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# Brescia House School

## Physical Science Paper I Grade 12 July 2022

Examiner: Mrs. K Trenor  
Moderator: Mrs. S Crossman & Mrs. A Bruns

**Total:** 200 marks  
**Time:** 3 hours

### PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of 28 pages and a **data sheet** of two pages. Ensure that your paper is complete.
2. Read the questions carefully.
3. Answer ALL the questions on the question paper and hand it in at the end of the examination.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. Two blank pages are included at the end of the paper. If you run out of space for an answer, use the page.
11. **IF YOU USE THIS SPACE TO COMPLETE A QUESTION, PLEASE MAKE A NOTE IN THE QUESTION TO DIRECT THE EXAMINER'S ATTENTION. WRITE DOWN THE CORRECT QUESTION NUMBER.**

NAME: \_\_\_\_\_

Examination Number: 22101402 \_ \_ \_ \_

|           | Q1  | Q2  | Q3  | Q4  | Q5  | Q6  | Q7  | Q8  | Q9  | TOTAL |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Mark      |     |     |     |     |     |     |     |     |     |       |
|           | /20 | /22 | /33 | /23 | /23 | /14 | /25 | /25 | /15 | /200  |
| Moderated |     |     |     |     |     |     |     |     |     |       |

**QUESTION 1:**

Answer these questions on the multiple-choice grid.

Make a cross (X) in the box corresponding to the letter that you consider to be correct.

|      |   |   |   |   |
|------|---|---|---|---|
| 1.1  | A | B | C | D |
| 1.2  | A | B | C | D |
| 1.3  | A | B | C | D |
| 1.4  | A | B | C | D |
| 1.5  | A | B | C | D |
| 1.6  | A | B | C | D |
| 1.7  | A | B | C | D |
| 1.8  | A | B | C | D |
| 1.9  | A | B | C | D |
| 1.10 | A | B | C | D |

1.1. The diagram below shows two vectors.



What is the magnitude of the resultant of these two vectors? (2)

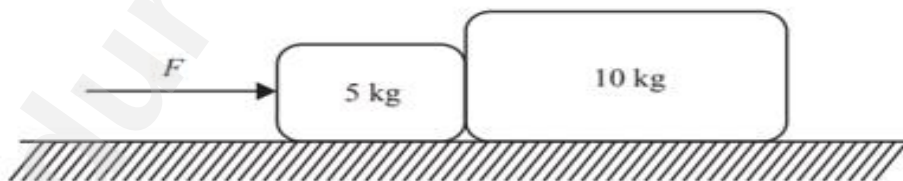
- A. 15 km
- B. 16,5 km
- C. 21 km
- D. 108 km

1.2. A person throws a ball vertically upwards. Which one of the following combinations of arrows accurately indicates the directions of the net force, acceleration, and velocity of the ball when it is **halfway up** after leaving their hand? (2)

|   | $F_{\text{net}}$ | $a$ | $v$ |
|---|------------------|-----|-----|
| A | ↑                | ↓   | ↑   |
| B | ↓                | ↓   | ↓   |
| C | ↑                | ↑   | ↑   |
| D | ↓                | ↓   | ↑   |

**Use the following information to answer questions 1.3 and 1.4.**

Two blocks of mass 5 kg and 10 kg are placed in contact on a frictionless horizontal surface, as shown in the diagram below. A constant horizontal force,  $F$ , is applied to the 5 kg block.



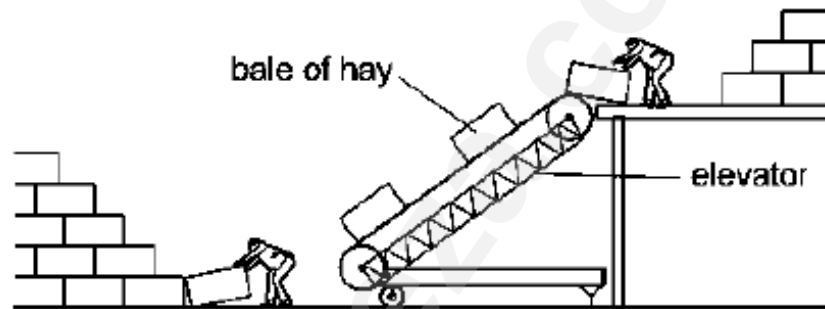
1.3. Which of the following statements is correct? (2)

- A. The net force on each block is the same.
- B. The acceleration experienced by the 5 kg block is twice the acceleration experienced by the 10 kg block.
- C. The magnitude of the net force on the 5 kg block is half the magnitude of the net force on the 10 kg block.
- D. The magnitude of the net force on the 5 kg block is twice the magnitude of the net force on the 10 kg block.

1.4. If the force  $F$  has a magnitude of 250 N, what is the work done by the force in moving the blocks in a straight line for 20 m? (2)

- A. 5 kJ
- B. 21 kJ
- C. 108 kJ
- D. 225 kJ

1.5. An electric motor runs a conveyor belt which lifts bales of hay as shown in the diagram below. All the bales of hay have the same mass.

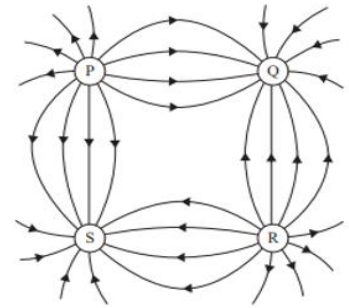


An hour before sunset, the speed of the motor is increased so that more bales are lifted per hour.

How does this affect the work done in lifting each bale, and the useful output power of the motor? (2)

|   | Work done in lifting each bale | Useful power output of the motor |
|---|--------------------------------|----------------------------------|
| A | Remains the same               | Increases                        |
| B | Increases                      | Increases                        |
| C | Decreases                      | Decreases                        |
| D | Remains the same               | Decreases                        |

- 1.6. The diagram below shows the electric field lines between four charged spheres: P, Q, R and S. The magnitude of the charge on each sphere is the same.



Which of the following correctly identifies the type of charge on each of the spheres?

(2)

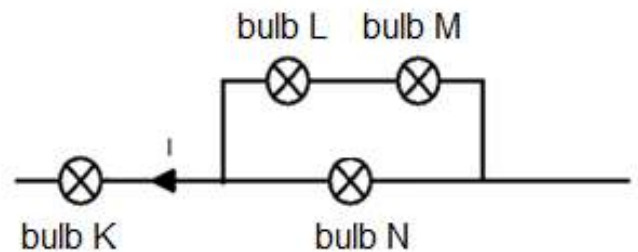
|   | P | Q | R | S |
|---|---|---|---|---|
| A | – | + | – | + |
| B | + | – | + | – |
| C | – | – | + | + |
| D | + | + | – | – |

- 1.7. The magnitude of acceleration due to gravity at the Earth's surface is  $g$ . Planet Y has twice the mass and half the radius of Earth. Which one of the following gives the correct magnitude of acceleration due to gravity on Planet Y?

(2)

- A.  $\frac{1}{2} g$   
 B.  $1 g$   
 C.  $4 g$   
 D.  $8 g$

- 1.8. Four identical bulbs, K, L, M and N, with the same resistance,  $R$ , are connected in a circuit as shown below. A current,  $I$ , flows through bulb, K.



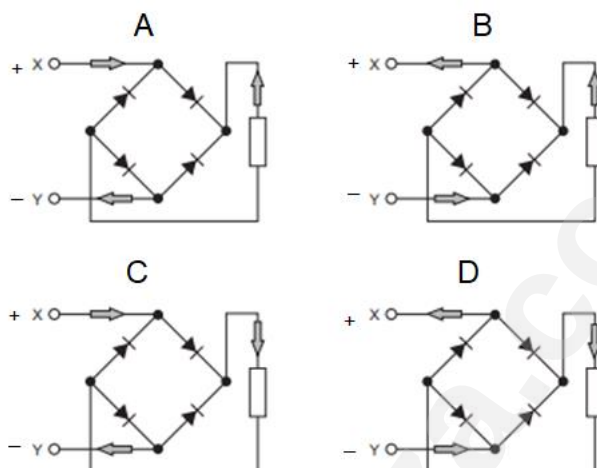
If the power in bulb K is equal to  $P$ , which combination of expressions regarding the power in the bulbs L and N is correct?

(2)

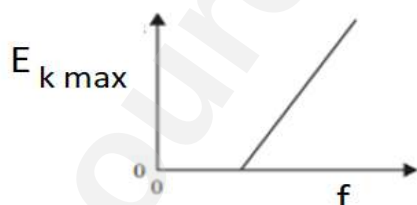
|   | Power in bulb L | Power in bulb N |
|---|-----------------|-----------------|
| A | $\frac{4}{9} P$ | $\frac{1}{9} P$ |
| B | $2 P$           | $\frac{1}{2} P$ |
| C | $\frac{1}{2} P$ | $P$             |
| D | $\frac{1}{9} P$ | $\frac{4}{9} P$ |

- 1.9. The following diagrams for a full wave rectifier are given. The grey shaded arrows (near the resistor, at input and output connections) show the current direction at these positions.

Which of the following diagrams correctly shows the path of conventional current? (2)

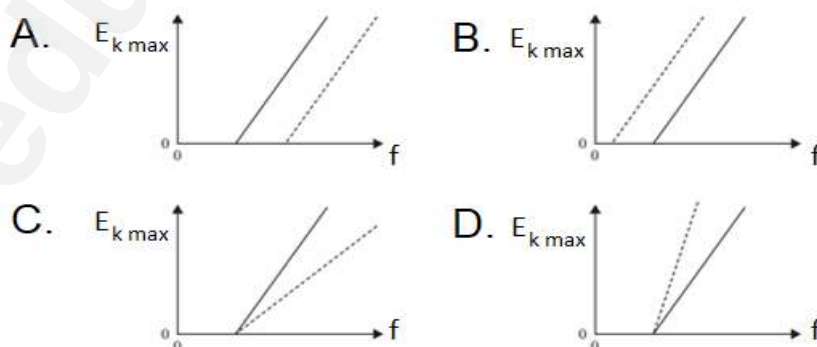


- 1.10. The results of a photoelectric experiment are displayed in the graph below. The graph shows a maximum kinetic energy ( $E_{k\max}$ ) of photoelectrons versus the frequency ( $f$ ) of light falling on the metal surface.



A second experiment is conducted with the original metal surface being replaced by one with a higher work function. The original data is shown with a solid line and the new experiment with a dashed line.

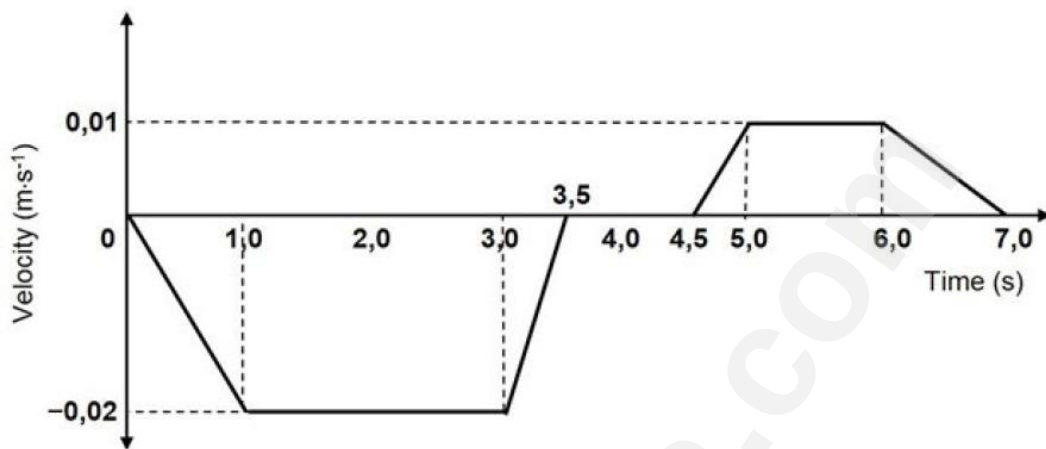
Which of the following graphs shows the correct results from this experiment?



[20 marks]

**QUESTION 2:**

An object initially moves due east. The graph below shows the relationship between its velocity and time.



2.1. Calculate the acceleration of the object for the following periods:

2.1.1. 0 s to 1,0 s (3)

2.1.2. 6,0 s to 7,0 s (2)

2.2. Describe the motion of the object, and give its direction of travel, from:

2.2.1. 3 s to 3,5 s (3)

2.2.2. 5 s to 6 s (2)

2.3. Define the term *displacement*. (2)

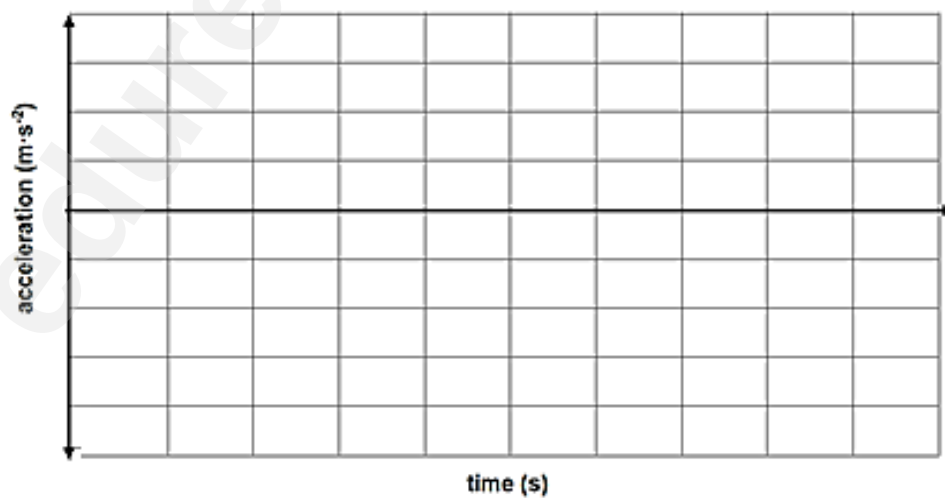
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2.4. Calculate the total displacement of the object. (4)

2.5. Calculate the magnitude of the average velocity of the object for the whole journey. (2)

2.6. Draw the graph showing the relationship between acceleration and time for 0 s to 3,5 s. Indicate all relevant values on the graph. Remember that sketch graphs do not have to be drawn to scale. (4)

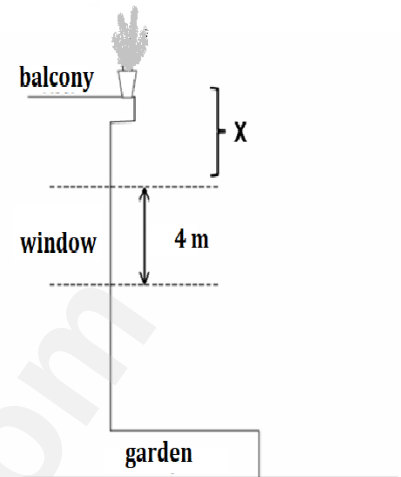


[22 marks]

**QUESTION 3:**

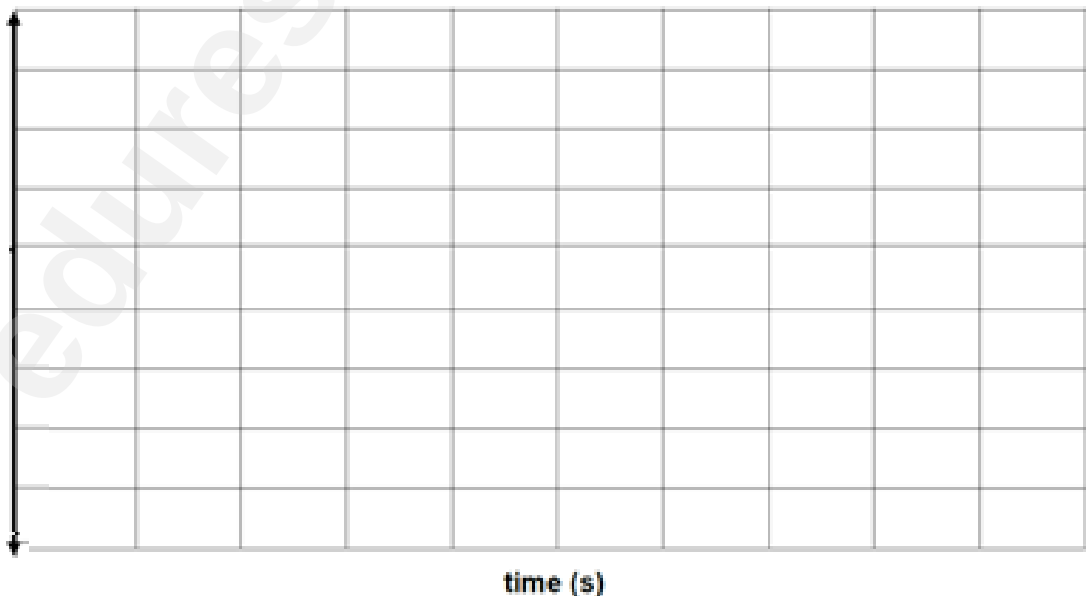
A heavy flowerpot of 40 kg falls from rest from a balcony of an apartment building. It falls freely past a window until it hits the garden below.

Ignore all effects of air resistance.



- 3.1. The flowerpot impacts the sandpit with a velocity of  $36.3 \text{ m} \cdot \text{s}^{-1}$ . Calculate the time it takes to fall from the top of the building to the sandpit. (3)

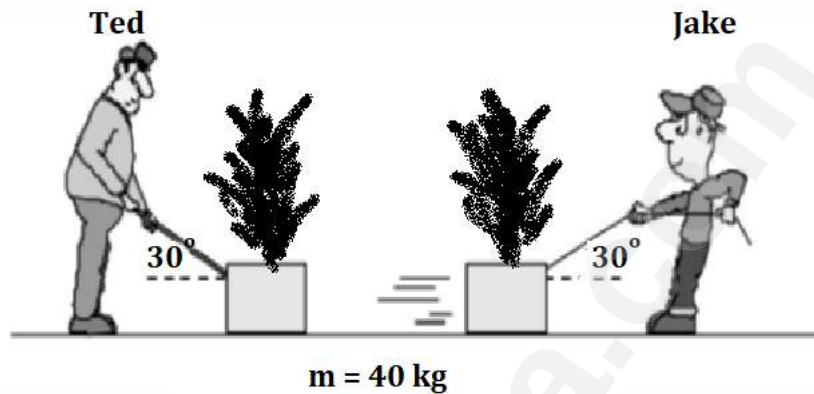
- 3.2. Draw a sketch graph of velocity vs time for the complete motion of the flowerpot. Indicate **all relevant values** on the graph. Remember that sketch graphs do not have to be drawn to scale. (3)



- 3.3. If the flowerpot took 0,20 s to fall past the window of height 4,00 m, calculate the distance marked **X** from the top of the window to the roof from where the flowerpot fell. (5)

Two gardeners Ted and Jake, take turns trying to move the 40 kg flowerpot across the rough surfaces.

- Ted exerts a force of 80 N by pushing with a stick.
- Jake exerts a force of 80 N by pulling on a cord.
- Jake gets his flowerpot to slide across the surface, but Ted cannot get his flowerpot to move at all.



3.4. For each of these situations draw a free body diagram to show all the forces acting on each of the flowerpots. (3)

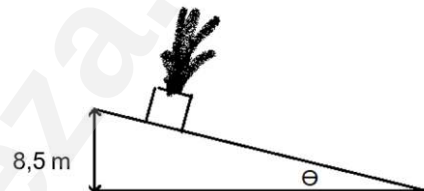
3.5. Calculate the magnitude and direction of the vertical component of their respective applied forces. (3)

- 3.6. Use principles of physics to explain why Jake can move his flowerpot while Ted cannot get his flowerpot to move. (3)

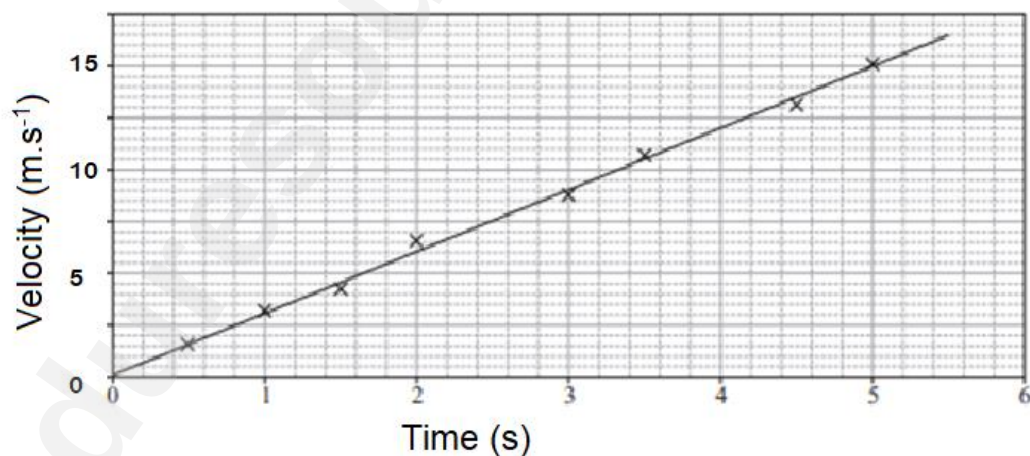
When Jake reaches a ramp, he lets go of the flowerpot, and allows it to slide from rest down the rough inclined plane with no external assistance.

NB. The diagram of the flowerpot on the ramp is NOT drawn to scale.

The flowerpot has a mass of 40 kg.  
It slides down from a height of 8,5 m.



The graph below shows the graph of velocity against time of the flowerpot.



- 3.7. Determine the gradient of the graph. Provide the appropriate unit. (3)

3.8. Draw a free body diagram showing ALL the forces acting on the flowerpot. (3)

3.9. Determine the net work done in 5 s. (4)

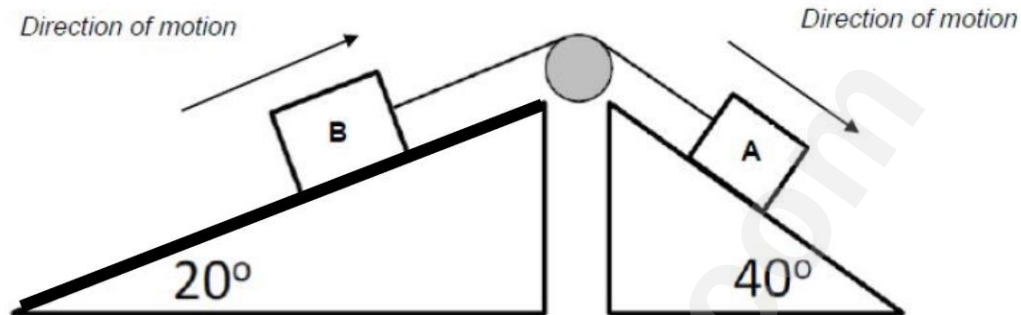
3.10 Determine the angle of incline,  $\theta$ , of the inclined plane. (3)

**[33 marks]**

**QUESTION 4:**

Two blocks, **A** and **B**, are arranged as indicated in the sketch.

- Each have a mass of 3 kg.
- The  $40^\circ$  incline is frictionless.
- The  $20^\circ$  incline has a coefficient of kinetic friction of 0,1.



The objects accelerate in the direction indicated on the sketch.

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

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4.2. Draw a free body diagram for the block labelled **B**. (3)

4.3. Define *normal force*. (2)

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4.4. Calculate the magnitude of the frictional force acting on block **B**. (4)

4.5. Calculate the magnitude of the acceleration of block **A**. (6)

4.6. Calculate the magnitude of the tension in the cable. (2)

4.7. The angle of the incline of **block A** is decreased steadily to  $30^\circ$ . What effect does this have on the magnitude of the acceleration of the system? Explain using relevant formulae. No calculations needed. (4)

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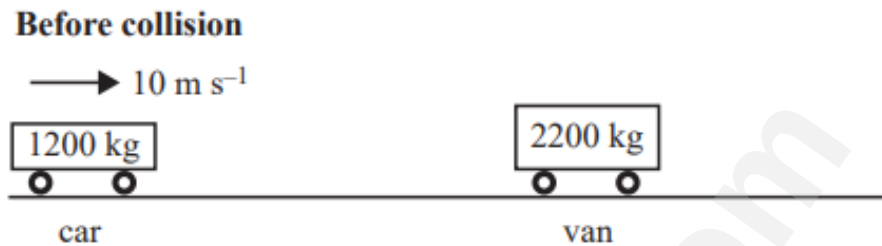
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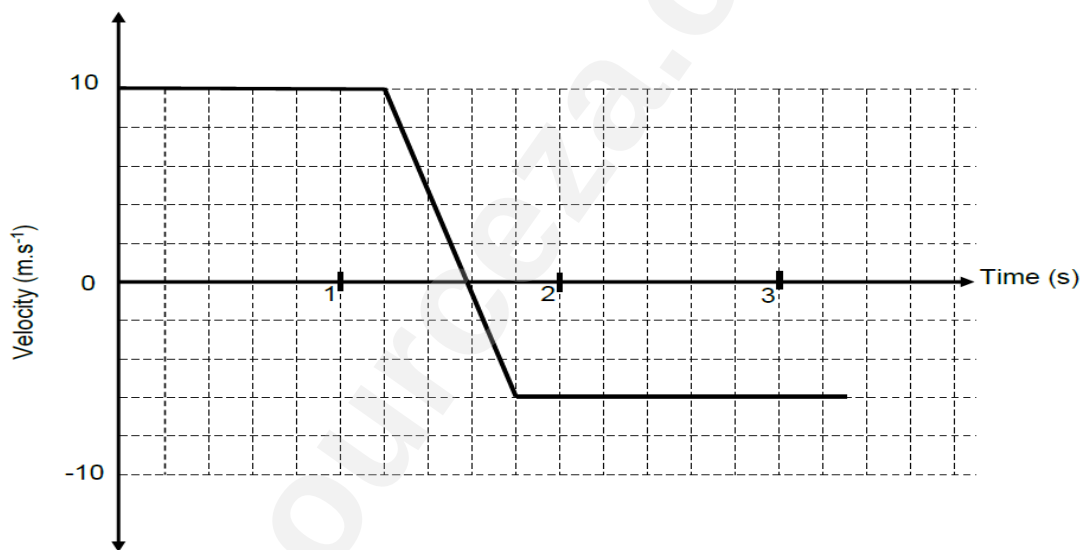
[23 marks]

**QUESTION 5:**

A car of mass 1 200 kg, moving at  $10 \text{ m s}^{-1}$  east collides with a stationary van of mass 2 200 kg.



The graph shows how **the velocity of the car changes with time**.



5.1. State *the law of conservation of linear momentum*. (2)

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5.2. Calculate the velocity of the van after the collision. (4)

5.3. Determine by calculation whether this represents an elastic or inelastic collision. (3)

5.4. Define the term *impulse*. (2)

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5.5. Calculate the net force exerted on the van by the car. (3)

5.6. Hence, determine the force that the van exerted on the car. (2)

5.7. Which law does this represent? (1)

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After the collision the car moves 15 m before coming to rest.

5.8. Define *frictional force due to a surface*. (2)

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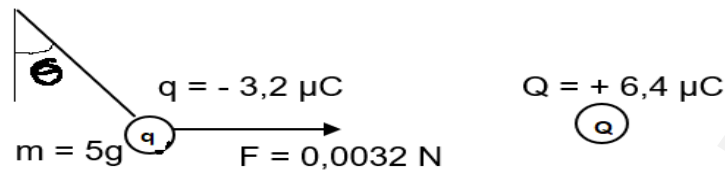
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5.9. Determine the magnitude of the frictional force acting on car. (4)

[23 marks]

**QUESTION 6:**

A small spherical conductor with a mass of 5 g and negative charge of  $-3,2 \mu\text{C}$  is suspended by a light string (which does not conduct charge). The spherical conductor is attracted to another fixed sphere Q carrying a charge of  $+6,4 \mu\text{C}$ . The horizontal electrostatic force has a magnitude of 0,0032 N, as shown in the diagram below.



6.1. Define *electric field strength*. (2)

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6.2. Calculate the magnitude of the electric field strength at the position of the suspended conductor carrying the charge  $q = -3,2 \mu\text{C}$ . (3)

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

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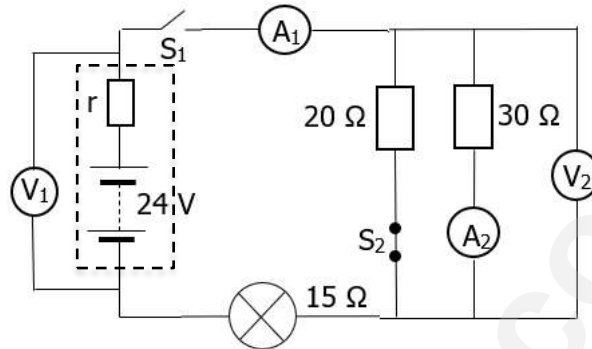
6.4. Calculate the distance between q and Q. (4)

6.5. Calculate the angle  $\theta$  that the string makes with the vertical. (3)

[14 marks]

**QUESTION 7:**

In the circuit below, the battery with an emf of 24 V and an unknown internal resistance is connected to a light bulb and two resistors as shown. The resistances of the switch, ammeters and connecting wires are negligible. The voltmeters have very high resistance.



7.1. Define *emf*. (2)

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7.2. When switch  $S_1$  is open, what will be the reading on

7.2.1.  $A_1$ . \_\_\_\_\_

7.2.2.  $V_1$ . \_\_\_\_\_

7.2.3.  $V_2$ . \_\_\_\_\_ (3)

**Switch  $S_1$  and  $S_2$  are now closed. Voltmeter  $V_1$  reads 21,6 V.**

7.3. Define *resistance*. (2)

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7.4. Determine the effective resistance of the parallel resistors. (2)

7.5. Find the reading on  $A_1$ . (3)

7.6. Calculate the internal resistance of the battery. (3)

7.7. Determine the reading on  $A_2$ . (3)

7.8. Calculate the rate of energy dissipation in the **light bulb**. (3)

7.9. If switch  $S_2$  is opened, how will each of the following compare to just before the switch was opened? Write down only INCREASE, DECREASE, STAY THE SAME or BECOME ZERO.

7.9.1. Ammeter  $A_1$ . \_\_\_\_\_

7.9.2. Voltmeter  $V_1$ . \_\_\_\_\_

7.9.3. Voltmeter  $V_2$ . \_\_\_\_\_

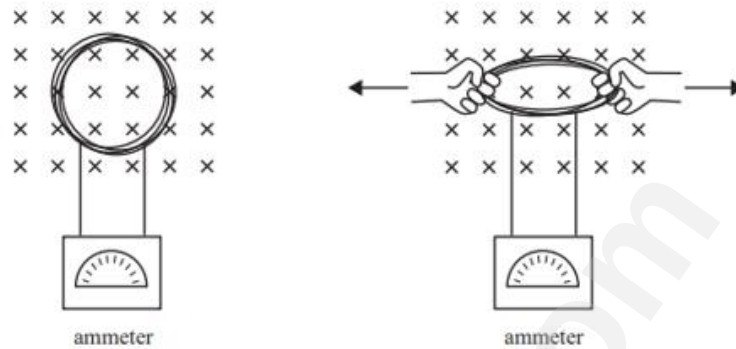
7.9.4. Ammeter  $A_2$ . \_\_\_\_\_

(4)

[25 marks]

**QUESTION 8:**

- 8.1. Two students hold a coil of wire in a constant uniform magnetic field as shown.



The students then change the shape of the coil by pulling each side of the coil in the horizontal direction as shown. They notice that a current registers on the ammeter.

- 8.1.1. Will a magnetic flux through the coil INCREASE, DECREASE or STAY THE SAME as the students change the shape of the coil as shown? (2)

- 8.1.2. Explain using physics principles why the ammeter registered a current in the coil. (3)

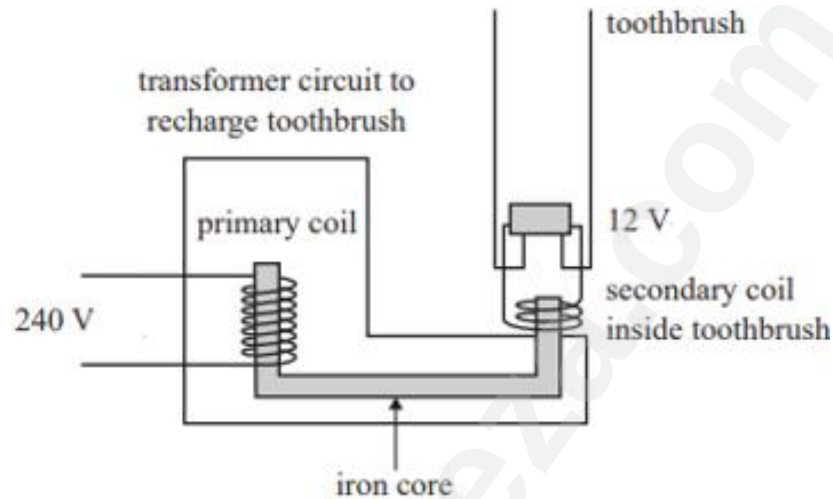
- 8.1.3 State *Lenz's law*. (2)

- 8.1.4 Apply Lenz's law to explain how to determine the direction of induced current in the coil. (2)

8.2. A rechargeable electric toothbrush uses a transformer circuit.

A secondary coil inside the toothbrush is connected via an iron core to a primary circuit coil, that is connected to the main power supply.

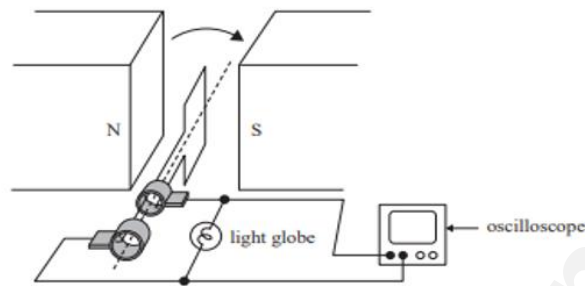
- The voltage of main power source is 240 V.
- The toothbrush needs to recharge at 12 V.
- The power delivered to the toothbrush is 0,9 W.



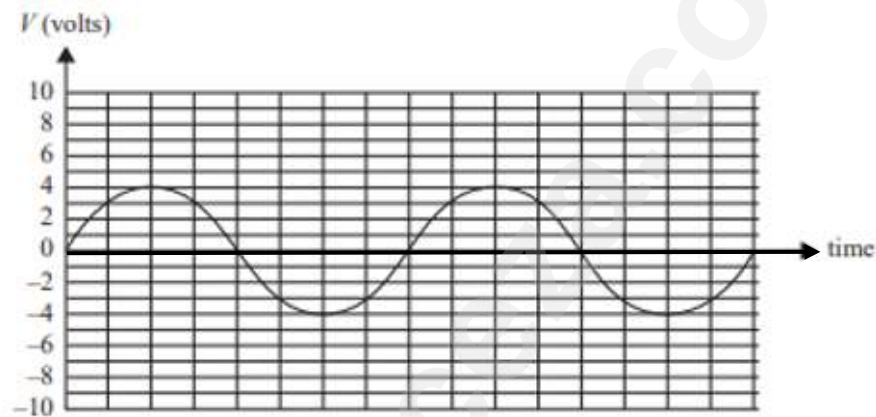
8.2.1. Determine the ratio of the number of turns in the secondary coil to those in the primary coil of this transformer. (2)

8.2.2. Determine the current delivered to the primary coil of the transformer. Assume it is an ideal transformer. (4)

- 8.3. A simple AC generator is connected to an oscilloscope with the coil being rotated clockwise as in the diagram below shown.

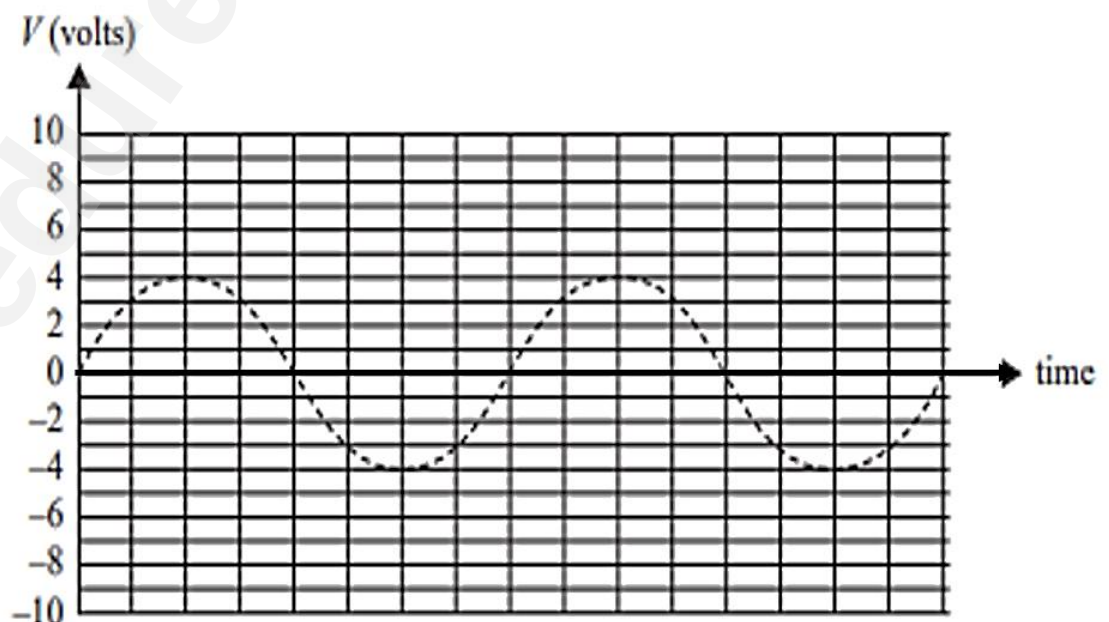


The output on the oscilloscope is shown below.



- 8.3.1. What was the position of the coil initially when the oscilloscope recording started? State only HORIZONTAL or VERTICAL. (2)

- 8.3.2. The rate of the rotation is doubled. On the graph below, sketch the output that will be seen on the oscilloscope. The original waveform is shown in dashed lines. (2)



8.4. Give **two** functions of the slip rings. (2)

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8.5. How could this AC generator be changed to a DC generator? (2)

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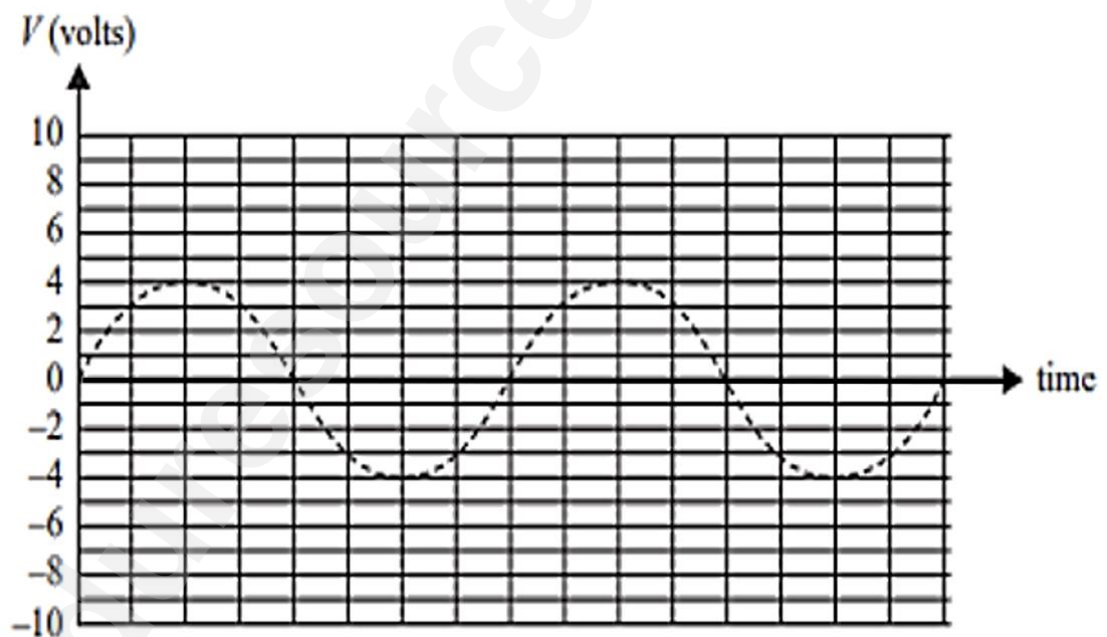


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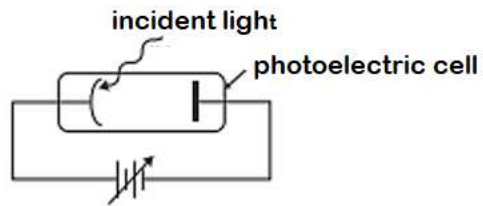
8.6. The AC generator is modified to work as a DC generator. The speed of its rotation is halved from the original speed when working as an AC generator. Sketch the output versus time for the DC generator on the grid below. (2)



[25 marks]

**QUESTION 9:**

A photo-electric experiment was conducted by shining different frequencies of light onto a plate made of an unknown metal. The graph shows the kinetic energies of ejected photoelectrons with respect to the frequency of incident light.



- 9.1. Immediately light of sufficiently high frequency shines on the metal, electrons are emitted. Explain why this happens and the significance of this observation. (2)

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- 9.2. The incident light has a frequency of  $7,73 \times 10^{14}$  Hz and the work function of the metal surface is  $3,7 \times 10^{-19}$  J.

- 9.2.1. Define *work function*. (2)

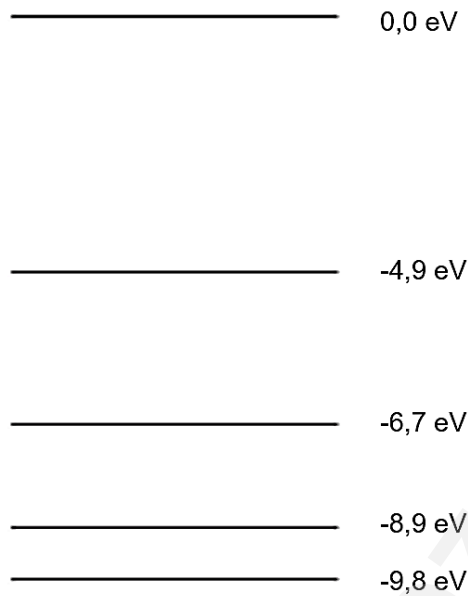
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- 9.2.2. Determine the maximum velocity at which electrons are emitted from the metal surface. (4)

9.3. The energy level diagram for a particular element is drawn to scale below.



9.3.1. Explain **how a line emission spectrum is produced** when a high voltage is applied to a low-pressure gas which glows. (2)

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9.3.2. Identify the transition on the energy level diagram that would result in the emission of a 565 nm photon. Show your calculations. (5)

[15 marks]