Ascham School

Centre Number

Student Number

2024 TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper

Total Marks: 100

Section I – 20 marks

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks

- Attempt Questions 21-34
- Allow about 2 hours and 25 minutes for this section

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Section I

20 marks
Attempt Questions 1-20
Allow about 35 minutes for this section

Use the separate multiple-choice answer sheet for Questions 1-20.

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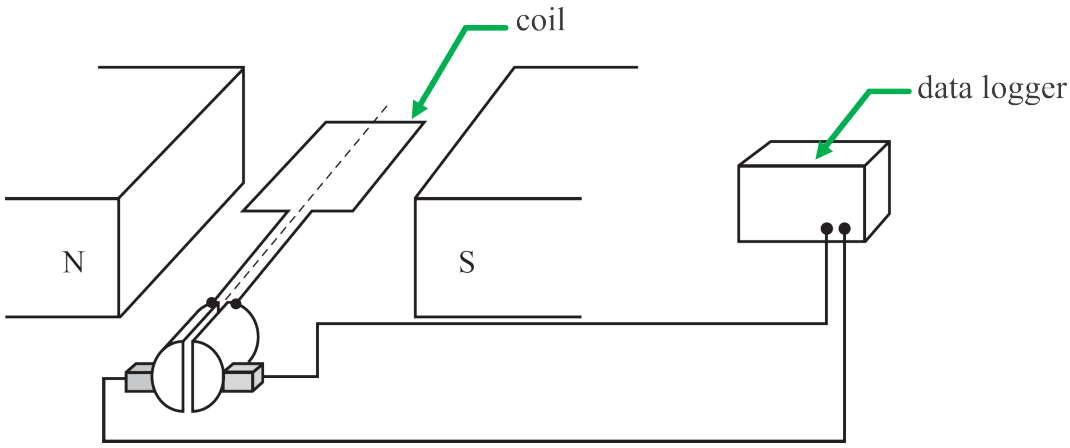
1 A group of Physics students conducts a controlled experiment to investigate the phenomenon of electromagnetic induction. The students place a coil within a uniform magnetic field, as shown in the diagram below.

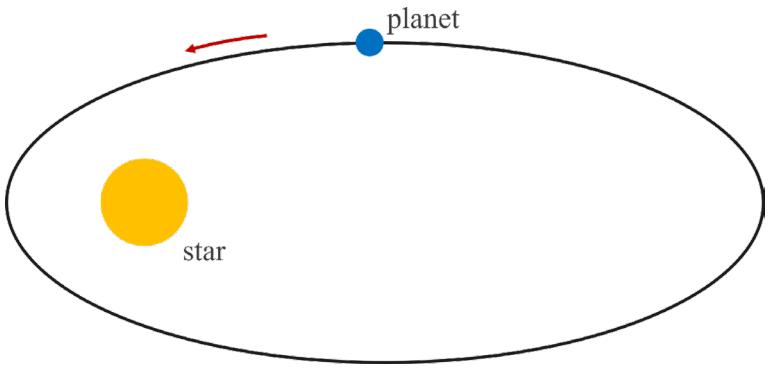


The coil is rotated at 50 revolutions per minute, 100 revolutions per minute and then 150 revolutions per minute. The peak EMF is measured each time using a data logger.

Which of the following best identifies the independent variable and a possible controlled variable in this experiment?

	Independent variable	***Controlled variable***
A.	peak EMF	rate of rotation
B.	peak EMF	strength of magnetic field
C.	rate of rotation	peak EMF
D.	rate of rotation	strength of magnetic field

2 A planet orbits a star in an elliptical orbit moving in the direction shown.



At the position shown, which quantity is **decreasing** for the planet?

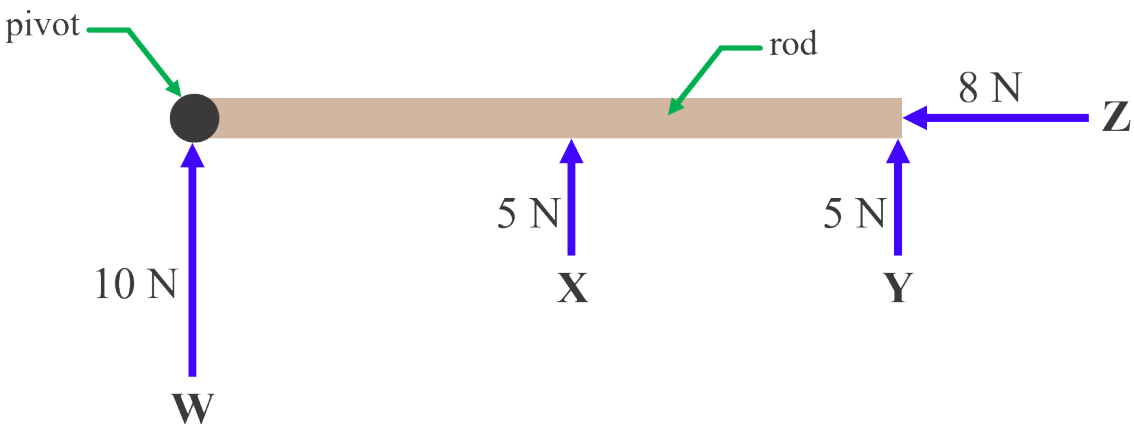
A. acceleration

B. gravitational potential energy

C. kinetic energy

D. total energy

3 The rod shown below can rotate about the pivot.



Which force shown exerts the largest magnitude torque on the rod?

A. W

B. X

C. Y

D. Z

4 Two golfers, Sam and Kim, used different golf clubs to hit identical golf balls from the same place.

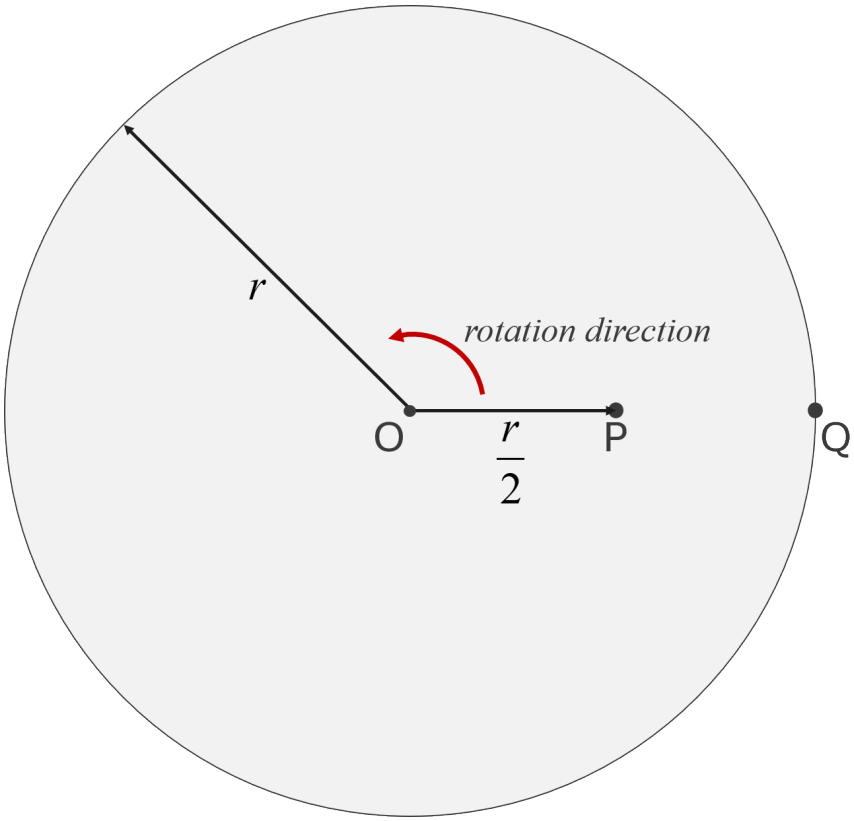
Sam's ball went higher than Kim's ball. Both golf balls first hit the ground 100m away from where they were hit.

Which set of vectors below best represents the horizontal and vertical components of the initial velocity of the two balls?

	SAM'S BALL		KIM'S BALL	
	Vertical	*Horizontal*	*Vertical*	*Horizontal*
A.				
B.				
C.				
D.				

5 A disk of radius *r*, rotates anti-clockwise about its axis, O, with angular speed ω.

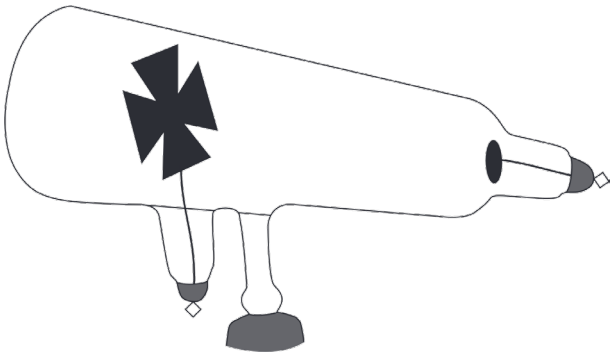
Point P is at a distance of $\frac{r}{2}$ from the centre. Point Q is on the circumference.



Which of the following correctly compares the linear speed, *v*, and acceleration, *a*, at locations P and Q?

	Linear speed 'v' (m/s)	***Acceleration 'a' (m/s^2)***
A.	$v_P < v_Q$	$a_P = \frac{1}{4} a_Q$
B.	$v_P < v_Q$	$a_P = \frac{1}{2} a_Q$
C.	$v_P = v_Q$	$a_P = \frac{1}{4} a_Q$
D.	$v_P = v_Q$	$a_P = \frac{1}{2} a_Q$

6 The diagram shows a type of cathode ray tube.



Which of the following statements CANNOT be inferred from observations made when using the apparatus shown?

A. Cathode rays possess energy.

B. Cathode rays possess momentum.

C. Cathode rays travel in straight lines.

D. Cathode rays cannot pass through metals.

7 Planets X and Y orbit the same star.

The average distance between planet X and the star is five times greater than the average distance between planet Y and the star.

What is $\frac{\text{orbital period of Planet X}}{\text{orbital period of Planet Y}}$?

A. $\left(\sqrt{5}\right)^{\frac{1}{3}}$

B. $\sqrt{5}$

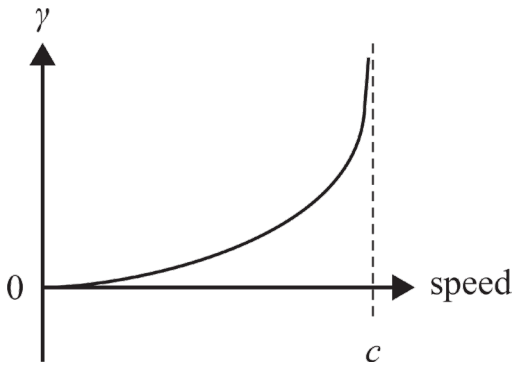
C. $\left(\sqrt{5^2}\right)^{\frac{1}{3}}$

D. $\sqrt{5^3}$

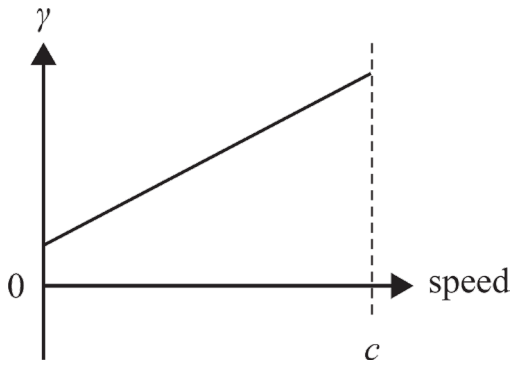
8 The effects of time dilation can be quantified using the relationship: $t = \gamma t_0$. The term γ is known as the Lorentz factor.

Which one of the following diagrams best represents the graph of γ (the Lorentz factor) versus speed for a negatively charged mass?

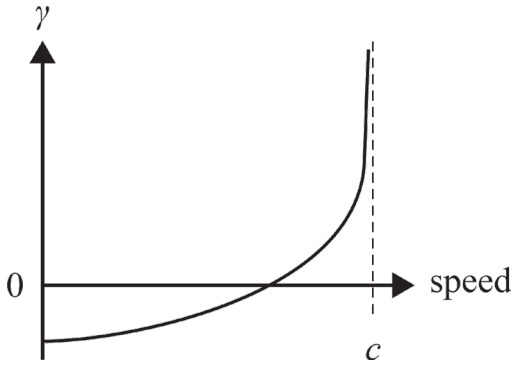
A.



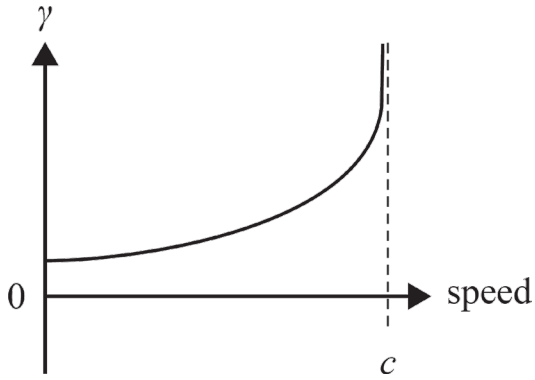
B.



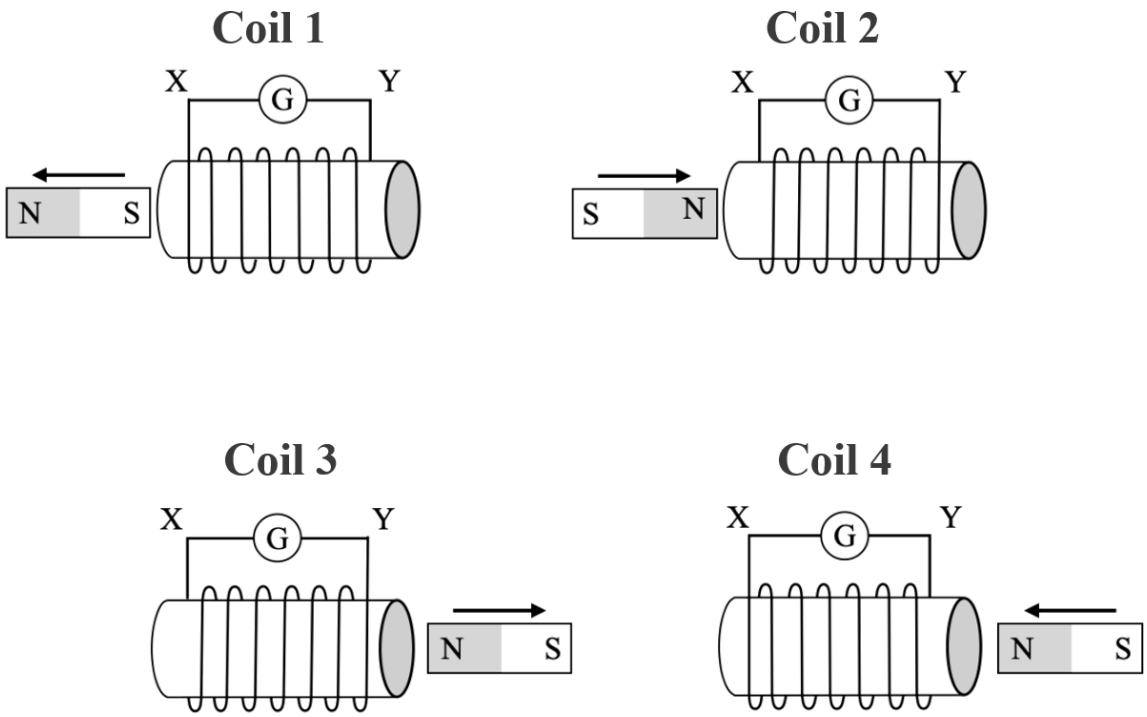
C.



D.



9 In which of the coils shown is the induced current moving from X to Y through the galvanometer at G?



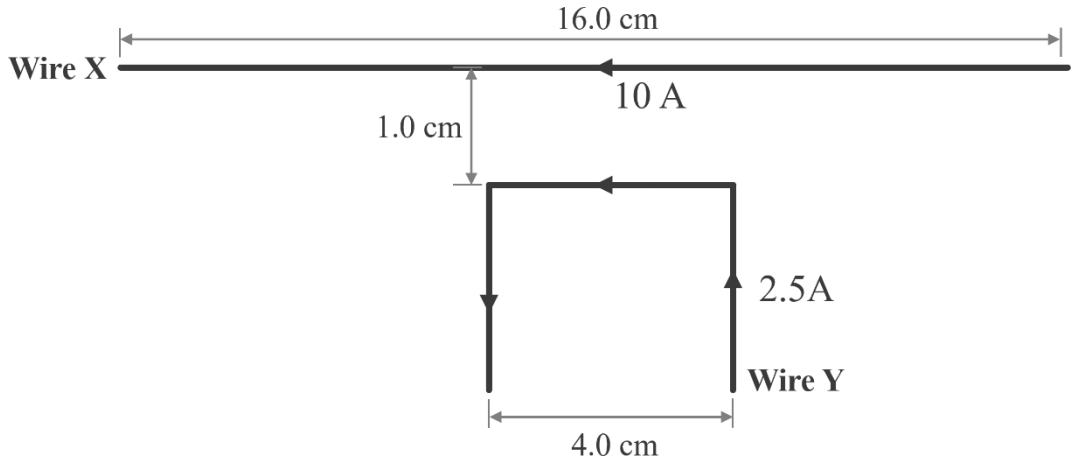
A. 1 only

B. 4 only

C. 1 and 2

D. 1 and 4

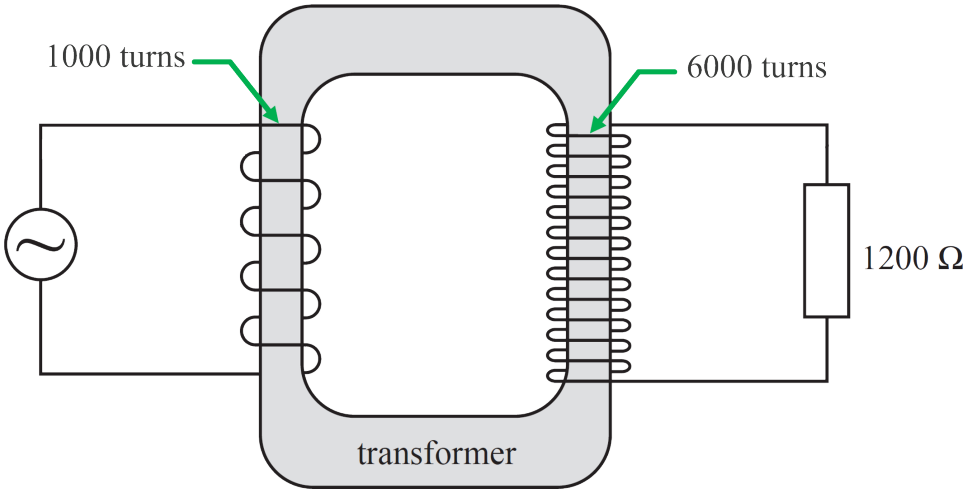
10 Wire Y carries a current of 2.5 A. A portion of Wire Y lies parallel to another 16.0cm long straight wire, Wire X, that carries a current of 10 A.



What is the magnitude of the force and the direction of the force acting on Wire X?

	Magnitude of Force on Wire X (N)	***Direction of Force on Wire X***
A.	1.25×10^{-6}	towards Wire Y
B.	1.25×10^{-6}	away from Wire Y
C.	2.00×10^{-5}	towards Wire Y
D.	2.00×10^{-5}	away from Wire Y

11 A 40 V primary circuit powers a transformer, shown below.

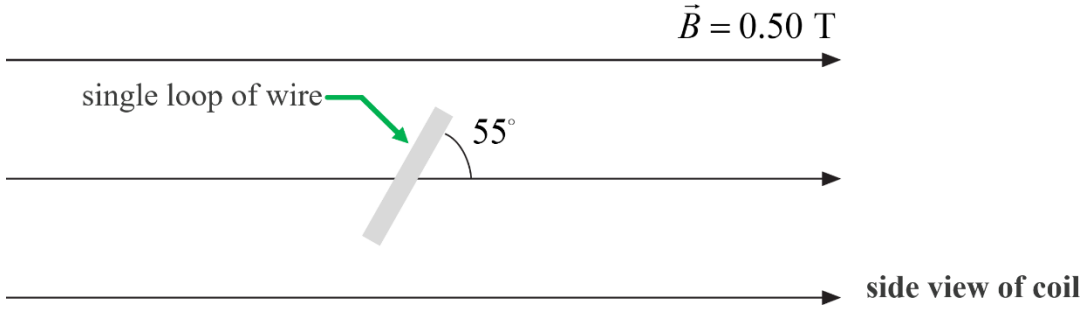


Which of the following correctly describes the voltage in the secondary circuit and the type of transformer shown?

	Voltage in secondary circuit (V)	*Type of transformer*
A.	6.7	step-down
B.	6.7	step-up
C.	240	step-down
D.	240	step-up

12 A metal wire loop has an area of 4.0×10^{-4} m^2.

The plane of the coil is positioned at 55° to the direction of a magnetic field of 0.50 T.



What is the value of the magnetic flux through the wire loop?

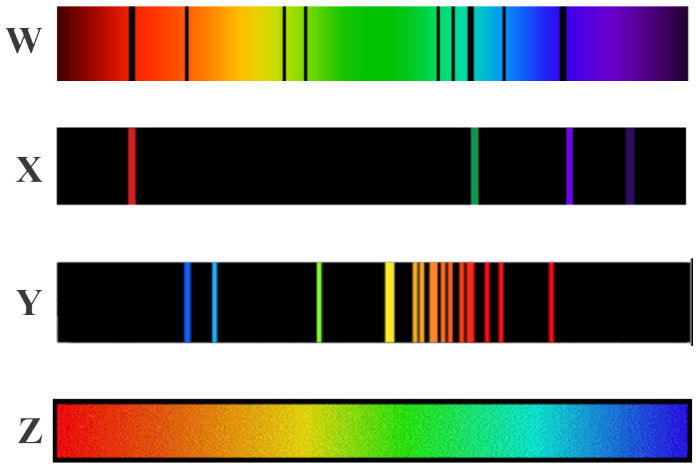
A. 5.75×10^{-5} Wb

B. 1.64×10^{-4} Wb

C. 2.00×10^{-4} Wb

D. 4.00×10^{-4} Wb

13 Four different types of spectra are shown below.



Which type of spectra would be produced by an incandescent globe?

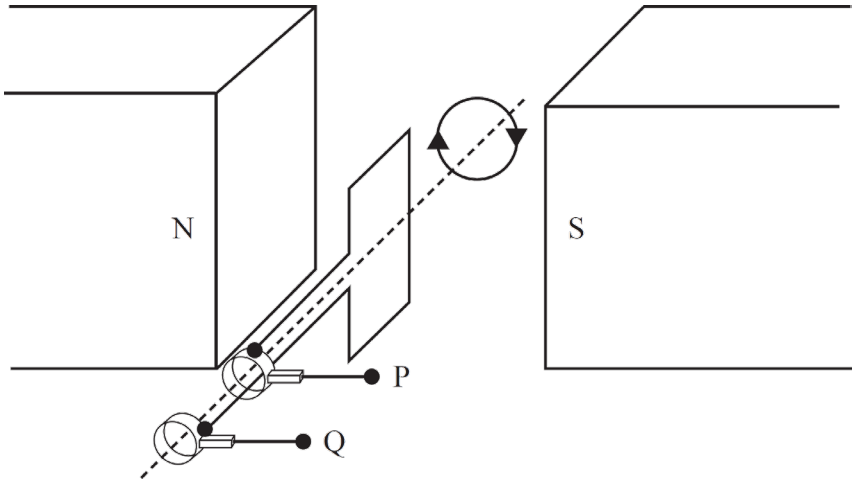
A. W

B. X

C. Y

D. Z

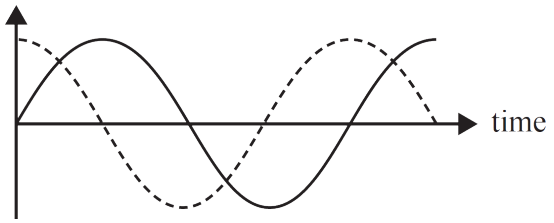
14 An electrical generator is shown in the diagram below. The generator is turning clockwise.

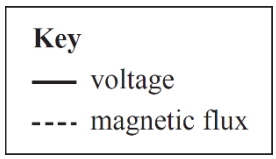


The voltage between P and Q and the magnetic flux through the loop are both graphed as a function of time, with voltage versus time shown as a solid line and magnetic flux versus time shown as a dashed line.

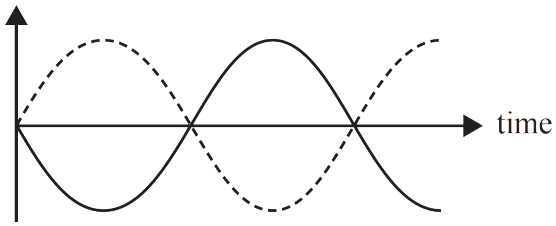
Which one of the following graphs best shows the relationships for this electrical generator?

A.

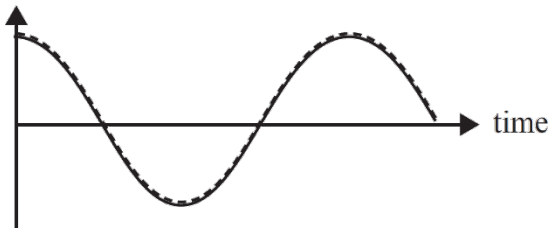




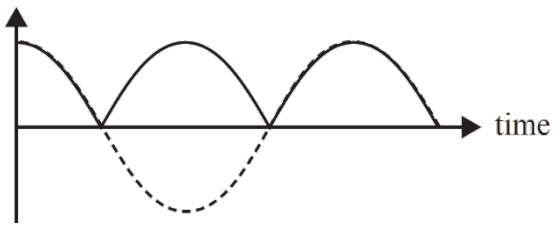
B.



C.

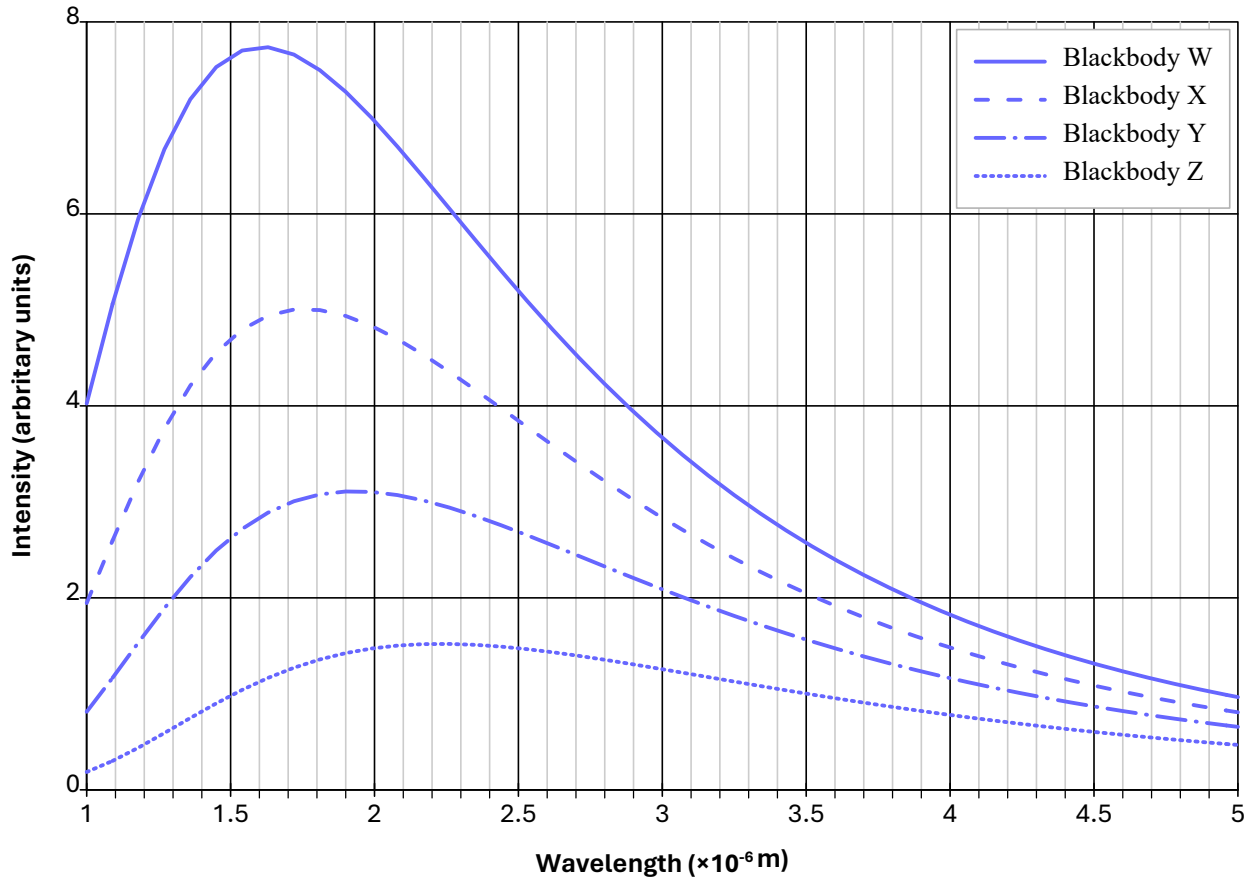


D.



15 The radiation emitted from a small hole in a heated furnace is measured. The temperature of the furnace is 1500 K.

Which of the following blackbody curves would best represent the measured radiation?



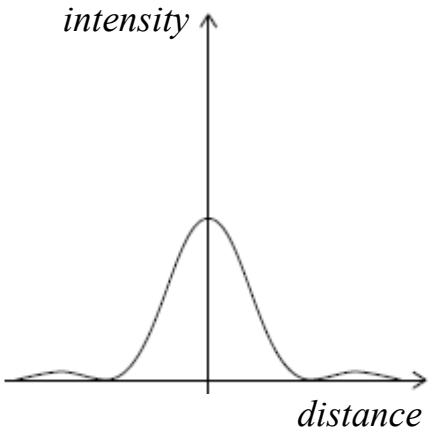
A. Blackbody W

B. Blackbody X

C. Blackbody Y

D. Blackbody Z

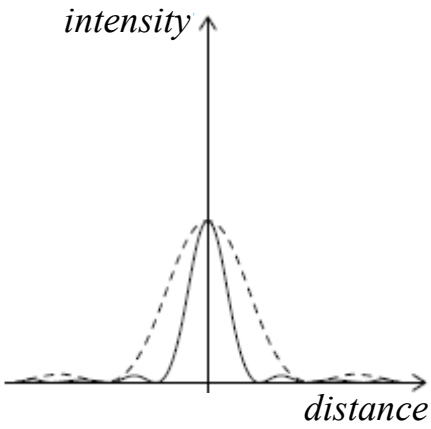
16 Light from a monochromatic source is incident on a single slit and the resulting diffraction pattern is viewed on a screen. The graph shows the variation of intensity with distance on the screen.



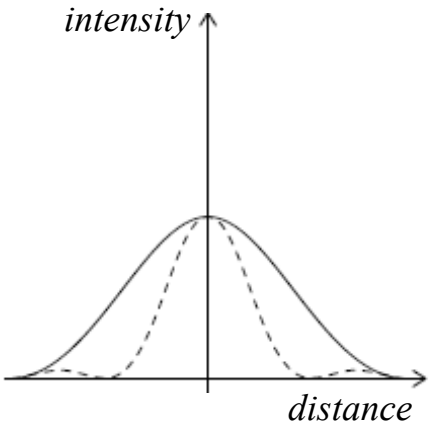
The intensity of the source remains the same. The width of the slit is increased.

Which graph correctly shows the variation of intensity after the change? The original curve is shown with a dashed line.

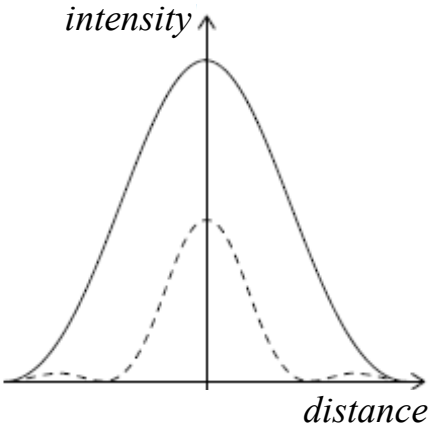
A.



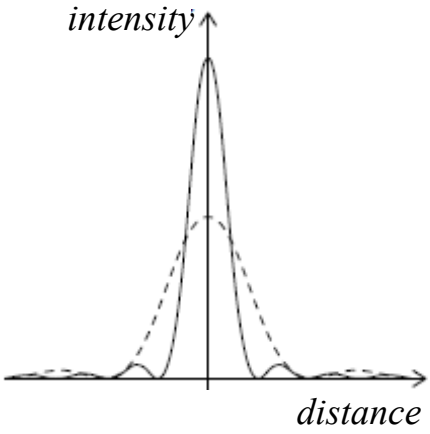
B.



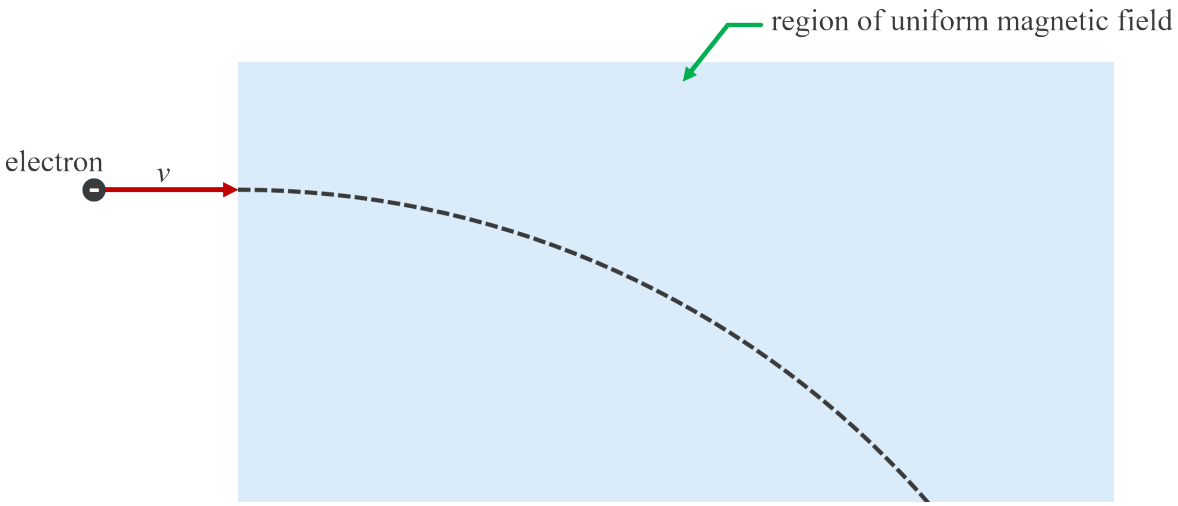
C.



D.



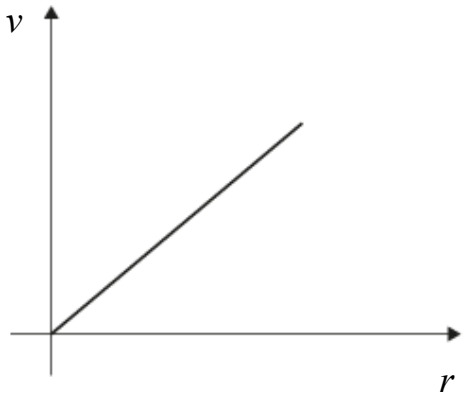
17 An electron enters a region of uniform magnetic field at a speed v. The direction of the electron is perpendicular to the magnetic field. The path of the electron inside the magnetic field is circular with radius r.



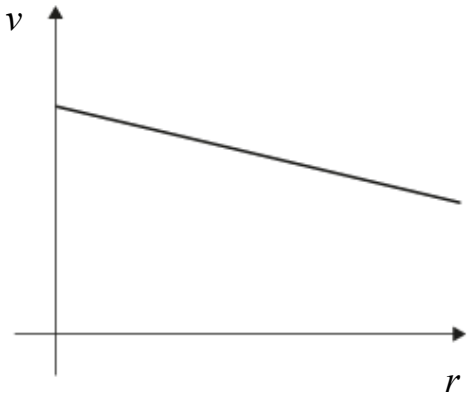
The speed of the electron is varied to obtain different values of r.

Which graph represents the variation of speed v with radius r?

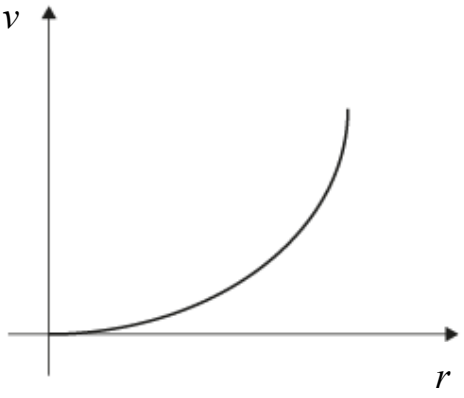
A.



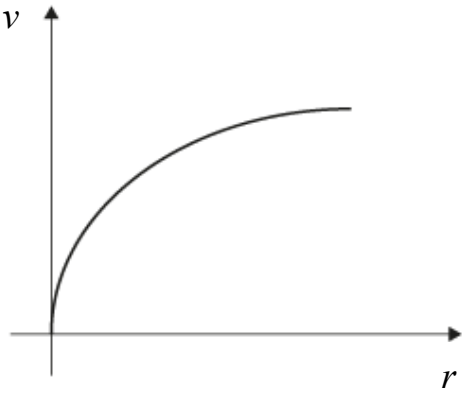
B.



C.



D.



18 A projectile is launched with an initial kinetic energy E.

The initial horizontal and vertical components of velocity are equal. Air resistance is negligible.

What is the kinetic energy of the projectile at the highest point of the motion?

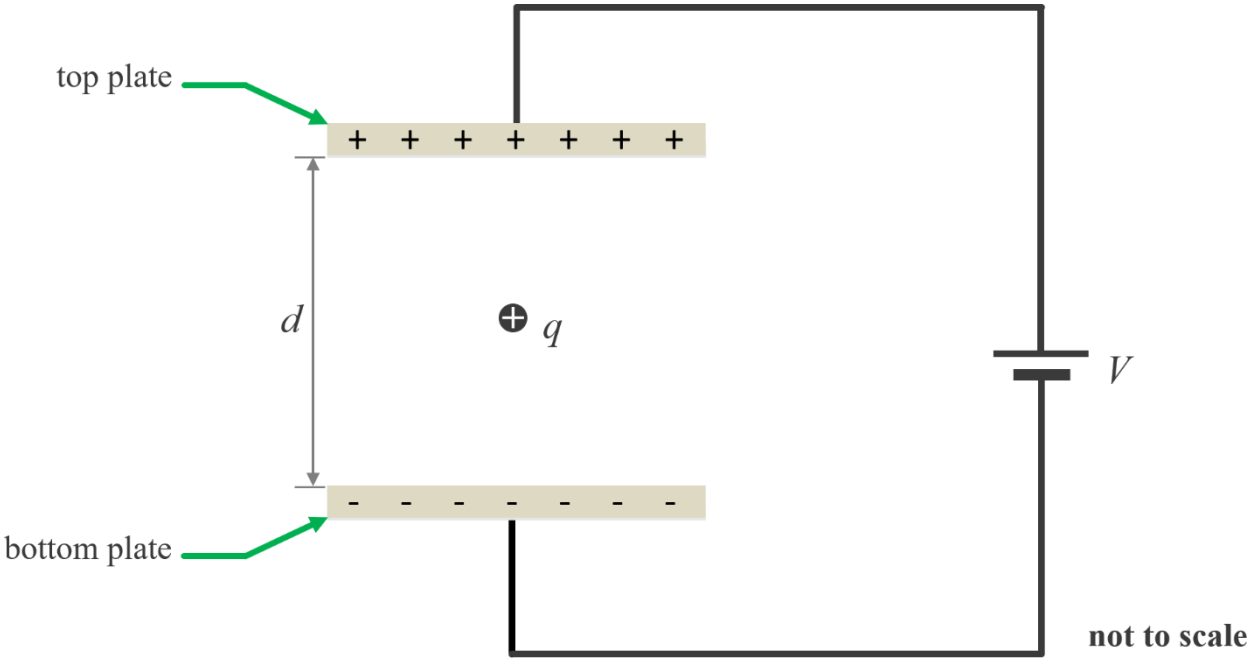
A. 0

B. $\frac{1}{4}E$

C. $\frac{1}{2}E$

D. E

19 A point particle of positive charge q and mass m is held at rest midway between the two parallel plates. A voltage V exists between the plates.



The particle is then released. You may assume that gravitational effects are negligible.

Which plate will the particle move toward and what kinetic energy does it have when it reaches the plate?

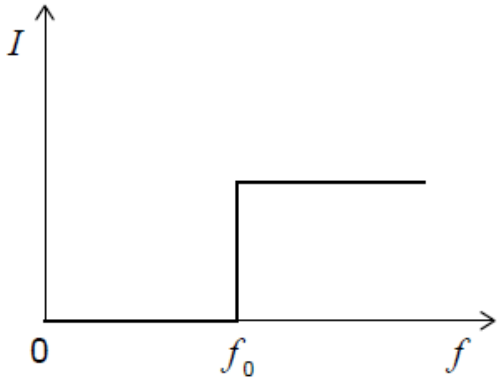
	Plate	***Kinetic Energy***
A.	bottom	qV
B.	bottom	$\frac{qV}{2}$
C.	top	qV
D.	top	$\frac{qV}{2}$

20 Light falls on a metallic surface whose threshold frequency is f_0.

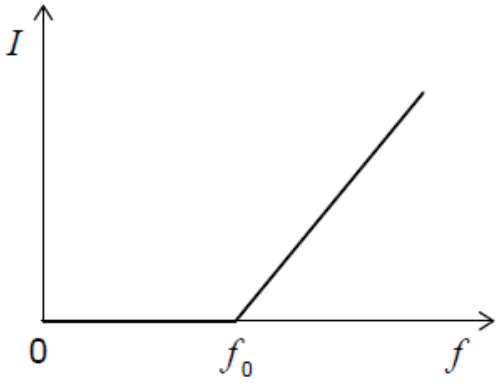
The number of photons incident per second is constant.

Which graph correctly shows how the current I emitted from the surface depends on the frequency f of the incident light?

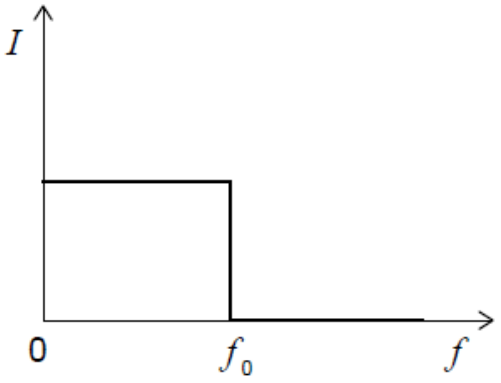
A.



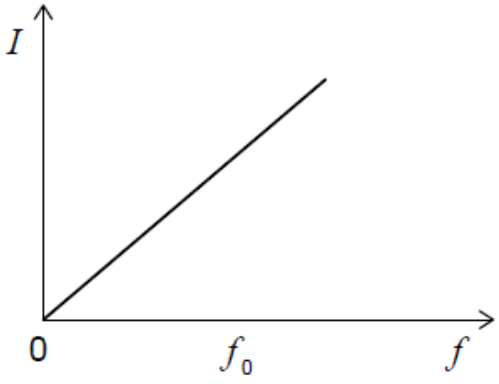
B.



C.



D.



Ascham School

Centre Number

Student Number

2024 TRIAL EXAMINATION

Physics

Section II Answer Booklet

80 marks
Attempt Questions 21-34
Allow about 2 hours and 25 minutes for this section

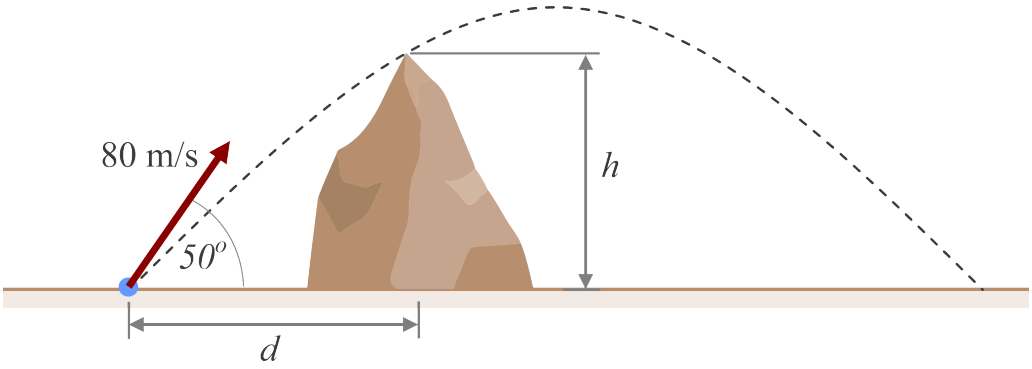
Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (6 marks) **Marks**

An object is launched from the ground at an initial velocity of 80m/s at an angle of 50º above the horizontal as shown below.



After 5 seconds, the object **just clears** the top of a hill.

(a) Draw a labelled vector diagram showing the magnitude and direction of the vertical and horizontal components of the object's initial velocity. Include suitable calculations to support your answer. **3**

Question 21 is continued over the page

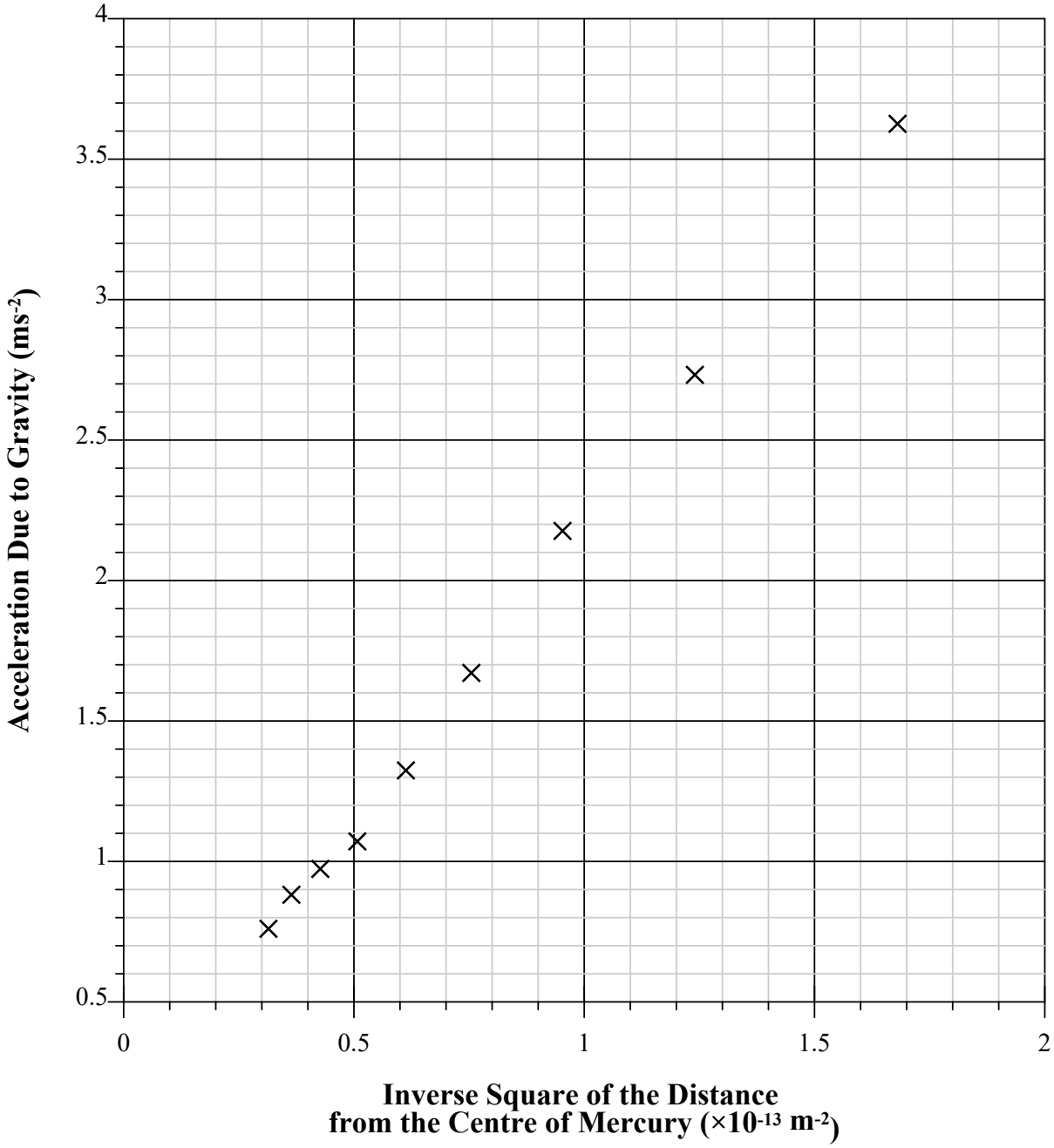
(b) What is the height of the hill above the ground, h? **2**

(c) What is the horizontal distance, d, between the launch point and the top of the hill? **1**

End of Question 21

Question 22 (6 marks) **Marks**

The graph below shows the acceleration due to gravity measured at different distances away from the centre of the planet Mercury. The horizontal axis is plotted as the inverse square of the distance from the centre of the planet.



Question 22 is continued over the page

Question 22 continued…

(a) Draw a suitable line of best fit and use this to determine the acceleration due to gravity at a distance of 3.0×10^6 m from the centre of Mercury. **2**

(b) Use the graph to determine the mass of Mercury. **2**

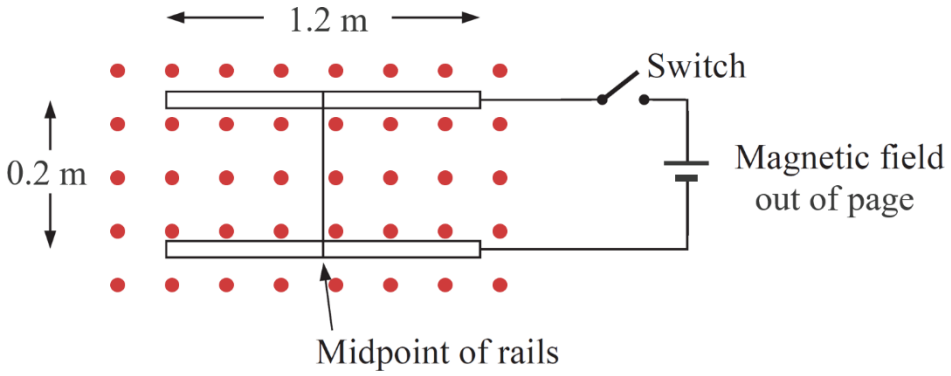
(c) A meteorite strikes the surface of Mercury at high speed. This causes a mass of rock to be ejected vertically from the planet surface at 1.5×10^3 m/s. The radius of Mercury is 2.4×10^6 m. **2**

Use suitable calculations to determine whether or not the ejected rock will fall back down to the surface of Mercury. You may assume that the effects of atmospheric drag are negligible.

End of Question 22

Question 23 (5 marks) **Marks**

Two conducting parallel rails are situated in a region of a uniform magnetic field and connected to a battery via a switch. A narrow conducting slider rod is laid across the rails at the midpoint of the rails as shown in the diagram.



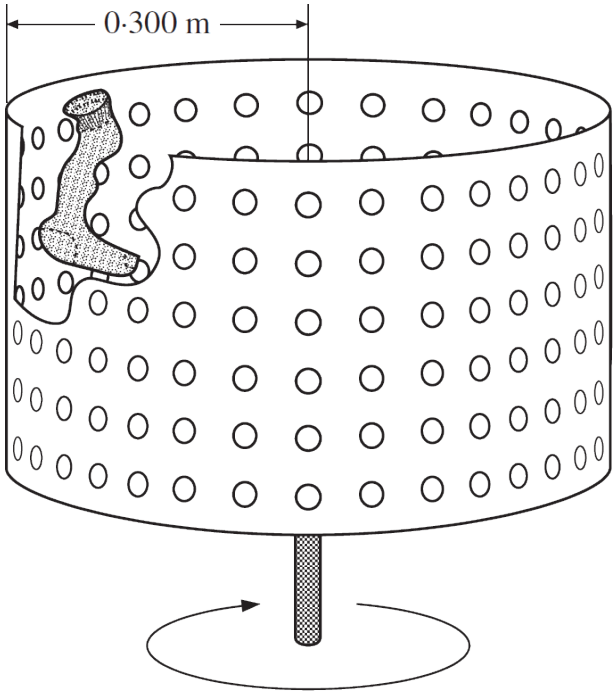
The magnetic field is 0.50 T directed out of the page. The slider is initially at rest. When the switch is closed a current of 20 A flows through the slider.

(a) Determine the magnitude and direction of the magnetic force acting on the slider. **2**

(b) The mass of the slider is 0·040 kg and the force of friction from the rails is 0·36 N. Calculate the velocity of the slider as it comes off the rails. **3**

Question 24 (3 marks) **Marks**

A washing machine has a drum of radius 0.300 m. The drum spins at 450 revolutions per minute. A sock of mass 0.025 kg is observed to be spinning in a horizontal circle against the inner wall of the drum.

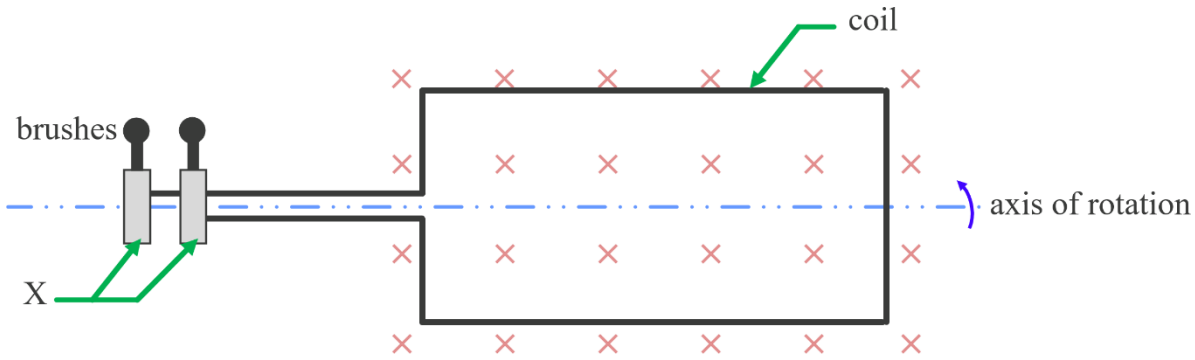


(a) What is the angular speed of the sock in rad/s? **1**

(b) Calculate the magnitude and direction of the centripetal force on the sock. **2**

Question 25 (6 marks) **Marks**

The diagram shows an alternating current generator with a rectangular coil rotating at a constant frequency in a uniform magnetic field.



(a) Identify the component labelled X. **1**

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(b) Explain how an alternating emf is induced within the coil as it is rotated. **3**

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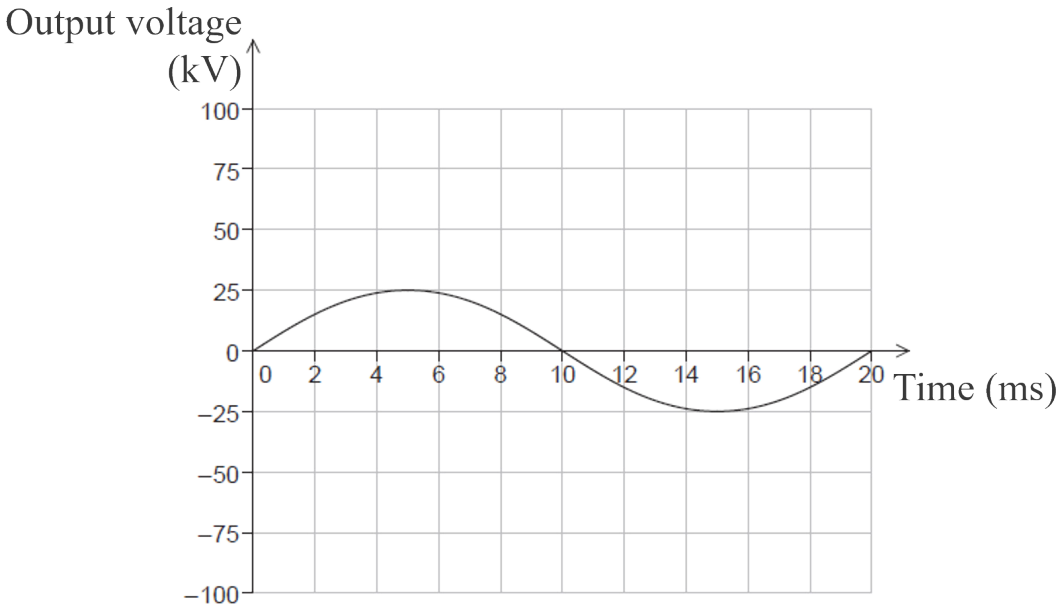
Question 25 is continued over the page

The graph below shows how the generator output voltage varies with time.



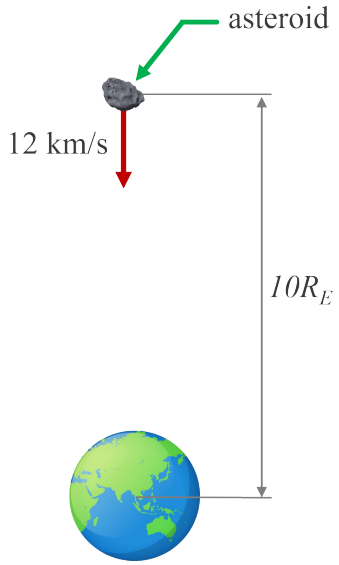
(c) The frequency of the generator is doubled with no other changes being made. **2**

Draw, on the graph above, the resulting voltage output of the generator over time due to this change.

End of Question 25

Question 26 (6 marks) **Marks**

An asteroid, headed directly toward Earth, has a speed of 12 km/s relative to the planet when the asteroid is 10 Earth radii ($10R_E$) from Earth's centre.



(a) Describe the change in energy of the asteroid as it approaches the Earth. **2**

(b) Use the law of conservation of energy to calculate the asteroid's speed when it reaches Earth's surface. You may neglect the effects of Earth's atmosphere on the asteroid. **4**

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Question 27 (6 marks) **Marks**

A rocket moving with speed 0.8c relative to the ground emits a pulse of light in the backward direction.

An astronaut in the rocket measures the speed of the flash of light to be c.

(a) Outline the conclusion from Maxwell's work on electromagnetism that led to one of the postulates of special relativity. **2**

(b) A person on the ground observes the pulse of light. The person is at rest relative to the ground. **2**

Compare the speed of the light pulse observed by the ground observer as predicted by Galilean Relativity to that predicted by Einstein relativity.

Question 27 is continued over the page

Question 27 continued…

(c) The ground observer measures the horizontal length of the rocket to be 35 m. **2**

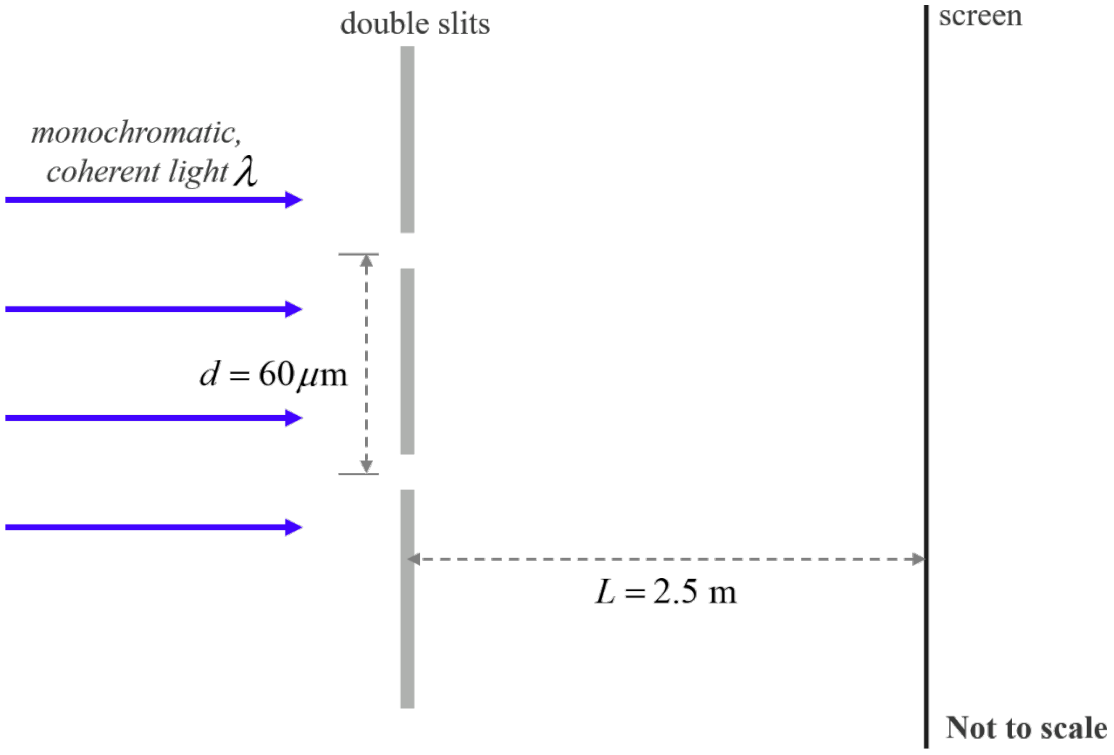
Calculate the length of the rocket according to the astronaut.

End of Question 27

Question 28 (6 marks) **Marks**

Blue light of wavelength λ is incident on a double slit. The separation of the double slit is 60 μm; the double slit is 2.5 m from the screen.

Light from the double slit falls on a screen. A student measures the distance between nine successive bright fringes on the screen to be 15 cm.



(a) Explain the formation of dark fringes observed by the student on the screen. **3**

Question 28 is continued over the page

(b) Calculate the wavelength, λ, of the blue light. **2**

(c) The student changes the light source to one that emits two colours: **1**

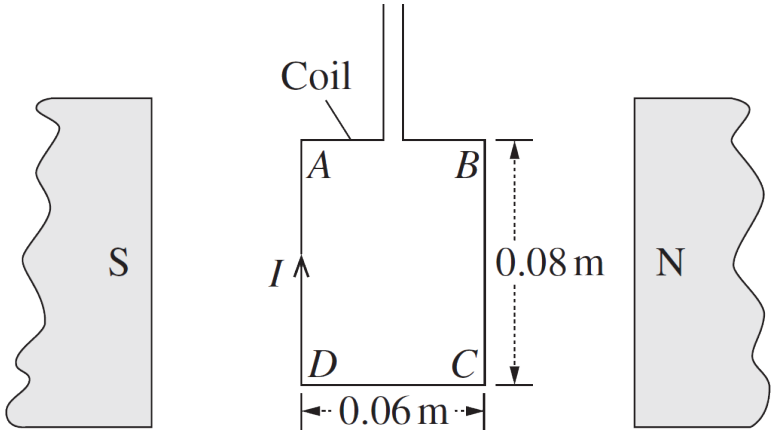
- blue light of wavelength λ, and
- red light of wavelength 1.5λ.

Predict the resulting pattern that the student will see on the screen.

End of Question 28

Question 29 (3 marks) **Marks**

A coil consisting of 5 turns is placed in a uniform 0.2 T magnetic field between two magnets. A current of 10.0 A flows in the direction shown. **3**



Calculate the magnitude and direction of the torque produced by the side *BC* of the coil.

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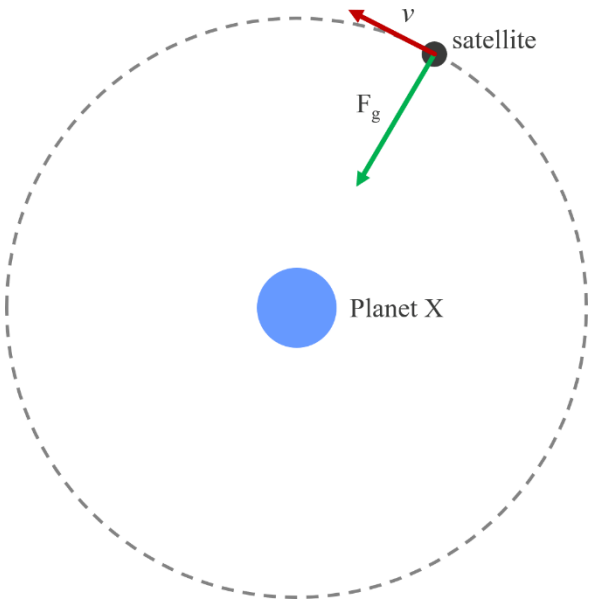
Question 30 (7 marks) **Marks**

A 50 kg satellite moves at a constant speed v, in a circular orbit around Planet X. The orbital period of the satellite is 2.16×10^4 s.



(a) Show that the orbital radius of a satellite in a circular orbit can be given by: **3**

$$r = \frac{T^2 F_g}{4\pi^2 m_s}$$

where:

r	=	orbital radius (m)
m_s	=	mass of satellite (kg)
T	=	orbital period (s)
F_g	=	gravitational force on satellite (N)

Question 30 is continued over the page

Question 30 continued…

(b) The gravitational force on the satellite is 80N. **1**

Calculate the orbital radius of the satellite.

(c) Determine the kinetic energy of the satellite. **3**

End of Question 30

Question 31 (5 marks) **Marks**

Discuss the role of thought and physical experiments in the development and validation of special relativity. Use a specific example of each type of experiment to support your answer. **5**

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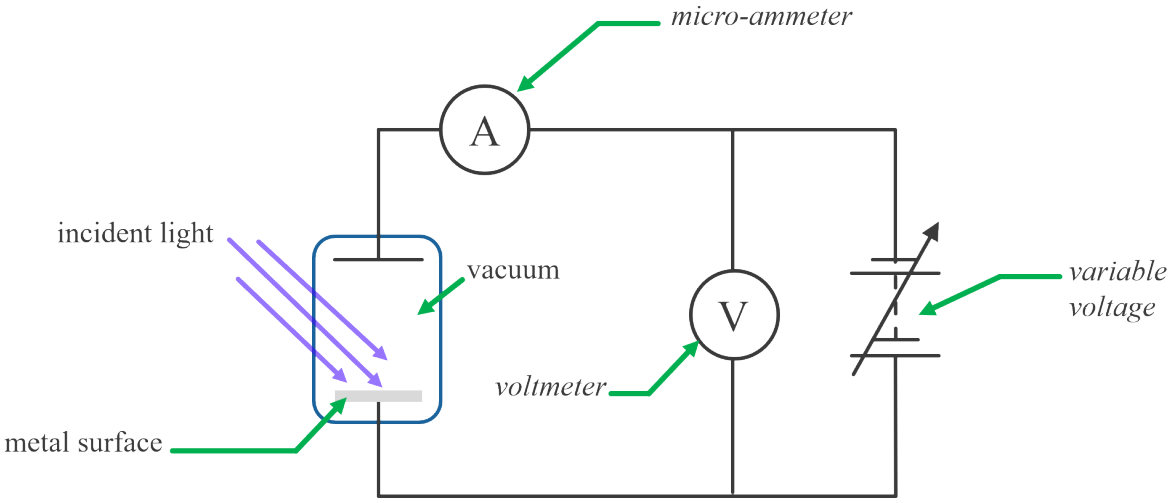
Question 32 (6 marks) **Marks**

A student investigates the photoelectric effect using the apparatus below.



The student adjusts the voltage until the reading in the micro-ammeter is zero. The stopping voltage that produces this reading is 1.40 V.

(a) Define the photoelectric effect. **1**

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(b) Show that the maximum velocity of the photoelectrons is 7×10^5 m/s. **2**

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Question 31 is continued over the page

Question 32 continued…

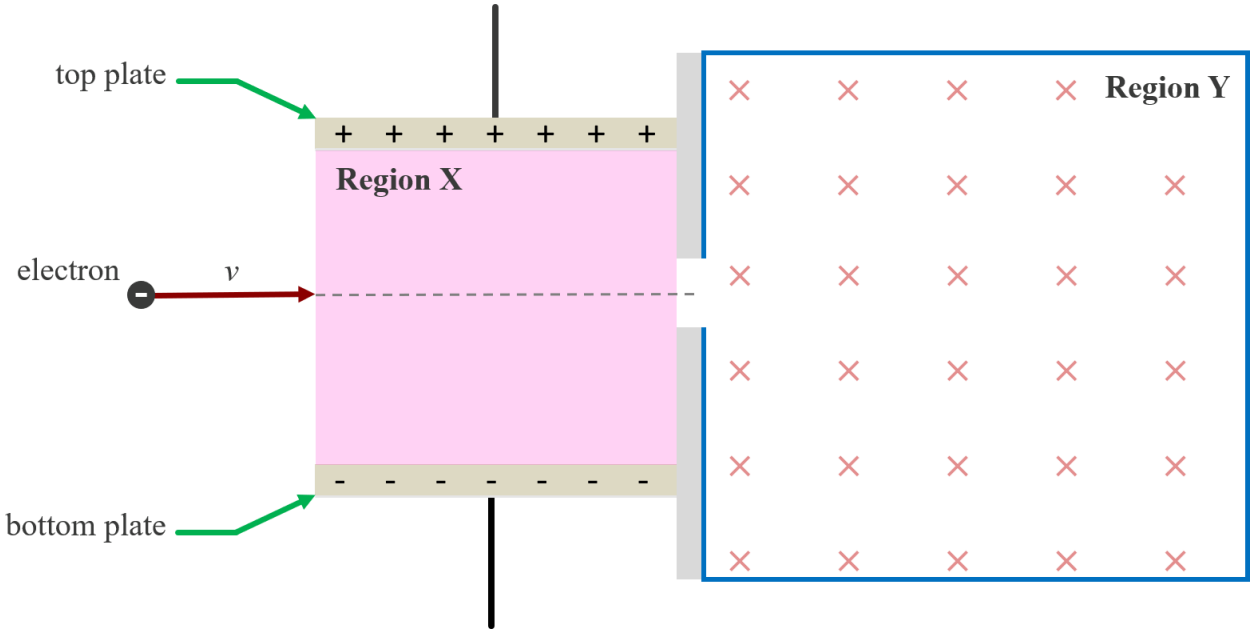
(c) The photoelectrons are emitted from a sodium surface. Sodium has a work function of 2.3 eV. **3**

Calculate the wavelength of the radiation incident on the sodium. Give your answer in terms of metres.

End of Question 31

Question 33 (8 marks) **Marks**

An electron moves horizontally at a constant velocity v before entering Region X between two electrically charged parallel plates as shown. The electric field strength between the plates is E.



A uniform magnetic field directed perpendicular to the page is also present within Region X. The strength and direction of the magnetic field is adjusted such that the electron travels undeflected through Region X.

(a) State the direction of the magnetic field in Region X. **1**

.....

(b) Show that the speed of the undeflected electron v, can be determined as: **2**

$$v = \frac{E}{B}$$

where: E = electric field strength between the parallel plates (N/C),
B = magnetic field strength in Region X (T).

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Question 32 is continued over the page

Question 33 continued…

(c) The electric field strength in Region X is 1.20×10^5 N/C. The magnetic field strength is 0.5 T. **1**

Calculate the speed of the undeflected electron, *v*.

The electron then enters Region Y where there is a uniform magnetic directed into the page.

(d) Sketch a possible trajectory of the electron in Region Y on the diagram. **1**

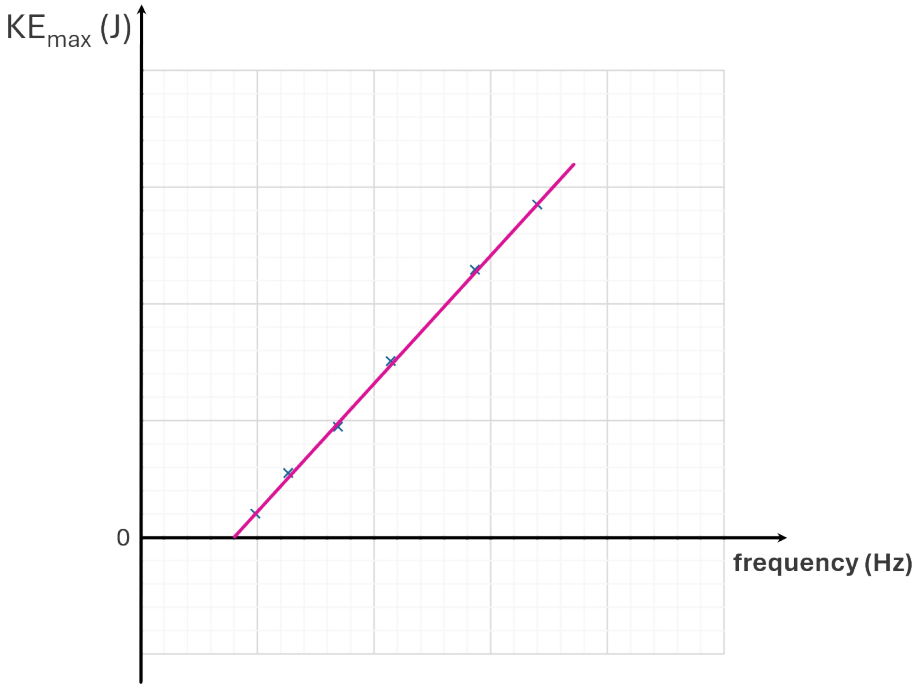
(e) The radius of the electron's trajectory was measured to be 22.3 mm. **3**

Determine the strength of the magnetic field in Region Y.
Show full working.

End of Question 33

Question 34 (7 marks) **Marks**

The plot below shows a typical set of results obtained from an experiment used to examine the photoelectric effect. **7**



Drawing on Planck's work and the law of conservation of energy, Einstein proposed a new model of light to explain the photo electric effect.

Analyse how Einstein's approach was able to address the limitations of the classical wave model of light to explain this phenomenon.

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End of Question 34

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