
Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL

2023

HSC

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 on separate sheets
- **Write your student number at the top of this booklet**

Total marks 100

Section I
20 marks (pages 2–17)
Attempt Questions 1–20
Allow about 35 minutes for this section

Section II
80 marks (pages 18–37)
Attempt Questions 21–34
Allow about 2 hour and 25 minutes

There are 34 questions to answer.

Attempt **Section I** in the multiple-choice answer sheet and **Section II** in the spaces provided. These spaces provide guidance for the expected length of each response.

Section I

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

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

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1. Two 5.9 m long current-carrying conductors are placed parallel to each other and separated by a distance of 19 cm. One conductor carries a current of 4.2 A and the other carries a current of 6.8 A.
Which of the following is the magnitude of the force acting on each conductor?

A. 1.84×10^{-7} N

B. 3.01×10^{-5} N

C. 1.10×10^{-4} N

D. 1.77×10^{-4} N

2. Which of the following is NOT stated by Kepler's Laws of Planetary Motion?

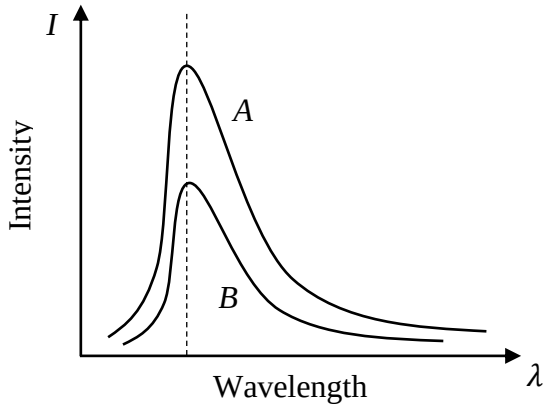
A. All planets move about the Sun in elliptical orbits where the Sun is at one of the foci.

B. The ratio of the square of the orbital period to the cube of the mean distances from the Sun is a constant for any planets orbiting the Sun.

C. The planes in which the planets move about the Sun is parallel to the plane of the equator of the Sun.

D. A radial distance joining any planet to the Sun sweeps out equal areas in equal lengths of time.

3. The diagram below shows the spectra of radiation from two objects *A* and *B* with their peak intensity occurring at the same wavelength.



Let T_A and T_B be the surface temperature of *A* and *B* respectively. Which of the following is correct?

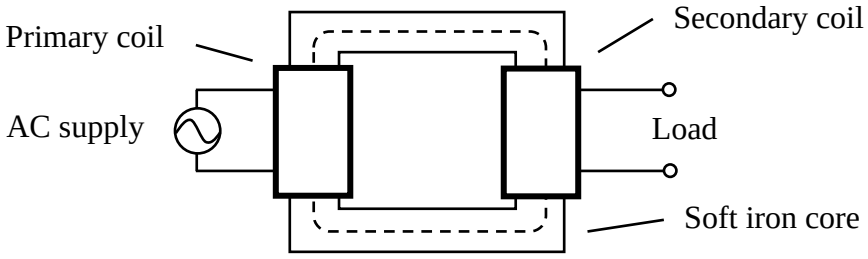
A. $T_A < T_B$

B. $T_A = T_B$

C. $T_A > T_B$

D. There is insufficient information to compare T_A and T_B

4. The diagram below shows an ideal step-down transformer.



Which of the following statements is correct?

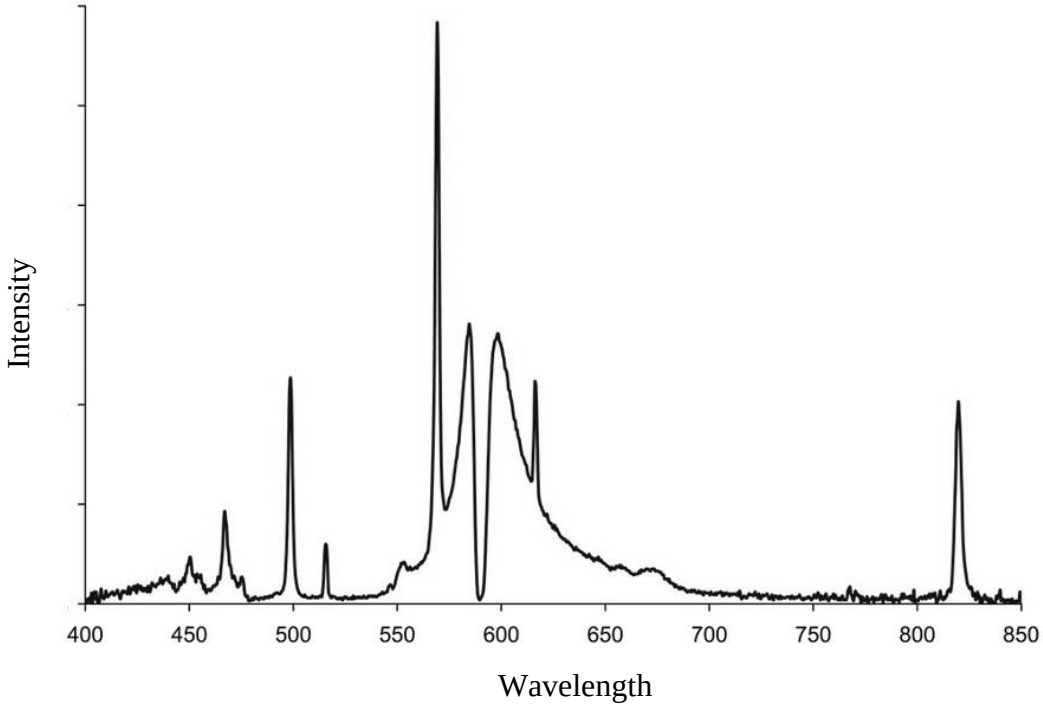
A. The dotted line indicates the path of the eddy current.

B. The soft iron core provides an electrical connection between the primary and the secondary coil.

C. The current in the primary coil is lower than that in the secondary coil.

D. The transformer will function the same if the AC supply is replaced by a constant DC supply.

5. Which of the following can produce the spectra shown below?



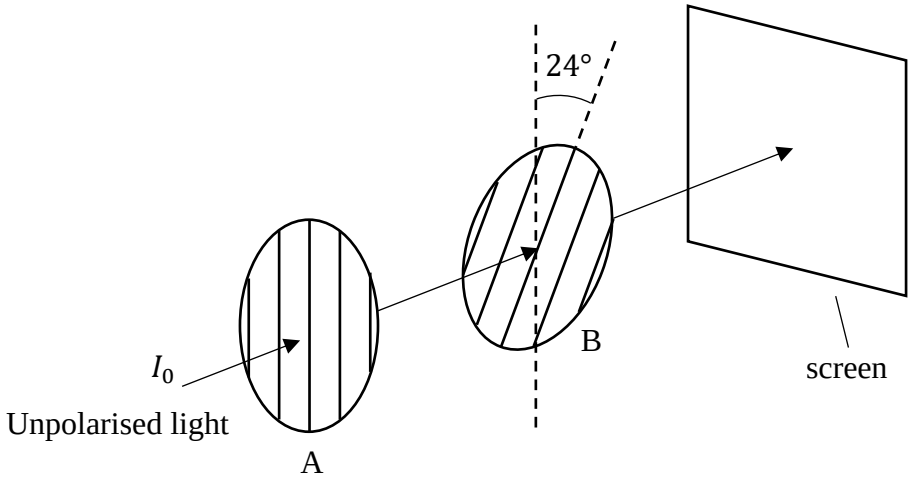
A. The spectrum from a gas discharge tube

B. The spectrum from an incandescent light bulb

C. The spectrum from a burning candle

D. The spectrum from sun light

6. Unpolarised light of intensity I_0 passes through two polarising filters *A* and *B* before arriving at a screen as shown in the diagram below. The polarising axis of *A* and *B* differ by 24°.



Which of the following gives the intensity of the light arriving at the screen in terms of I_0?

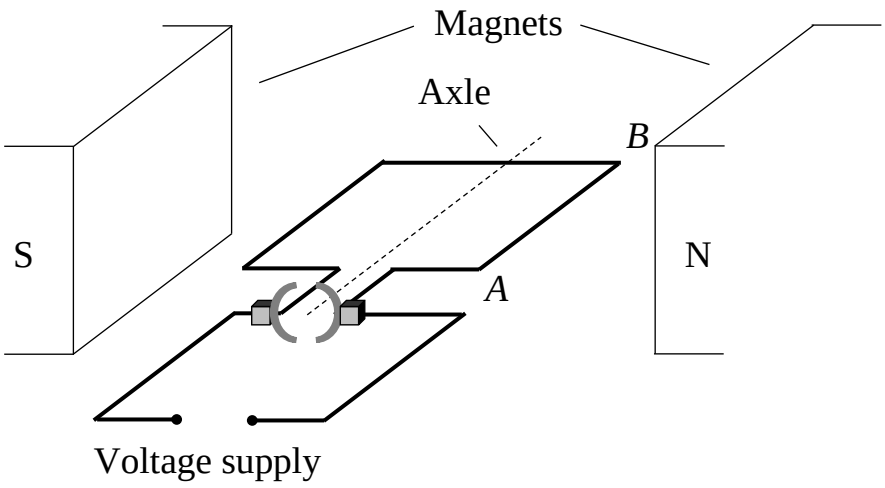
A. $0.42\ I_0$

B. $0.46\ I_0$

C. $0.83\ I_0$

D. $0.91\ I_0$

7. The diagram below shows a simple DC motor.



Which of the following is the reason why the magnitude of the torque acting on a DC motor varies with time?

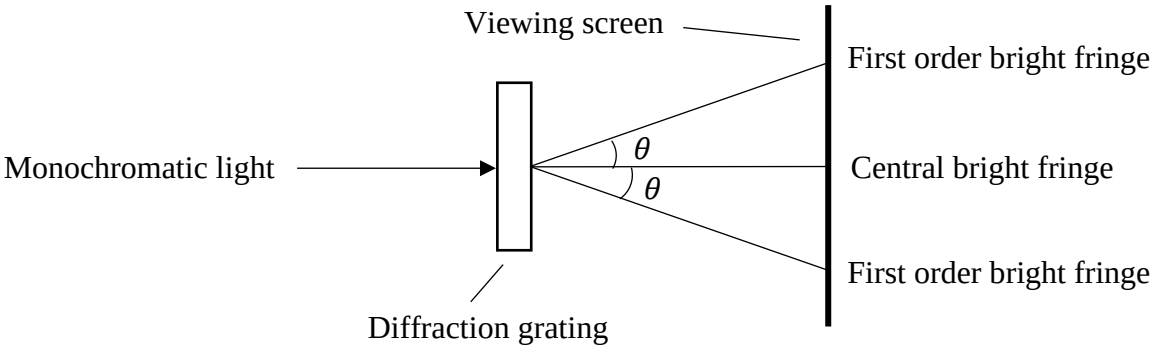
A. The magnitude of the force acting on *AB* varies with time.

B. The perpendicular distance between the force acting on *AB* and the axle varies with time.

C. The voltage supply to the DC motor varies with time.

D. The strength of the magnetic field provided by the magnets varies with time.

8. When monochromatic light passes through a diffraction grating, a pattern of bright fringes is formed on a viewing screen.



Which of the following arrangements would produce the greatest angle θ between the central and first order bright fringes?

	Diffraction grating (lines per mm)	Colour of monochromatic light
A.	400	Violet
B.	400	Yellow
C.	600	Violet
D.	600	Yellow

9. The information about a nuclear reaction is given below.

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + \text{energy released}$$

Nucleus	**Mass (u)**
$^{2}_{1}H$	2.014102
$^{3}_{1}H$	3.016049
$^{4}_{2}He$	4.002602
$^{1}_{0}n$	1.008665

What is the energy released in this reaction?

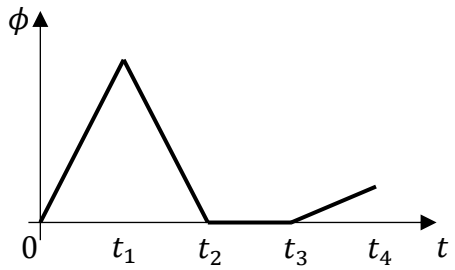
A. 17.6 MeV

B. 20.3 eV

C. 1.14×10^{19} MeV

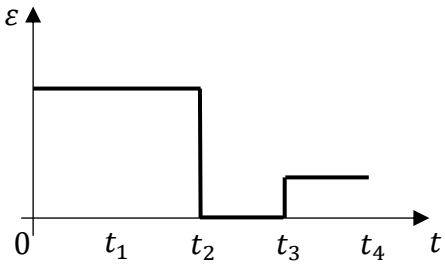
D. 2.82×10^{-12} eV

10. The magnetic flux through a coil over time is recorded by the graph below.

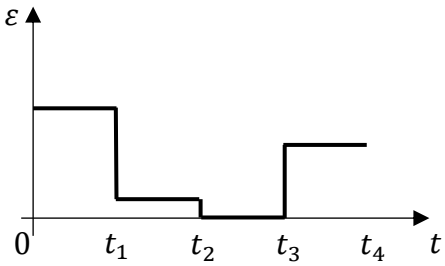


Which of the following graphs best represents how the magnitude of the induced emf varies over the same period?

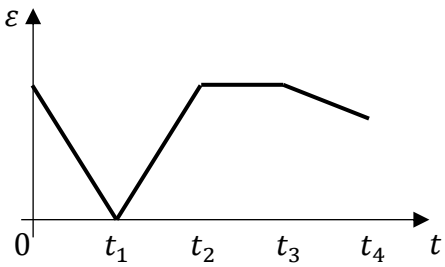
A.



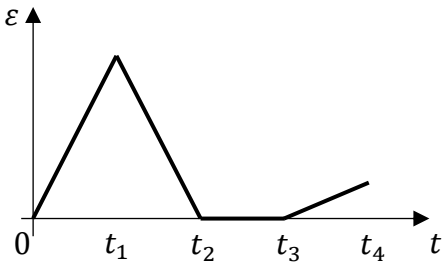
B.



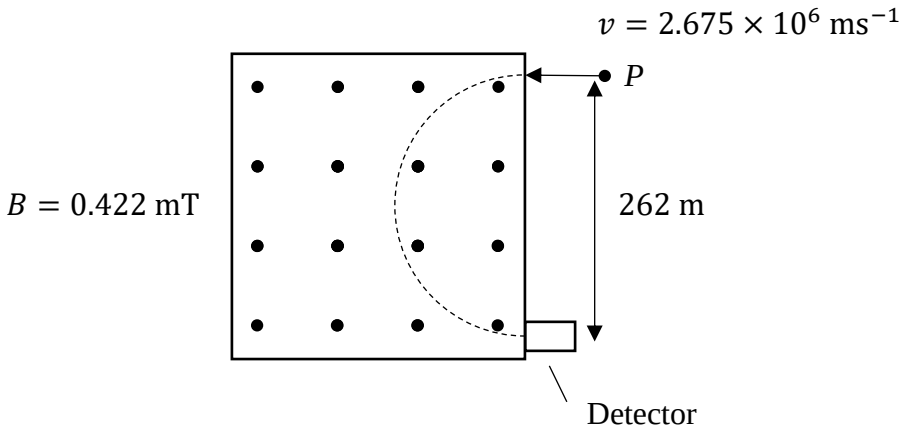
C.



D.



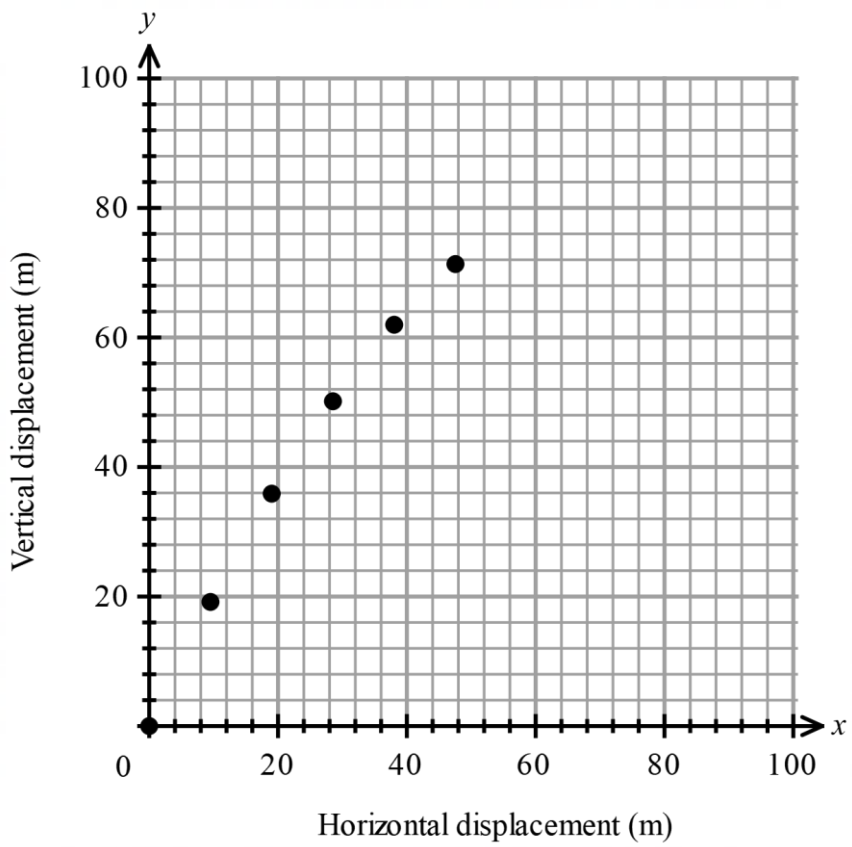
11. A charged particle enters a magnetic field of strength 0.422 mT perpendicular to the field with a speed of 2.675×10^6 ms^{-1} as shown in the diagram below. The particle follows a semi-circular path and arrives at a detector 262 m from where it entered the magnetic field.



Which of the following is the correct mass and charge of P?

	Mass (kg)	Charge (C)
A.	2.487×10^{-28}	1.602×10^{-19}
B.	2.487×10^{-28}	-1.602×10^{-19}
C.	6.644×10^{-27}	3.204×10^{-19}
D.	6.644×10^{-27}	-3.204×10^{-19}

12. A stroboscopic camera with a frequency of 2.00 Hz captured part of a projectile's motion before it malfunctioned. The images captured by the camera are shown in the graph below.



If the initial speed of projection is $45.0\ \text{ms}^{-1}$, which of the following is closest to the angle of projection of the projectile?

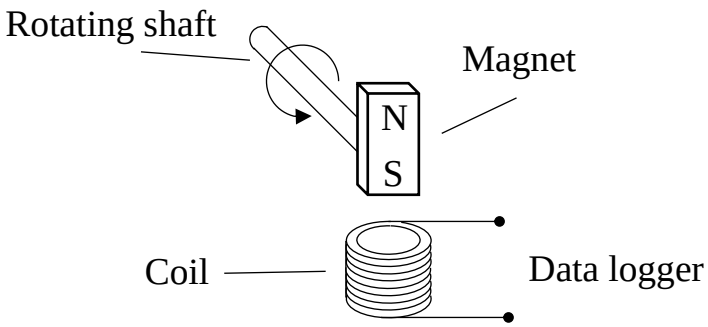
A. 37°

B. 58°

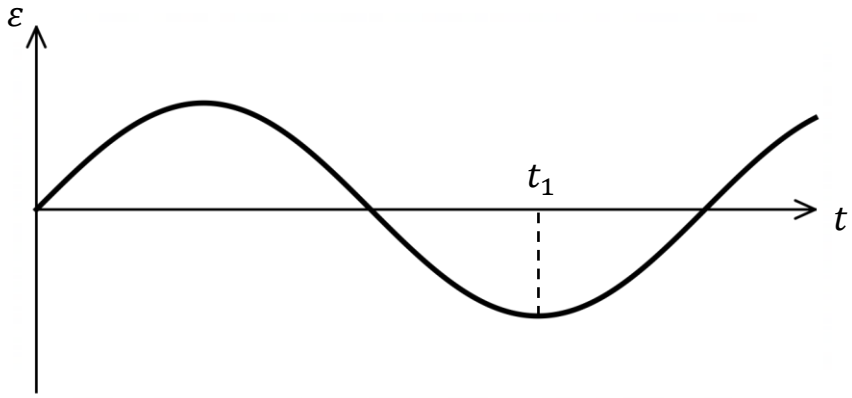
C. 65°

D. 81°

13. In a regular maintenance check of a motor, its rate of rotation is measured to ensure that its performance is up to standard. A small bar magnet is attached to the rotating shaft of the motor and a coil is placed directly under the magnet. The starting position of the magnet is shown in the diagram below.



As the magnet rotates, the induced emf across the coil is recorded by a data logger and shown in the graph below.



Which of the following is the position of the magnet at t_1?

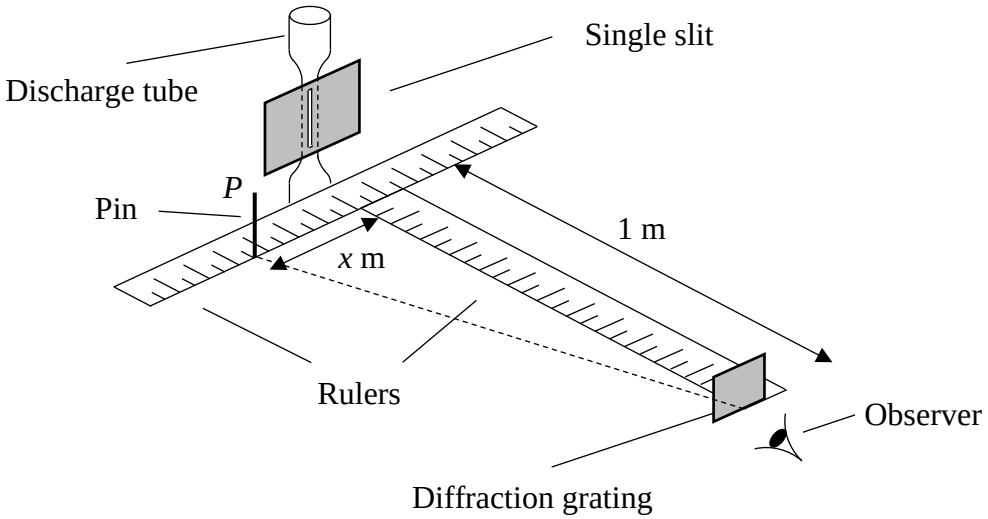
A. 

B. 

C. 

D. 

14. A group of students uses the apparatus below to determine the wavelength of the monochromatic light emitted from a discharge tube behind a narrow slit. Two 1 m rulers are placed perpendicular to each other with one ruler pointing in the direction of the discharge tube as shown in the diagram below.



A diffraction grating is placed at the end of the ruler and the students observed the diffracted image of the first order fringe. The students then move the pin *P* to align with the first order fringe and measure the distance *x* to calculate the wavelength of the monochromatic light.

Which of the following would improve the accuracy of the results?

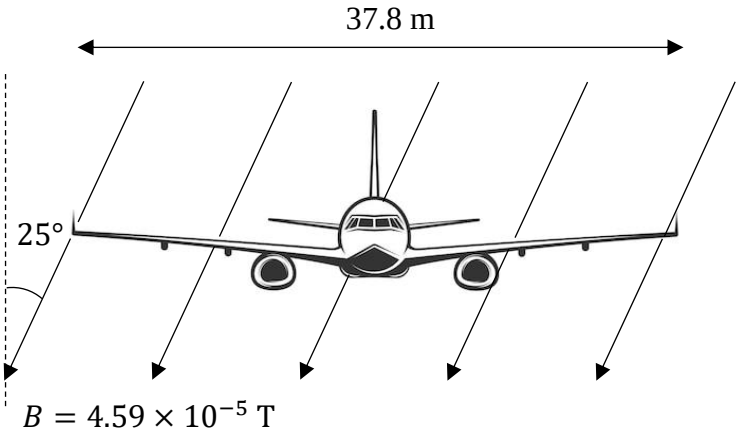
A. Increase the voltage supplied to the discharge tube.

B. Repeat the experiment three times.

C. Replace the two 1 m rulers with 30 cm rulers of the same scale.

D. Measure the position of the second order bright fringe instead of the first order.

15. An aeroplane with a wingspan of 37.8 m is flying at a speed of $230\ \text{ms}^{-1}$ parallel to the Earth's surface as shown in the diagram below. It travels through an area with a magnetic field strength of 4.59×10^{-5} T. The magnetic field makes an angle of $25°$ to the vertical.



Which of the following is the induced emf between the ends of the aeroplane's wings?

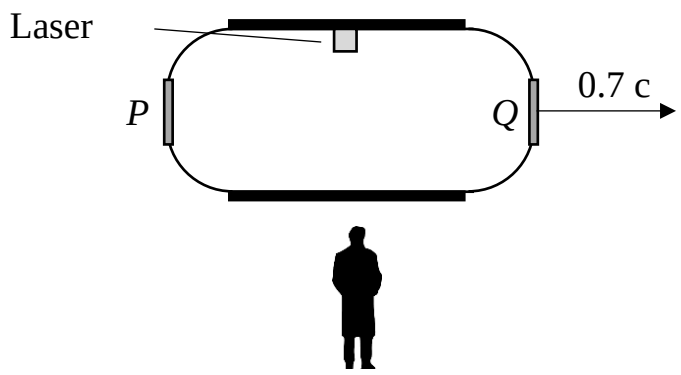
A. 0.17 V

B. 0.36 V

C. 0.40 V

D. 0.44 V

16. In a thought experiment, a laser is positioned inside a space capsule exactly half-way between two emergency hatches *P* and *Q*. The emergency hatches will open automatically when light from the laser reaches them.



The space capsule travels past a scientist on Earth at a constant speed of 0.7 *c* and the laser is switched on due to an emergency at the exact time it passes the scientist.

Which of the following best describes the observation made by the scientist?

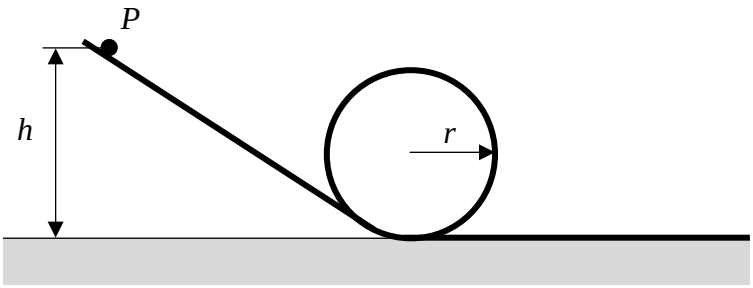
A. *P* opens before *Q*

B. *P* and *Q* opens simultaneously

C. *P* opens after *Q*

D. *P* and *Q* stays closed.

17. A particle *P* is placed at a height *h* above the ground on a loop-the-loop track as shown in the diagram below. The radius of the loop is *r*.



If *P* is released from rest, what is the minimum value of *h* in order for *P* to complete the loop?

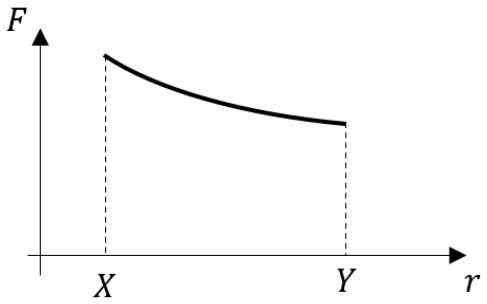
A. 2 *r*

B. 2.5 *r*

C. 3 *r*

D. 3.5 *r*

18. The gravitation force *F* acting on a planet due to the Sun's gravitational field varies with the planet's distance *r* from the centre of the Sun as shown in the graph below.



Which of the following quantity of the planet is given by the area under the graph between *X* and *Y* ?

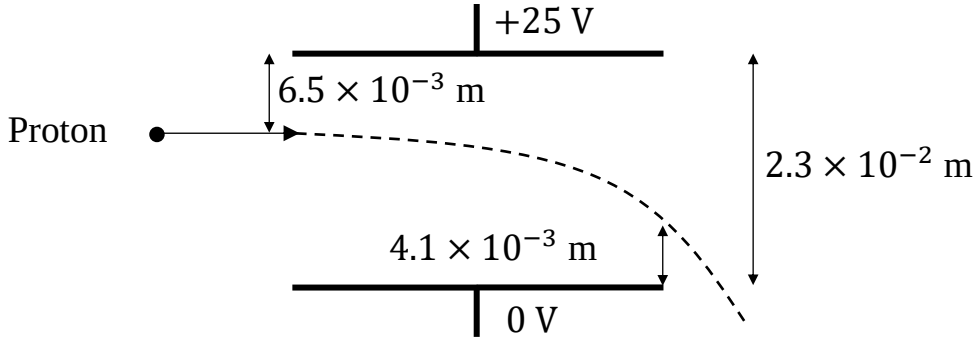
A. The impulse of the gravitation force

B. The change in the gravitational potential energy

C. The kinetic energy

D. The centripetal force

19. A proton enters a region of uniform electric field formed by two parallel charged plates with a potential difference of 25 V separated by 2.3×10^{-2} m as shown in the diagram below. The proton enters the electric field at 6.5×10^{-3} m below the positive plate and exits the field at 4.1×10^{-3} m above the negative plate.



NOT TO SCALE

What is the work done on the proton by the electric field?

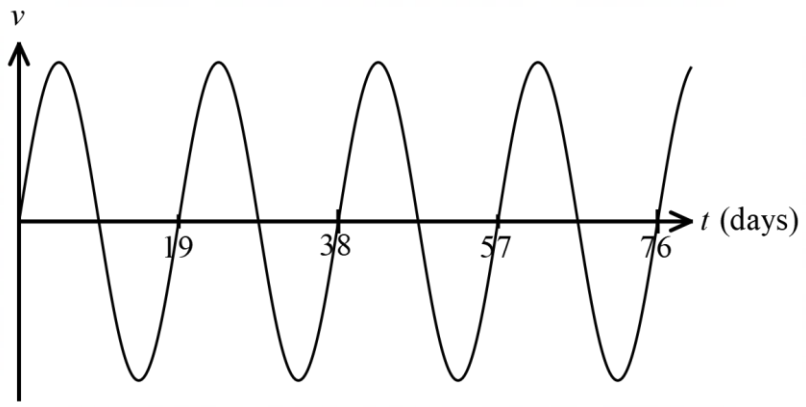
A. 4.2×10^{-19} J

B. 7.1×10^{-19} J

C. 1.1×10^{-18} J

D. 2.2×10^{-18} J

20. Astronomers detected an asteroid orbiting Proxima Centauri with a radius of 2.55×10^{13} m. The asteroid was detected because of the small change in velocity of Proxima Centauri as the asteroid orbits it. The graph below shows how the component of Proxima Centauri's velocity towards the Earth varied over time.



Which of the following is closest to the velocity required for the asteroid to escape Proxima Centauri's gravitational field from its orbit?

A. 9.76×10^{7} ms^{-1}

B. 1.38×10^{8} ms^{-1}

C. 8.43×10^{12} ms^{-1}

D. 1.19×10^{13} ms^{-1}

Section II

80 marks
Attempt Question 21-34
Allow about 2 hour and 25 minutes for this section

Question 21 (6 marks)

(a) Describe the main differences between the models of light proposed by Newton and Huygens. **2**

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(b) In 1801, Thomas Young conducted his famous double slit experiment. Explain which model of light was supported by his experimental results. **4**

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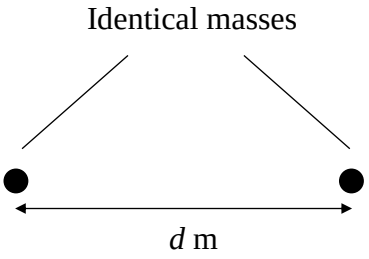
Question 22 (4 marks)

Two identical masses of 26.5 kg are placed with their centres separated by a distance of d m.



(a) Given that $d = 11.0$ m, calculate the gravitational force between the two masses. **2**

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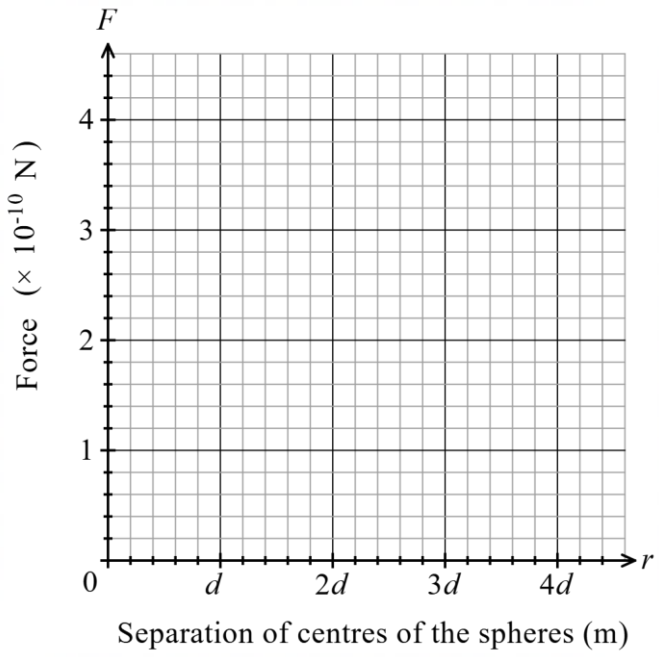
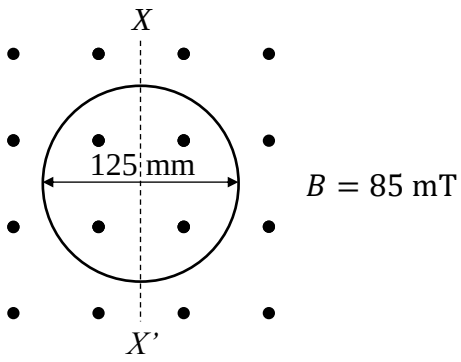
(b) On the axes below, sketch a graph to show the variation of the gravitational force between the two masses as they are separated. In your sketch, you should indicate the magnitude of the forces when the separation of the centres are 2d and 4d. **2**



Question 23 (5 marks)

A circular coil of diameter 125 mm has 450.0 turns. It is placed in a uniform magnetic field of 85 mT such that its plane is perpendicular to the magnetic field as shown in the diagram below.



(a) Calculate the magnetic flux passing through the coil when it is in the position shown. **2**

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The coil is then rotated through 90° about the axis *XX'* in a time of 135 ms.

(b) Calculate the average emf induced in the coil during this time. **3**

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Question 24 (3 marks)

Explain how the Hafele-Keating experiment validated Einstein's theory of special relativity. **3**

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Question 25 (5 marks)

Matthew and Anna conducted an experiment to measure the length of a 1.00 metre ruler. Matthew takes the ruler and sets off in a spaceship. He travels past Anna at a speed of 0.75c whilst the ruler is aligned in the direction of travel. Matthew and Anna both measure the length of the ruler at the instant they passed each other.

(a) How long does Anna measure the ruler to be? **2**

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(b) When Matthew returns, they compare the results of their measurements. How are they able to explain their seemingly contradictory results? **3**

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Question 26 (7 marks)

Mimas is a moon of Saturn and orbits Saturn with a mean radius of 1.86×10^8 m and orbital period of 0.942 Earth days.

(a) Calculate the mass of Saturn. **2**

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(b) Dione is another moon of Saturn and orbits Saturn with a mean radius of 3.78×10^8 m. Calculate the orbital period of Dione in Earth days. **2**

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(c) Explain why the orbital velocity of Dione changes as it orbits Saturn. **3**

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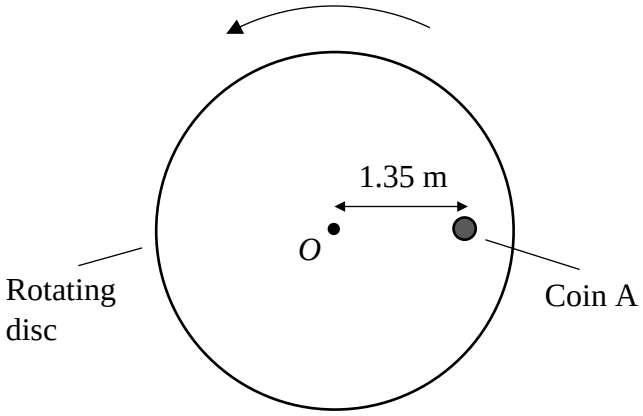
Question 27 (6 marks)

Coin A, is placed on a rotating disc at 1.35 m from the centre of the disc. It has a mass of 15.0 g. The disc begins to rotate and when the frequency of rotation reaches 2.5 Hz, the coin flies off the disc.



(a) Give a reason for why Coin A flies off the disc. **1**

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(b) Calculate the centripetal force experienced by Coin A just before it flies off. **2**

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Question 27 continues on page 25

Coin A is now placed back onto its original position. Another identical coin, Coin B, is placed on the same rotating disc but closer to the centre of the disc. The disc begins to rotate.

(c) Explain which coin will fly off the disc first. **3**

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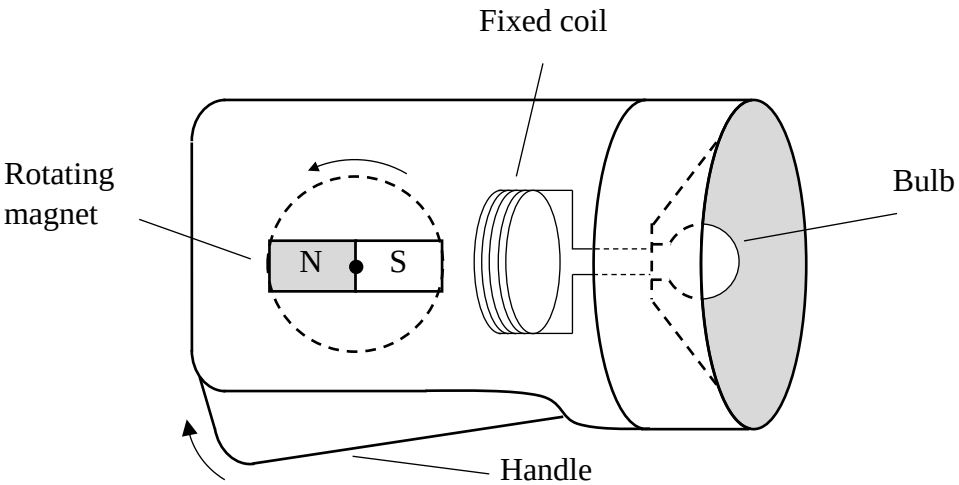
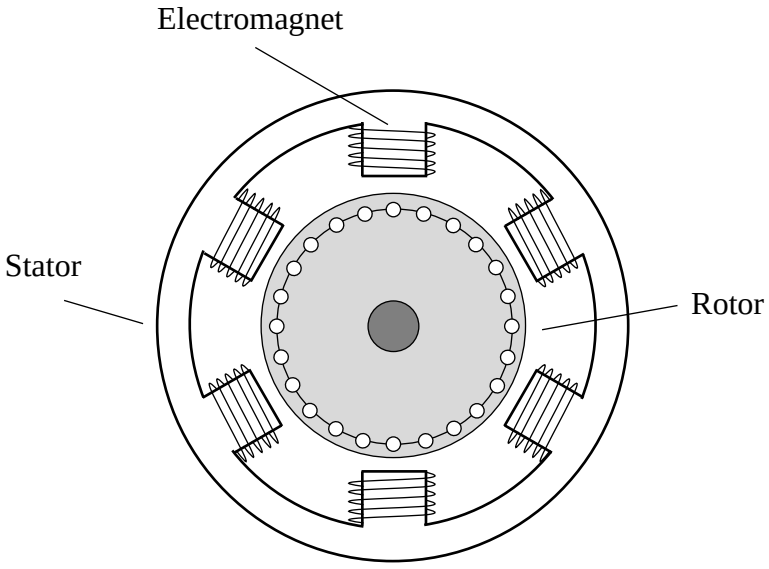
End of Question 27

Question 28 (7 marks)

The diagram below shows the key components of two devices, a dynamo torch and an AC induction motor. A dynamo torch operates by squeezing the handle continuously which then causes a permanent magnet to rotate near a fixed coil inside the torch.



Dynamo Torch



AC Induction Motor

Question 28 continues on page 27

Question 28 (continued)

Compare the physics principles that allows the two devices to operate. **7**

In your answer, make reference to the conservation of energy and the components of the devices.

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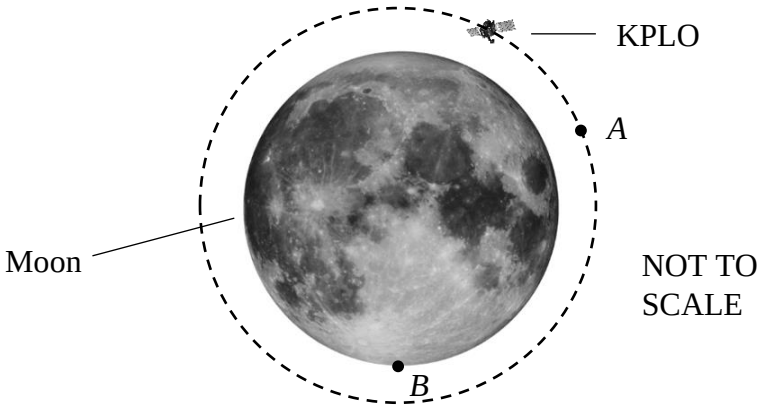
End of Question 28

Question 29 (5 marks)

KPLO is a satellite of mass 678.0 kg in a circular orbit about the Moon as shown in the diagram below. Point A is a point in KPLO's orbit and point B is a point on the surface of the Moon.



(a) Define gravitational potential of an object at a point in a gravitational field. **2**

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(b) Given that the gravitational potential energy of KPLO at *A* is 95% of its gravitational potential energy at B and the gravitational field strength at *B* is 1.622 N/kg, calculate the gravitational field strength at *A*. **3**

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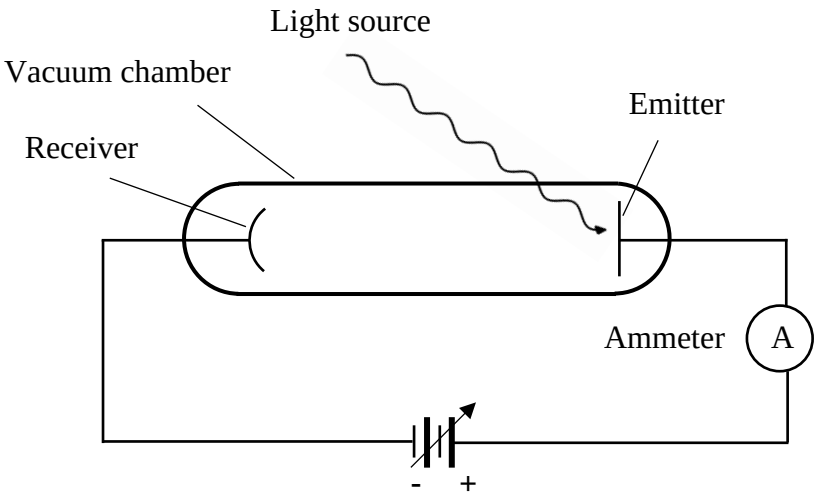
Question 30 (4 marks)

At the end of the 1900's scientists recognised that there was a relationship between light and electromagnetism. They began performing experiments which used the apparatus shown below. **4**



Discuss how the experimental results could only be explained by the development of a new model of light.

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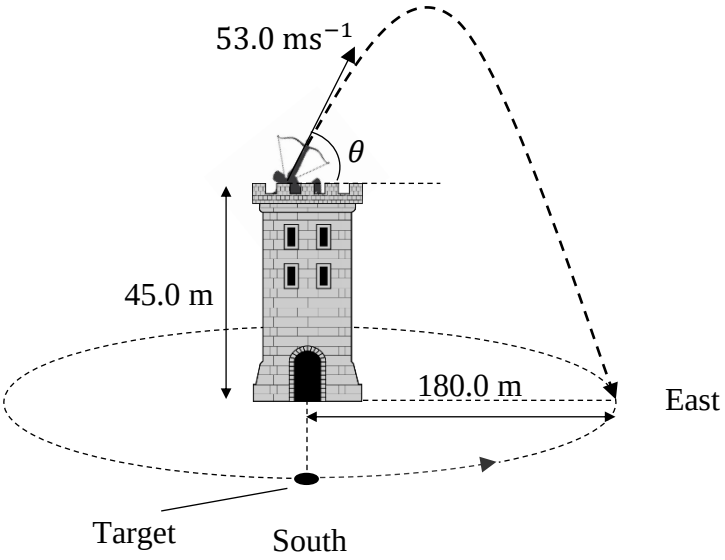
Question 31 (5 marks)

In a video game, the player fires arrows at a fixed speed of $53.0\ \text{ms}^{-1}$ to the East from the top of a 45.0 m high castle tower to hit a moving target. The player can adjust the angle of projection θ as shown in the diagram below. Assume air resistance is negligible.



The target moves around the castle in a circular path of radius 180.0 m in an anti-clockwise direction. It takes 16.0 s for the target to complete one revolution around the tower. The target is initially placed South of the castle.

(a) Show that the angle of projection of the arrow is 72.3° if the arrow reaches a maximum height of 175.0 m above the ground. **2**

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Question 31 continues on page 31

(b) Given that the arrow will have a range of 180.0 m when projected at 72.3°, how long should the player wait before firing the arrow such that it will hit the target? **3**

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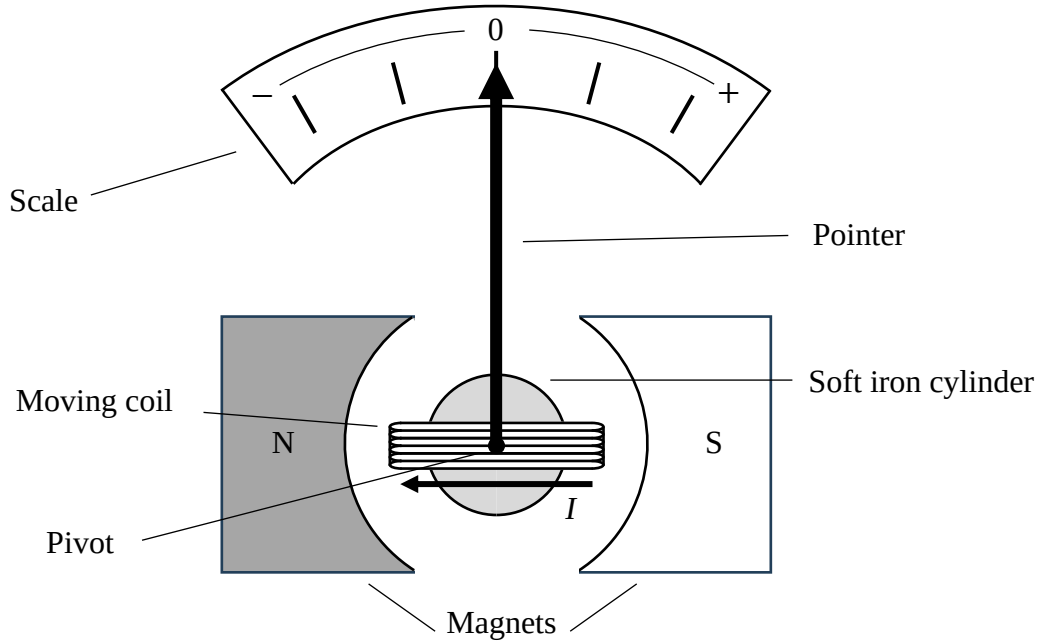
End of Question 31

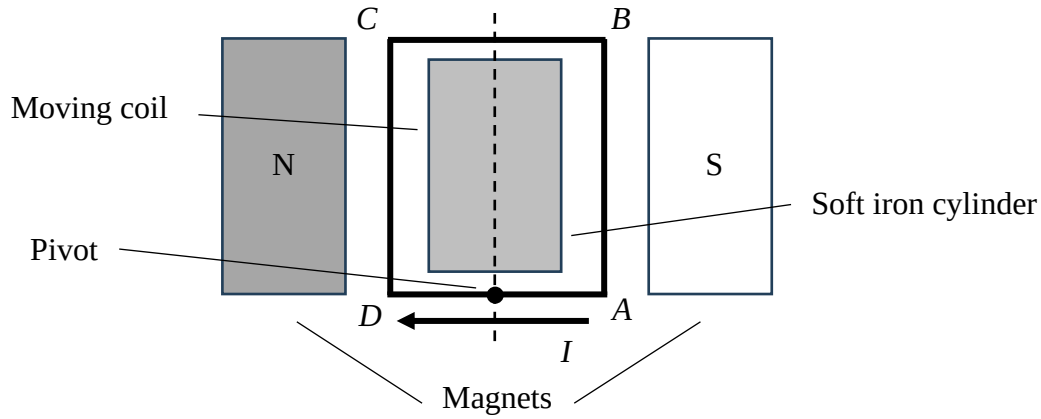
Question 32 (6 marks)

The diagrams below show the front view and top view of a moving coil galvanometer. A galvanometer measures the size and direction of the current when its terminals are connected to a circuit.

Front view



Top view



The fixed soft iron cylinder and magnets produce a uniform magnetic field between the magnets. The coil is able to rotate within this magnetic field. A current *I* flows in the coil in the direction shown on the diagram.

Question 32 continues on page 33

Question 32 (continued)

(a) Explain which direction the pointer will move. **2**

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(b) The coil can be damaged when the galvanometer is transported due to the free rotation of the coil. A student suggests that the terminals of the galvanometer could be connected to reduce the movement of the coil which would make it less likely to be damaged. Evaluate the student's suggestion. **4**

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End of Question 32

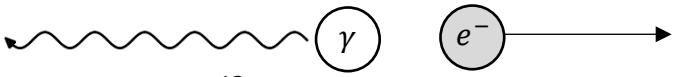
Question 33 (8 marks)

A photon of wavelength 6.924×10^{-12} m collides with a stationary electron as shown in the diagram below. After the collision, the photon travels back to the direction it came from with a new wavelength of 9.351×10^{-12} m. No other particles or photons are produced in the collision.

Before collision

$\lambda_i = 6.924 \times 10^{-12}$ m

After collision



$\lambda_f = 9.351 \times 10^{-12}$ m

(a) What is the original energy of the photon in eV? **2**

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(b) Explain why the wavelength of the photon is greater after the collision. **3**

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Question 33 continues on page 35

(c) Calculate the speed of the electron after the collision. **3**

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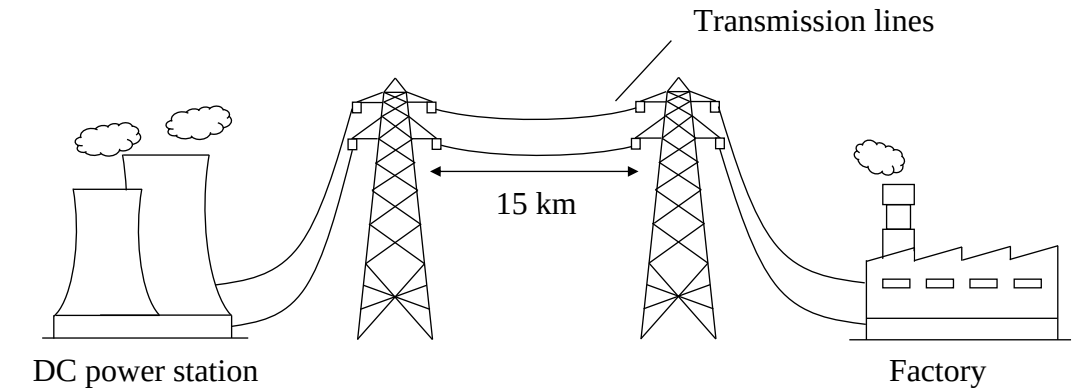
End of Question 33

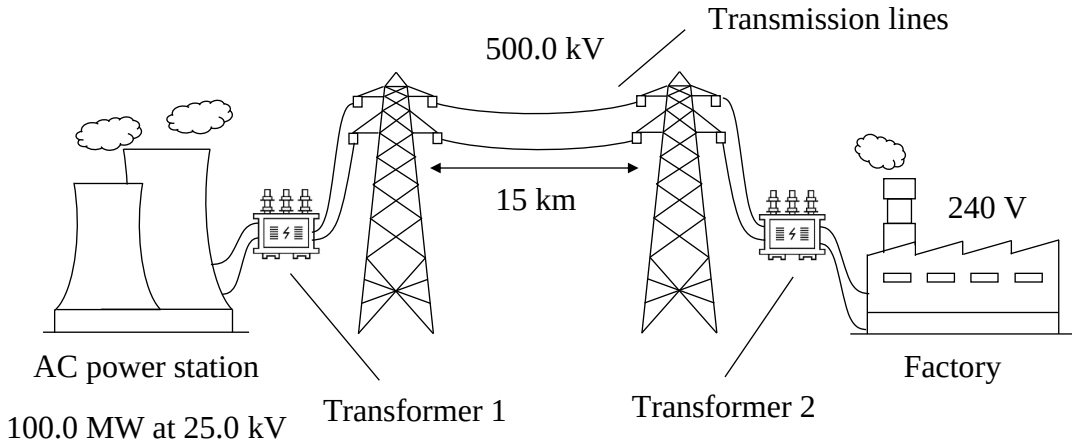
Question 34 (9 marks)

The diagram below shows two proposals for a new power station to supply electricity to a rural town. The resistance of the transmission lines in both proposals is $3.21 \times 10^{-4}\ \Omega\ \text{m}^{-1}$.

Proposal 1



Proposal 2



Question 34 continues on page 37

Question 34 (continued)

Assess the efficiency of the two power station proposals for the town and suggest a way to improve the efficiency of each proposal. **9**

Your analysis should include power delivered, conservation of energy and the efficiency of the transformer. Include both qualitative and quantitative information.

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End of Paper

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