Physics Unit 3 and 4 Practice Exam 1

Question and Answer Book

- **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 52 pages
- Formula Sheet
- Multiple-Choice Answer Sheet

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book.

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

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Section A (20 questions, 20 marks)	2–15
Section B (17 questions, 100 marks)	16–52

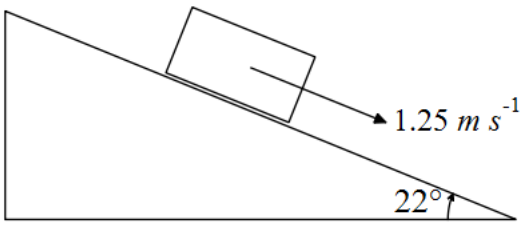
Section A – Multiple-choice questions

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

Question 1

A rectangular block that has a mass of 3.00 kg and is moving down a slope that has friction. The plane is inclined at an angle of 22.0° to the horizontal. The block is moving down the slope with a constant velocity of 1.25 m s^{-1} down the slope.



Which of the following accurately gives the net force on the block?

A. 0 N

B. 1.25 N

C. 11.0 N

D. 29.4 N

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Question 2

The banked curve has a radius of 150 m. A car is travelling at a constant speed of 72.0 km h^{-1} around the curve. Calculate the banking angle that will enable the car to travel around the banked curve without relying on friction.



A. 0.779°

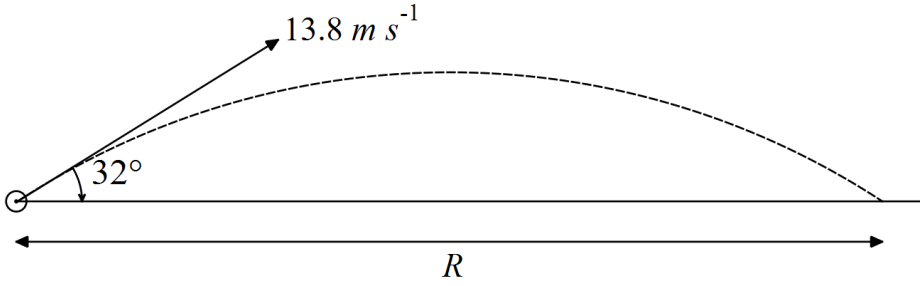
B. 13.2°

C. 15.2°

D. 17.2°

Question 3

A ball is launched from the ground at an angle of 32.0° and at a speed of 13.8 m s^{-1}, as shown below.



The range, R, that this ball achieves is equal to:

A. 17.4 m

B. 14.3 m

C. 12.2 m

D. 1.26 m

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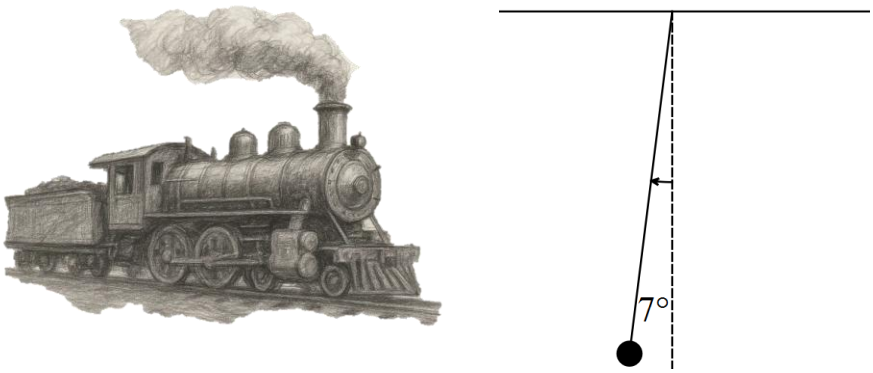
Use the information below to answer Questions 4 and 5

A mass of 0.250 kg hangs on a string from the roof of the train. When the train is at rest the mass hangs vertically. As the train takes off, it accelerates uniformly along the tracks as shown below. The driver of the train observes the mass hanging at an angle of 7.00°.



Question 4

What is the acceleration of the train?

A. 0.300 m s^{-2}

B. 0.600 m s^{-2}

C. 0.900 m s^{-2}

D. 1.20 m s^{-2}

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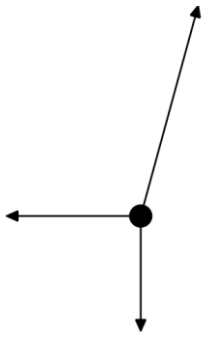
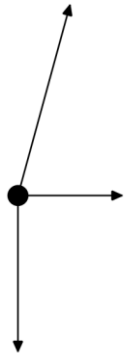
Question 5

Which of the diagrams below best represents the forces acting on the mass during acceleration?

A.



B.



C.



D.



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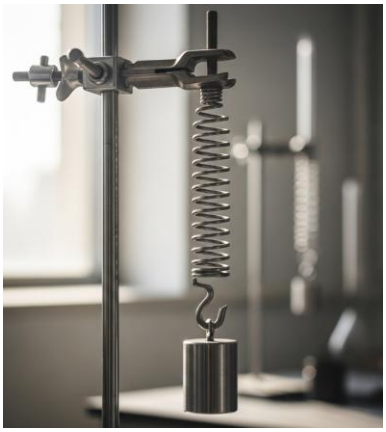
Use the information below to answer Question 6 and 7

Alex and Sophie hang a mass of 1.50 kg on an ideal spring. They hold the mass so that the spring starts in its unstretched position, they then release the spring and allow it to fall freely. The spring oscillates so that it has a maximum extension of 58.9 cm. A diagram of this setup is shown below:



Question 6

What is the spring constant of the spring used in this experiment?

- **A.** 20.0 N m^{-1}
- **B.** 30.0 N m^{-1}
- **C.** 40.0 N m^{-1}
- **D.** 50.0 N m^{-1}

Question 7

What is the acceleration of the mass when it is travelling at its maximum velocity?

- **A.** 9.81 m $s^{—2}$ down
- **B.** 9.81 m $s^{—2}$ up
- **C.** 4.40 m $s^{—2}$ down
- **D.** 0 m $s^{—2}$

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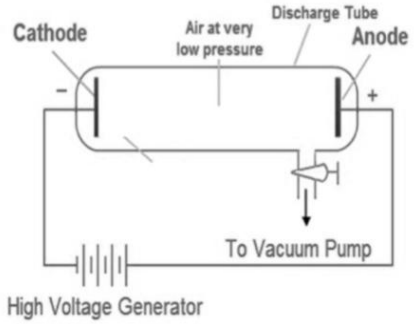
Use the information below to answer Questions 8 and 9

In the mid 1800s Michael Faraday noticed that, after removing most of the air in a glass tube containing a cathode and anode, a faint glow could be seen between the positive and negative electrodes. It was later discovered that this glow was caused by a stream of electrons crossing the gap. A diagram of a cathode ray tube is shown below.



Question 8

In the example above the cathode and anode are separated by 0.250 m. The electric field strength is known to be 2000 N C^{-1}. The potential difference between the cathode and the anode is:

A. 2000 V
B. 1500 V
C. 1000 V
D. 500 V

Question 9

The speed of an electron when it hits the anode in the situation above is:

A. $1.33 \times 10^{7} ms^{-1}$
B. $1.23 \times 10^{7} ms^{-1}$
C. $9.88 \times 10^{6} ms^{-1}$
D. $4.22 \times 10^{6} ms^{-1}$

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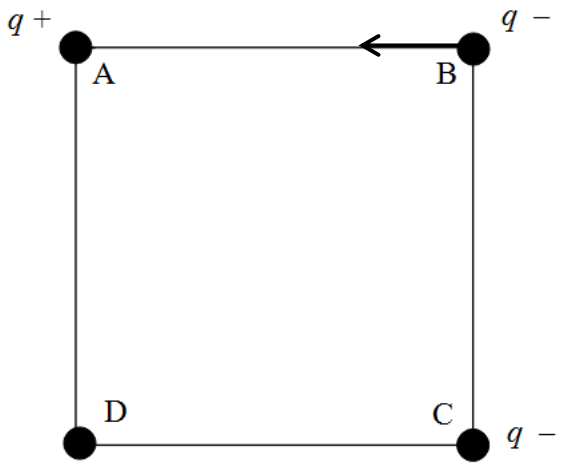
Question 10

Three charges q+, q− and q− are placed at corners A, B and C of a square as shown:



A fourth charge, Q, is placed at D, after which the charge at B experiences a net electrostatic force left as indicated by the arrow. What is the charge of Q?

A. Impossible to tell

B. Neutral

C. Positive

D. Negative

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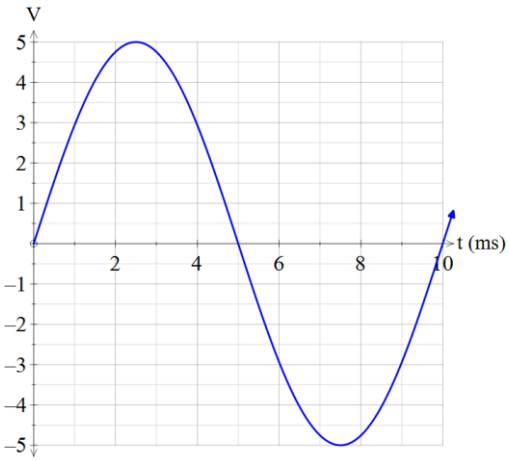
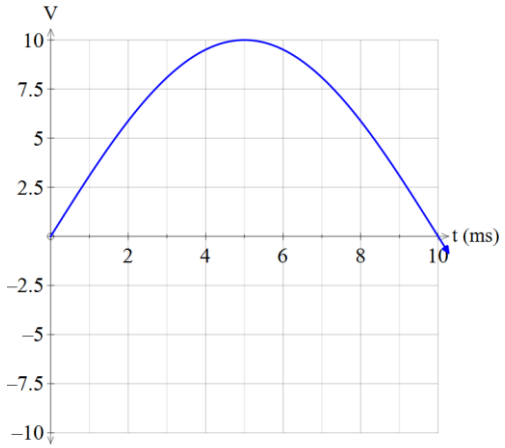
Question 11

The output of an AC generator is shown:

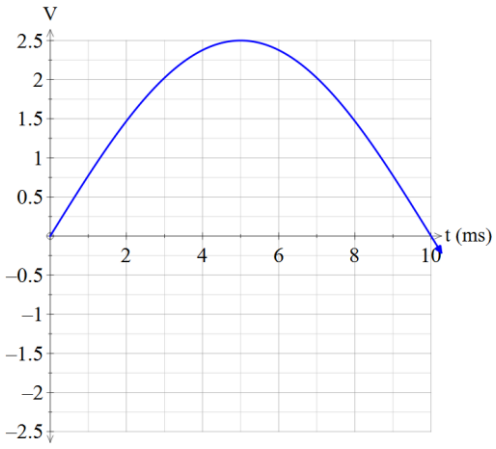


The frequency of the coil rotating in the generator is halved. Which of the following represents its resulting output?

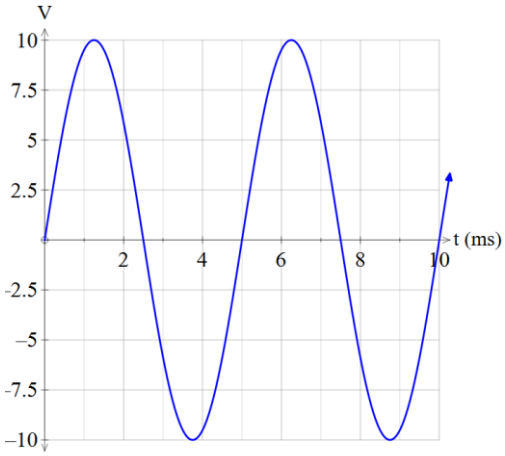
A.



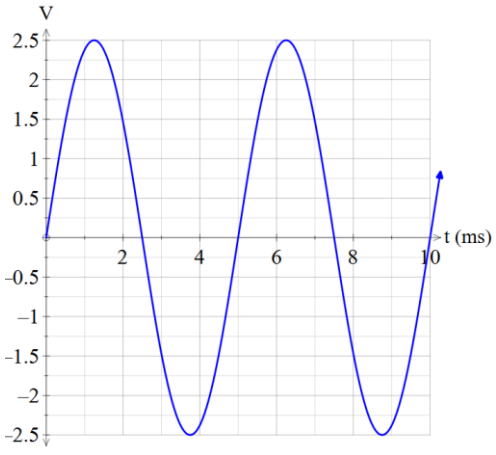
B.



C.



D.



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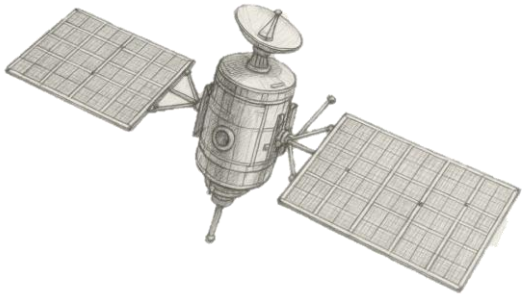
Use the information below to answer Question 12 and 13

Satellites and spacecraft rely heavily on solar panels as their primary power source in space. A typical individual photovoltaic cell will have a power output of 1.00 W and a voltage of 0.4 V.



Question 12

What is the current produced by a typical individual photovoltaic cell?

A. 0.400 A
B. 1.20 A
C. 1.40 A
D. 2.50 A

Question 13

The onboard system on a satellite requires a voltage of 32.0 V to operate correctly. Which of the following set-ups would allow the satellite to operate correctly?

A. 80 photovoltaic cells in series.
B. 80 photovoltaic cells in parallel.
C. 32 photovoltaic cells in series.
D. 32 photovoltaic cells in parallel.

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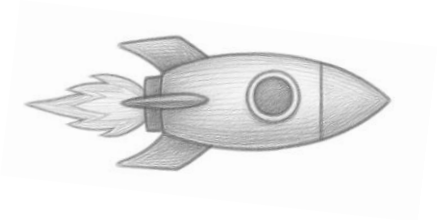
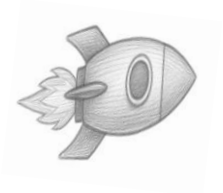
Question 14

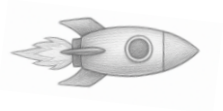
The spaceship picture below is to scale:



It travels from the left to the right (relative to an observer) at a significant fraction of the speed of light. Which of the following is the most accurate representation of what an observer would see as the spaceship moves from the left to the right relative to them (note the diagrams are to scale):

A. 

B. 

C. 

D. 

Question 15

According to special relativity (ignoring general relativity), how must GPS satellite clocks be adjusted to remain synchronised with clocks on Earth? Assume the satellite and the Earth are both separate inertial reference frames.

A. They must be slowed down because the satellite moves relative to the Earth
B. They must be sped up because the satellite moves relative to the Earth
C. No adjustment is needed since all clocks tick at the same rate in space
D. They must be adjusted randomly depending on the satellite's position

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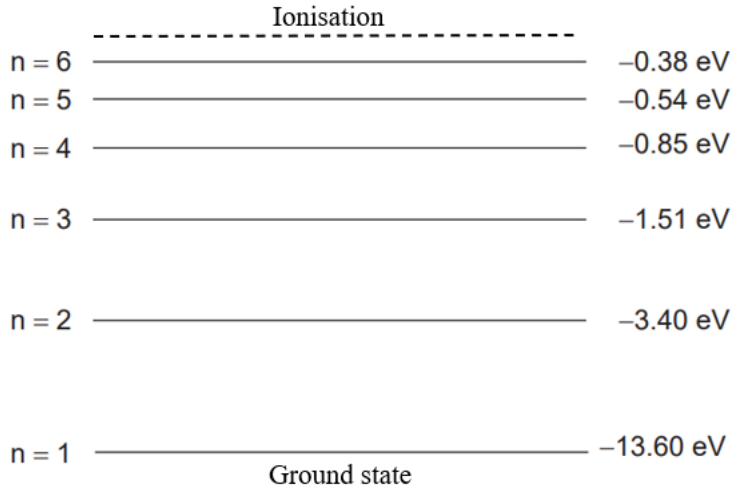
Question 16

The diagram below shows the electron energy levels for hydrogen:



When an electron is excited to the third excited state what is the energy of the photon that it can give off with the longest wavelength as it transitions back down to the ground state.

A. 0.66 eV

B. 1.89 eV

C. 12.09 eV

D. 12.75 eV

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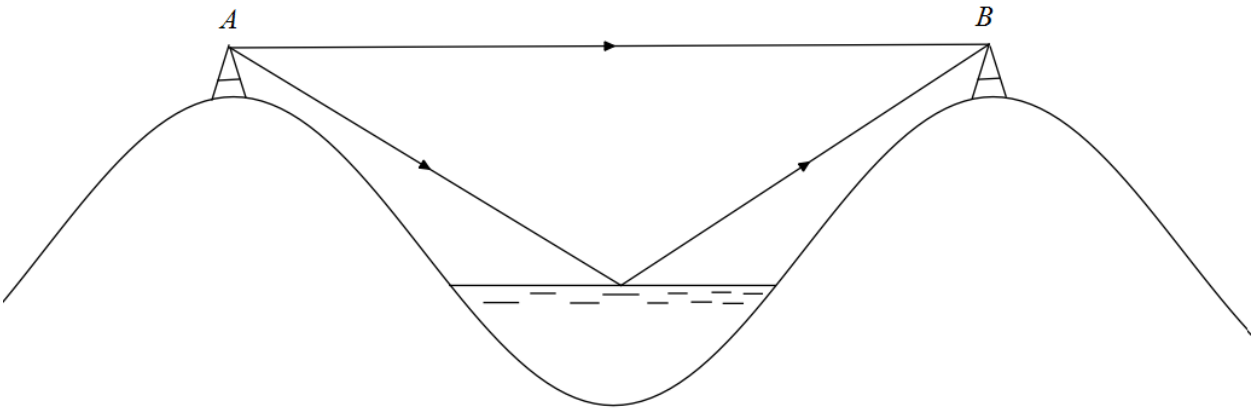
Question 17

Radio waves with a wavelength of 1.40 m form the link between two radio stations perched on the mountain tops as seen below (diagram not to scale).



There is a lake in the valley below and some of the radio waves reflect off the surface with no phase change. The direct distance that the radio waves travel from A to B is 800 m. Which one of the distances below for the reflected path would cause destructive interference?

A. 844.8 m

B. 866.5 m

C. 886.8 m

D. 937.2 m

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Question 18

When photons with energy, E, strike a metal surface, electrons may be emitted. The maximum kinetic energy (E_k) of the electrons is given by:

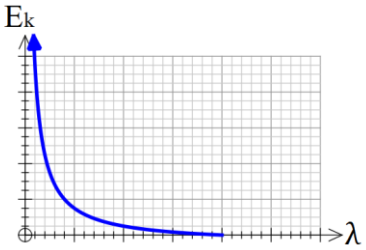
$$E_k = E - \phi$$

Which of the following graphs shows the relationship between the maximum kinetic energy of these electrons (E_k) and the wavelength of the photons (λ)?

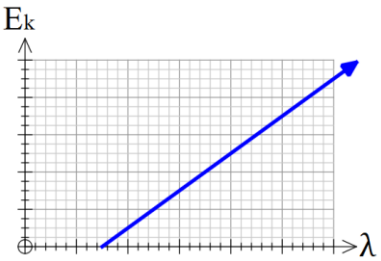
A.



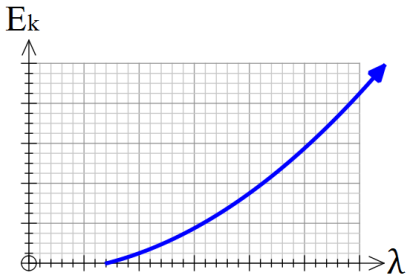
B.



C.



D.



Question 19

A student measures the length of a metal rod several times using a ruler. The values are: 24.1 cm, 24.0 cm, 24.2 cm, 24.0 cm. The true length is 25.0 cm. Which statement is correct?

A. The measurements are accurate but not precise

B. The measurements are both precise and accurate

C. The measurements are precise but not accurate

D. The measurements show random error only

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Question 20

Which of the following is most likely to reduce random error in an experiment?

A. Calibrating the equipment

B. Using a different variable

C. Repeating the experiment multiple times

D. Averaging systematic errors

End of Section A

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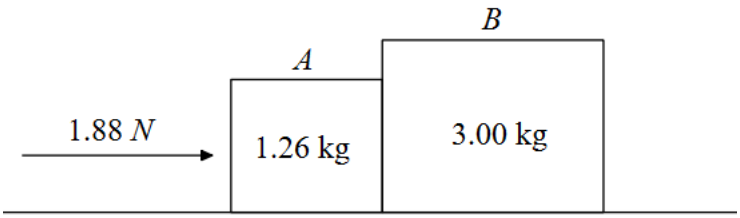
Section B – Short answer questions

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 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.

Question 1 (5 marks)

Two blocks are placed side by side, block A has a mass of 1.26 kg and block B has a mass of 3.00 kg. A horizontal force of 1.88 N west is applied to block A, pushing both blocks which move as one along a frictionless surface.



a. What is the magnitude of the acceleration of the two blocks? 2 marks

$m\ s^{-2}$

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b. What is the force on A due to B? 3 marks

N	$Direction$:

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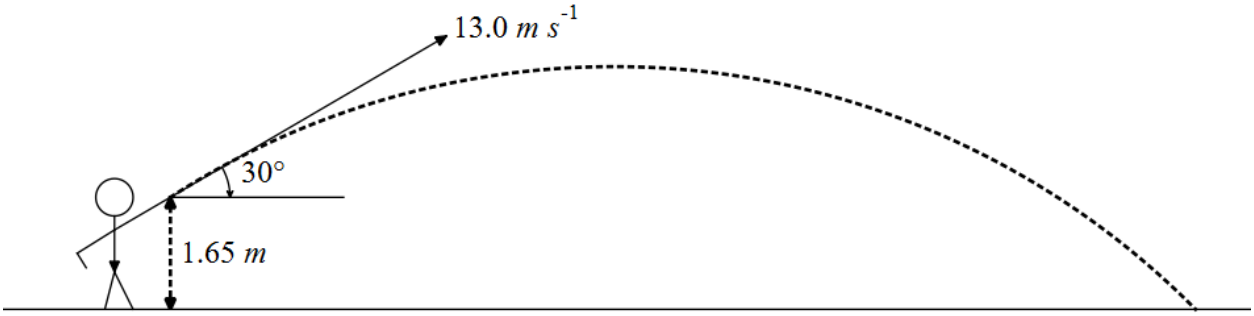
Question 2 (6 marks)

A girl throws a tennis ball of mass 56.0 grams with an initial velocity of 13.0 m s^{-1} at an angle of 30.0° from a height 1.65 m above the ground.



The ball travels in a path shown in the diagram. Air resistance can be assumed to be negligible.

a. What is the maximum height achieved by the projectile. 3 marks

m

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b. What is the magnitude of the final velocity of the ball, just before it hits the ground.

3 marks

$m\ s^{-1}$

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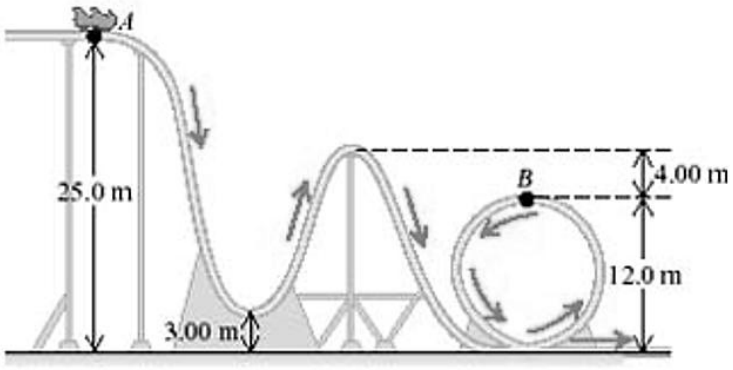
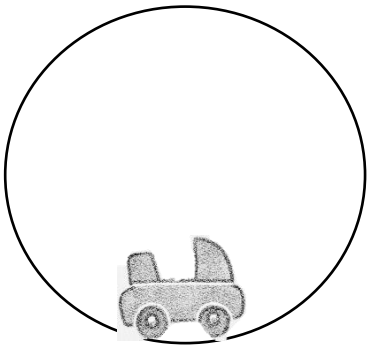
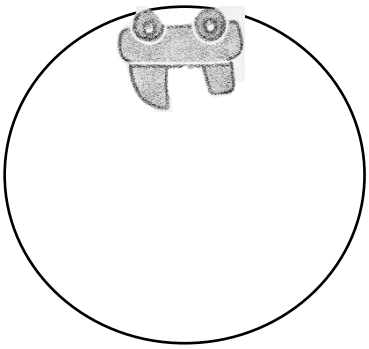
Question 3 (7 marks)

The diagram below shows a roller coaster. The roller coaster starts 25.0 m above the ground. It then falls down and does a circular vertical loop at section B (section B is 12.0 m above the ground). The circular loop has a diameter of 12.0 m.



a. On the diagram below draw and label all of the forces on the roller coaster at both the top and the bottom of the loop. 2 marks

Bottom of the loop	Top of the loop
	

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b. What is the minimum velocity required such that the occupants of the roller coaster experience no normal force at the top of the loop? 2 marks

$m\ s^{-1}$

c. Assume that this roller coaster loses no energy as it travels and that the initial kinetic energy is negligible. Will the occupants of this roller coaster experience no normal force? Justify your answer with appropriate calculations. 3 marks

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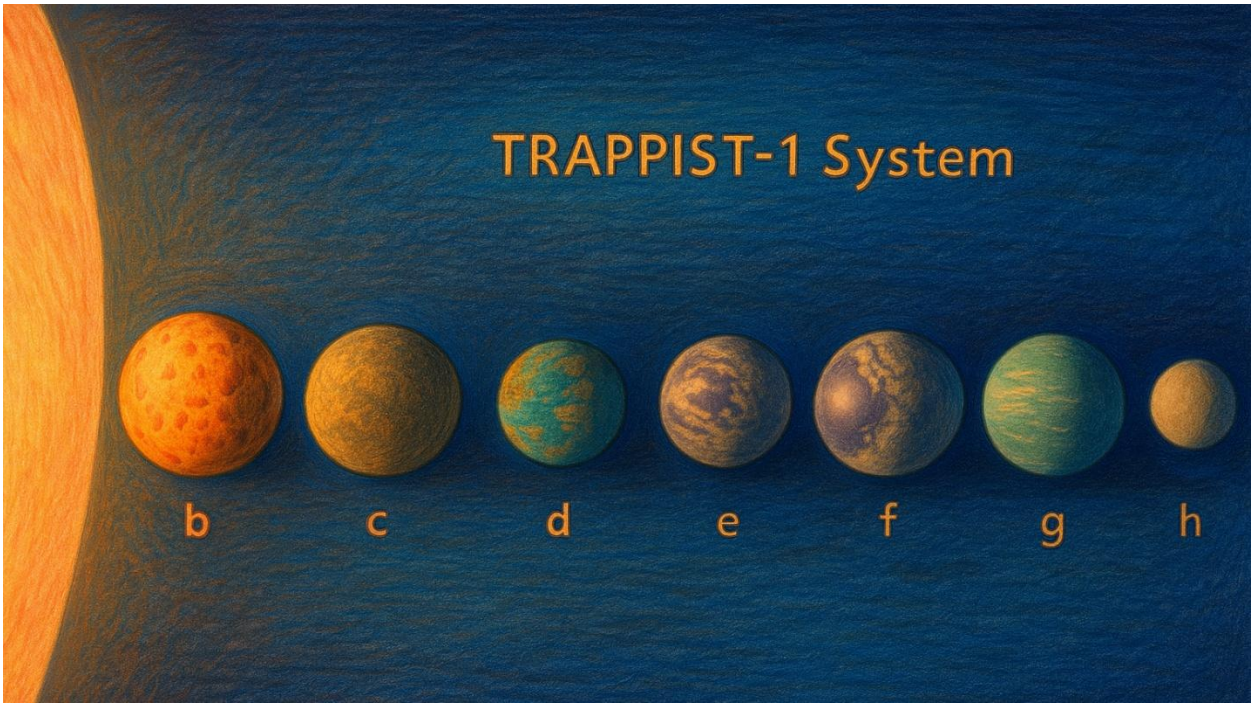
Question 4 (6 marks)

Some 40 light years from Earth lies the TRAPPIST-1 system. This system contains seven rocky Earth-sized planets around their small, dim, red star.

Any of these planets could harbour liquid water, but the fourth planet from the TRAPPIST-1 star, named TRAPPIST-1e, is in the habitable zone. The habitable zone is the area around the star where liquid water is most likely to be detected.



a. The planet TRAPPIST-1e orbits its sun every six (6) Earth days and has a mean orbital radius (from the centre of the star to the centre of TRAPPIST-1e) of 4.20×10^9 m. Use this information to show that the mass of the star that TRAPPIST-1e orbits is 1.63×10^{29} kg. 1 mark

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The mass of TRAPPIST-1e is 3.72×10^{24} kg

b. Calculate the magnitude of the force that TRAPPIST-1e exerts on the star. 2 marks

N

c. The mean gravity on the surface of TRAPPIST-1e is 7.62 m s^{-2}. What is the mean radius of TRAPPIST-1e? 2 marks

m

d. If humans are to live on TRAPPIST-1e, we would likely put a satellite in geostationary orbit. Explain what it means to say "a satellite is in geostationary orbit". 1 mark

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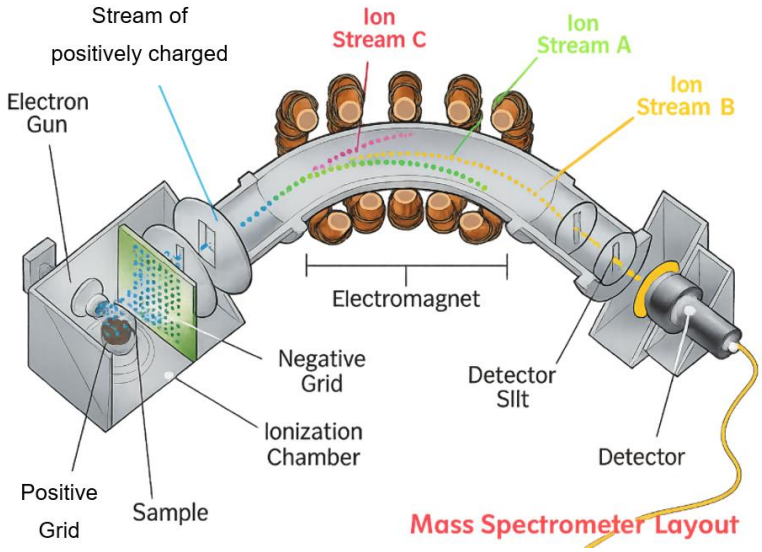
Question 5 (3 marks)

A mass spectrometer is used for analysing various isotopes of a substance. In mass spectrometry all samples gain a charge of +1.60 x 10^{-19} C (by the removal of an electron) and are accelerated by a potential difference and then deflected through a large electromagnet. The ions can then be focused through the detector slit by varying the magnetic field strength.



a. If a scientist wanted to focus 'Ion stream C' through the detector slit, would she have to increase or decrease the strength of the magnetic field? 1 mark

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b. A carbon−12 ion has a mass of 1.99 x 10^{-26} kg, and is accelerated to 4000 m s^{-1}. It then passes perpendicular to the uniform magnetic field in the mass spectrometer which has a strength of 5.39 × 10^{-2} T. Calculate the force acting on the carbon−12 ion.

2 marks

N

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Question 6 (3 marks)

When an electron is placed at a distance of 2.00×10^{-9} m from a point charge q, it experiences a repulsive force of 1.70×10^{-10} N. Determine the magnitude and sign of point charge q.

C

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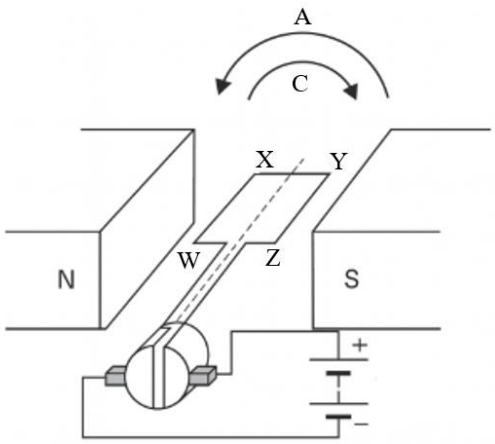
Question 7 (7 marks)

A diagram of a simple DC motor is shown below:



a. Will this motor rotate in a clockwise or anticlockwise direction? Justify your answer.

3 marks

b. The DC motor has a split ring commutator. Explain the role of the split ring commutator.

2 marks

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c. If the number of loops is increased, what effect will this have on the torque of the motor. Justify your answer. 2 marks

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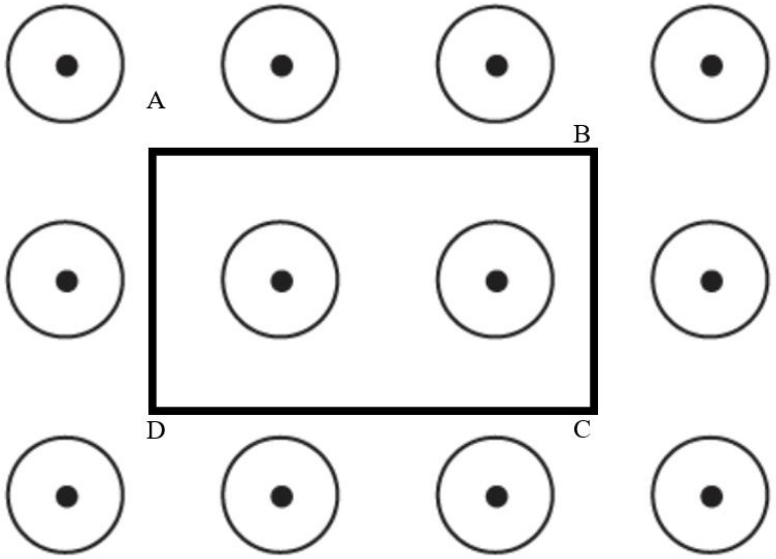
Question 8 (9 marks)

A rectangular coil with 100 turns is placed in a magnetic field, that is out of the page. The external magnetic field is being generated by a powerful electromagnet. The magnetic field initially has a strength of 1.50 T and the rectangular coil has the following measurements:

AB = CD = 6.99 m

AD = BC = 4.13 m



The magnetic field is increased at a rate of 0.250 T per second for four (4) seconds. The magnetic field then remains constant at its new strength for two (2) seconds, before decreasing by 0.500 T per second for three (3) seconds.

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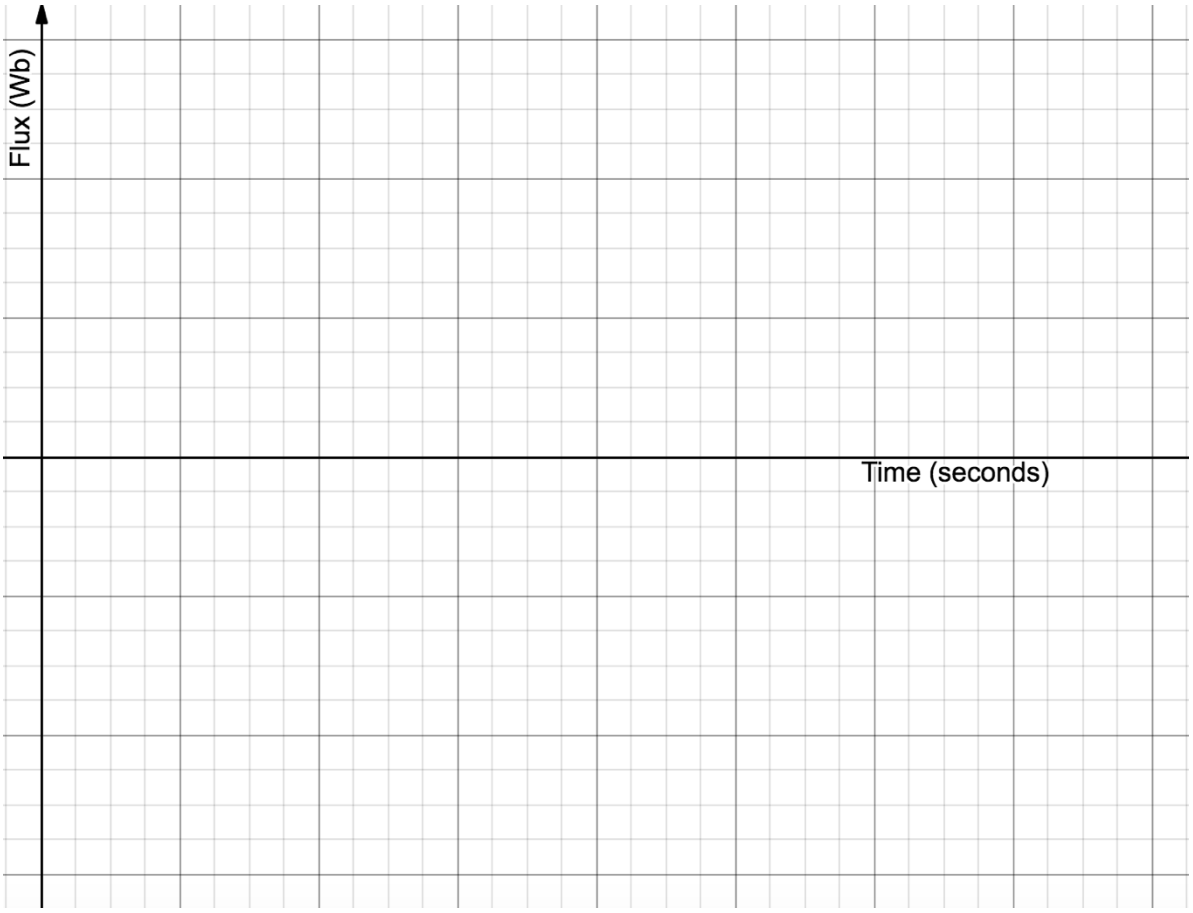
a. On the axis below draw a graph of the flux vs time graph. Be sure to include a scale so that the important points on the graph can be clearly identified. Use the space below for working. 3 marks



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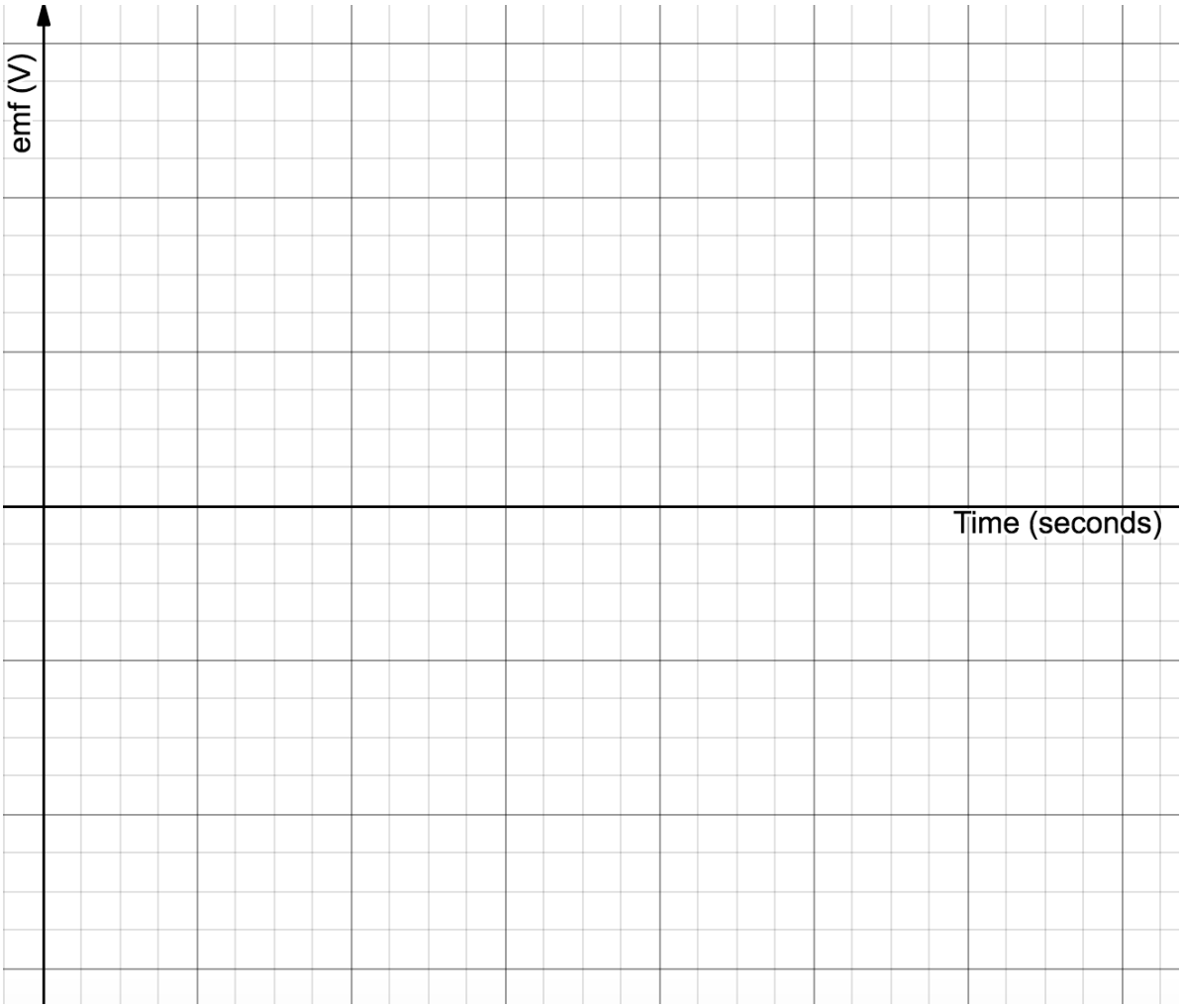
b. On the axis below, draw a graph of the EMF vs time graph. Be sure to include a scale so that the important points on the graph can be clearly identified. Use the space below for working. 3 marks



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c. When the magnetic field is decreasing, the direction of the induced current is: (circle the correct answer) 1 mark

ABCD DCBA

d. The magnetic field is then set to 1.00 T and the coil is dragged through the magnetic field at a constant velocity of 3.00 m s^{-1} for 2.40 seconds. What is the EMF that will be induced during that time? Justify your answer. 2 marks

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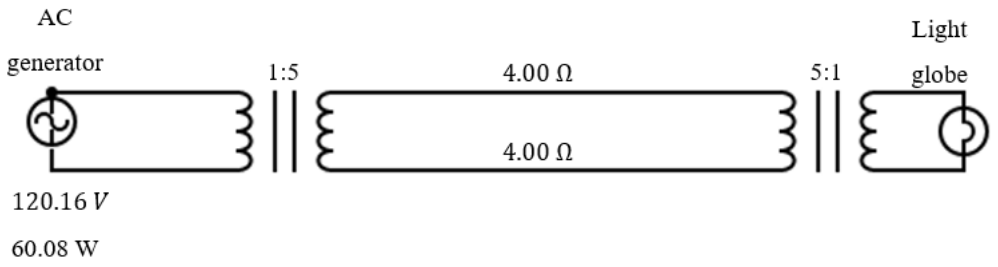
Question 9 (5 marks)

A rural farm has a generator that produces 60.08 W of power and 120.16 V that is used to power a light in his shed. The farm's shed is far from the generator and electricity must be transmitted via two long transmission cables each with a resistance of 4.00 Ω. The farmer places a step-up transformer (1:5) before the transmission cables and a step-down transformer (5:1) after the transmission cables. A diagram of this situation is shown below:



a. Show that the current in the AC generator is 0.500 A. 1 mark

b. Calculate the voltage delivered to the light globe. 3 marks

V

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c. Calculate the power loss in the transmission lines. 1 mark

W

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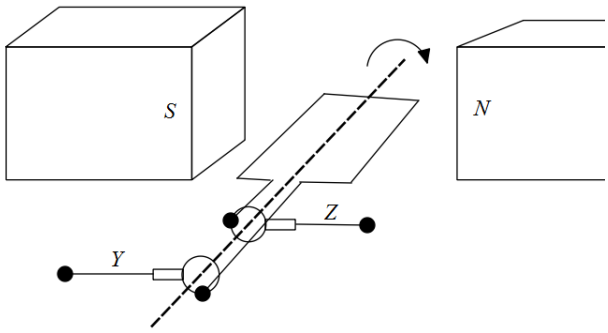
Question 10 (6 marks)

An electrical generator is shown in the diagram below, the generator is turning clockwise as seen from the front.

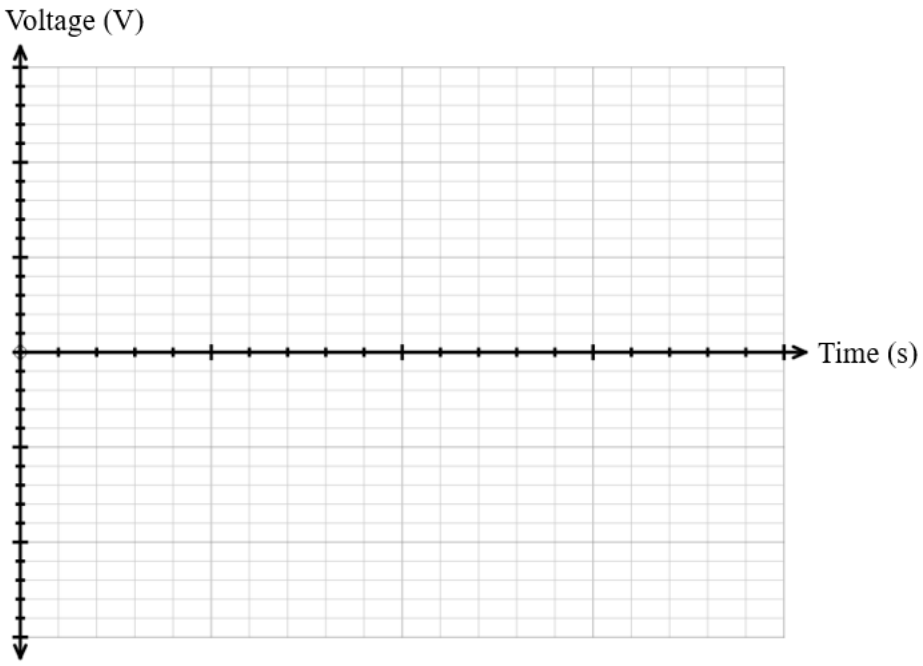


a. Which direction will the induced current flow? 1 mark

Y to Z Z to Y

The frequency of the generator is known to be 50.0 Hz and the maximum voltage is 30 V.

b. On the graph below draw the EMF vs time for two full rotations. Include a time and voltage scale and assume the coil starts at time zero in the position shown in the diagram (parallel to the magnetic field). 3 marks



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c. What is the root mean square voltage of this generator? 2 marks

V

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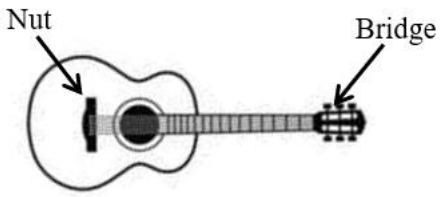
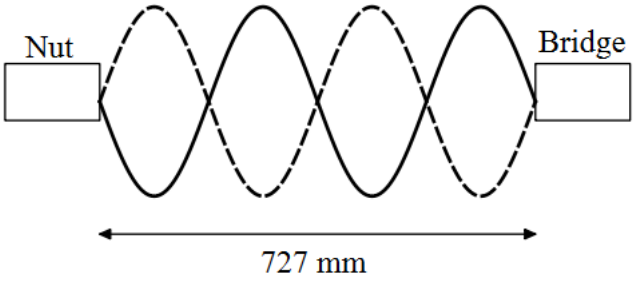
Question 11 (4 marks)

A guitar string is fixed at both ends (at the bridge and the nut, as shown below).



This means that when the string is plucked a standing wave can be created. The different harmonics produced by the string correspond to different standing wave patterns. A musician plucks a string on a guitar and it forms the pattern below:



As shown, the distance between the two fixed ends (the nut and bridge) is 727 mm. The velocity of the wave through this string is known to be 130 m s^{-1}.

a. What is the frequency of the standing wave shown in the figure above? 2 marks

Hz

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b. Can a standing wave that has a frequency of 268.2 Hz be formed? Justify your answer.

2 marks

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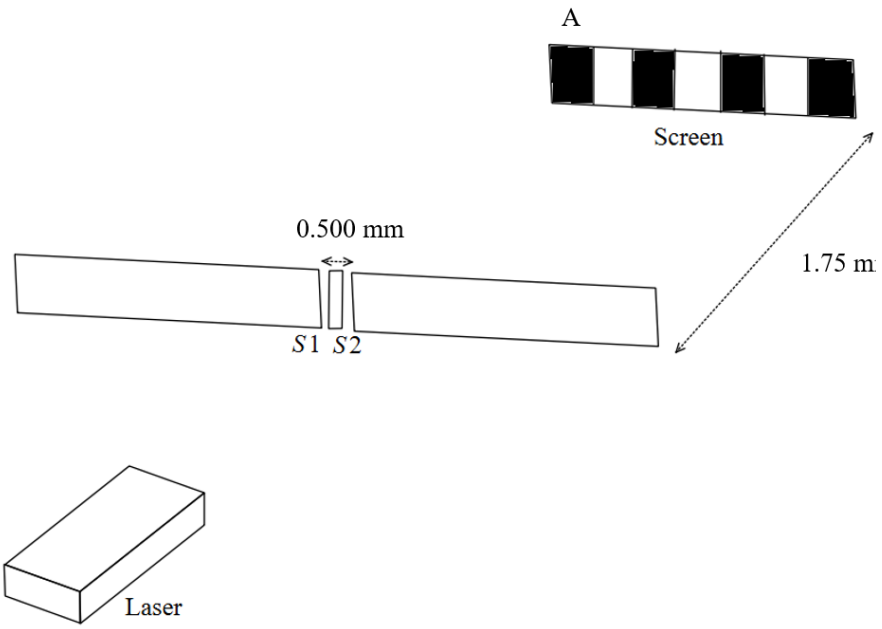
Question 12 (6 marks)

A group of students in a lab recreated Young's double slit experiment. The students use a laser of wavelength 400 nm, the space between the double slits is set to 0.500 mm and they place the screen 1.75 m away from the double slits. A diagram of this situation is shown below:



a. Explain why the point marked A in the diagram above is a region of minimum light intensity. 2 marks

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b. What is the fringe spacing for this interference pattern? 2 marks

m

c. Explain how the results of Young's double-slit experiment provide evidence for the wave-like nature of light. 2 marks

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Question 13 (8 marks)

Photoelectric sensors work by using the photoelectric effect to detect the presence or absence of an object based on light. One application of a photoelectric sensor is for use in an automatic door. As a person approaches the automatic door they break a 900 nm infrared light beam. A sensor detects a sharp drop in photoelectric current which sends a signal to open the door.



Caesium (Cs) is used as the metal that coats the sensor, it has a work function of 1.10 eV.

a. Calculate the kinetic energy of the electrons ejected from the caesium when they are hit by the infrared beam. 2 marks

eV

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b. When designing this automatic door the engineers considered using an infrared beam with a wavelength of 1200 nm. Suggest a reason why the engineers did not use this wavelength, include at least one calculation in your answer. 2 marks

c. The engineers decide to change the wavelength by decreasing it, but they keep the power output of the laser the same. Will the photocurrent detected by the sensor increase, decrease or stay the same? Justify your answer. No calculations or numerical values are required. 2 marks

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d. State one piece of evidence in the photoelectric effect experiment that supports the particle nature of light. 2 marks

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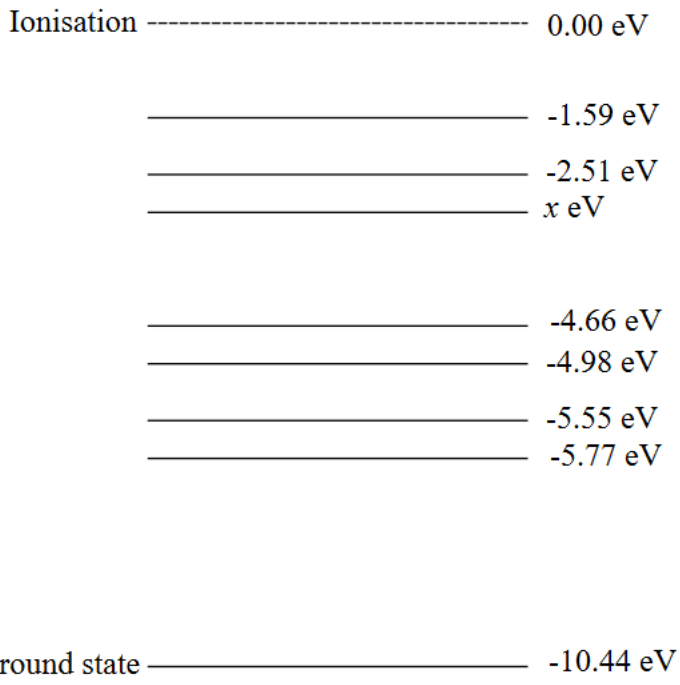
Question 14 (5 marks)

The diagram below shows the energy levels of mercury:



a. An electron is in the fourth excited state. What is the shortest possible wavelength that can be emitted as it transitions down? 3 marks

nm

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b. An electron is excited to the energy level $x\ eV$. It then moves from the energy level $x\ eV$ directly down to the ground state and emits a 161 nm wavelength of light. Calculate the value x for this energy level. 2 marks

eV

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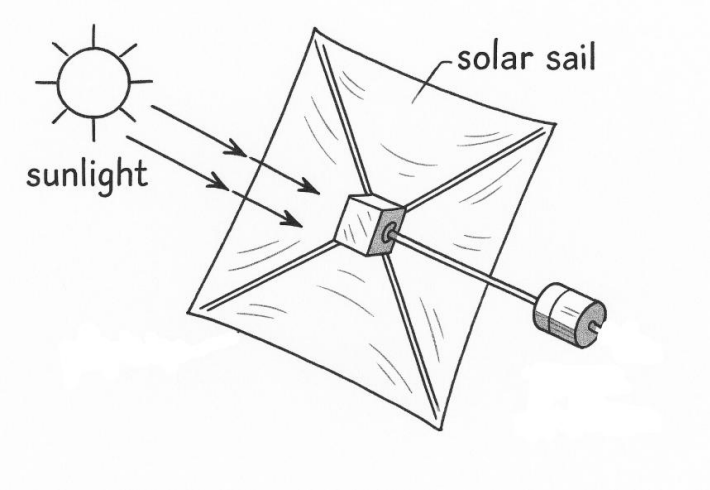
Question 15 (4 marks)

LightSail 2 was a pioneering solar sail spacecraft launched by The Planetary Society in 2019 to demonstrate propulsion using sunlight alone. The spacecraft deployed a large, reflective Mylar sail in Earth's orbit, allowing it to gradually raise its orbit by harnessing the momentum of photons from the Sun. A simplified diagram is shown below:



Photons strike the solar sail at 90° to its surface and reflect elastically. Assume that the photons hitting the surface of the solar sail have a wavelength of 350 nm.

a. Show that the momentum of the 350 nm photons is equal to $1.89 \times 10^{-27} kg\ ms^{-1}$

1 mark

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b. Each second, 3.54×10^{25} photons of this wavelength hit the solar sail. Assuming the sail starts at rest, calculate its velocity after being exposed to this photon stream for one day (24 hours). The mass of the solar sail is 5.00 kilograms. 3 marks

$m\ s^{-1}$

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Question 16 (6 marks)

In a linear particle accelerator, muons are accelerated to a speed of 0.600 c ($\gamma = 1.25$) before entering a straight section of the accelerator for experiments. Muons are unstable subatomic particles that have a mean lifetime of 2.20 μs when measured stationary in the lab. The straight section of the accelerator is 500 m long as measured by the scientist in the lab.

a. Calculate the mean lifetime of the muons as measured in the scientists' frame when the muons are travelling at 0.600 c relative to her. 2 marks

μs

b. Calculate the length of the 500 m straight section as measured in the muons' frame of reference when they are travelling at 0.600 c relative to the straight section. 2 marks

m

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c. Calculate the total energy of a muon moving at 0.600 c given that the rest mass of a muon is 1.88×10^{-28} kg. 2 marks

J

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Question 17 (10 marks)

A concussion is a type of mild traumatic brain injury caused by a sudden blow or jolt to the head. Repeated concussions increase the risk of long-term cognitive issues, including memory loss and depression.

A group of researchers are investigating the effect of impact time on the average force during simulated head collisions. To do this, a dummy head that has a mass of 4.50 kg was dropped from a fixed height onto a force sensor which measured the average force.

The average force experienced was measured first with no padding. The experiment was then repeated using different amounts of padding. For each trial, the time of the collision and average force were both measured. It was found that the timer used had a measurement uncertainty of $\pm 0.5\ ms$.

The results are shown below:

Amount of padding (cm)	Time of the collision (ms)	Average Force (kN)	$\frac{1}{Average\ force\ (kN)}$
0	2	12.2	0.082
0.5	10	2.44	0.410
1	13	1.88	0.532
1.5	15	1.63	0.613
2	17	1.44	0.694
2.5	20	1.22	0.820
3	22	1.11	0.901

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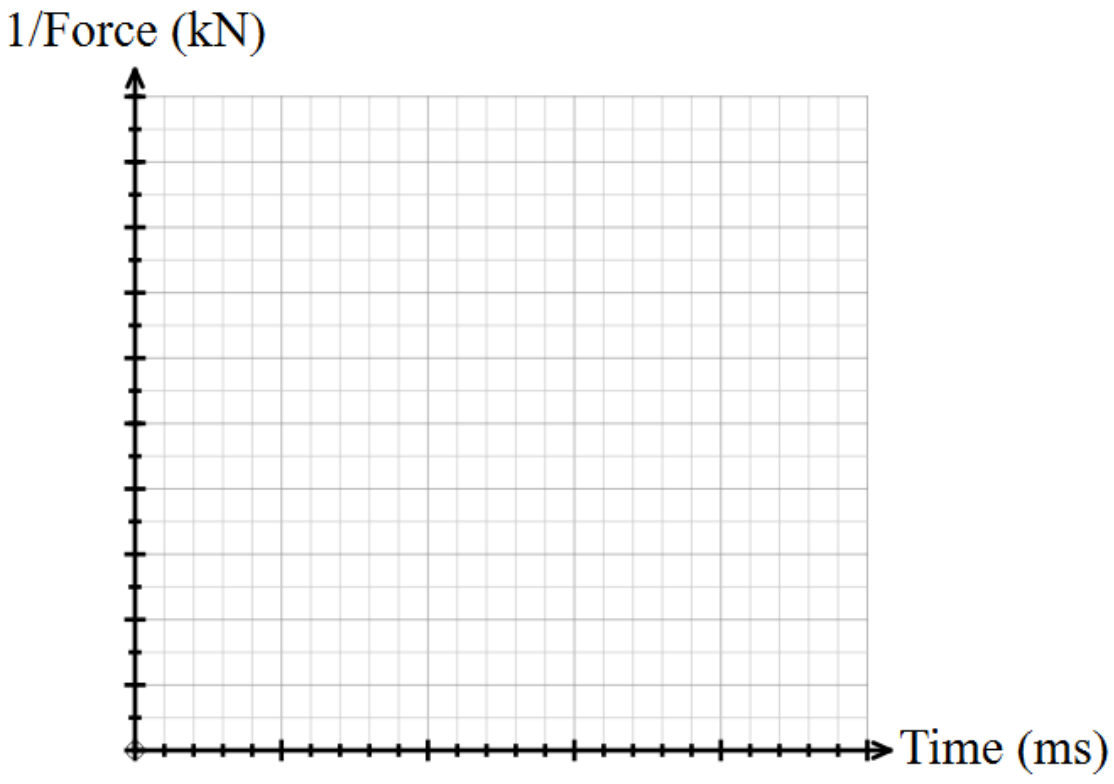
a. The variables in this experiment can be classified as independent, dependent or controlled. Complete the table below by providing one variable from the experiment for each classification. 3 marks

Classification	Variable
Independent variable	
Dependent variable	
Controlled variable	

b. Use the graph provided below to graph the results of the experiment. Your graph should include a clear scale, a line of best fit and error bars for the time. 4 marks



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c. Find the gradient of the line of best fit and use the gradient to calculate the impulse of the collisions. 3 marks

Ns

End of Section B

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