper accelerated upward off the ground from rest reaching a speed of $30 \text{ m}\cdot\text{s}^{-1}$
B to C: Grasshopper continued upward to maximum height
C to D: Grasshopper hovered at maximum height
D to E: Grasshopper was in free fall for 300 m
E to F: Grasshopper slowed down to touch down on the ground again

The position-time graph for this test flight is shown below. Position values have been omitted.

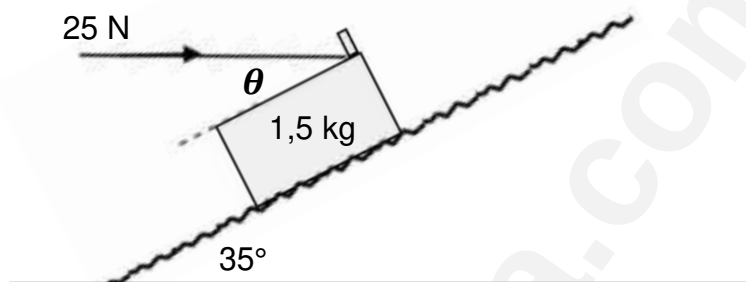


- 3.1 Define *position*. (2)
- 3.2 What reference point was chosen for this graph? (1)
- 3.3 How long did it take for Grasshopper to reach maximum height? (1)
- 3.4 What maximum height was reached by Grasshopper? (6)

- 3.5 How long was Grasshopper in free fall for? (4)
- 3.6 Calculate Grasshopper's velocity at **E**. (5)
- 3.7 In order to land, Grasshopper's engines needed to fire, exerting a **thrust** on the vehicle, so that it reached the ground with a speed of $1 \text{ m}\cdot\text{s}^{-1}$.
- 3.7.1 Describe Grasshopper's motion during the landing phase (**E** to **F**). (3)
- 3.7.2 State *Newton's third law*. (2)
- 3.7.3 Use Newton's third law to explain how Grasshopper firing its engines results in an upward thrust. (3)
- [27]**

QUESTION 4 I WANTED TO TEACH YOU ABOUT INERTIA...BUT I JUST DIDN'T KNOW HOW TO GET THE BALL ROLLING

Jody applies a horizontal force of 25 N onto a 1,5 kg wooden block, using a rigid wooden dowling rod as shown. The block stays at REST on the rough inclined surface, which makes an angle of 35° to the horizontal. The coefficient of static friction is 0,75.

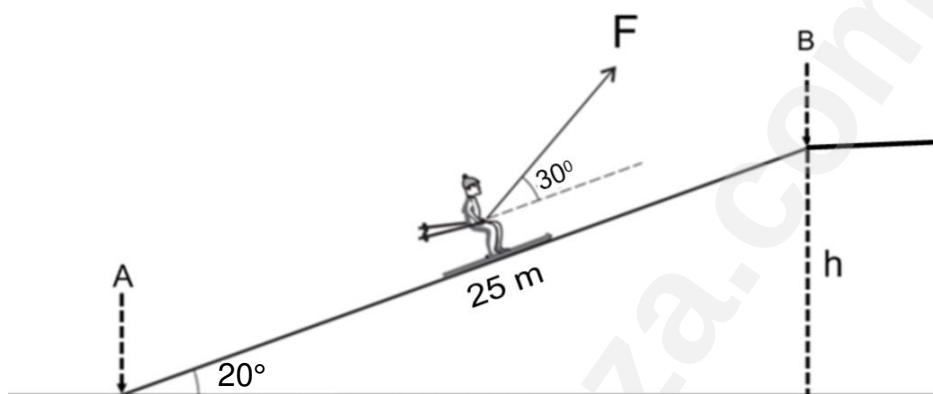


- 4.1 State *Newton's first law*. (2)
- 4.2 Draw a free-body diagram for the block, showing all forces. (4)
- 4.3 What is the angle, θ , shown in the diagram? (1)
- 4.4 4.4.1 Define *normal force*. (2)
- 4.4.2 Determine the magnitude of the component of the applied force perpendicular to the slope. (2)
- 4.4.3 Calculate the magnitude of the normal force acting on the block. (4)
- 4.5 Calculate the frictional force acting on the block. (4)
- 4.6 The applied force is now removed. Determine, by calculation, whether the block will slide down the slope. (5)

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QUESTION 5 WHAT IS HERMIONE'S PREFERRED METHOD OF GETTING DOWN AN INCLINE? WALKING...JK, ROLLING!

A skier with a mass 80 kg is pulled up a slope, which makes an angle of 20° with the horizontal, by a motor with a maximum power rating of 2 kW. The motor is NOT 100 % efficient. The skier is subject to a constant frictional force of magnitude 70 N. The speed of the skier increases from $2 \text{ m}\cdot\text{s}^{-1}$ at point **A** to $5 \text{ m}\cdot\text{s}^{-1}$ at the point **B**. The skier covers the 25 m distance from **A** to **B** in 7,14 s.



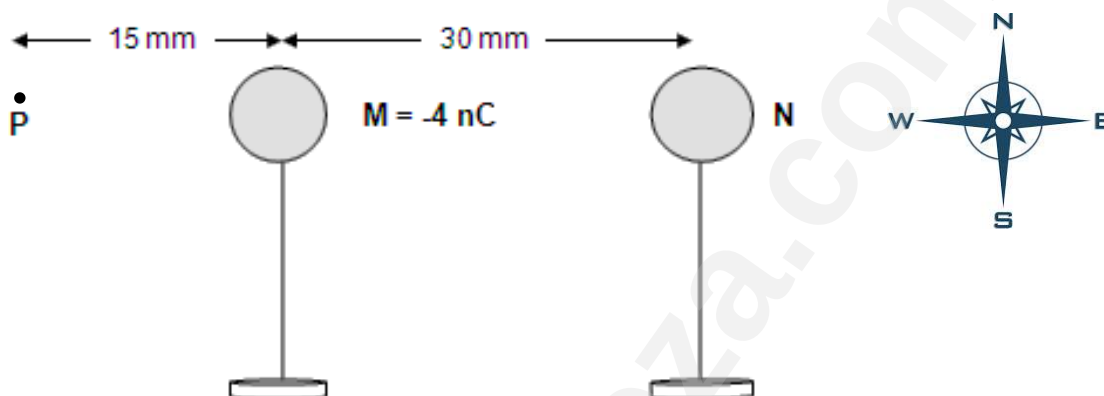
- 5.1 5.1.1 State *the work-energy theorem*. (2)
- 5.1.2 Calculate the work done by the applied force as the skier moves from **A** to **B**. (6)
- 5.1.3 Calculate the applied force that acts at a constant angle of 30° above the slope. (4)
- 5.2 5.2.1 Define *power*. (2)
- 5.2.2 Calculate the mechanical power developed by the electric motor. (4)
- 5.2.3 Calculate the percentage efficiency of the motor. (3)

[21]

QUESTION 6 **WHEN YOU'RE DONE WITH THIS QUESTION, YOU WILL BE EX-STATIC**

Two metal spheres, **M** and **N**, are on insulated stands. **M** with charge of -4 nC is placed 30 mm away from **N** of unknown charge. **P** is a point in space a distance 15 mm west of sphere **M** as shown below.

The NET electric field at point **P** due to presence of both **M** and **N** is $2 \times 10^5 \text{ N} \cdot \text{C}^{-1}$ east.



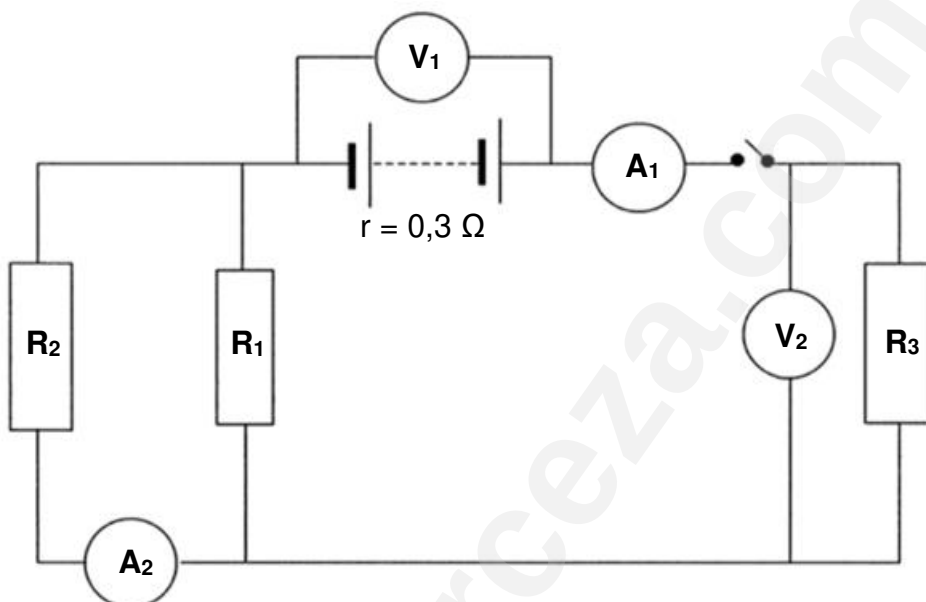
- 6.1 Define the *magnitude of the electric field at a point*. (2)
- 6.2 Calculate the magnitude and direction of the electric field at point **P** due to the presence of sphere **M** alone. (5)
- 6.3 Calculate the magnitude of the charge on sphere **N**. (5)
- 6.4 Is the charge on sphere **N** POSITIVE or NEGATIVE? (1)
- 6.5 Calculate the net electric force that an electron will experience when placed at point **P**. (4)

[17]

QUESTION 7 WHAT DID SOUTH AFRICAN'S USE TO LIGHT THEIR HOMES BEFORE CANDLES? ELECTRICITY.

Consider the circuit diagram below. R_1 has an unknown resistance and is in parallel with R_2 , which has a resistance of $8\ \Omega$. R_3 has a resistance of $1,5\ \Omega$.

With the switch open, voltmeter V_1 has a reading of 35 V . The internal resistance of the battery is $0,3\ \Omega$



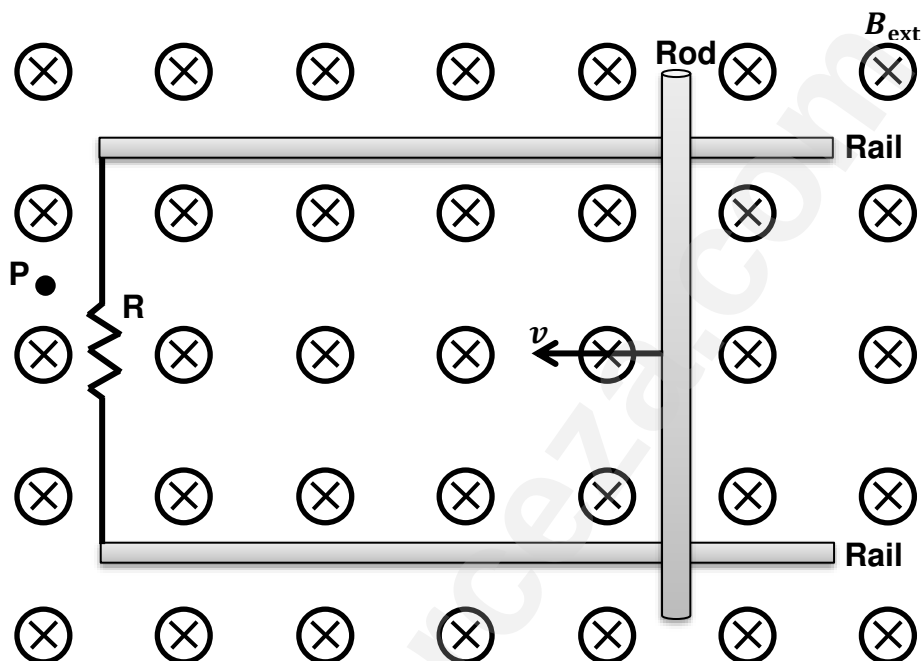
The switch is **CLOSED** and voltmeter V_2 reads 15 V .

- 7.1 Define *emf*. (2)
- 7.2 Calculate the reading on ammeter A_1 . (3)
- 7.3 Calculate the reading on voltmeter V_1 . (4)
- 7.4 Define *resistance*. (2)
- 7.5 Calculate resistance R_1 . (6)
- 7.6 Calculate the reading on ammeter A_2 . (3)
- 7.7 Calculate the rate at which the internal resistance of the battery transfers energy. (4)
- 7.8 Resistor R_2 is replaced with a $10\ \Omega$ resistor.
 - 7.8.1 What effect will this have on the reading on ammeter A_1 ? State only INCREASE, DECREASE or REMAINS THE SAME. (2)
 - 7.8.2 With reference to a suitable equation, fully explain how this change will affect the reading on voltmeter V_2 . (3)

[29]

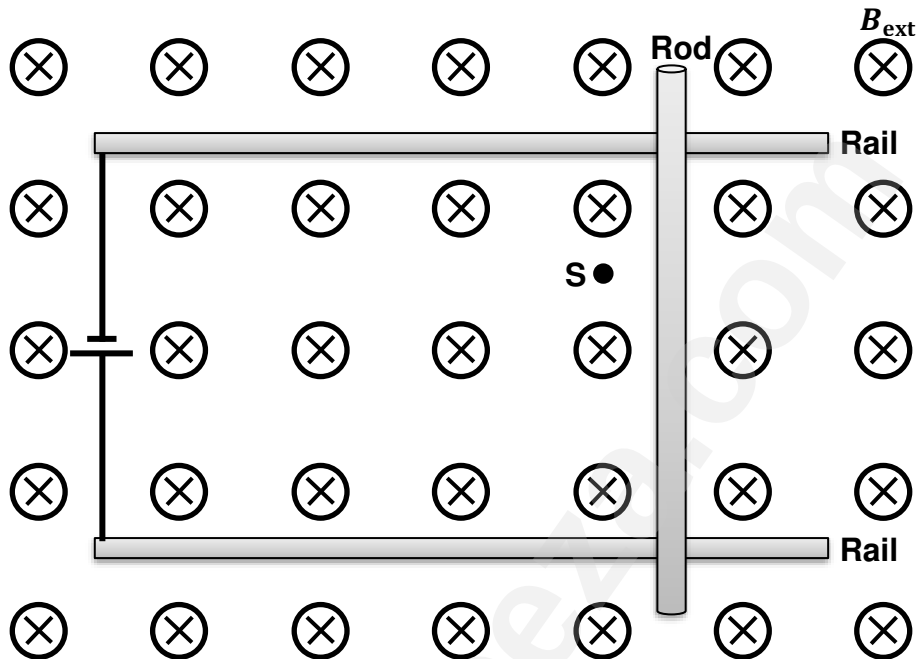
QUESTION 8 WHAT DO YOU GET WHEN YOU CROSS A PUN WITH A RHETORICAL QUESTION?

A resistor R is connected to two stationary rails. A rod is placed onto the rails, creating a closed loop, as shown in the diagram below. A uniform external field of magnetic flux density B_{ext} is present as shown.



- 8.1 State what is meant by *magnetic flux density*. (2)
- 8.2 The rod is then pulled to the left with a constant velocity v as shown.
 - 8.2.1 With reference to an electromagnetic law, fully explain why pulling the rod to the left as shown causes a **current** to be induced in resistor R . (5)
 - 8.2.2 State the direction of the induced magnetic field at point P . State either INTO THE PAGE or OUT OF THE PAGE. (2)
 - 8.2.3 State the direction of the induced current through resistor R . State either UP or DOWN. (2)
- 8.3 The position of the rod is reset and it is now pulled to the left with a constant velocity $3v$. State the new current in terms of the original current, I . (2)
- 8.4 The position of the rod is reset. The rails are brought **closer** together, to **half** the original separation distance and resistor R is replaced with a new resistor of $2R$. The rod is pulled away with a constant velocity v . State the new current in terms of the original current, I . (2)

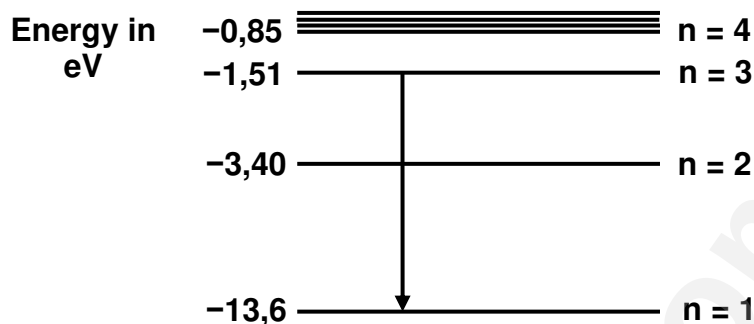
- 8.5 The resistor is now replaced with a DC supply, causing the rod to move. The setup is shown in the diagram below.



- 8.5.1 NAME the electromagnetic principle illustrated here. (1)
- 8.5.2 What direction does the rod move? State only LEFT or RIGHT. (2)
- 8.5.3 State the direction of the magnetic field induced by the rod at point **S**. (2)
- [20]

QUESTION 9 HERE IS SOME LIGHT READING

9.1 The diagram below shows the energy levels for a hydrogen atom.

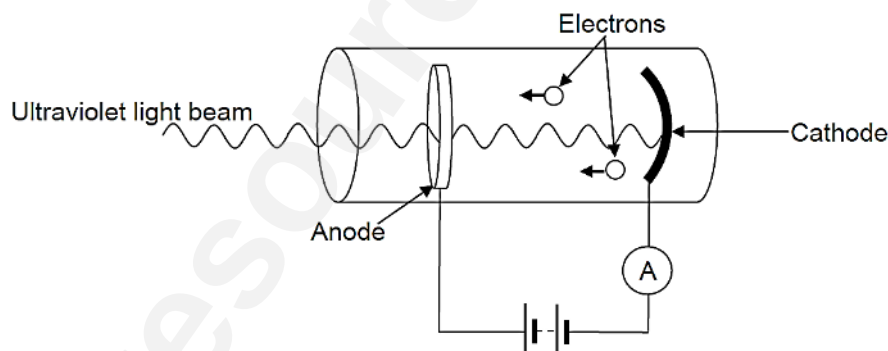


Energy level diagram of a hydrogen atom

9.1.1 Calculate the energy (in joules) of the photon emitted when an electron drops from $n = 3$ back to its ground state as shown. (3)

9.1.2 Determine the wavelength (in nm) of the light given off as a result of the electron transition from $n = 3$ back to its ground state. (4)

9.2 The photo-electric effect has many practical applications. A photocell, such as the one below used in burglar alarm systems, is one such application.



Ultraviolet light of frequency $1,2 \times 10^{15}$ Hz is used to illuminate the photocell. When a person interrupts the ultraviolet beam, the sudden drop in current activates a switch, which sets off the alarm.

The work function of the metal used as a cathode in the photocell is $6,9 \times 10^{-19}$ J.

9.2.1 Define *work function*. (2)

9.2.2 Calculate the maximum velocity of an electron that is emitted from the surface of the metal. Give your answer in scientific notation. (6)

9.2.3 How will an increase in intensity of the ultraviolet light influence the ammeter reading? State only INCREASE, DECREASE, or REMAIN THE SAME. (1)
[16]