

# Physics

## Question and Answer Book

2024 Insight Publications Trial Examination

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- Reading time is **15 minutes**
- Writing time is **2 hours 30 minutes**

### Approved materials

- One scientific calculator
- Pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape)

### Materials supplied

- Question and Answer Book of 43 pages
- Multiple-Choice Answer Sheet

### Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Students should refer to the VCAA Formula Sheet available at

<https://www.vcaa.vic.edu.au/assessment/vce-assessment/past-examinations/Pages/physics.aspx> as needed.

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## Section A – Multiple-choice questions

### Instructions

- Answer **all** questions in pencil on the Multiple-Choice Answer Sheet.
  - Choose the response that is **correct** or that **best answers** the question.
  - A correct answer scores 1; an incorrect answer scores 0.
  - Marks will **not** be deducted for incorrect answers.
  - No marks will be given if more than one answer is completed for any question.
  - Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
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### Question 1

Jurgen was driving his car north at a speed of  $18 \text{ m s}^{-1}$  when he saw his friend Virgil jogging in the same direction. Jurgen slowed his car to  $3 \text{ m s}^{-1}$  over a period of  $5 \text{ s}$  to chat with Virgil.

Taking north as positive, what was the car's average acceleration?

- A.  $-3.6 \text{ m s}^{-2}$
- B.  $-3.0 \text{ m s}^{-2}$
- C.  $3.0 \text{ m s}^{-2}$
- D.  $3.6 \text{ m s}^{-2}$

### Question 2

Trent is playing snooker and uses a cue to strike the ball, as shown in the diagram below.



The ball is observed to move away from the cue in a straight line.

Which one of the following is the best application of Newton's first law of motion in this situation?

- A. As there is a net force on the ball, there is also a net force on the cue in the opposite direction.
- B. The ball and the cue both accelerate, but the ball speeds up and the cue slows down.
- C. As the ball accelerates after being struck, there must be a net force on the ball.
- D. As the ball accelerates more than the cue, the force on the ball is greater than the force on the cue.

**Question 3**

Andi is a stunt driver in movies. In one movie scene, she drove her car at speed  $v$ , then applied a constant braking force  $F$ . The car stopped in a distance of  $d$ .

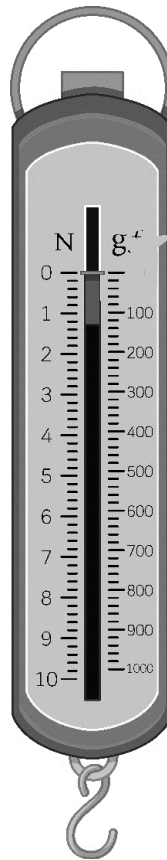
In the next movie scene, she would like to stop in a distance of  $2d$  while applying the same constant braking force  $F$ .

What speed should she drive at?

- A.  $v$
- B.  $\sqrt{2}v$
- C.  $2v$
- D.  $4v$

**Question 4**

A spring balance designed for use on Earth is taken to Mars. It displays both force and mass (as shown below).



An object is hung on the spring and a reading is taken.

Which one of the following statements is correct?

- A. The force reading is correct and the mass reading is incorrect.
- B. The force reading is incorrect and the mass reading is correct.
- C. The force reading is correct and the mass reading is correct.
- D. The force reading is incorrect and the mass reading is incorrect.

**Question 5**

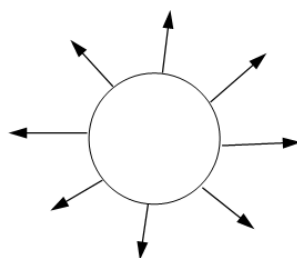
A length of wire is carrying an alternating current (AC).

Which one of the following is the best description of the magnetic field around the wire?

- A. uniform
- B. static
- C. none
- D. changing with time

**Question 6**

Matip traced the force field lines around several objects in a physics laboratory and obtained the diagram below for one of these objects.



Which one of the following objects produces the field lines depicted above?

- A. the south pole of a magnet
- B. a positive charge
- C. a mass
- D. a negative charge

**Question 7**

A satellite orbits the Earth in a circular orbit.

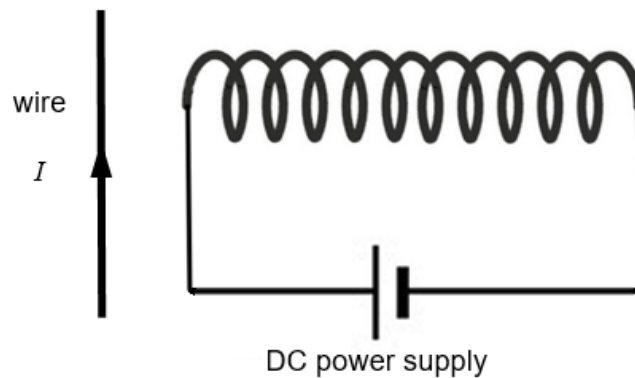


Which one of the following is the best explanation of the satellite's orbital motion?

- A. The satellite travels fast enough to prevent it from being attracted by Earth's gravity.
- B. The orbital speed of the satellite creates centripetal force that opposes Earth's gravity.
- C. As the satellite falls towards Earth because of Earth's gravity, its path follows the curvature of Earth.
- D. None of the above.

**Question 8**

A straight wire with a constant current,  $I$ , flowing through it is placed next to a coil that is connected to a DC power supply. When the power supply is switched on, the wire experiences a magnetic force **out of the page**.

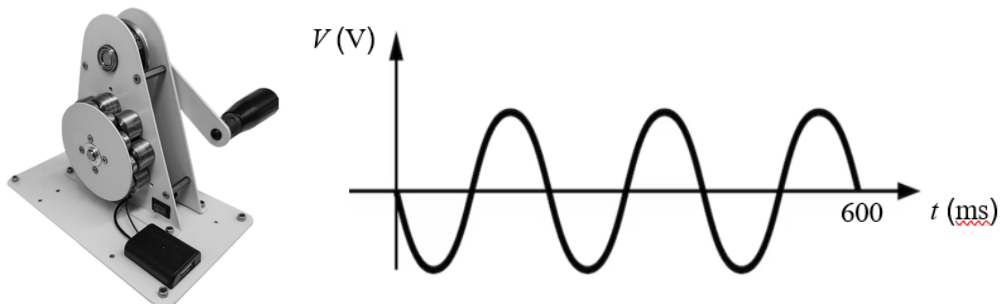


Which one of the following actions will cause the wire to experience a magnetic force **into the page**?

- A. reversing the direction of the DC power supply
- B. switching off the DC power supply
- C. increasing the voltage of the DC power supply
- D. decreasing the voltage of the DC power supply

Use the following information to answer Questions 9 and 10.

A hand-crank generator can be used to provide emergency power for lighting. The crank is rotated by hand continuously and an AC output is generated, as shown below.



### Question 9

The frequency with which the crank is rotated is closest to

- A.  $5 \times 10^{-3}$  Hz
- B. 1.7 Hz
- C. 5.0 Hz
- D. 20 Hz

### Question 10

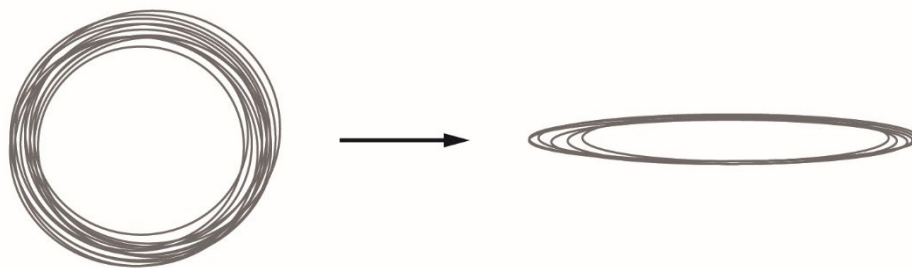
The peak-to-peak voltage of the AC output is found to be 36 V.

The RMS voltage of the output is nearest to

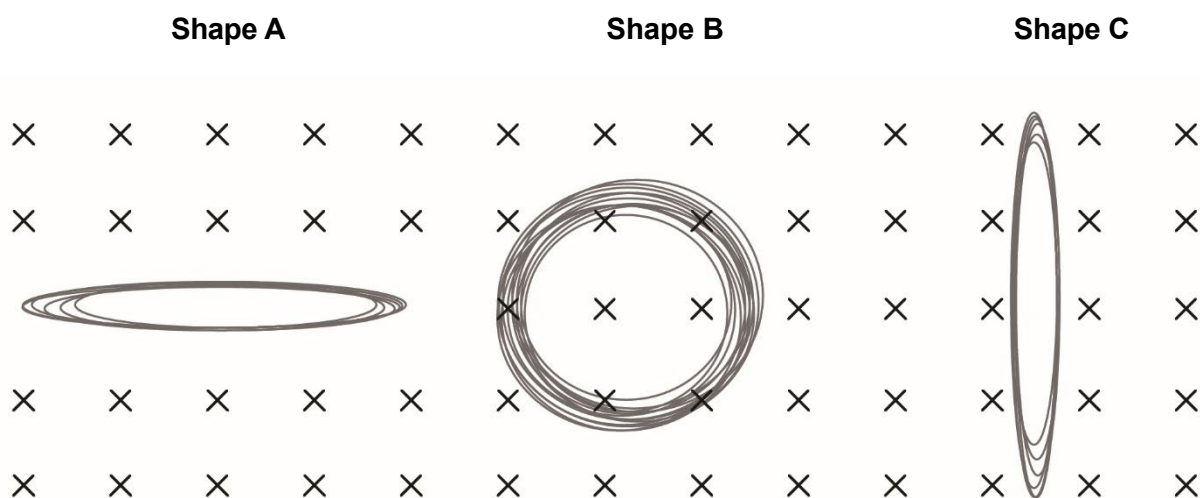
- A. 13 V
- B. 18 V
- C. 25 V
- D. 51 V

Use the following information to answer Questions 11 and 12.

Ibou took a closed loop of copper wire and coiled it into a continuous circular coil. He then squashed the circular coil into a flat coil. The circular coil and flattened coil are shown below.



Ibou took the flattened coil and placed it inside a magnetic field that is directed into the page.



Starting with Shape A, he stretched the coil until it returned to its original circular shape (Shape B). He continued to stretch it until it became flat again (Shape C).

### Question 11

Which one of the following statements best describes the current induced in the coil as the coil changed from Shape A to Shape B, and from Shape B to Shape C?

	Shape A to Shape B	Shape B to Shape C
A.	no current is induced	no current is induced
B.	current is induced	no current is induced
C.	no current is induced	current is induced
D.	current is induced	current is induced



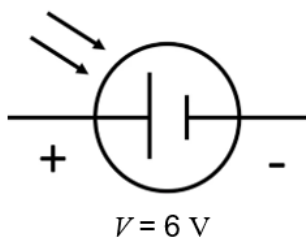
**Question 12**

Which one of the following statements best describes the direction of the current induced in the coil as it changes from Shape A to Shape B, and from Shape B to Shape C?

	Shape A to Shape B	Shape B to Shape C
A.	no current is induced	no current is induced
B.	clockwise	anticlockwise
C.	anticlockwise	clockwise
D.	clockwise	clockwise

**Question 13**

Alexa and Dominik found some photovoltaic cells in their physics laboratory. The cells are identical and each produces 6 V under full sunlight.



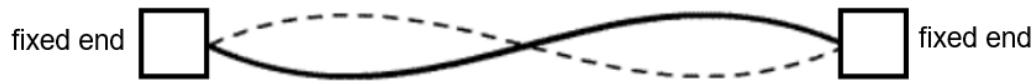
Alexa and Dominik would like to use these photovoltaic cells to produce an EMF of 9 V.

What should they do?

- A. It is impossible to produce 9 V using these cells.
- B. Connect two cells in series and then connect one more cell in parallel.
- C. Connect three cells in parallel.
- D. Connect two cells in series.

**Question 14**

The diagram below depicts a standing wave on a guitar string between two fixed ends. The frequency of the wave is 294 Hz.

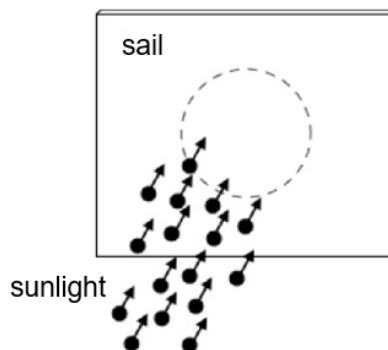


Which one of the following frequencies is **unlikely** to produce a standing wave pattern in the string?

- A. 98 Hz
- B. 147 Hz
- C. 441 Hz
- D. 588 Hz

**Question 15**

Physicists have proposed using sunlight to propel a small spacecraft by attaching a very large sail to it. Photons emitted from the Sun exert a force on the sail by elastic collision and momentum transfer.

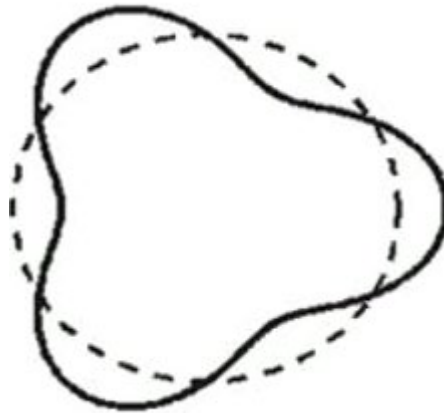


Which one of the following statements does **not** form part of the correct explanation of the physics of this propulsion system?

- A. Light can be modelled as particles.
- B. All the light energy,  $E = \frac{hc}{\lambda}$ , is transferred to the sail as kinetic energy,  $E_k$ .
- C. The momentum of light particles is given by  $p = \frac{h}{\lambda}$ .
- D. Photons have momentum even though they have no mass.

Use the following information to answer Questions 16 and 17.

The diagram below depicts one of the harmonics of an electron's orbit around the nucleus of an atom as a standing wave.



### Question 16

When the electron returns to ground state, how many different lines would be observed in the atom's emission spectrum?

- A. 1
- B. 2
- C. 3
- D. 4

### Question 17

Which one of the following statements best describes the standing wave model of the electron's orbit around the nucleus of the atom?

- A. The electron does not lose energy, as it exists as a standing wave around the nucleus.
- B. The standing wave can take on a continuously varying energy level as it orbits the nucleus.
- C. The standing wave depicts the path the electron takes as it orbits the nucleus.
- D. The standing wave depicts the shape that the electron takes as it orbits the nucleus.

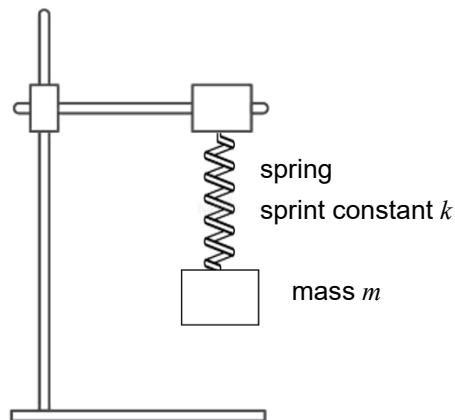
### Question 18

Which one of the following objects is in an inertial frame of reference?

- A. a satellite orbiting Earth at a constant speed
- B. an electron moving in a synchrotron ring at a constant speed
- C. a muon moving in a linear accelerator at a constant speed
- D. a train travelling at a constant speed around a bend

Use the following information to answer Questions 19 and 20.

Missy and Naga are conducting a series of experiments with a mass oscillating on a spring. They want to determine the oscillation period,  $T$ , of mass,  $m$ , on the spring with spring constant  $k$ . The set-up is shown below.



Missy and Naga want to explore the effect that changing the mass has on the oscillation period.

### Question 19

Which one of the following options correctly identifies the independent, dependent and controlled variables in the experiment?

	Independent variable	Dependent variable	Controlled variable
A.	$T$	$m$	$k$
B.	$m$	$T$	$k$
C.	$k$	$T$	$m$
D.	$T$	$k$	$m$

### Question 20

Missy and Naga's background research suggests that the equation for the spring constant is

$$k = 4\pi^2 \frac{m}{T^2}.$$

To achieve a graph of a linear relationship, which one of the following combinations of variables should be plotted?

- A.  $T^2$  and  $m$
- B.  $T^2$  and  $m^2$
- C.  $T$  and  $m$
- D.  $\sqrt{T}$  and  $m$

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## Section B

### Instructions

- Answer **all** questions in the spaces provided.
- Write your responses in English.
- Where an answer box is provided, write your final answer in the box.
- In the questions where more than one mark is available, appropriate working **must** be shown.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

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### Question 1 (4 marks)

Diogo went on a holiday to New Zealand. He visited a famous bungee jumping attraction and took a jump. Starting from rest, Diogo accelerated at an average of  $8.1 \text{ m s}^{-2}$  for a period of 4.2 s.



Figure 1

- a. Calculate Diogo's speed after falling for 4.2 s.

1 mark

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- b. Diogo's mass at the time was 70 kg. Show that the net force on Diogo when he was accelerating is 567 N.

1 mark

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As Diogo fell further, the bungee cord started to stretch, which slowed him down.



Figure 2

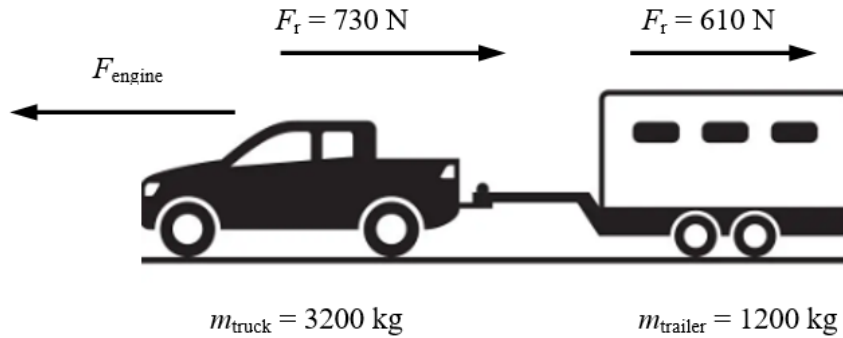
- c. On Figure 2 above, draw an arrow or arrows to represent **all** the forces acting on Diogo at this stage of his jump. Label each arrow. (Air resistance can be ignored.)

2 marks

**Question 2** (6 marks)

Arvi and Elliott are driving a ute that is towing a trailer. The ute’s engine provides the force on the ute to move it forward. The mass of the ute is 3200 kg and the mass of the trailer is 1200 kg.

They are driving directly west at a constant speed of  $80 \text{ km h}^{-1}$ . The resistive forces on the ute and on the trailer are 730 N and 610 N, respectively.



**Figure 3**

- a. State the magnitude of  $F_{\text{engine}}$ , the ute engine’s force.

1 mark

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The transmission of the ute malfunctions and  $F_{\text{engine}}$  decreases to 0 N. The ute and trailer start to slow down because of the constant resistive forces on them.

- b. Calculate the magnitude and direction of the acceleration of the ute and trailer system, giving your answer to 3 significant figures. Show your working.

3 marks

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Magnitude

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

Direction



A coupling connects the ute to the trailer. It allows the ute to exert a force on the coupling and pull the trailer.



Figure 4

- c. Calculate the size of the force on the coupling as the ute and trailer are slowing down. The coupling can be assumed to have no mass.

2 marks

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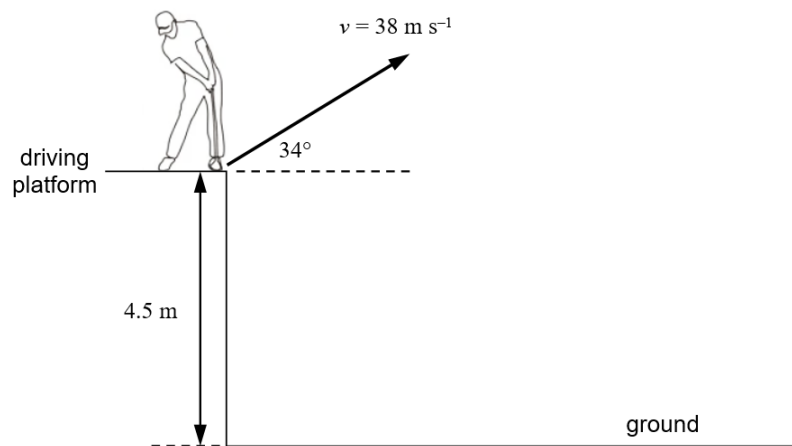
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**Question 3** (7 marks)

Sophie tees off at a golf driving range. The golf ball leaves the edge of the driving platform at a speed of  $38 \text{ m s}^{-1}$  and an angle of  $34^\circ$  to the horizontal. The driving platform is  $4.5 \text{ m}$  above the ground. Air resistance can be ignored.

**Figure 5**

- a. Show that the initial vertical speed of the golf ball is  $21.2 \text{ m s}^{-1}$ .

1 mark

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- b. Show that the initial horizontal speed of the ball is  $31.5 \text{ m s}^{-1}$ .

1 mark

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- c. Determine the maximum height the ball reached above ground level.

2 marks

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- d. Calculate the total flight time of the ball, from the time it is hit until the time it reaches the ground.

3 marks

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**Question 4** (10 marks)

Two toy trains are placed on a frictionless track. A compressed spring is placed between them and the trains are held stationary.

The mass of the train on the left is 300 g and the mass of the train on the right is 200 g. The mass of the spring is negligible. The length of the compressed spring is 28 mm (as shown in Figure 6a).

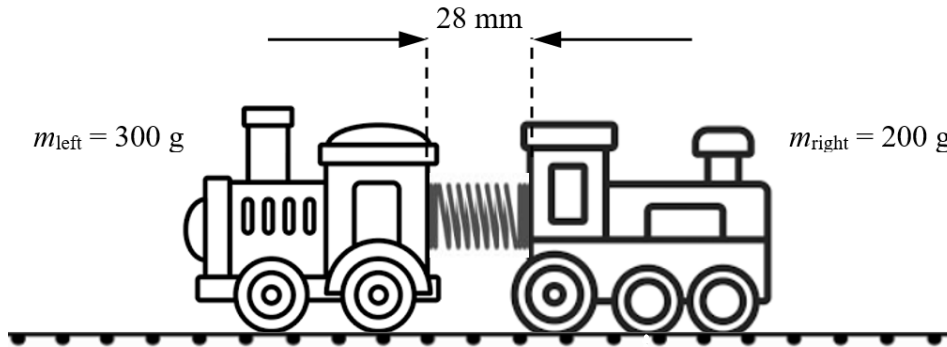


Figure 6a

The trains are released and the spring returns to its natural length of 42 mm, pushing the two trains apart (as shown in Figure 6b). The train on the right reaches a velocity of  $21.9 \text{ cm s}^{-1}$ .

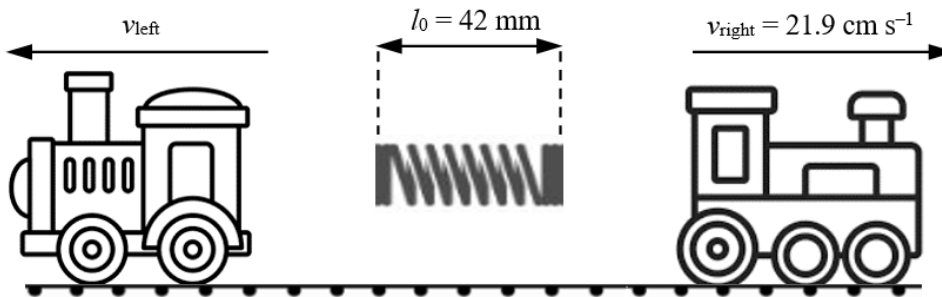


Figure 6b

- a. Name the physics principle that could be used to determine the velocity of the train on the left,  $v_{\text{left}}$ . Describe the assumption(s) made when applying that principle.

2 marks

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- b. Determine the magnitude and direction of the velocity of the toy train on the left,  $v_{\text{left}}$ .  
Show your working.

3 marks

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Magnitude

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

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- c. Calculate the total kinetic energy of the toy trains after they were released.

2 marks

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- d. State the elastic potential energy in the spring before the two trains were released.  
Energy losses may be ignored.

1 mark

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- e. Determine the spring constant of the spring.

2 marks

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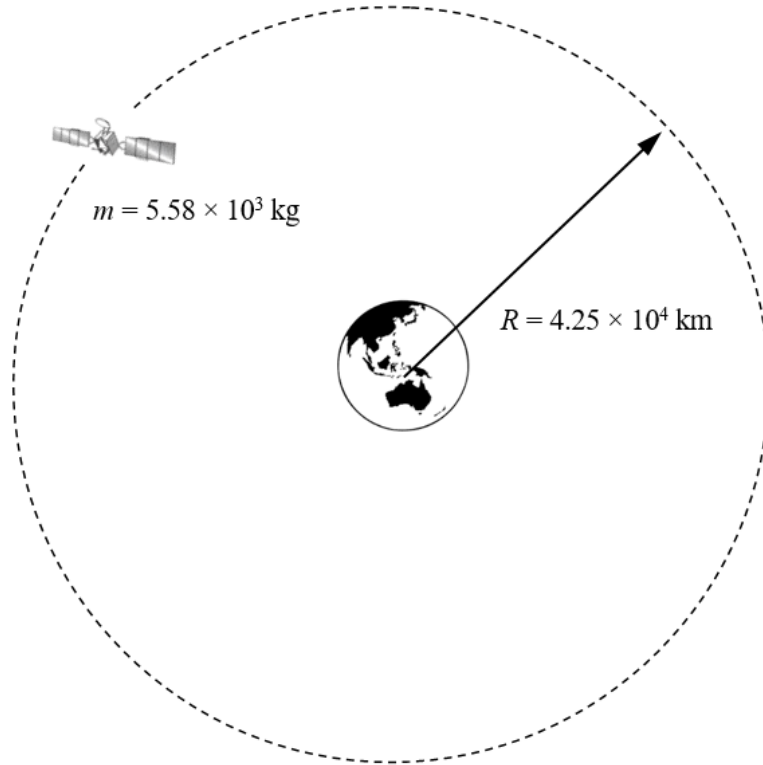
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**Question 5** (8 marks)

Geostationary satellites are in orbit but they remain above the same point on the surface of Earth. When they reach the end of their operational lives, they are moved to a higher orbit. This reduces the probability that they will collide with operational satellites.

One such non-operational satellite is Intelsat 10-02, which is orbiting at an orbital radius of  $R = 4.25 \times 10^4$  km. The mass of Intelsat 10-02 is  $5.58 \times 10^3$  kg.

**Figure 7**

- a. Show that the gravitational force of Earth on Intelsat 10-02 is  $1.23 \times 10^3$  N.

1 mark

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- b. Determine the orbital speed of the satellite.

2 marks

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In an effort to reduce the number of rocket launches and expenditure, a mission extension vehicle was sent to retrieve Intelsat 10-02 and place it back in geostationary orbit at the lower orbital radius of  $R = 4.22 \times 10^4$  km.

The graph below shows the variation in the gravitational force of Earth ( $F_g$ ) on Intelsat 10-02 between the two orbital positions ( $R$ ).

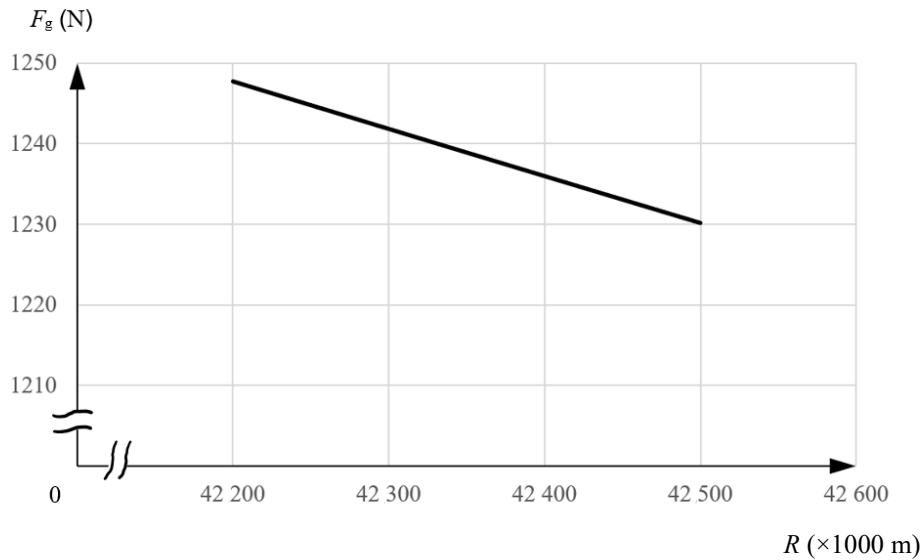


Figure 8

- c. For each of the following properties of the satellite, describe how it changes as the satellite is moved from the higher orbit to the geostationary orbit. Use the words 'decreases', 'stays the same' or 'increases' to correctly fill in the boxes below.

3 marks

Gravitational potential energy:	
Kinetic energy:	
Orbital period:	

- d. Calculate the difference in gravitational potential energy of Intelsat 10-02 between the two positions.

2 marks

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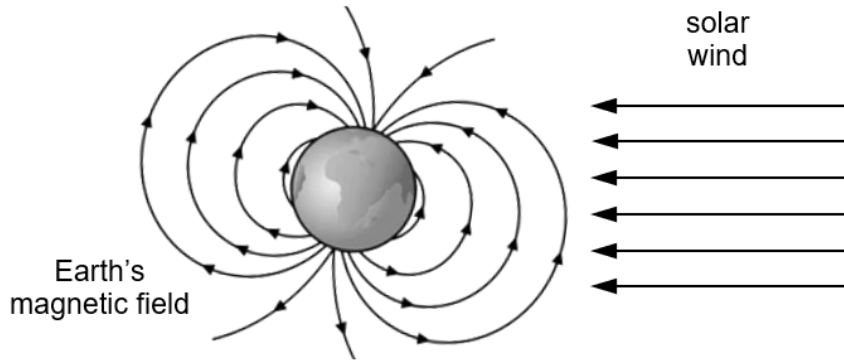
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**Question 6** (4 marks)

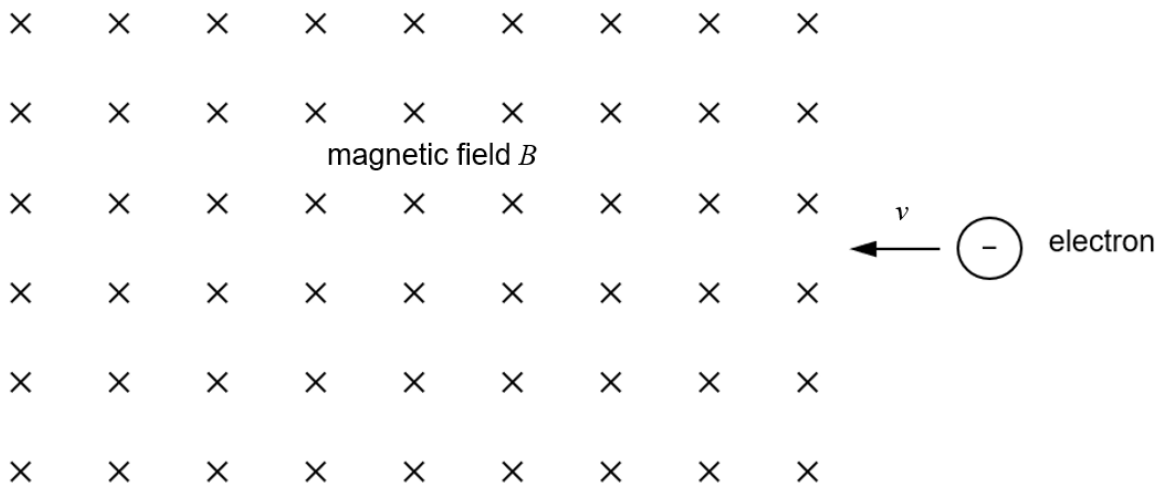
Auroras, often called northern lights or southern lights, are regularly visible near Earth’s north and south poles. They are caused when solar wind – positively and negatively charged particles emitted from the Sun – collide with particles in Earth’s atmosphere. These collisions emit electromagnetic radiation.



**Figure 9a**

Although solar wind approaches the Earth towards all latitudes between the North and South Poles, auroras are mostly seen at latitudes closer to the Poles. This is because as the solar winds enter Earth’s magnetic field, they experience a magnetic force that causes them to spiral towards the Poles.

The behaviour of solar wind when entering Earth’s magnetic field is similar to the behaviour of an electron on entering a magnetic field. Consider the situation represented in Figure 9b, where an electron enters a magnetic field that is directed into the page.



**Figure 9b**

a. The path taken by the electron will be curved.

In which direction will the electron be deflected: upwards or downwards?

1 mark



As these charged particles get closer to Earth their speeds do not change, as there is no atmosphere to produce air resistance. Furthermore, as the magnetic force acts perpendicular to their velocity vector, this does not cause any change in their speed.

However, these particles will spiral in tighter circular paths, with the radius of the paths becoming smaller.

- b. Using physics principles, explain why the radius of these circular paths becomes smaller as the charged particles get closer to Earth.

3 marks

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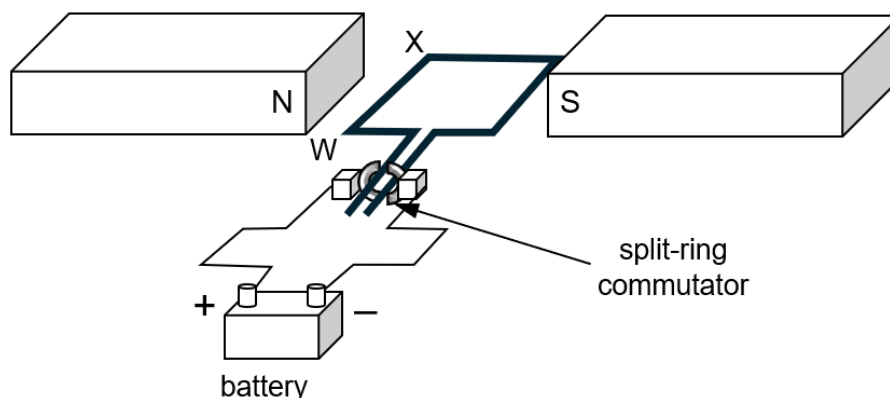
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**Question 7** (4 marks)

Mo and Luis are experimenting with a model DC motor that has a square coil of 50 turns and with side lengths,  $l$ , of 2.5 cm.

**Figure 10a**

The battery is switched on and a current of 1.3 A flows in the circuit. The magnetic field strength is uniform in the region of the coil and has a magnitude of 47 mT.

- a. Determine the magnitude and direction of the force on side WX.

2 marks

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Magnitude

Direction

Mo and Luis removed the magnet on the right. The magnetic field strength from the remaining magnet at position A (as shown in Figure 10b) is sufficient to create a magnetic force on side WX so that the coil rotates when the battery is switched on.

Mo and Luis then moved the magnet from position A to position B, with the north pole facing side XY and at the same distance from the coil. The battery is switched on.

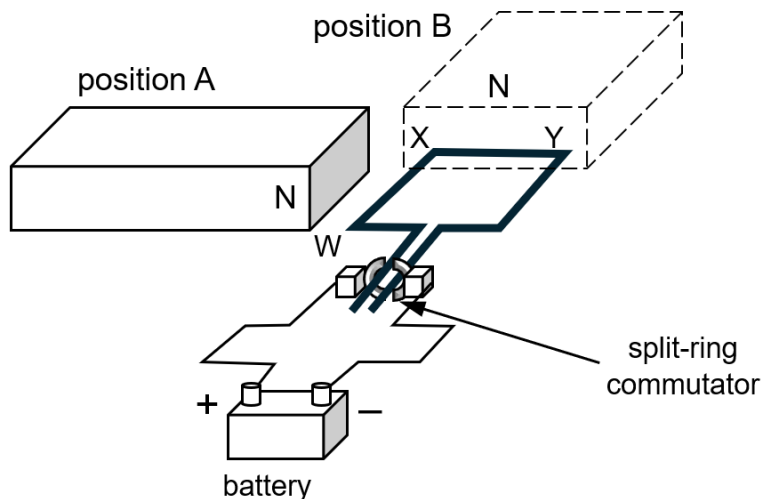
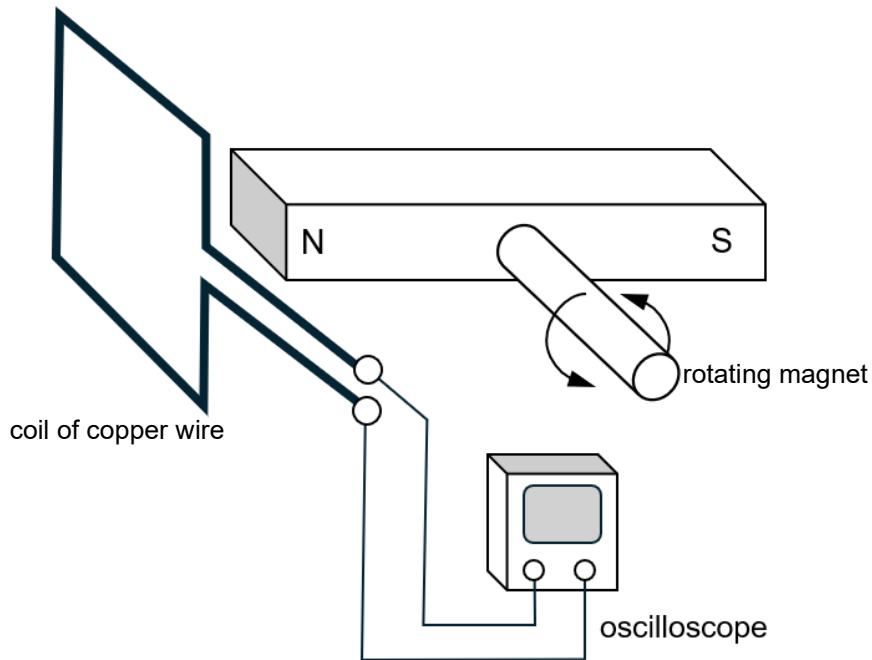


Figure 10b

- b. i. Will there be a force on side XY? 1 mark  
\_\_\_\_\_
  
- ii. Will the coil rotate? 1 mark  
\_\_\_\_\_

**Question 8** (7 marks)

Leanne and Mia constructed an AC generator using a square coil of copper wire with 75 turns. Each side of the coil is 38 mm long. They fixed the coil in a vertical position and placed a rotating magnet next to it. The magnetic field strength,  $B$ , at the coil is a maximum of 0.08 T when the north pole of the magnet is next to the coil. Half a turn later, when the south pole is next to the coil, the size of the magnetic field strength is the same.



**Figure 11**

**a.** Show that the maximum flux is  $1.16 \times 10^{-4}$  Wb.

2 marks

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**b.** Explain why this set-up, without slip rings, is still able to produce an AC output.

2 marks

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Leanne and Mia rotate the magnet at a frequency of 12 Hz.

c. Calculate the average EMF produced over a quarter turn.

3 marks

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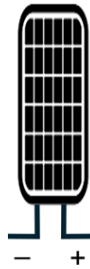
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**Question 9** (8 marks)

Alisson and Becker are using solar photovoltaic cells to charge their laptops and mobile phones. One panel of solar cells (shown in Figure 12a) can supply electricity at 23 V DC and 1 A under full sunlight.



**Figure 12a**

- a. Calculate the maximum power output of one panel of these solar cells.

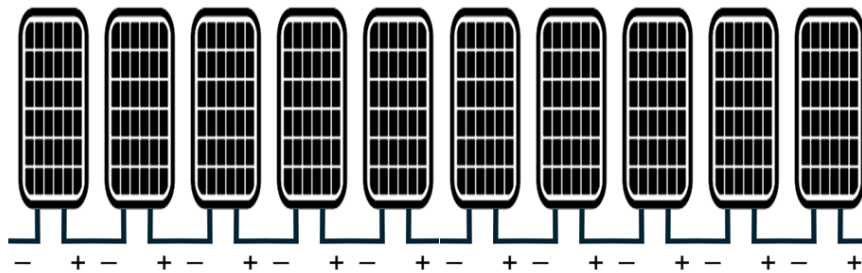
1 mark

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Alisson and Becker connected 10 panels of solar cells into a bank, using the circuit connection shown in Figure 12b.



**Figure 12b**

- b. Identify the circuit connection used: series or parallel?

1 mark

- c. Determine the output voltage and current of the bank of 10 solar cells shown in Figure 12b.

2 marks

 V

 A

Alisson and Becker charge their electronic devices using the same plugs they normally use with mains power, which delivers  $230\text{ V}_{\text{RMS}}$  AC. One of their chargers reduces the voltage using a step-down transformer. The output from the bank of solar cells first goes into another device (labelled Device A in Figure 12c).

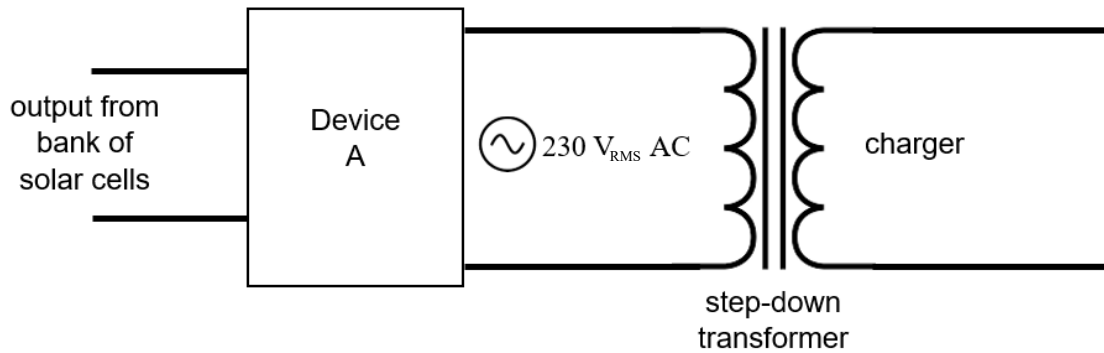


Figure 12c

- d. Identify Device A and explain its role in the circuit.

2 marks

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- e. Will the current on the secondary side of the transformer be higher or lower than the current on the primary side? Explain your answer with reference to a physics principle or concept. (Calculation is not required and you may assume that the transformer is ideal.)

2 marks

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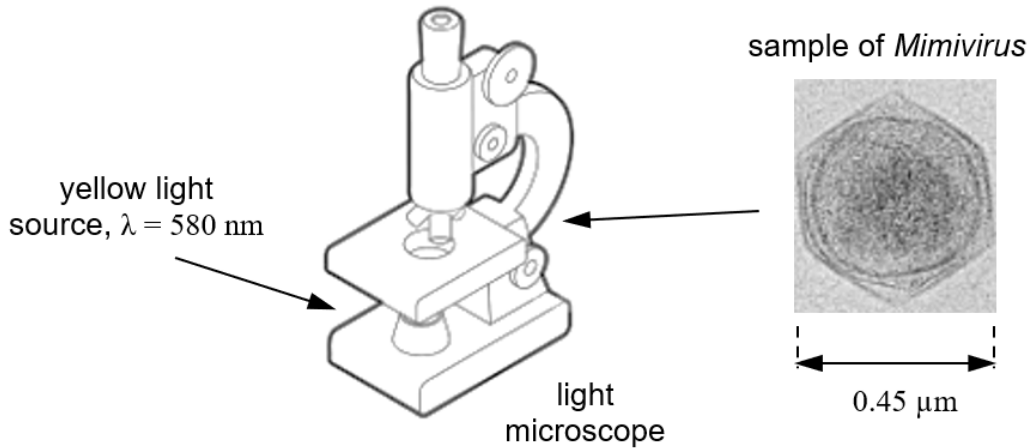


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**Question 10** (4 marks)

Jenna and Cody are using a light microscope with a yellow light source to observe a giant virus known as *Mimivirus*.

The wavelength of the yellow light is 580 nm and the sample of *Mimivirus* on the microscope stage is approximately 0.45  $\mu\text{m}$  across. The light illuminates the sample on the stage from below and the magnified image is observed through the eyepiece of the microscope.



**Figure 13**

- a. Would you expect the yellow light to diffract significantly around the *Mimivirus*? Justify your answer.

2 marks

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Jenna suggests that the quality of the image could be improved by using a red light source, whereas Cody thinks that the quality of the image could be improved by using a violet light source.

- b. Is Jenna or Cody correct? Justify your answer with physics principles.

2 marks

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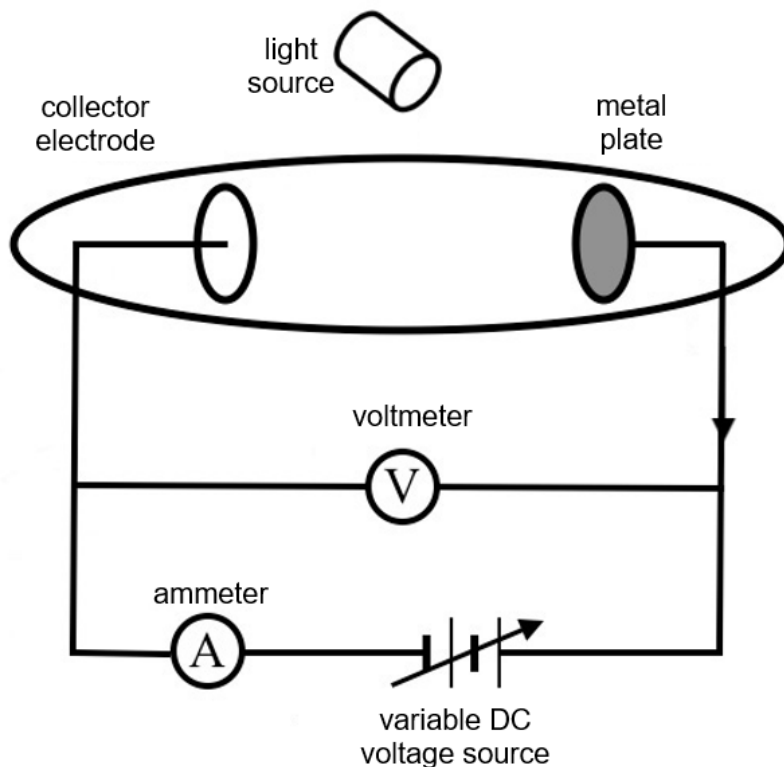
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**Question 11** (9 marks)

Adrian and Bobbi are exploring the photoelectric effect using LED light sources of different frequencies. Their experimental set-up is shown in Figure 14.



**Figure 14**

Using an orange LED with a frequency of 492 THz, they recorded a maximum photocurrent of 1.1 mA when the LED was operated at half its maximum power.

They slowly increased the voltage and obtained a stopping voltage of 88 mV.

- a. Determine the threshold frequency,  $f_0$ .

3 marks

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THz

- b.** Explain what the wave model of light predicts about the relationship between the frequencies of incident photons and the emission of photoelectrons in this experiment. Include an explanation of why the wave model of light cannot explain the experimental observation of a cut-off frequency and how the particle model of light can.

4 marks

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Adrian claimed that the photoelectric effect demonstrates the particle-like behaviour of light. Therefore the maximum photocurrent cannot be increased by operating the LED at a higher power output.

- c.** Using physics principles, evaluate whether Adrian's claim is correct.

2 marks

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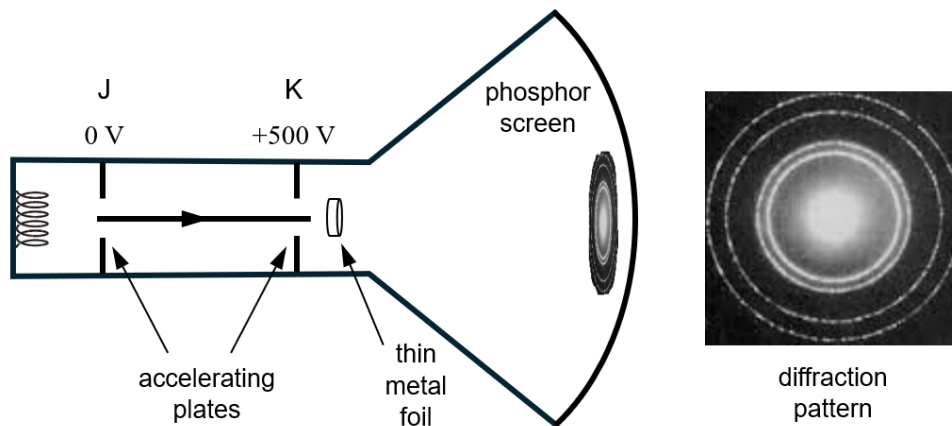
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**Question 12** (7 marks)

A physics class is using a cathode-ray tube to produce a diffraction pattern as part of their studies of the wave-like behaviour of matter.

Inside the tube electrons are accelerated between a pair of plates, labelled J and K in Figure 15. The accelerated electrons then pass through a thin metal foil before striking a phosphor screen, upon which is displayed a diffraction pattern.



**Figure 15**

The voltage between the accelerating plates is 500 V. The kinetic energy of the electrons at location J can be considered negligible.

- a. Show that the work done on the electrons by the electric field after they are accelerated is  $8.0 \times 10^{-17}$  J.

1 mark

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- b. When the electrons are being accelerated between J and K, which physics model better describes their behaviour: particle or wave?

1 mark

c. Calculate the de Broglie wavelength of the electrons.

3 marks

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The students wish to bombard the same metal foil with X-rays and produce the same diffraction pattern.

d. Determine the energy the X-rays must have to achieve the same diffraction pattern. Give your answer in eV.

2 marks

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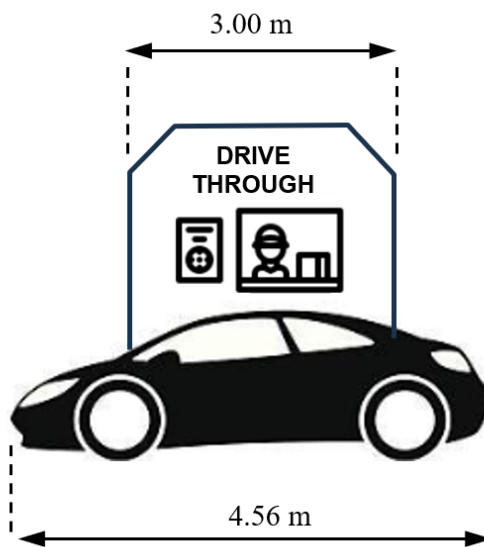
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**Question 13** (5 marks)

Luisa is driving a 4.56 m long car and her friend Diaz is standing inside a drive-through area that is 3.00 m long.



**Figure 16**

Diaz suggests to Luisa, ‘If you drive at a constant velocity that is sufficiently fast, your car should be able to fit within the drive-through because of length contraction.’

- a. Determine the Lorentz factor for the length contraction required for Diaz to be able to observe Luisa’s car fitting within the drive-through in his frame of reference.

1 mark

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- b. Calculate the velocity of the car relative to the drive-through if Diaz is to see Luisa’s car fit within the drive-through. Give your answer in terms of  $c$ , the speed of light in a vacuum.

2 marks

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$c$

Luisa replies to Diaz, 'In my frame of reference, my car is 4.56 m long. Since the drive-through area is moving past my car at a very high velocity, I will measure the drive-through to be shorter than 3.00 m. So my car will not fit within the drive-through.'

c. Is Luisa correct? Explain your answer using physics principles.

2 marks

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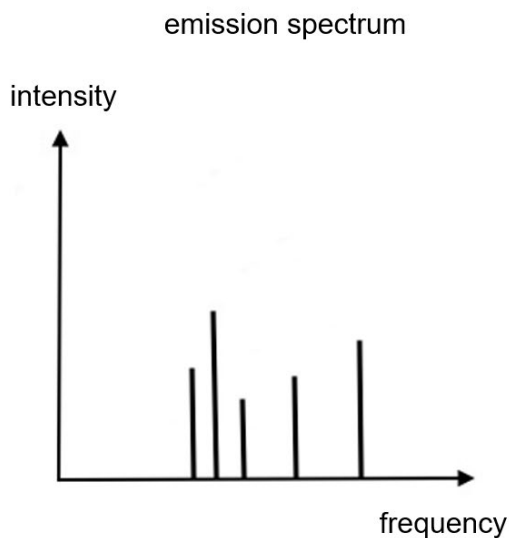
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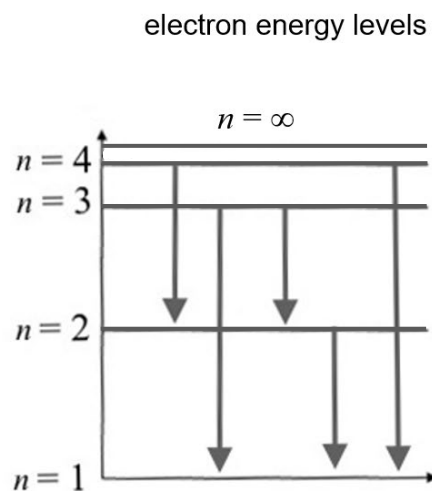
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**Question 14** (5 marks)

The emission spectrum of an element shows discrete lines corresponding to light being emitted by electrons as they transition between energy levels within the atoms of that element.



**Figure 17a**



**Figure 17b**

- a. Using physics principles, explain how the emission spectrum provides evidence for both the particle-like nature of light and the wave-like nature of matter.

3 marks

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Figure 17b represents electrons that have been excited from ground state to  $n = 4$  and various transition paths for their return to ground state.

b. State the possible transition path that is not shown.

i. From  $n = \underline{\hspace{2cm}}$  to  $n = \underline{\hspace{2cm}}$ .

1 mark

ii. Will the discrete line on the spectrum from this transition path be to the left or to the right of the lines on the spectrum shown in Figure 17a?

1 mark

### Question 15 (12 marks)

Priya and Conor are carrying out a physics experiment to determine the factors that affect the period of an oscillating cantilever. Figure 18a shows the set-up of their apparatus. A piece of timber with a constant rectangular cross-section is clamped rigidly onto a laboratory bench. A mass,  $m$ , is attached to the oscillating end of the timber. The oscillating length,  $L$ , is the distance between the bench and the tip of the timber.

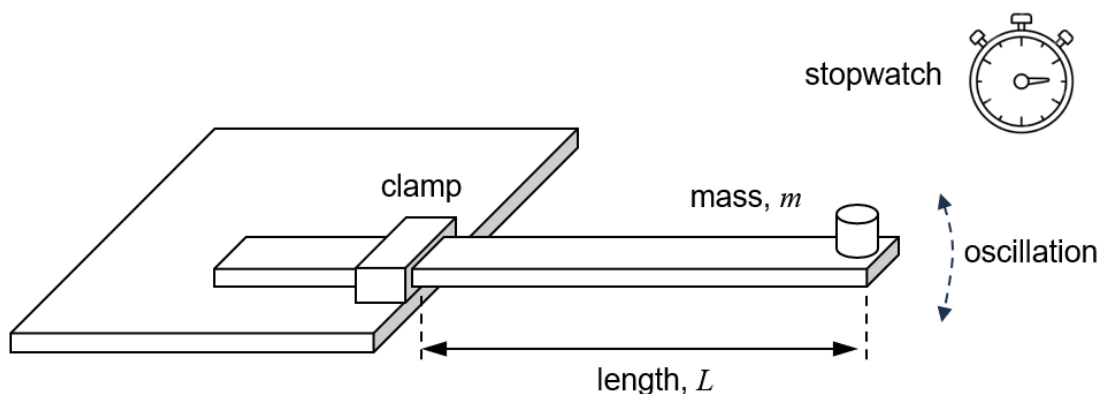


Figure 18a

$L$  is measured using a 1 metre ruler, to the closest mm.

a. State the uncertainty in the measurement of  $L$ .

1 mark

$\pm$	$\text{m}$
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A stopwatch is used to measure time intervals. It can measure intervals to the closest 0.01 s. Priya is responsible for measuring the time intervals. In preliminary preparations for the experiment, she calculated her average reaction time as 0.26 s.

Priya and Conor decided that the uncertainty in the stopwatch measurement is not significant in their reporting.

- b. Explain why they could ignore the uncertainty in the stopwatch measurement.

1 mark

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Priya and Conor decided that the uncertainty in Priya's measurement of time intervals is  $\pm 0.26$  s.

The cantilever oscillates between two extreme positions, one above and one below its rest position. The oscillation period of the cantilever,  $T$ , is the time it takes for the cantilever to travel from one extreme position to the other and return to its starting position.

They considered two methods for determining the oscillation period:

Method 1: Measure the time interval for two oscillations and divide that time interval by two to obtain the period for one oscillation.

OR

Method 2: Measure the time interval for one oscillation twice and take the average of these two measurements to obtain the period of one oscillation.

- c. Explain why method 1 is the better approach.

4 marks

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Priya and Conor record their results in the table, reproduced below.

Cantilever length, $L$ (m)	Time for 2 oscillations (s)	Period, $T$ (s)	$L^3$ (m <sup>3</sup> )	$T^2$ (s <sup>2</sup> )
0.400	0.56	0.28	0.064	0.080
0.500	0.72	0.36	0.125	0.130
0.600	1.00	0.50	0.216	0.250
0.700	1.20	0.60	0.343	0.360
0.800	1.48	0.74	0.512	0.550
0.900	1.81	0.91	0.729	0.820

Their background research suggests that the relationship between  $T$ ,  $L$  and  $m$  is given by the formula  $T^2 = KmL^3$ , where  $K$  is a constant of proportionality.

d. State the units for  $K$ .

1 mark

Priya and Conor plotted their data on a graph with  $T^2$  on the  $y$ -axis and  $L^3$  on the  $x$ -axis. They then drew a straight line of best fit through the data points, as shown in Figure 18b.

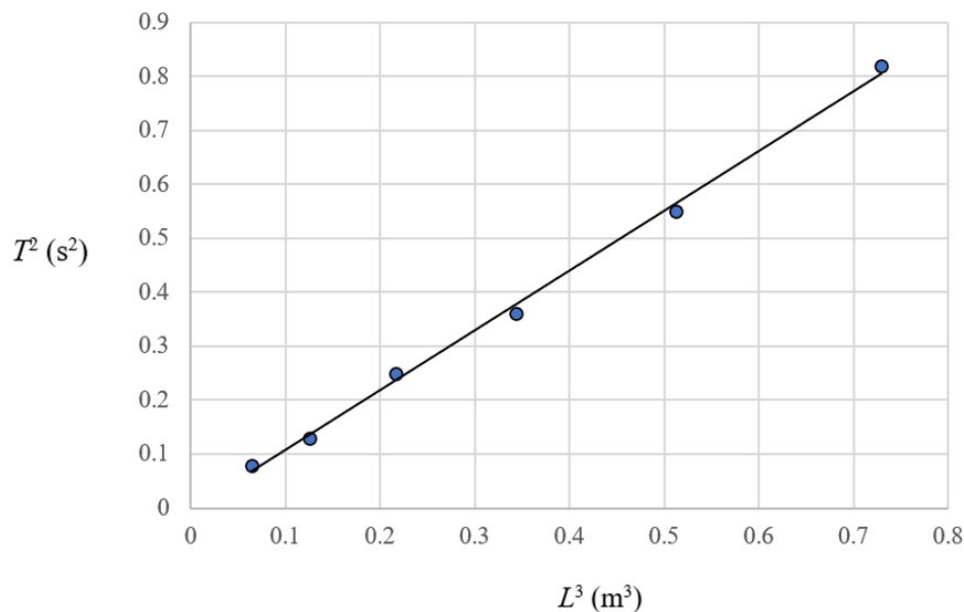


Figure 18b

e. Calculate the gradient of the line of best fit plotted in Figure 18b.

2 marks

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- f. Given that  $K$  is 2.74, use the gradient calculated in **part e.** to determine the mass,  $m$ , of the object attached to the oscillating end of the piece of timber.

3 marks

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