# THE SCHOOL FOR EXCELLENCE (TSFX)

# VCE PHYSICS UNIT 3 & 4

## WRITTEN EXAMINATION 2020

**Reading Time:** 15 minutes
**Writing Time:** 2 hours 30 minutes

## QUESTION AND ANSWER BOOK

**Student Number:** | | | | | | | | | | **Letter** |

**Structure of Book**

| *Section* | *Number of questions* | *Number of questions to be answered* | *Number of marks* |
|---|---|---|---|
| A | 20 | 20 | 20 |
| B | 20 | 20 | 110 |
| | | | **Total 130** |

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers pre-written notes (one A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

**Materials Supplied**

- Question and answer book of 32 pages
- Formula sheet
- Answer sheet for multiple choice questions

**Instructions**

- Write your **student number** in the space provided above on this page.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

**At the End of the Examination**

Place the answer sheet for multiple-choice questions inside the front cover of this book.

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



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# SECTION A – MULTIPLE CHOICE QUESTIONS

**Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

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.

Take the value of $g$ to be $9.8\,ms^{-2}$.

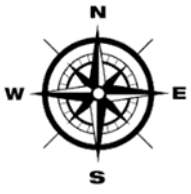
**QUESTION 1**

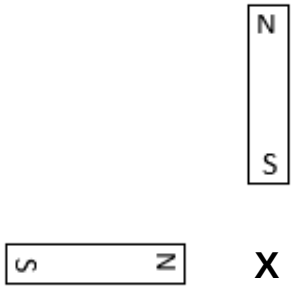
An electron is travelling horizontally northwards at a speed of 3.7 X $10^5$ m $s^{-1}$. It enters a region of horizontal magnetic field with a strength of 1.4 T directed eastwards. State the direction of the initial force experienced by the electron.


**A.** East
**B.** West
**C.** Down
**D.** Up

**QUESTION 2**

The direction of the resultant magnetic field at point X is:




**A.** North
**B.** South-East
**C.** South-West
**D.** North-East

**QUESTION 3**
Two parallel metal plates are separated by 4 cm and have a potential difference of 120 volts. Calculate the electric field strength between the plates.

**A.** 30 V $m^{-1}$

**B.** 300 V $m^{-1}$

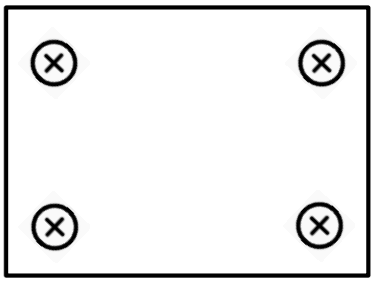
**C.** 3 V $m^{-1}$

**D.** 3000 V $m^{-1}$

**QUESTION 4**
Electricity transmission systems in Victoria use transformers because:

**A.** they increase the current in the transmission lines and reduce power losses.
**B.** it is a more efficient way to transmit DC current.
**C.** they reduce the current in the transmission lines and reduce the power losses.
**D.** they reduce the voltage in the transmission lines and reduce the power losses.

**QUESTION 5**



The rectangular coil above has 12 turns and dimensions of 4.0 cm by 5.0 cm. There is a constant magnetic field perpendicular to the coil as shown. The magnetic field has a strength of 2.6 X $10^{-3}$ T.

The magnetic flux passing through the coil is:

**A.** 5.2 X $10^{-6}$ Wb
**B.** 6.2 X $10^{-5}$ Wb
**C.** 5.2 X $10^{-2}$ Wb
**D.** 0.62 Wb

**QUESTION 6**
The purpose of the split-ring commutator in a DC motor is:

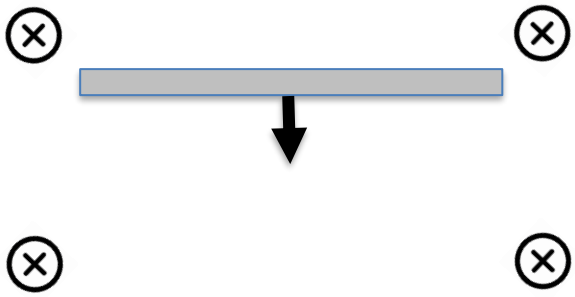
**A.** to reverse the current every 180° at the position where the force on the wires has the maximum turning effect.

**B.** to reverse the current every 180° at the position where the force on the wires has the minimum turning effect.

**C.** to allow the generated AC current to flow out.

**D.** to keep both sides of the coil connected to the current at all times.

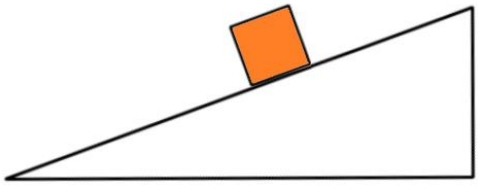
**QUESTION 7**



A metal rod is falling in an area where the magnetic field is horizontal as shown.
Which one of the following is true?

**A.** The right hand end has a positive charge.
**B.** The left hand end has a positive charge.
**C.** The top edge of the rod has a positive charge.
**D.** There is no separation of charge in the rod.

**QUESTION 8**



A box slides down a sloped surface at a constant speed. The surface makes an angle of 28.0° with the horizontal. The box has a mass of 12.0 kg.

Calculate the magnitude of the friction force acting on the box by the surface.

**A.** 55.2 N
**B.** 114.6 N
**C.** 5.6 N
**D.** 10.6 N

**QUESTION 9**
The Lorentz factor for a relative velocity of $2.4 \times 10^8$ m $s^{-1}$ is closest to:

**A.** 2.2
**B.** 1.7
**C.** 0.60
**D.** 0.45

**QUESTION 10**
A ball falls vertically onto a horizontal surface. The impact speed is 12 m $s^{-1}$ and the rebound speed is 8 m $s^{-1}$. The ball has a mass of 300 grams.

Calculate the magnitude of the impulse exerted on the ball by the surface.

**A.** 1200 kg m $s^{-1}$
**B.** 6000 kg m $s^{-1}$
**C.** 6.0 kg m $s^{-1}$
**D.** 1.2 kg m $s^{-1}$

**QUESTION 11**
An athlete leaps off a 2 m ledge to the ground below. The athlete believes that he experienced true weightlessness while in the air.

Which of the following statements is the most accurate?

**A.** He was not falling long enough to experience true weightlessness.
**B.** He experienced true weightlessness because there is no reaction force while falling.
**C.** He could not experience true weightlessness because gravity still applies.
**D.** He experienced true weightlessness because you don't feel gravity while falling.

**QUESTION 12**
A student creates an interference pattern with a red laser and 2 narrow slits. She photographs the pattern. She then changes to a green laser (with a shorter wavelength) but makes no other changes.

What happens to the interference pattern?

**A.** The pattern is unchanged.
**B.** The pattern gets closer together. The distance between bright lines is smaller.
**C.** The pattern spreads out. The distance between bright lines is larger.
**D.** The bright lines are wider, but are the same distance apart.

**QUESTION 13**
Sound waves are diffracting through a partly opened sliding door. Which of the following would reduce the spread of the diffraction?

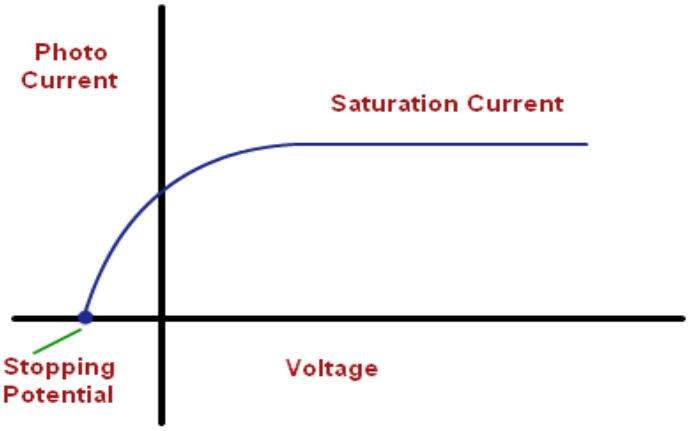
**A.** Close the door further, but still have it partly open.
**B.** Increase the frequency of the sound.
**C.** Reduce the frequency of the sound.
**D.** Increase the wavelength of the sound.

**QUESTION 14**
An observer measures the period of a wave to be 0.125 seconds and the wavelength to be 18 cm.

Calculate the speed of the wave.

**A.** 2.25 m $s^{-1}$
**B.** 144 m $s^{-1}$
**C.** 0.023 m $s^{-1}$
**D.** 1.44 m $s^{-1}$

*Use the following information to answer Question 15.*




**QUESTION 15**
In the graph above (photoelectric experiment), stopping potential means:

**A.** The voltage required to stop most of the current.
**B.** The voltage required to start a current flowing.
**C.** The voltage required to overcome the work function.
**D.** The voltage required to stop the most energetic electron.

*Use the following information to answer Questions 16 and 17.*

A continuous wave is transmitted into a string with one fixed end. The wavelength of the incoming wave is 1.5 m. The wave reflects from the fixed end and forms a standing wave pattern.

**QUESTION 16**
Why does the standing wave pattern form?

**A.** All reflected waves form a standing wave pattern.

**B.** The reflected wave and the incoming wave are in phase, so superposition creates a standing wave pattern.

**C.** The incoming wave is stronger than the reflected wave and forces a standing pattern to occur.

**D.** The reflected wave and the incoming wave are out of phase by 90°, so a standing wave pattern forms.

**QUESTION 17**
In the standing wave pattern from **Question 16**, the distance between stationary points (nodes) is:

**A.** 1.5 m
**B.** 3.0 m
**C.** 2.25 m
**D.** 0.75 m

**QUESTION 18**
Students record the following sets of results when attempting to measure a known length of 47.5 cm.

**Set 1:** 45.6 cm, 45.8 cm, 45.7 cm
**Set 2:** 46.9 cm, 47.8 cm, 47.3 cm
**Set 3:** 47.6 cm, 48.3 cm, 45.9 cm
**Set 4:** 48.0 cm, 48.4 cm, 46.3 cm

Which set of results has the highest level of precision?

**A.** Set 1
**B.** Set 2
**C.** Set 3
**D.** Set 4

**QUESTION 19**
Two students are discussing random and systematic errors.
Which statement is correct?

**A.** The effect of systematic errors can be reduced by doing multiple measurements.
**B.** The effect of random errors can be reduced by doing multiple measurements.
**C.** Systematic errors can be reduced if you are more careful.
**D.** Random errors get worse if you take a lot of measurements.

**QUESTION 20**
A star releases $8.2 \times 10^{26}$ Joules of energy per second. What amount of mass would need to be converted directly to energy to release this amount of energy each second?

**A.** $2.7 \times 10^{15}$ tonnes
**B.** $9.1 \times 10^{9}$ tonnes
**C.** $2.7 \times 10^{18}$ tonnes
**D.** $9.1 \times 10^{6}$ tonnes

## SECTION B – SHORT ANSWER QUESTIONS

**Instructions for Section B**

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

Where an answer box is provided, write your final answer in the box.

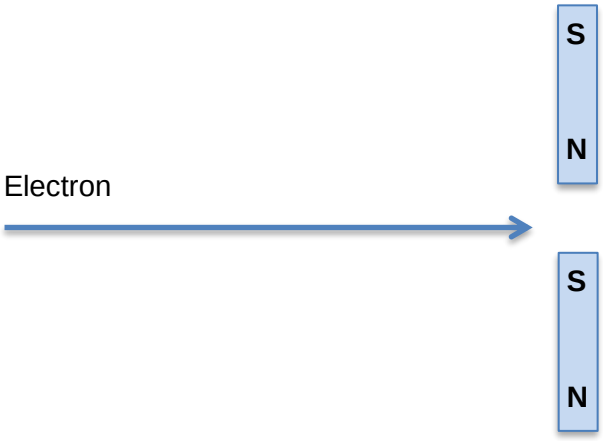
If an answer box has a unit printed in it, give your answer in that unit.

In 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.

Take the value of $g$ to be $9.8\ ms^{-2}$.

**QUESTION 1** (3 marks)




An electron is moving horizontally into the area between two magnets. Describe the changes to the path of the electron (if any). Justify your answer.

**QUESTION 2** (6 marks)
Point **X** is 20 cm from a positive charge (A) of 5.3 X $10^{-5}$ C.

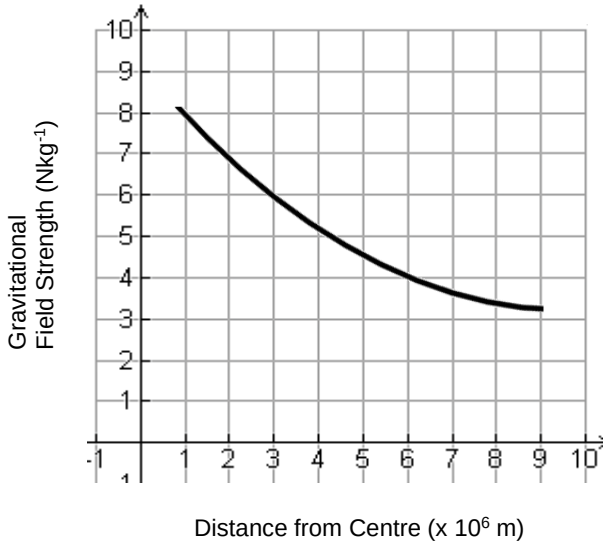

**a.** Calculate the electric field strength at point X due to charge A. 3 marks

| V $m^{-1}$ | Direction |
|---|---|

**b.** A second identical charge is introduced at a distance of 40 cm from X as shown. 3 marks
Calculate the resultant electric field at X due to both charges.


| V $m^{-1}$ | Direction |
|---|---|

**QUESTION 3** (4 marks)
The following graph shows the gravitational field strength due to Planet Cow as a function of the distance from the centre of the planet.




**a.** What is the gravitational field strength at a radius of 6 X $10^6$ m? 1 mark

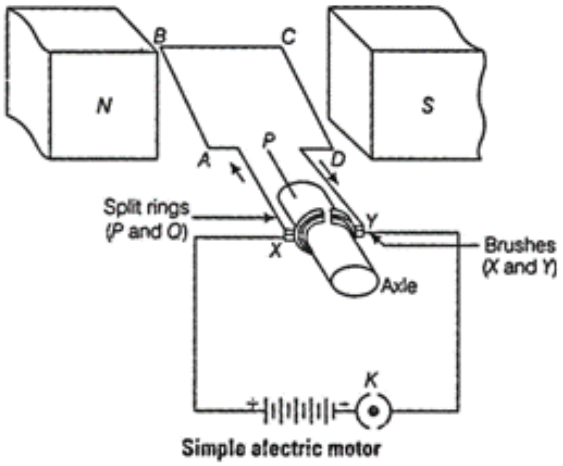
N $kg^{-1}$

**b.** A large rock (240 kg) falls towards planet Cow. 3 marks

Calculate the increase in kinetic energy of the rock as it falls from 5 X $10^6$ m to 2 X $10^6$ m from the centre of the planet.

J

**QUESTION 4** (7 marks)
The diagram below shows an electric motor with 8 turns on the coil.




**a.** Explain the role of the split-ring commutator in this motor. 2 marks

The magnetic field strength is 0.7 T. The coil is a 6 cm square with 8 turns.
The current is 2.4 A.

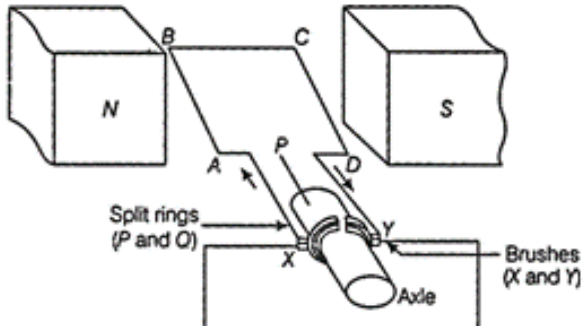
**b.** Determine the magnitude and direction of the force on the side BC. 2 marks

| N | Direction |
|---|---|

**c.** Determine the magnitude and direction of the force on the side AB. 3 marks

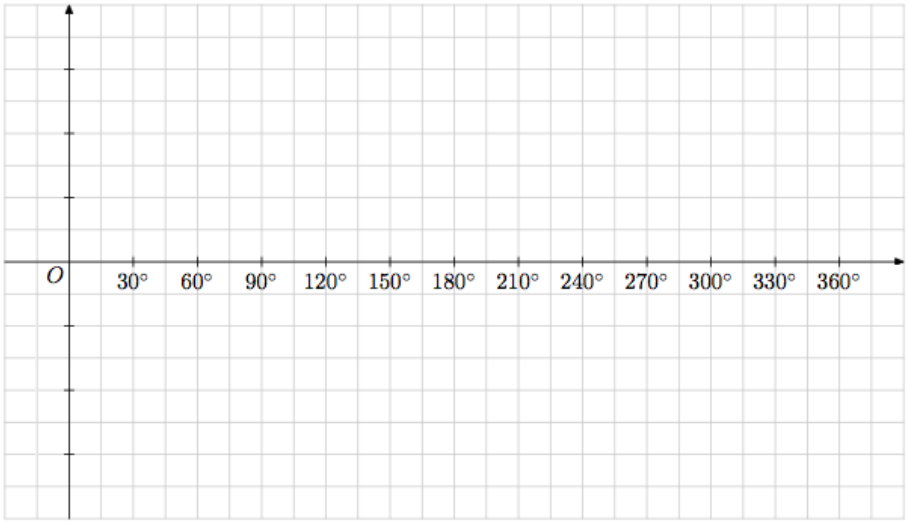
| N | Direction |
|---|---|

**QUESTION 5** (9 marks)
A diagram of an **electric generator** is shown below. It is rotated clockwise at 8 Hz from the current position.



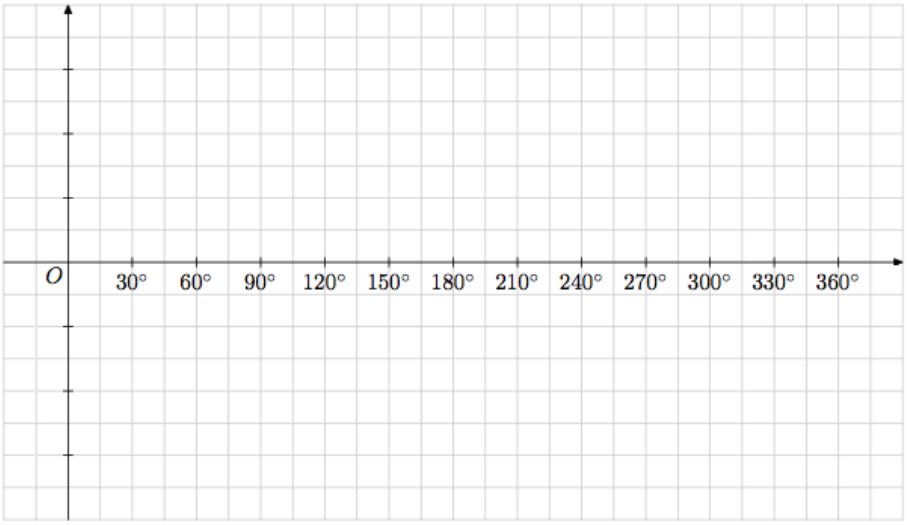

**a.** Sketch a graph of Magnetic Flux vs Angle of Rotation for this generator. Assume the angle is measured from the position shown in the diagram (i.e. position shown is 0°). 2 marks

Magnetic Flux




**b.** Sketch a graph of Induced EMF vs Angle of Rotation for this generator. Assume the angle is measured from the position shown in the diagram (i.e. position shown is 0°). 2 marks

Induced EMF



**c.** Explain the role of the split-ring commutator in the generator. 2 marks

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**d.** If the magnetic field has a strength of 0.6 T, calculate the average EMF generated in one quarter of a turn. The coil starts from the position shown and has 6 turns. The coil is a 6 cm square. 3 marks

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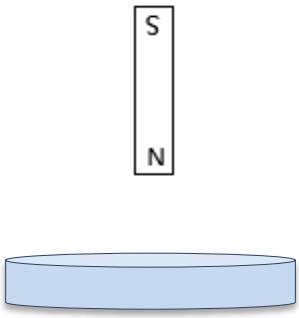
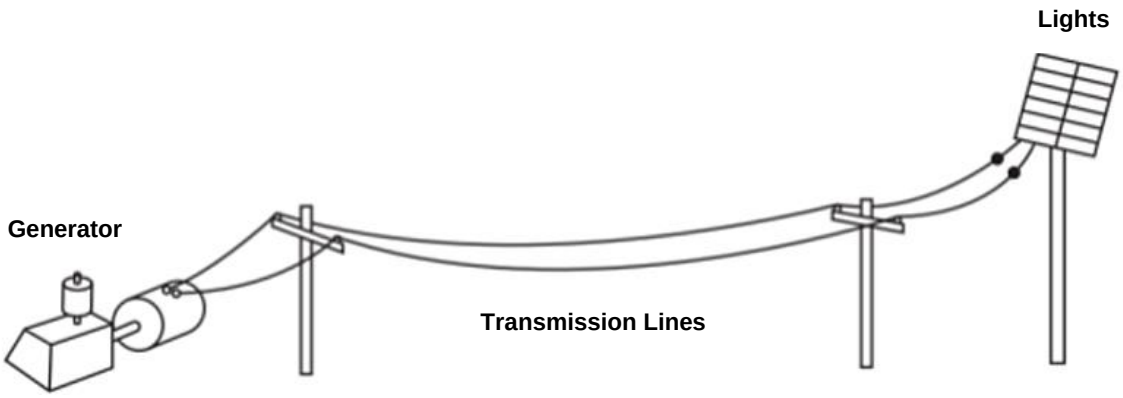
V

**QUESTION 6** (3 marks)




A magnet is falling towards a horizontal circular loop of wire. Describe any induced current in the loop as the magnet approaches and the changes that occur when looking down on the loop. Indicate your reasoning.

**QUESTION 7** (9 marks)
A farmer runs long transmission lines to a light for his cows. The light is working correctly at 250 V and 1500 W. The transmission lines have a total resistance of 8 Ohms.




**a.** Calculate the current in the transmission lines. 1 mark

A

**b.** Calculate the power output of the generator. 2 marks

W

The farmer isn't happy with the power losses in the lines. A friend suggests a 2:1 step down transformer next to the generator.

**c.** Does this reduce the power losses? Justify your answer. 3 marks

**d.** The farmer then tries a 1:4 step-up transformer at the generator and a 4:1 step-down transformer before the light. 3 marks

With the light running correctly, find the power losses in the transmission lines.

W

**QUESTION 8** (4 marks)
A toy car (800 grams) is accelerated from rest with a constant force that acts for 4.0 seconds. It reaches a speed of 8.0 m $s^{-1}$ after the 4.0 seconds.

**a.** Calculate the resultant force on the car while it is accelerating. 2 marks

N

**b.** The car then travels over a section of floor that exerts a frictional force of 1.2 N. 2 marks
How far does the car travel on the frictional surface before coming to rest?

m

**QUESTION 9** (2 marks)
A car is travelling over a circular section of road with a radius of 90 m. The 70 kg driver enjoys the hill because he experiences a reduced normal force of 100 N at the top.

Calculate the speed required to create the experienced weight.

m $s^{-1}$

**QUESTION 10** (8 marks)
A small train carriage (4.5 tonnes) runs into a large locomotive (20.0 tonnes). The small carriage was travelling east at 6.0 m $s^{-1}$ before hitting the stationary locomotive. After the collision, the carriage is moving west at 2.0 m $s^{-1}$.

**a.** Calculate the velocity of the locomotive after the collision. Include a direction with your answer. 2 marks

| m $s^{-1}$ | Direction |
|---|---|

**b.** Calculate the impulse exerted on the carriage by the locomotive. Include a direction with your answer. 3 marks

| | Unit | Direction |
|---|---|---|

**c.** Is the collision elastic? Justify your answer. 3 marks

**QUESTION 11** (5 marks)


A rock is launched from ground level with a speed of 42 m $s^{-1}$ at 27° above the horizontal.

**a.** Calculate the maximum height reached by the rock. 2 marks

m

**b.** The rock is fired towards a vertical wall 100 m away. Calculate the height at which the rock hits the wall. 3 marks

m

**QUESTION 12** (4 marks)
While travelling in a space ship with a velocity of 0.97c, a scientist measures a stick inside the space ship to be exactly 1.5 m long.

**a.** Has the scientist measured the proper length of the stick? Explain your answer. 2 marks

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**b.** An observer on a stationary asteroid watches the space ship race past. The stick's length is parallel with the direction of relative motion for the observer. 2 marks

What is the length of the stick measured by the observer on the asteroid?

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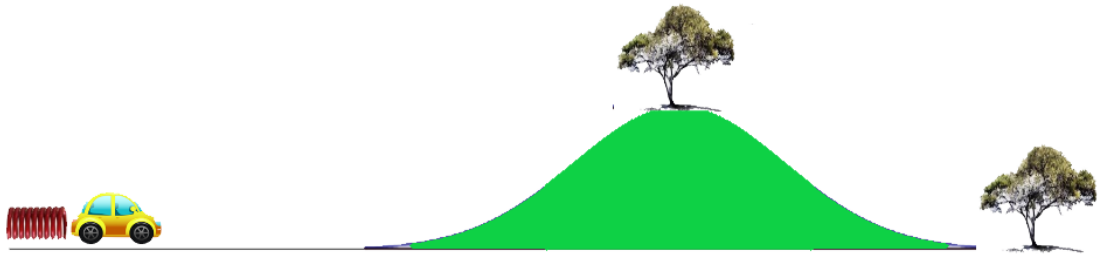
| | |
|---|---|
| | m |

**QUESTION 13** (7 marks)
A spring with a constant of 500 N $m^{-1}$ is compressed by 4.0 cm.



**a.** Calculate the energy stored in the spring. 2 marks

J

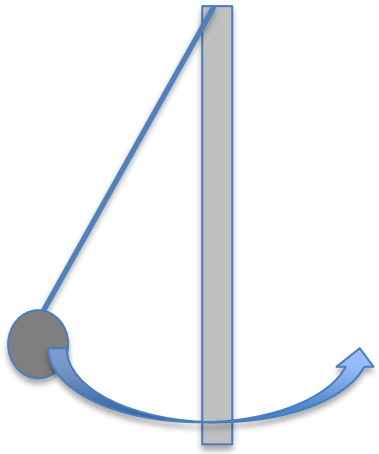
**b.** All of the energy stored in the spring is transferred to a toy car with a mass of 80.0 grams. 2 marks

Calculate the speed of the car after the spring is released (ignore friction).

m $s^{-1}$

**c.** The car reaches a frictionless hill with a maximum height of 42 cm. At the bottom of the hill the car has a speed of 3.0 m $s^{-1}$. Does the car make it over the hill? Justify your answer. 3 marks

**QUESTION 14** (4 marks)
A conic pendulum rotates as shown in the diagram. The string holding the mass is 1.6 m long. The ball has a mass of 2.2 kg and the string makes an angle of 30° with the support pole.



**a.** Label the forces acting on the mass. Use arrows to indicate the direction of each force. 2 marks

**b.** Calculate the magnitude of the tension in the string. 2 marks

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_____

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_____

N

**QUESTION 15** (9 marks)
Two students conduct an experiment in which they compress a balloon by placing masses on top of it. They use a flat piece of wood to hold the masses added to the balloon. They find it difficult to measure the height each time and are only confident the measurements are accurate to the nearest 0.5 cm. They use the same type of balloon, at the same starting diameter each time.

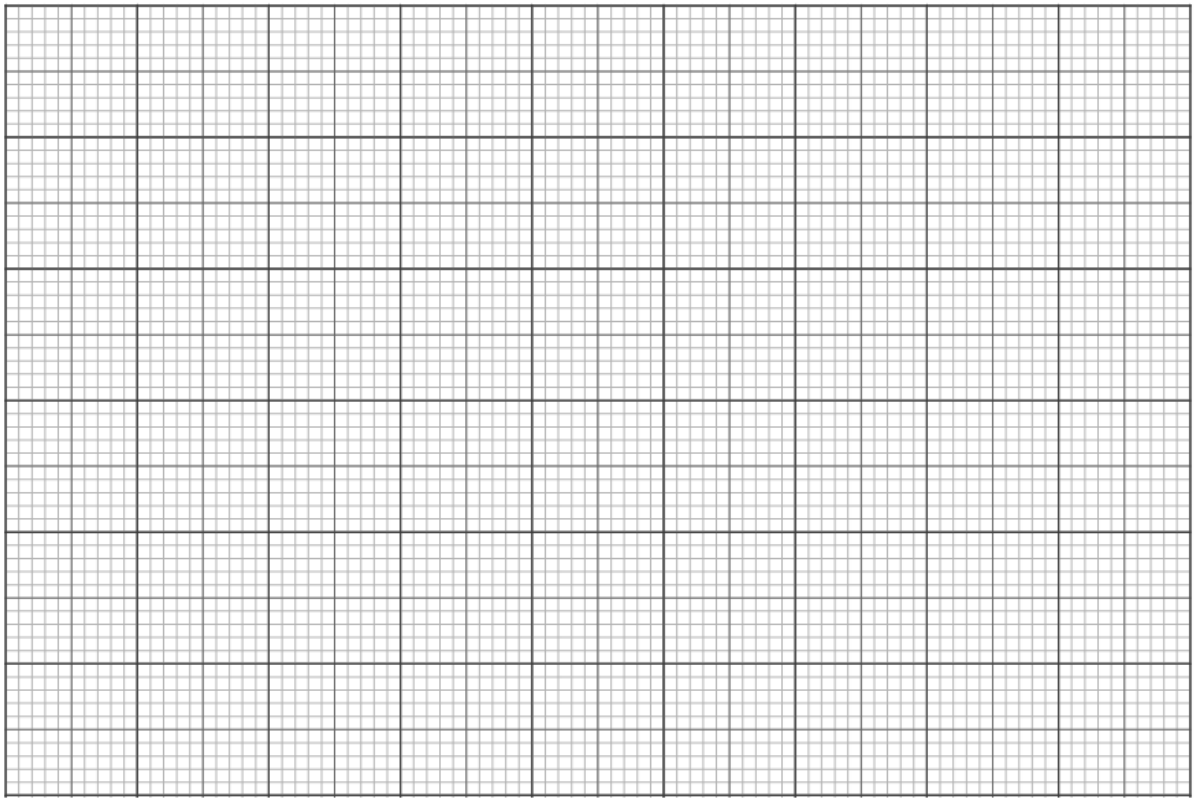
**a.** Complete the table below. 3 marks

| | |
|---|---|
| Controlled Variable | |
| Independent Variable | |
| Dependent Variable | |

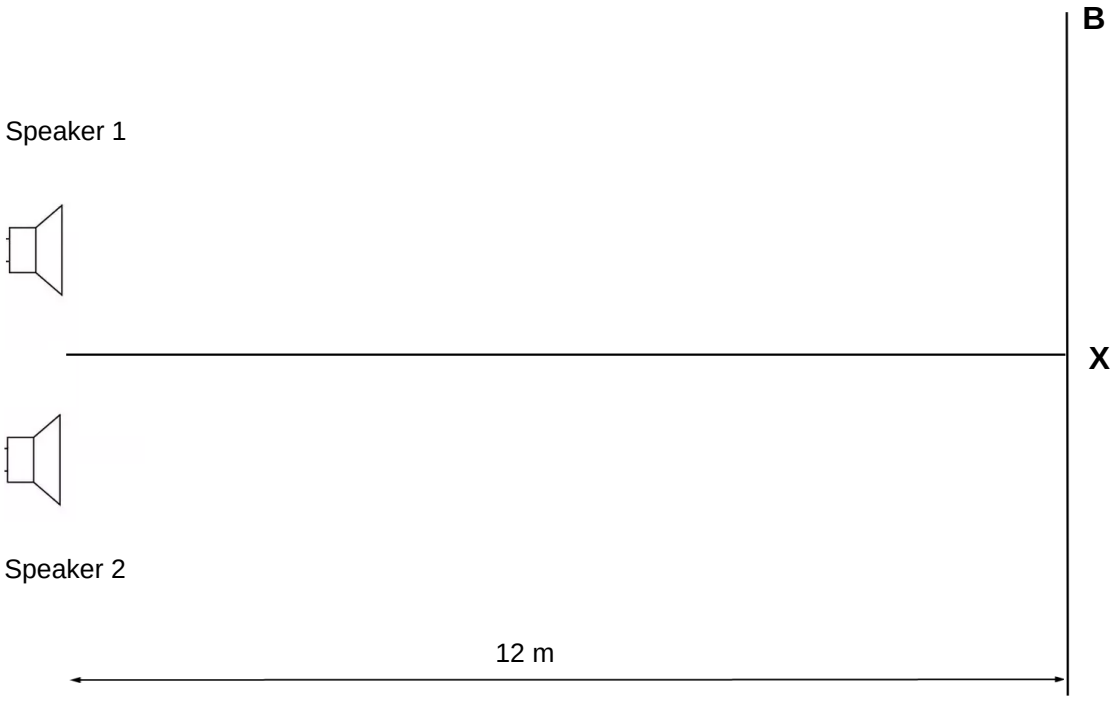
**b.** The results of the student's experiment are given below. 6 marks

| Weight added (N) | 7.0 | 8.0 | 14.0 | 21.5 | 26.0 |
|---|---|---|---|---|---|
| Height (m) | 0.25 | 0.22 | 0.14 | 0.08 | 0.06 |

Plot the results on the graph paper below with the height on the vertical axis. Label the axes, add uncertainty bars for the height and draw a line of best fit.



**QUESTION 16** (6 marks)
A teacher sets up two speakers connected in phase to a sound with a frequency of 680 Hz. The speed of sound is 340 m $s^{-1}$ and the speakers are 2.0 m apart. Point X is opposite the mid-point between the speakers.




**a.** Calculate the wavelength of the sound. 1 mark

m

**b.** Describe the sound detected at point X and explain why it occurs. 2 marks

**c.** The teacher walks from point X towards point B. How far does the teacher need to walk to reach the second minimum point? Justify your answer. 3 marks

m

**QUESTION 17** (4 marks)

**a.** Explain the significance of Young's double slit experiment to the understanding of the nature of light. 2 marks

**b.** Explain the significance of the photoelectric effect to the understanding of the nature of light. 2 marks

**QUESTION 18** (7 marks)
A stream of electrons passes through a hole and produces a diffraction pattern.
The electrons have a speed of $5.7 \times 10^6$ m $s^{-1}$.

**a.** Calculate the momentum of each electron. 3 marks

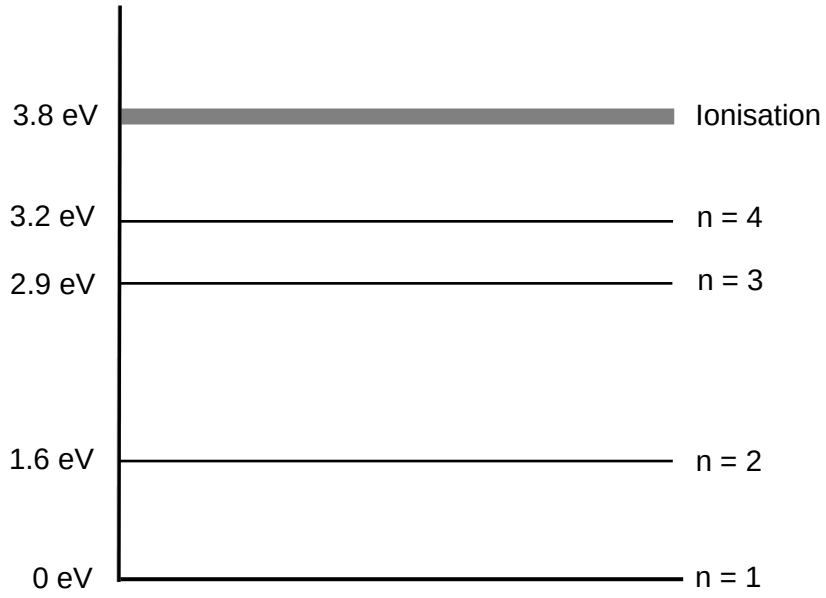
| | Unit |
|---|---|
| | |

**b.** A beam of light passes through the same hole and produces a very similar diffraction pattern. Calculate the frequency of the light. 2 marks

| Hz |
|---|
| |

**c.** If the diameter of the hole was increased, what effect would this have on the diffraction pattern? Justify your answer. 2 marks

**QUESTION 19** (5 marks)
The diagram below represents the electron energy levels of an atom.




**a.** List the possible photon emission energies when an electron is in level 3. 3 marks

**b.** Calculate the wavelength of the photon emitted when an electron drops from level 3 to level 2. 2 marks

m

**QUESTION 20** (4 marks)
In a photoelectric effect experiment, green light with a frequency of $5.5 \times 10^{14}$ Hz is shone onto a metal cathode with an unknown work function. The threshold frequency for the cathode is $4.2 \times 10^{14}$ Hz. The graph of the photocurrent versus potential difference across the photocell is shown below.


**a.** Determine the cut-off potential when the green light is shone onto the cathode. 2 marks

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_____

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_____

V

**b.** On the graph of photocurrent versus potential difference, sketch the curve expected if **both** the intensity **and** the wavelength of the light is decreased. 2 marks

**End of Paper**