



# **INSIGHT**

## **Year 12 Trial Exam Paper**

### **2013**

### **PHYSICS**

### **Written examination**

**STUDENT NAME:**

### **QUESTION AND ANSWER BOOK I – CORE**

**Reading time (Core & Detailed Studies): 15 minutes**

**Writing time (Core & Detailed Studies): 2 hours 30 minutes**

#### **Structure of book**

| <i>Section</i>   | <i>Number of questions</i> | <i>Number of questions to be answered</i> | <i>Number of marks</i> |
|------------------|----------------------------|-------------------------------------------|------------------------|
| A – Core studies | 24                         | 24                                        | 128                    |
| Total            |                            |                                           | 128                    |

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.
- Students are NOT permitted to bring sheets of blank paper or white out liquid/tape into the examination.

#### **Materials provided**

- The **Core** question and answer book of 43 pages, with a separate data sheet.
- The **Detailed studies** question and book of 43 pages
- An answer sheet for multiple-choice questions.

#### **Instructions**

- Write your **name** in the box provided, and on the answer sheet for multiple-choice questions.
- Remove the data sheet during reading time.
- Unless otherwise indicated, the diagrams in this book are NOT drawn to scale.
- You must answer all questions in English.

**Students are NOT permitted to bring mobile phones or any other unauthorised electronic devices into the examination room.**

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## Table of contents

### SECTION A

| Areas of study                        | Page |
|---------------------------------------|------|
| Motion in one and two dimensions..... | 3    |
| Electronics and photonics.....        | 14   |
| Electric power.....                   | 24   |
| Interactions of light and matter..... | 36   |

**SECTION A – Core studies****Instructions for Section A**

Answer **all** questions in this section in the spaces provided. Write using black or blue pen.

Where an answer box has a unit printed in it, give your answer in that unit.

You should take the value of  $g$  to be  $10 \text{ m s}^{-2}$ .

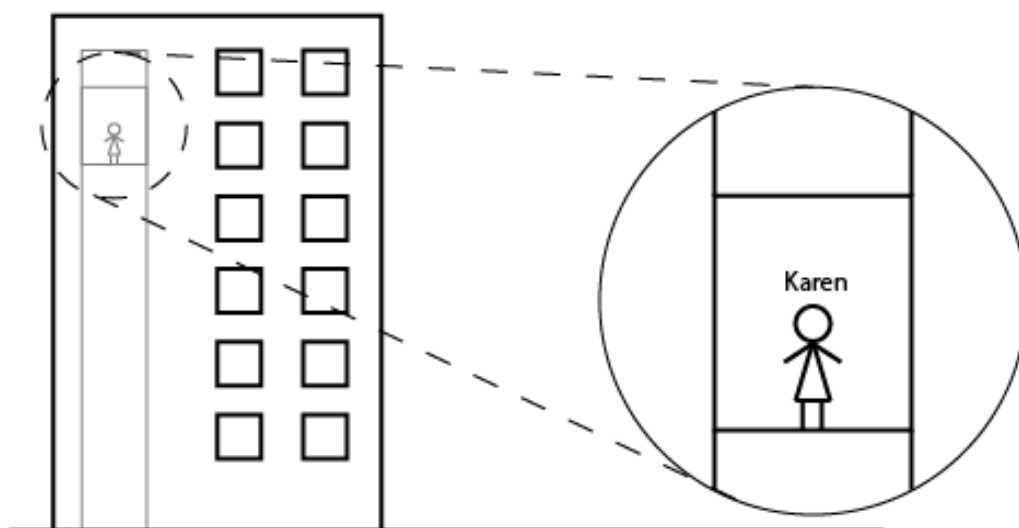
Where answer boxes are provided write your final answer in the box.

In questions worth more than 1 mark appropriate working should be shown.

Unless otherwise indicated, diagrams are not to scale.

**Area of Study – Motion in one and two dimensions****Question 1 (8 marks)**

Karen, who has a mass of  $60 \text{ kg}$ , lives on the top floor of an apartment building. Every morning she rides the elevator down to the ground floor, as shown in Figure 1.

**Figure 1**

- a. The elevator travels at a constant speed of  $1.1 \text{ m s}^{-1}$  for most of the time that Karen is travelling down. What is Karen's apparent weight during this time?

2 marks

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|   |
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- b.** As the elevator approaches the ground floor, it slows to a stop at a constant rate over a period of 2 seconds. What is the magnitude and direction of the elevator's acceleration in this time?

3 marks

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|                   |
|-------------------|
| $\text{m s}^{-2}$ |
|-------------------|

|                                                    |
|----------------------------------------------------|
| <b>Direction: upwards / downwards (circle one)</b> |
|----------------------------------------------------|

- c.** What is Karen's apparent weight while the elevator is slowing to a stop at the ground floor?

3 marks

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**Question 2 (4 marks)**

*Air resistance may be ignored for this question. Acceleration due to gravity may be approximated as  $10 \text{ m s}^{-2}$ .*

Sarah also lives in an apartment building and is curious to know how tall her building is. She goes onto the roof with a bag of water balloons and times how long it takes for each water balloon to fall to the ground when dropped. Of course, she makes sure no one is below her before she drops them.

- a.** If Sarah notices that, on average, the water balloons take 3.5 seconds to reach the ground, how tall is her apartment building?

2 marks

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| <b>m</b> |
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- b.** An object dropped from a height of 2 m will hit the ground in 0.63 seconds. Calculate the time it takes for an object thrown horizontally at  $5 \text{ m s}^{-1}$  at a height of 2 m to reach the ground. Be sure to show all your working.

2 marks

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**Question 3 (6 marks)**

Cliff, who has a mass of 80 kg, is a stuntman working on a film set in a shopping centre. In one scene, Cliff is running at  $8.0 \text{ m s}^{-1}$  when he collides with a stationary, fully loaded shopping trolley (mass 50 kg), as shown in Figure 2.

**Figure 2**

- a. Cliff and the trolley move off together. What is the magnitude of their velocity after the collision?

2 marks

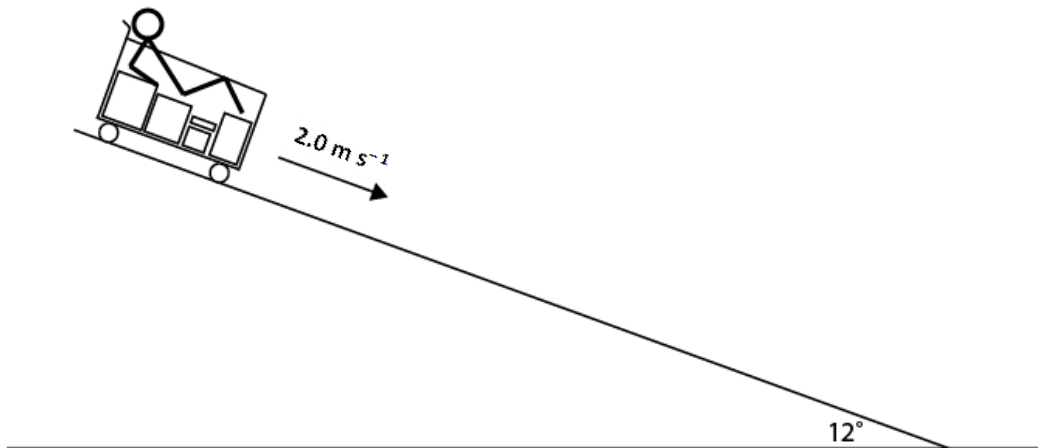
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$\text{m s}^{-1}$

Cliff manages to slow the trolley to  $2.0 \text{ m s}^{-1}$  when they start rolling down a ramp inclined at  $12^\circ$  to the horizontal, as shown in Figure 3.



**Figure 3**

- b.** If friction can be ignored, what is the magnitude of the acceleration of Cliff and the trolley down the ramp?

2 marks

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$\text{m s}^{-1}$

- c.** If the ramp is 15 m long, what is the magnitude of Cliff's velocity when he reaches the end of the ramp?

2 marks

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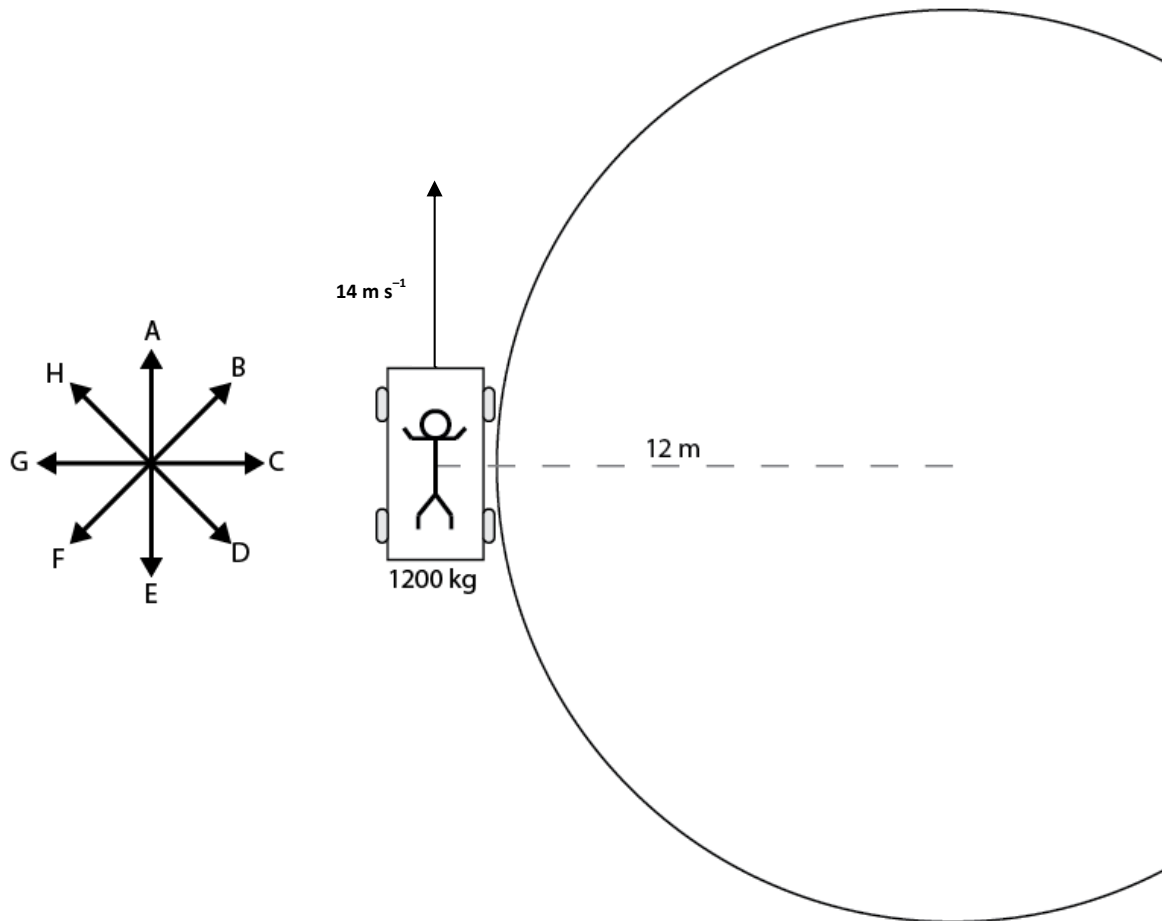


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$\text{m s}^{-1}$

**Question 4 (3 marks)**

Lucinda is a physicist who likes to test scenes from her favourite movies. She drives a car around a roundabout of radius 12 m at a constant speed of  $14 \text{ m s}^{-1}$ , as shown in Figure 4. Strapped to the roof of the car is a crash-test dummy. The combined mass of Lucinda, the car and the dummy is 1200 kg.



**Figure 4**

- a.** What is the magnitude of the net force acting on the dummy and the car as it drives around the roundabout?

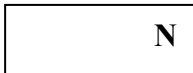
2 marks

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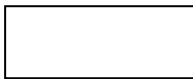
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As the car drives around the roundabout, the straps holding the dummy to the car are released and the dummy slides off the car.

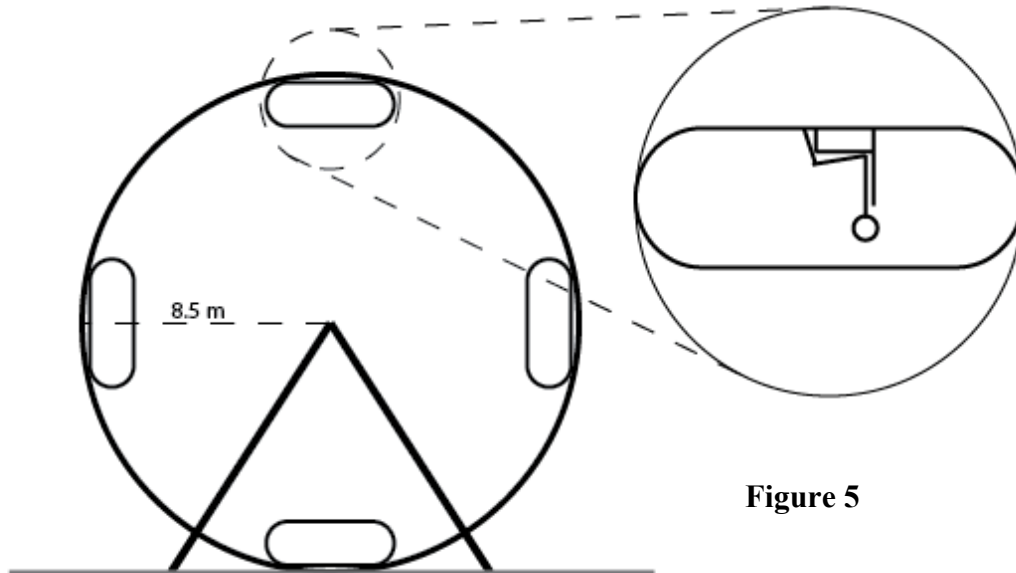
- b.** Which of the arrows in Figure 4 shows the direction in which the dummy will travel if it slides off the car at the instant shown?

1 mark



**Question 5 (5 marks)**

At the Royal Melbourne Show, a highlight is the Vertical Velocitron ride in which riders are spun in a vertical circle, as shown in Figure 5. The ride starts spinning slowly before speeding up to a maximum velocity and then slowing down again. The radius of the Vertical Velocitron is 8.5 m.

**Figure 5**

- a. At one point during the ride, the instantaneous velocity of a 60 kg rider is  $5 \text{ m s}^{-1}$ . What is the magnitude of the net force acting on the rider at this velocity?

2 marks

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The maximum velocity of the ride is calculated so that riders will experience apparent weightlessness when they are upside down at the top of the circle.

- b.** What is the maximum velocity of the ride?

3 marks

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**$\text{m s}^{-1}$**

**Question 6 (5 marks)**

Brian's favourite carnival attraction is the dodgem cars.

- a.** Brian weighs 73 kg and is riding in a 200 kg dodgem car moving at  $3.2 \text{ m s}^{-1}$ .  
What is the combined kinetic energy of Brian and the car?

2 marks

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**J**

Some time later, Brian is travelling in the same dodgem car at  $2.0 \text{ m s}^{-1}$  when he collides with the solid wall of the dodgem car enclosure. In the collision, the rubber bumper on his car deforms by 10 cm.

- b.** What is the spring constant of the bumper?

3 marks

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**$\text{kN m}^{-1}$**

**Question 7 (6 marks)**

In 2001 and 2002, the United States launched two weather satellites: the geostationary GOES-12 and the lower-orbiting NOAA-17.

The following information may be useful in parts **a–c**.

Radius of GOES-12 orbit =  $4.22 \times 10^7$  m

Radius of NOAA-17 orbit =  $7.22 \times 10^6$  m

Radius of Earth =  $6.37 \times 10^6$  m

Mass of Earth =  $5.97 \times 10^{24}$  kg

Gravitational constant,  $G = 6.67 \times 10^{-11}$  N m<sup>2</sup> kg<sup>-2</sup>

- a.** What is the centripetal acceleration of the geostationary satellite GOES-12?

2 marks

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|                         |
|-------------------------|
| <b>m s<sup>-2</sup></b> |
|-------------------------|

- b.** What is the value of  $g$ , Earth's gravitational field strength, experienced by GOES-12?

1 mark

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|                          |
|--------------------------|
| <b>N kg<sup>-1</sup></b> |
|--------------------------|

- c. What is the period of rotation (in seconds) of NOAA-17?

3 marks

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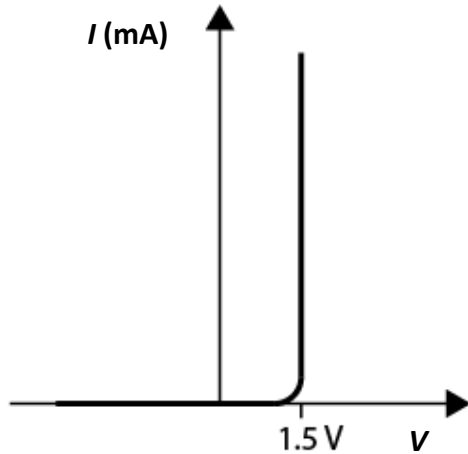
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**Area of study – Electronics and photonics**

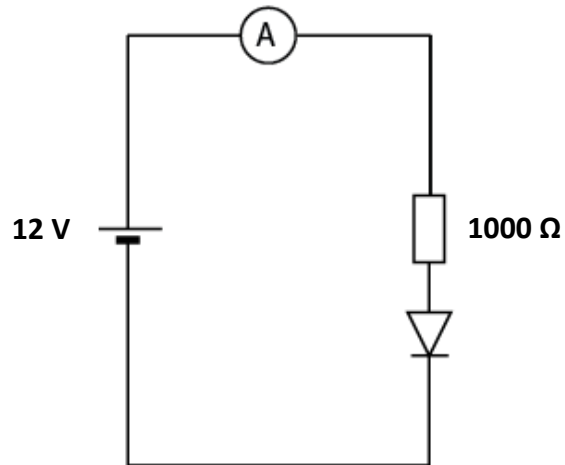
**Question 8 (6 marks)**

A diode has characteristics as shown in Figure 6. It has a reverse bias breakdown voltage of 50 V.

This diode is used in a circuit, as shown in Figure 7.



**Figure 6**



**Figure 7**

- a. What current flows through the ammeter?

2 marks

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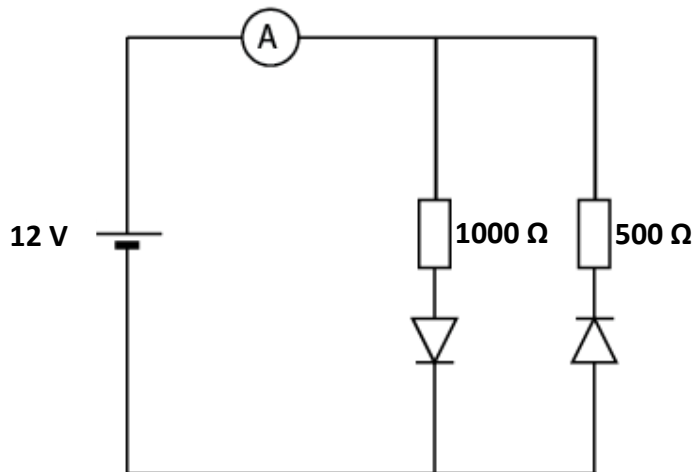
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**mA**

The circuit is altered to include a second resistor and a second identical diode is added, as shown in Figure 8.



**Figure 8**

- b.** What current flows through the ammeter now?

1 mark

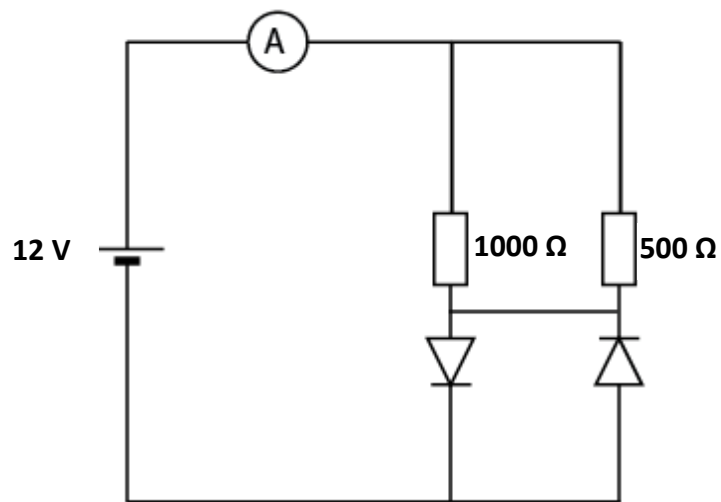
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**mA**

The circuit is altered again, as shown in Figure 9.



**Figure 9**

- c. What current flows through the ammeter now?

3 marks

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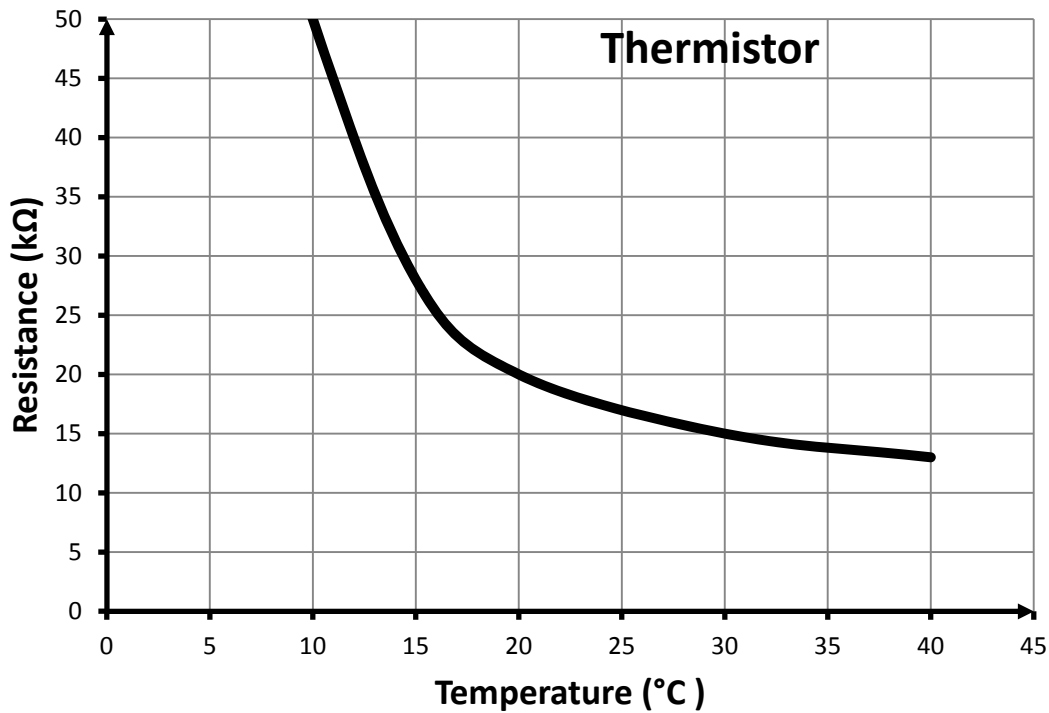


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**mA**

**Question 9 (9 marks)**

A thermistor is used as part of a voltage divider circuit to control a fan. The thermistor has a characteristic as shown in Figure 10.



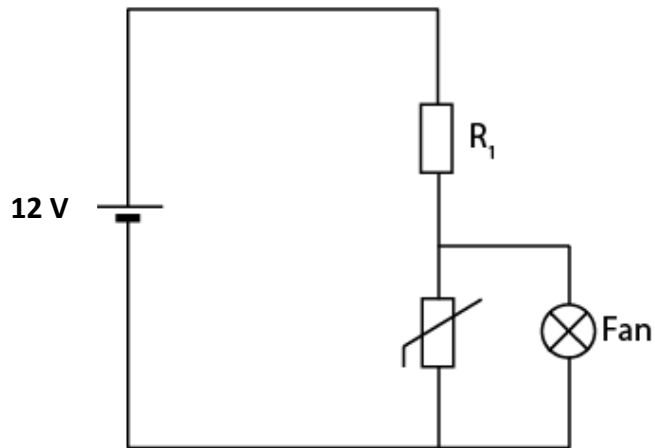
**Figure 10**

- a. What is the resistance of the thermistor at 20°C?

1 mark

|           |
|-----------|
| <b>kΩ</b> |
|-----------|

The thermistor is connected with a variable resistor  $R_1$  in the circuit, as shown in Figure 11. The fan will switch on at 4 V or above.



**Figure 11**

- b.** What value should  $R_1$  be so that the fan will switch on at  $20^\circ\text{C}$ ?

2 marks

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|                             |
|-----------------------------|
| <b>k<math>\Omega</math></b> |
|-----------------------------|

- c.** Will this fan operate at  $20^\circ\text{C}$  **and above**? Explain your answer.  
YES / NO (circle one)

3 marks

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- d.** To have the fan switch on at a lower temperature, should the value of  $R_1$  be increased or decreased? Justify your answer.

3 marks

INCREASED / DECREASED

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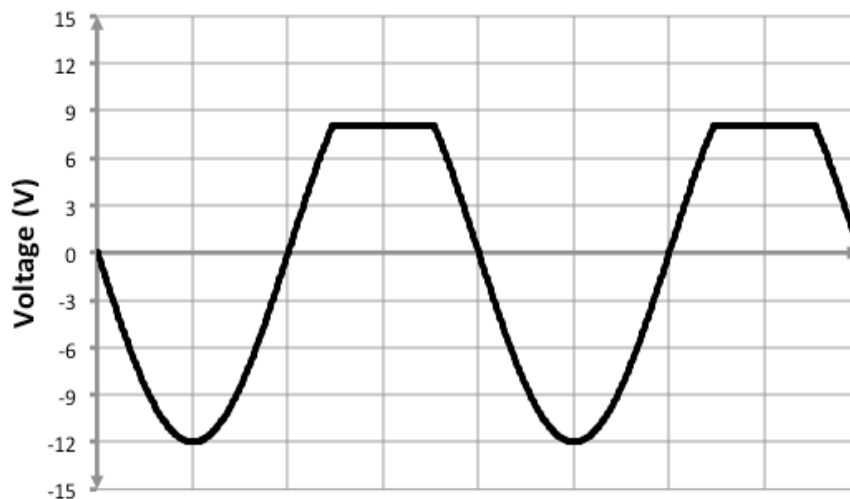
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**Question 10 (7 marks)**

Some Physics students are investigating an amplifier. They use a cathode ray oscilloscope to examine the input and output waveforms, which are shown in Figures 12 and 13.

**Input****Figure 12****Output****Figure 13**

- a. Calculate the gain of the amplifier in the linear region.

2 marks

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- b. On the axes shown in Figure 14, sketch the characteristic for the amplifier.

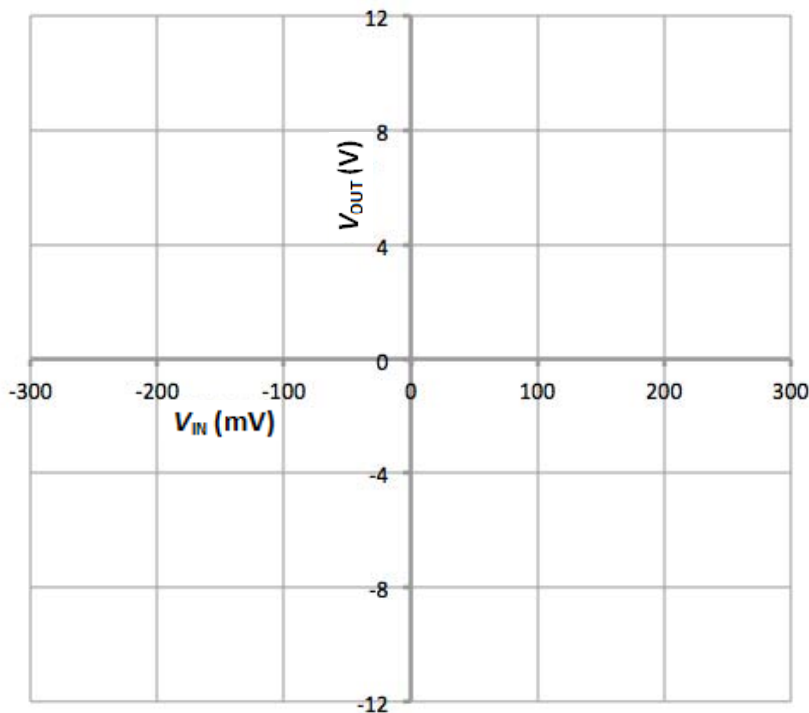


Figure 14

3 marks

- c. This amplifier is used in an audio system. A microphone transmits an electrical signal wave as  $V_{in}$ , and  $V_{out}$  is provided to a loudspeaker. If a sound wave from a microphone were input to this amplifier with limits of  $\pm 250$  mV, would the loudspeaker reproduce this sound accurately? Give a reason for your answer.

2 marks

YES /NO (circle one)

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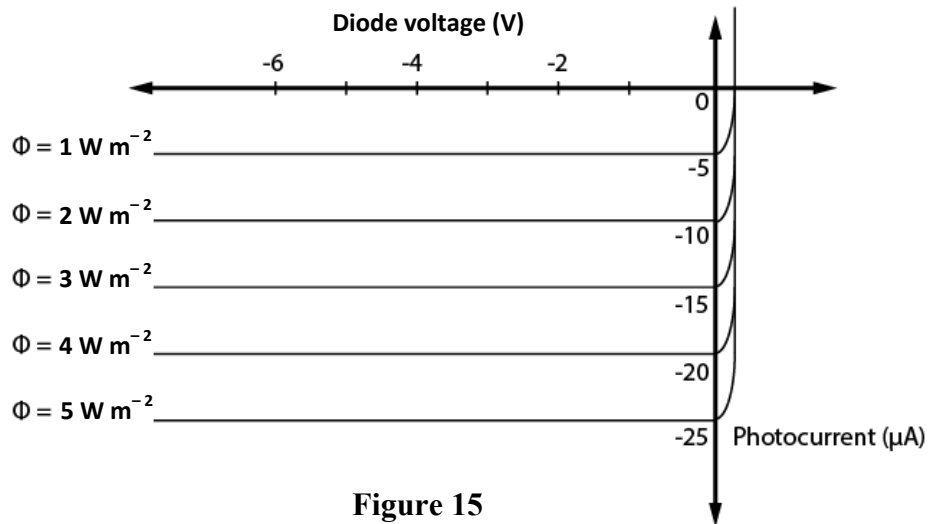
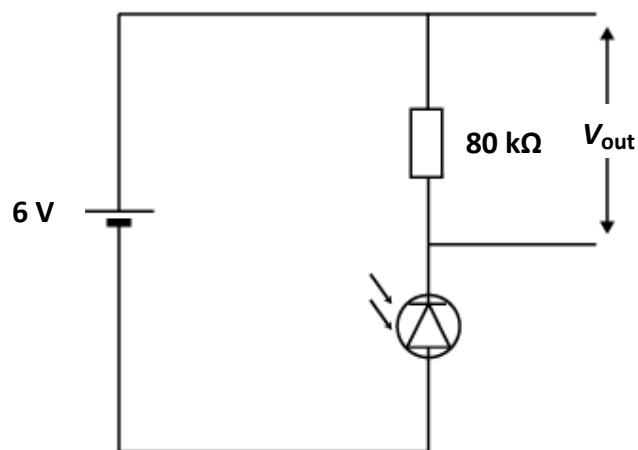
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**Question 11 (5 marks)**

A photodiode is used as part of a photonics system. It has a characteristic as shown in Figure 15 and is installed in the circuit shown in Figure 16.

**Figure 15****Figure 16**

- a. The photodiode has a surface area of  $25 \text{ mm}^2$ . If light of  $0.10 \text{ mW}$  falls on this surface, what is the magnitude of the current that will flow through the photodiode?

3 marks

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$\mu\text{A}$

- b.** With light of  $5 \text{ W m}^{-2}$  incident on the photodiode, calculate the voltage drop ( $V_{\text{out}}$ ) across the fixed resistor.

2 marks

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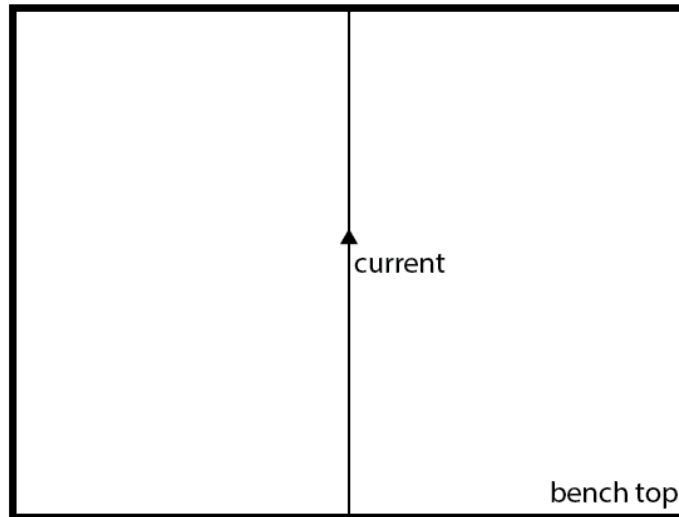
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|   |
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| V |
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**Area of study – Electric power****Question 12 (4 marks)**

Electric current flows through a straight conductor lying on a bench top, as shown in Figure 17.

- a. On Figure 17, show the direction of the magnetic field produced by the current as it passes through the bench top on either side of the conductor. Use  $\times$  to indicate a field directed into the page and  $\bullet$  to indicate a field directed out of the page.



**Figure 17**

2 marks

- b. As shown in Figure 18, an external magnetic field of 0.01 T is supplied to a 10 cm length of the conductor. If the conductor carries 5 A of current, calculate the magnitude of the force it experiences. Assume the magnetic field is entirely contained within the 10 cm length.

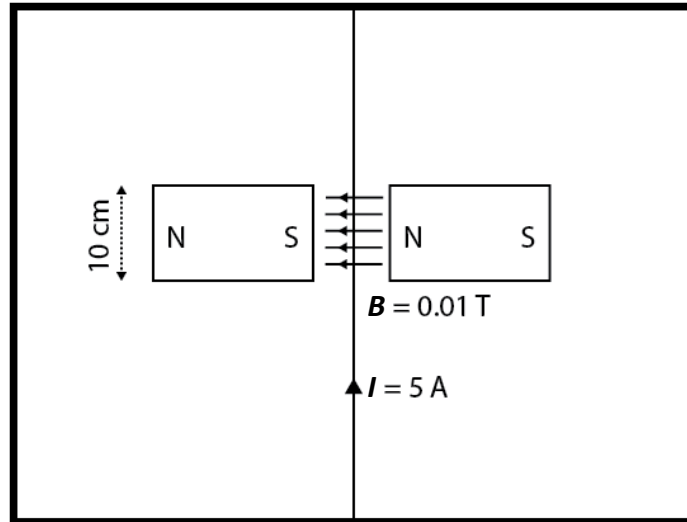


Figure 18

2 marks

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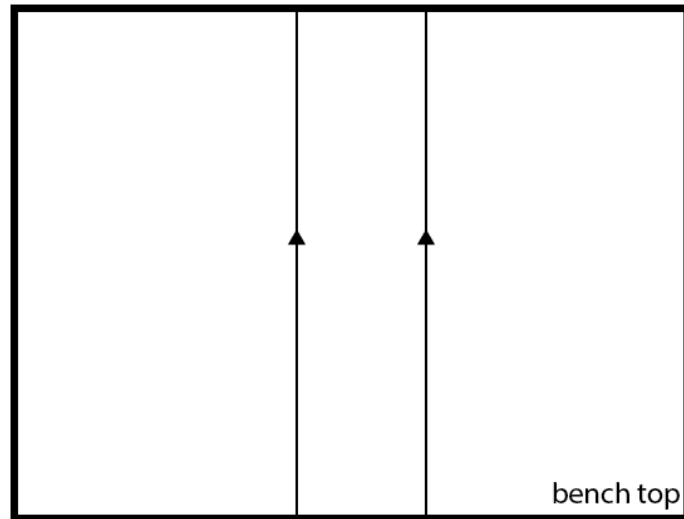


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N

**Question 13 (2 marks)**

Two identical conductors are placed on a bench top, as shown in Figure 19. They each carry an identical current in the direction shown. Each conductor experiences a magnetic force. Draw an arrow on each conductor to show the direction of these forces.

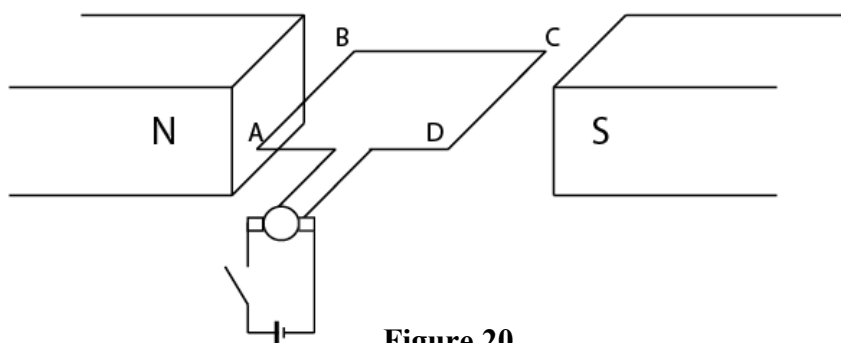
**Figure 19**

2 marks

**Question 14 (6 marks)**

A simple DC motor is constructed with 100 turns of wire within a magnetic field of 0.001 T. 12 V is supplied to the coil, which has a resistance of 50  $\Omega$ .

- a. Figure 20 shows that the motor is connected to a power supply by a split-ring commutator. Complete the diagram by drawing the split in the commutator in the correct orientation.



**Figure 20**

1 mark

When the switch is closed, the coil experiences a force that turns the coil from its initial perfectly horizontal position.

- b. Calculate the magnitude of the force on side AB (of length 12 cm) at the instant the power is switched on.

3 marks

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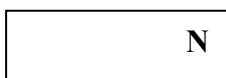
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- c. Explain why side AB experiences a magnetic force but side BC experiences no magnetic force at this instant.

2 marks

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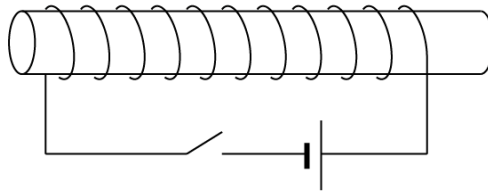


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**Question 15 (4 marks)**

A solenoid is constructed by winding insulated copper wire around a soft iron core, as shown in Figure 21.

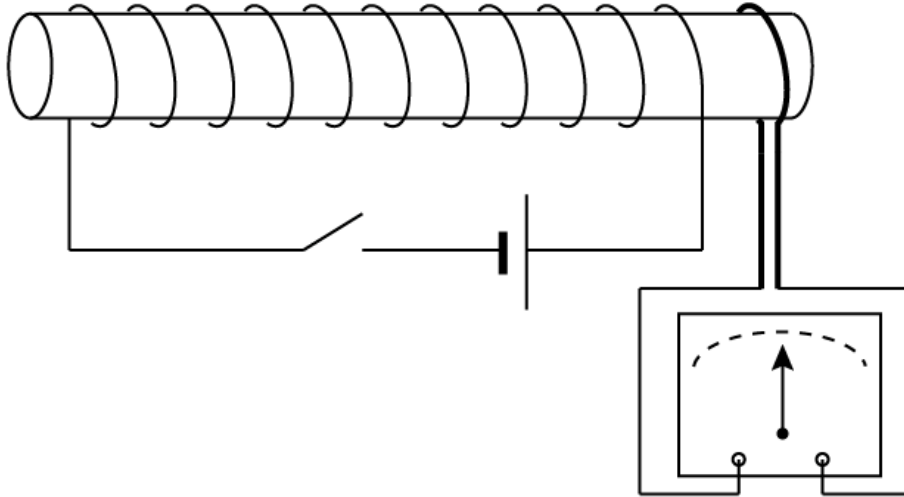
- a. When the current is connected as shown, the solenoid acts as an electromagnet. Draw three lines to show the direction of the magnetic field around the solenoid.



**Figure 21**

2 marks

A single loop of wire connected to a galvanometer is placed around the end of the iron core, as shown in Figure 22. When the current supplied to the solenoid is turned off, the galvanometer needle moves to the right before returning to its central position.



**Figure 22**

- b.** Describe how the galvanometer needle moves when the current to the solenoid is switched back on again.

2 marks

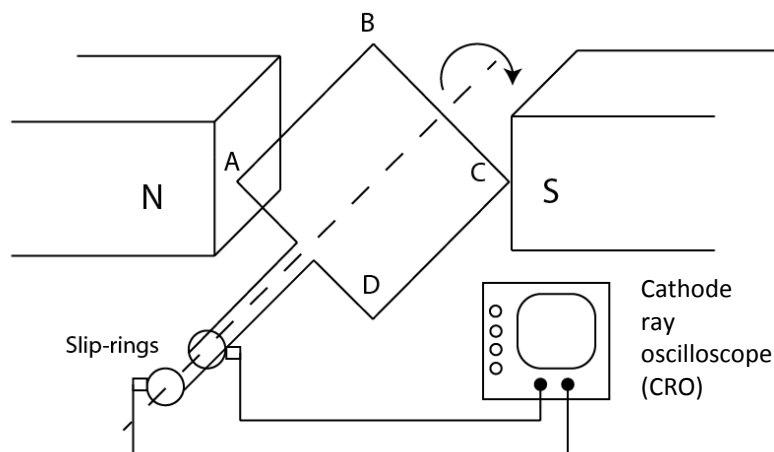
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**Question 16 (6 marks)**

A generator consists of a rectangular loop of 25 turns within a magnetic field of 0.005 T. The loop has an area of  $6.0 \times 10^{-4} \text{ m}^2$ . The generator is connected to a cathode ray oscilloscope through a set of slip rings, as shown in Figure 23.

**Figure 23**

When the loop is rotated from the position shown, a current is induced, flowing from A to B.

- a. Use Lenz's law to explain why a current flows in this direction.

3 marks

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- b.** The loop is rotated at 50 Hz. Calculate the average emf induced in the loop by this rotation.

3 marks

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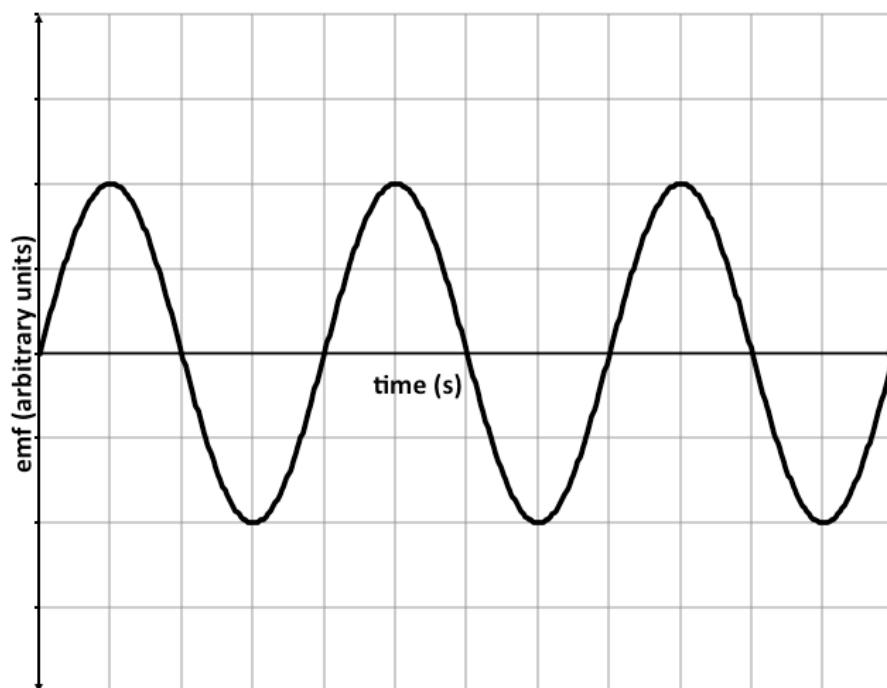
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**mV**

**Question 17 (4 marks)**

- a. The cathode ray oscilloscope trace observed when a generator with slip rings attached is rotated at 60 Hz is displayed in Figure 24. On the same axes, sketch the trace that would be observed if the loop was rotated at 30 Hz instead.

**Figure 24**

2 marks

- b. In what way could this generator be changed if DC power output was required?

2 marks

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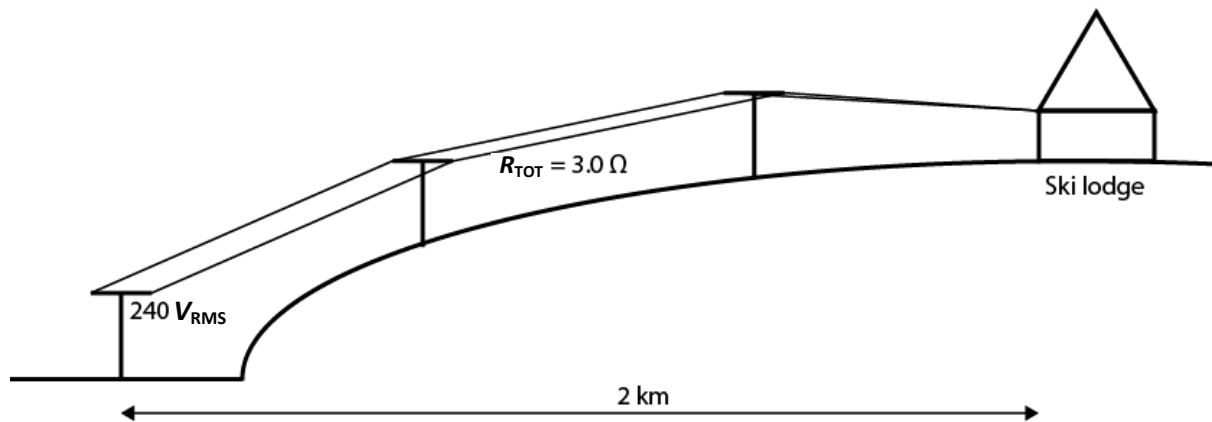
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**Question 18 (6 marks)**

A ski lodge relies on mains electricity from a power line at the bottom of a hill 2 km away (Figure 25). The mains electricity is provided at  $240\text{ V}_{\text{RMS}}$  from the power line and passes through wires with a total resistance of  $3.0\ \Omega$ .

**Figure 25**

- a. The lodge draws  $30\text{ A}$  of current but the occupants notice that their electronic devices don't operate properly. What voltage is supplied to the lodge under these conditions?

3 marks

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V

A suggested solution to this problem is to run two more identical power lines up to the lodge so that each line carries 10 A.

- b. What voltage reaches the lodge when delivered through three parallel lines totalling 30 A?

3 marks

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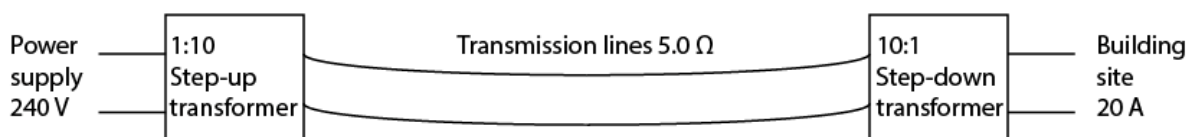


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**V**

### Question 19 (7 marks)

An electrician is installing a temporary power line to a building site. He installs a transformer at each end of the transmission lines, as shown in Figure 26.



**Figure 26**

- a. If there are 240 V in the primary coil of the step-up transformer, how many volts are in the secondary coil?

2 marks

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**V**

- b.** If there are 20 A in the secondary coil of the step-down transformer at the building site, what current is passing through the transmission lines?

2 marks

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| <b>A</b> |
|----------|

- c.** Find the power loss in the transmission lines under these circumstances and use this value to find the voltage provided to the workers on the building site.

3 marks

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| <b>V</b> |
|----------|

**Area of study – Interactions of light and matter****Question 20 (4 marks)**

A green laser operates at 5 mW and emits light of wavelength 500 nm.

- a.** What is the energy of a single photon of light from this laser? Give your answer in joules.

2 marks

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| <b>J</b> |
|----------|

- b.** Would a 5 mW laser that emits red light emit more or fewer photons per second than the green laser? Explain your answer (calculations not required).

2 marks

MORE / FEWER (circle one)

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**Question 21 (3 marks)**

Some Physics students shine a laser through a pair of narrow vertical slits and onto a dark surface. They observe a pattern of light and dark bands.

Explain how both the bright bands and the dark bands are formed and why this supports the wave model of light rather than the particle model of light.

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**Question 22 (7 marks)**

The following physical constants may be of use in Question 22:

Charge on an electron,  $e = 1.6 \times 10^{-19}$  C

Mass of an electron,  $m_e = 9.1 \times 10^{-31}$  kg

An electron gun in a cathode ray tube accelerates electrons across a potential difference of 250 V, giving each electron 250 eV of kinetic energy.

- a. Calculate the velocity of these electrons, assuming all their kinetic energy comes from the electron gun.

3 marks

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|-------------------|
| $\text{m s}^{-1}$ |
|-------------------|

- b. The electron gun is tuned so that electrons now have a velocity of  $8.1 \times 10^6 \text{ m s}^{-1}$ . Calculate the de Broglie wavelength of an electron fired from this gun.

2 marks

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|------------|
| $\text{m}$ |
|------------|

Electrons travelling at this velocity can be used to create diffraction patterns when passed through or around microscopic materials.

- c. What frequency of electromagnetic radiation would be required to produce the same diffraction pattern as electrons with a de Broglie wavelength of  $1.6 \times 10^{-10} \text{ m}$ ?

2 marks

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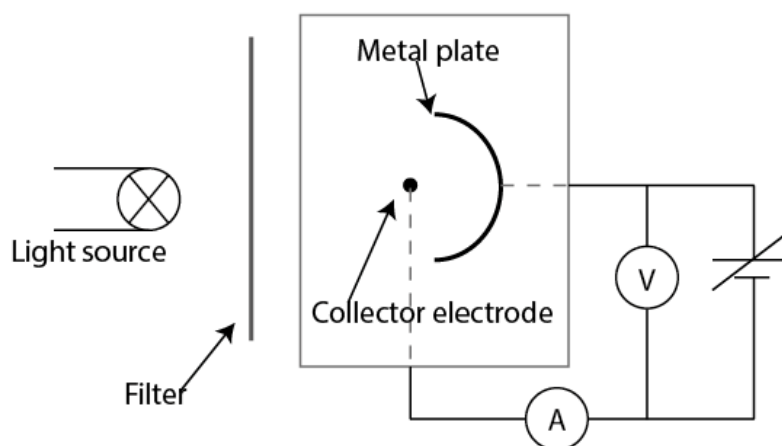
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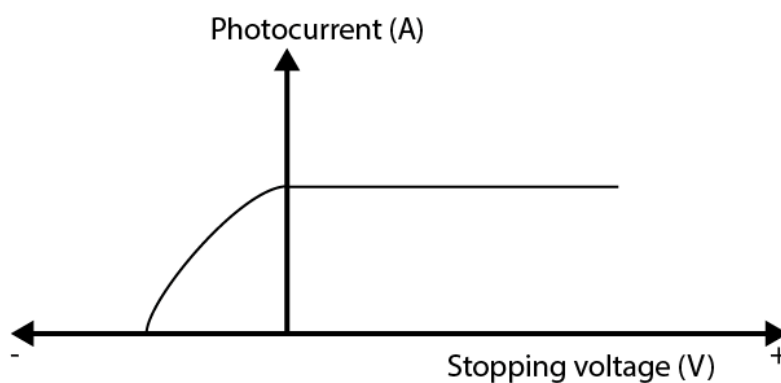
|           |
|-----------|
| <b>Hz</b> |
|-----------|

**Question 23 (7 marks)**

When investigating the photoelectric effect, some Physics students construct an apparatus in which light of a single wavelength can be shone onto a clean metal film in an evacuated tube. A potential difference can be applied between the metal plate and the collector electrode and any photocurrent can be measured. The apparatus is shown in Figure 27.

**Figure 27**

A student uses a particular frequency of light while varying the stopping voltage and achieves the result shown in Figure 28.

**Figure 28**

- a. If the frequency of the light is increased, which of the graphs shown in Figure 29 would be produced? Justify your answer.

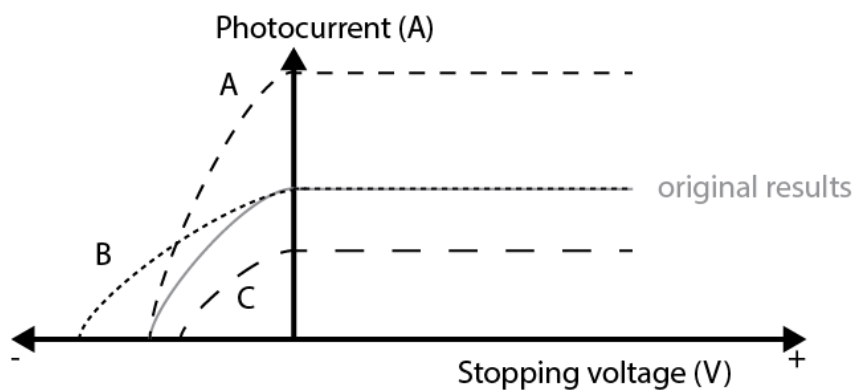


Figure 29

3 marks

A / B / C (circle one)

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When using UV light, the students found that when they increased the voltage to 3.4 V the photocurrent dropped to zero.

- b. What was the kinetic energy of the fastest-moving electron emitted by the UV light? Give your answer in joules.

2 marks

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|          |
|----------|
| <b>J</b> |
|----------|

- c. The students use a piece of lithium metal that is known to have a work function of 2.93 eV. What is the minimum frequency of light they will need to obtain a photocurrent?

2 marks

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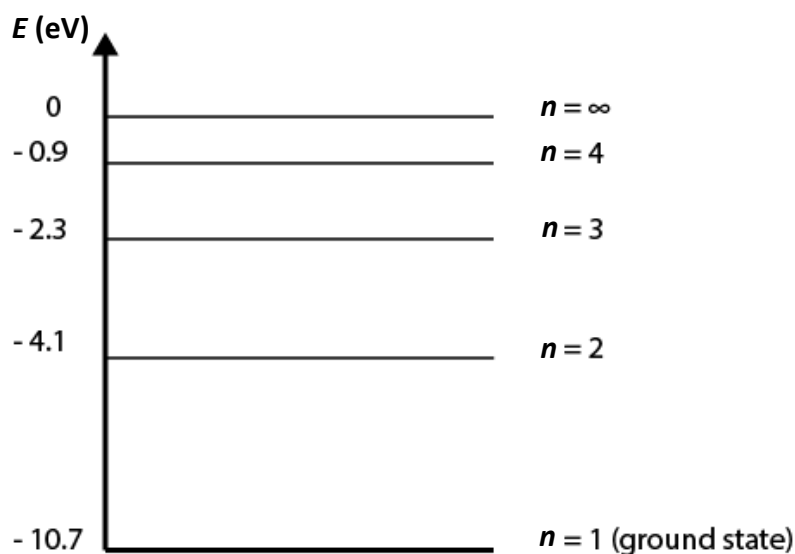
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|    |
|----|
| Hz |
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**Question 24 (4 marks)**

Figure 30 is a diagram showing the electron energy levels for a certain element.

**Figure 30**

- a. Which of the following is a list of all possible photon energies emitted when an excited electron transitions from the second excited state to the ground state?

2 marks

- A. 1.4, 3.2, 9.8 eV  
 B. 8.4, 3.2, 1.8 eV  
 C. 0.9, 2.3, 4.1 eV  
 D. 1.8, 6.6, 8.4 eV

- b. Explain why only certain electron energies are observed in excited atoms. Mention 'de Broglie wavelength' in your answer.

2 marks

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**END OF CORE STUDIES**