Paper Reference(s) **9PH0/01**

Pearson Edexcel Level 3 GCE

Physics
Advanced
Paper 1: Advanced Physics I

Monday 20 May 2019 – Afternoon

Time: 1 hour 45 minutes plus your additional time allowance

INSTRUCTIONS TO CANDIDATES
Write your centre number, candidate number, surname, other names and your signature in the boxes below. Check that you have the correct question paper.

Centre No.						
Candidate No.						
Surname						
Other names						
Signature						
Paper Reference	9	P	H	0	/	0	1

- Use BLACK ink or ball-point pen.
- Answer ALL questions.
- Answer the questions in the spaces provided – there may be more space than you need.

MATERIALS REQUIRED FOR EXAMINATION

Nil

ITEMS INCLUDED WITH QUESTION PAPERS

Data, Formulae and Relationships Booklet

INFORMATION FOR CANDIDATES

- The total mark for this paper is 90.
- The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.
- You may use a scientific calculator.
- In questions marked with an ASTERISK (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

ADVICE TO CANDIDATES

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations including units where appropriate.

(Turn over)

Answer ALL questions.

All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

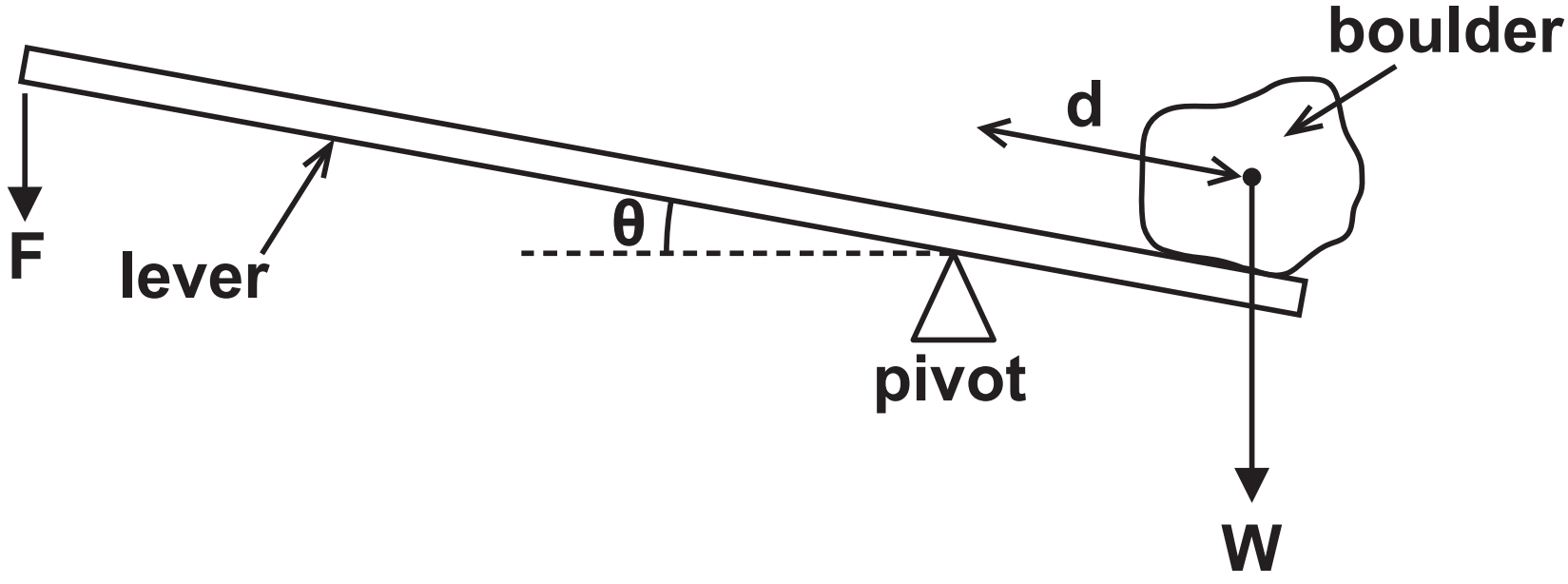
1 Which of the following particles is an example of a fundamental particle?

- ☐ **A** nucleus
- ☐ **B** neutrino
- ☐ **C** pion
- ☐ **D** proton

(TOTAL FOR QUESTION 1 = 1 MARK)

(Questions continue on next page)

2 **A person uses a pivoted lever to lift a boulder of weight W as shown.**



The centre of gravity of the boulder is a distance d from the pivot. The angle of the lever to the horizontal is θ.

Which expression is equal to the moment of W about the pivot?

☐ **A** Wd

☐ **B** $Wd \cos\theta$

☐ **C** $Wd \sin\theta$

☐ **D** $Wd \tan\theta$

(TOTAL FOR QUESTION 2 = 1 MARK)

(Questions continue on next page)

3 A space rocket lifts off vertically.

The rocket lifts off because

☐ **A** the exhaust gases exert a force on the ground.

☐ **B** the exhaust gases exert a force on the rocket.

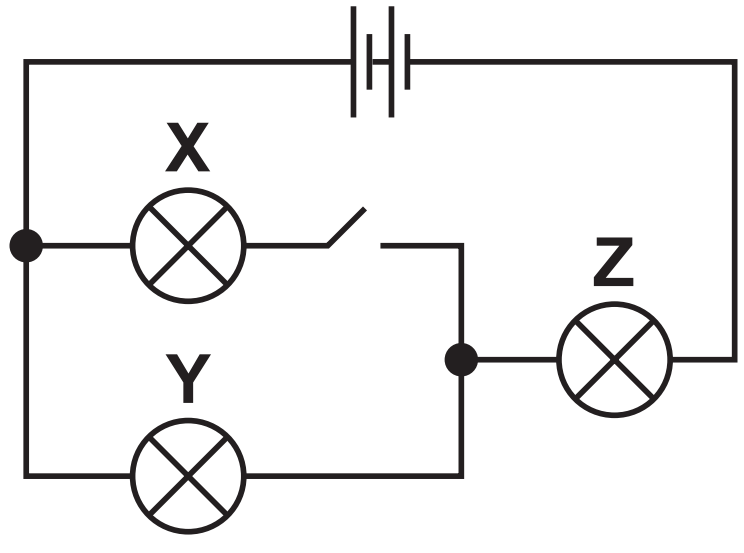
☐ **C** the ground exerts a force on the rocket.

☐ **D** the rocket exerts a force on the ground.

(TOTAL FOR QUESTION 3 = 1 MARK)

(Questions continue on next page)

4 **A circuit consists of three identical 1·5V bulbs connected to two 1·5V cells.**



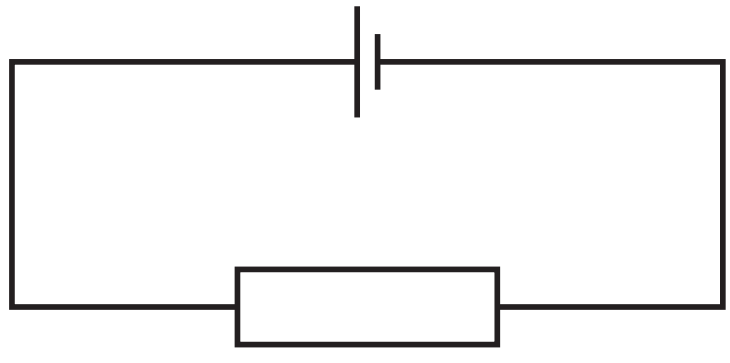
The switch is closed.
Which row describes the change in brightness of bulb Y and bulb Z?

	Y	Z
☐ A	brighter	brighter
☐ B	brighter	dimmer
☐ C	dimmer	brighter
☐ D	dimmer	dimmer

(TOTAL FOR QUESTION 4 = 1 MARK)

(Questions continue on next page)

5 A cell of e.m.f. 1·5 V is connected to a 5·0 Ω resistor.
The terminal potential difference across the cell is 1·0 V.



Which of the following is the current in the circuit?

☐ **A** 0·1 A

☐ **B** 0·2 A

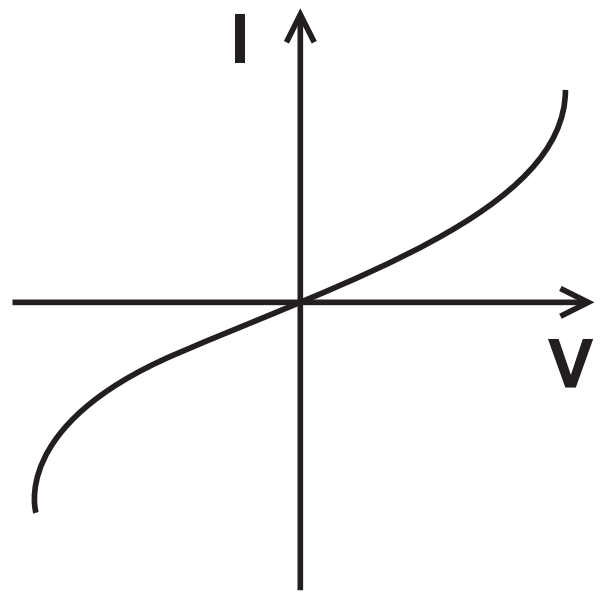
☐ **C** 0·3 A

☐ **D** 0·5 A

(TOTAL FOR QUESTION 5 = 1 MARK)

(Questions continue on next page)

6 The diagram shows a graph of current I against potential difference V for an electrical component.



Which of the following components would produce a graph of this shape?

- ☐ **A** filament bulb
- ☐ **B** metallic conductor
- ☐ **C** negative temperature coefficient thermistor
- ☐ **D** ohmic conductor

(TOTAL FOR QUESTION 6 = 1 MARK)

(Questions continue on next page)

7 The force between two identical point charges, X and Y, is F.

Charge X is doubled; charge Y remains the same.

Which row of the table gives the force on each charge?

	X	Y
☐ A	F	F
☐ B	F	2F
☐ C	2F	F
☐ D	2F	2F

(TOTAL FOR QUESTION 7 = 1 MARK)

(Questions continue on next page)

8 A capacitor of capacitance C is discharged through a resistor of resistance R.
The initial discharge current is I_0.

Which of the following expressions gives the current after a time equal to RC?

☐ A $\frac{I_0}{e}$

☐ B $\frac{I_0}{2}$

☐ C $I_0 e^{-RC}$

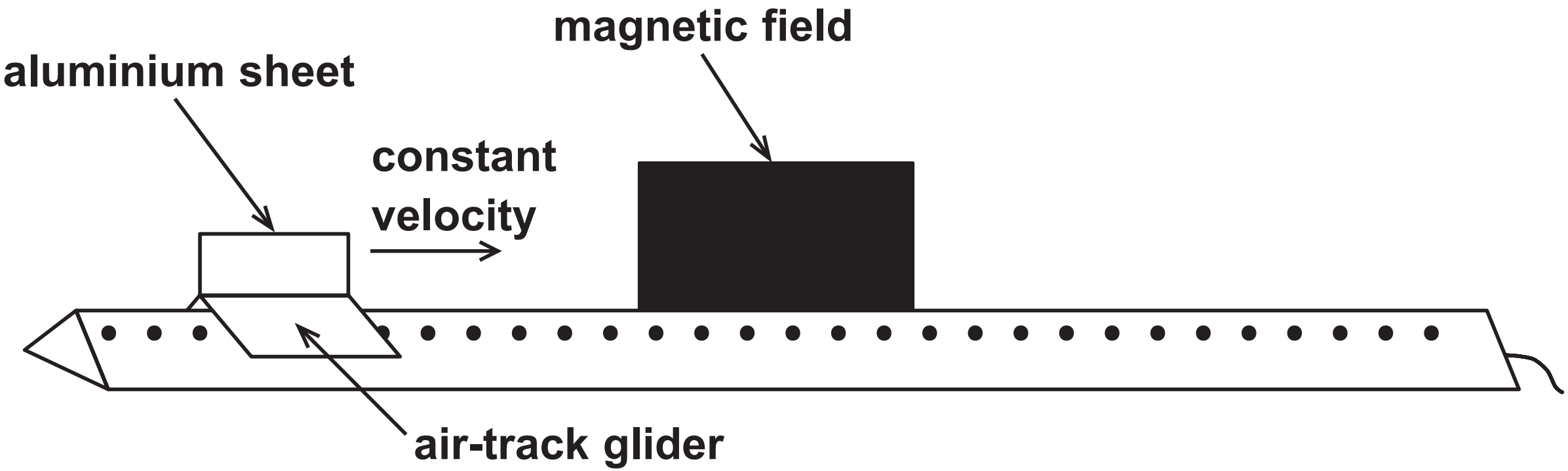
☐ D $I_0 \log_e \frac{1}{e}$

(TOTAL FOR QUESTION 8 = 1 MARK)

(Questions continue on next page)

9 A rectangular sheet of aluminium is attached to an air-track glider as shown.

The glider moves towards a region of uniform magnetic field at a constant velocity. When the glider enters the magnetic field, the magnetic flux is perpendicular to the aluminium sheet.



(Question continues on next page)

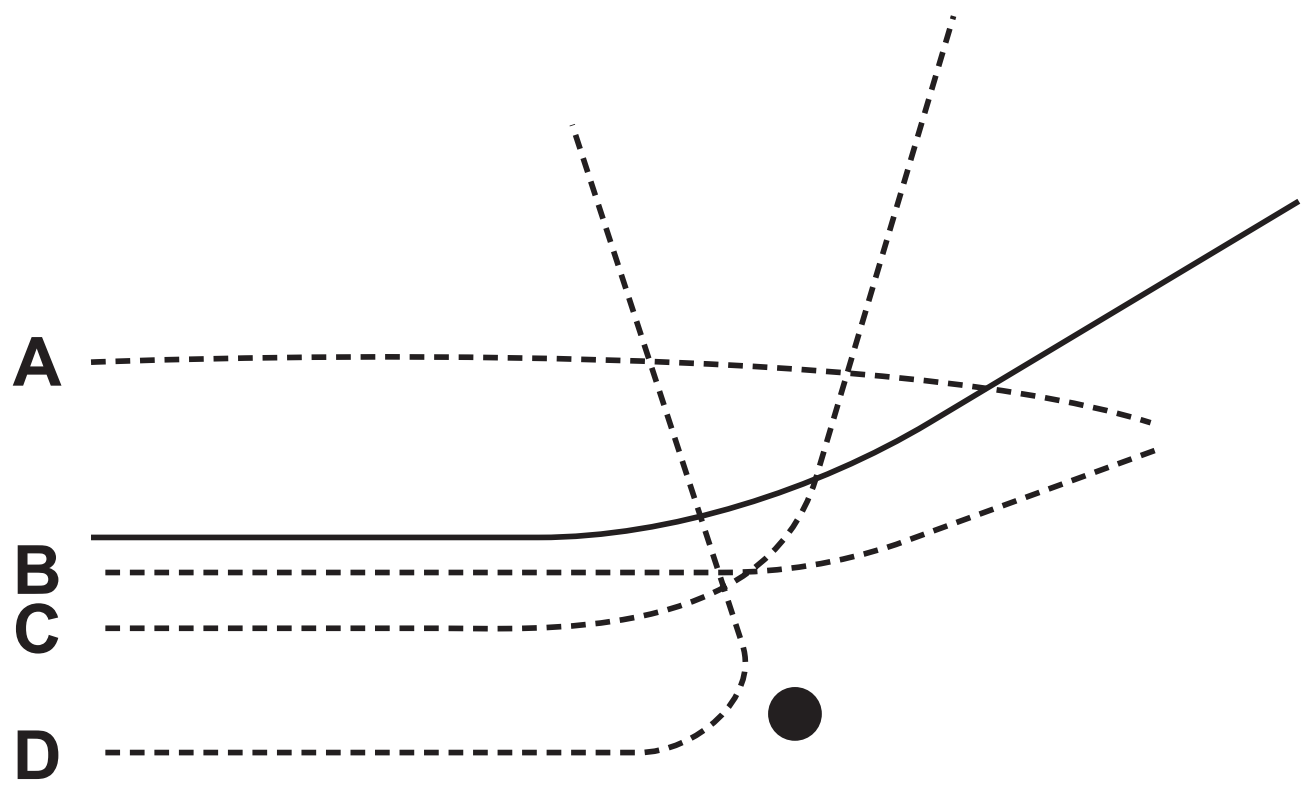
Which row of the table describes the velocity of the glider as it enters the magnetic field, when it is completely within the magnetic field and as it leaves the magnetic field?

	Enters the magnetic field	Within the magnetic field	Leaves the magnetic field
☐ A	constant	decreasing	constant
☐ B	decreasing	constant	increasing
☐ C	decreasing	constant	decreasing
☐ D	decreasing	decreasing	decreasing

(TOTAL FOR QUESTION 9 = 1 MARK)

(Questions continue on next page)

10 The solid line shows the path of an alpha particle as it passes close to a nucleus.



Another alpha particle approaches the nucleus with the same initial kinetic energy.

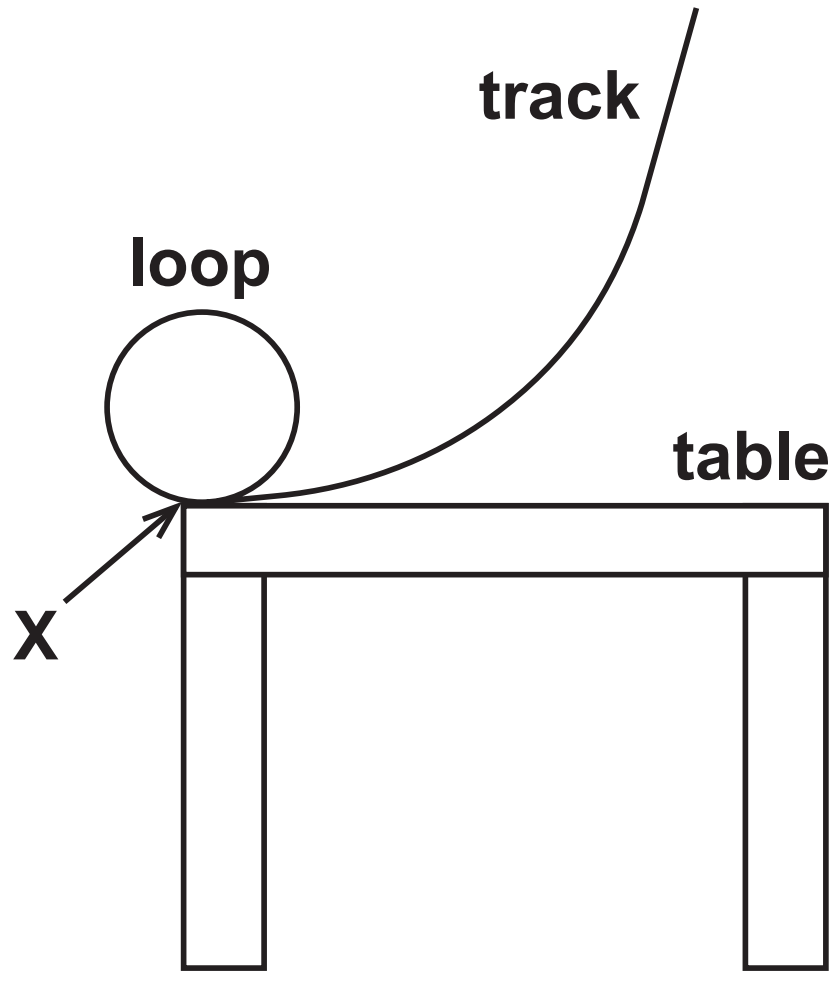
Which dashed path is possible for this alpha particle?

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

(TOTAL FOR QUESTION 10 = 1 MARK)

(Questions continue on next page)

11 A track for toy cars can be built with a circular loop as shown.



A toy car is placed on the track at various heights. It travels around the loop before leaving the track horizontally at X.

(Question continues on next page)

(a) The loop has radius r and the mass of the toy car is m. It is possible for a toy car to complete the loop without losing contact with the inside of the track.

For this to occur the minimum speed of the toy car at the top of the loop v_{top} is given by

$$v_{top} = \sqrt{gr}$$

Explain why. (2 marks)

(Question continues on next page)

(b) The toy car just completes the loop without losing contact with the track.

Show that the speed of the toy car at the bottom of the loop is about $3\,m\,s^{-1}$.

$r = 0{\cdot}15\,m$ (3 marks)

(c) The toy car leaves the track at X with a horizontal velocity of $3{\cdot}0\,m\,s^{-1}$.

X is 0·65 m above the floor.

Calculate the horizontal displacement of the car from X when it hits the floor. (4 marks)

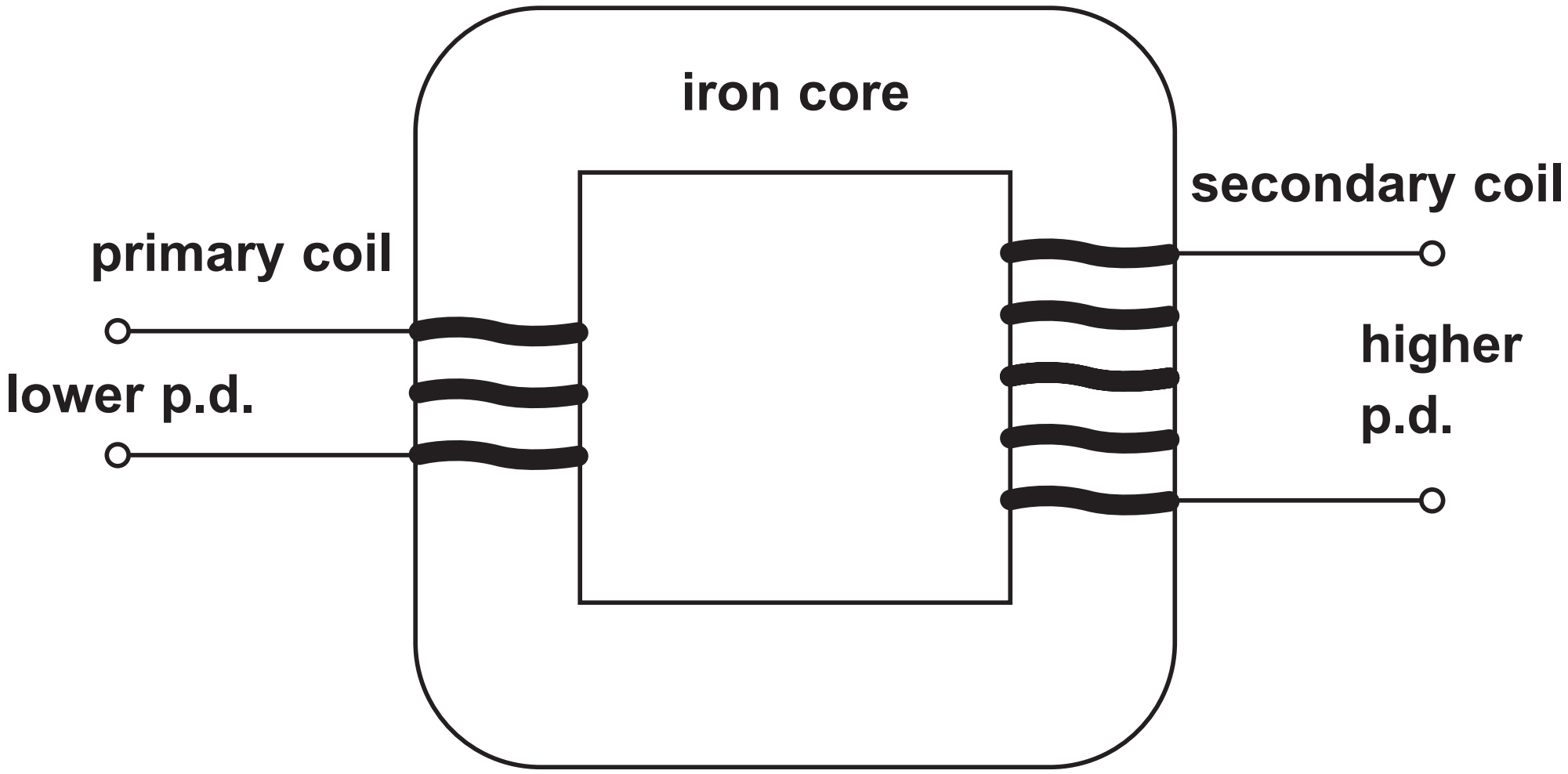
Horizontal displacement = _____

(TOTAL FOR QUESTION 11 = 9 MARKS)

(Questions continue on next page)

12 Electrical transmission systems are used to transmit electrical power from place to place. Transformers are used to change potential differences (p.d.) and power transmission cables are used to transmit power.

(a) The diagram shows a step-up transformer.



A step-up transformer is used to convert a lower p.d. to a higher p.d. An alternating p.d. is applied to the primary coil.

(Question continues on next page)

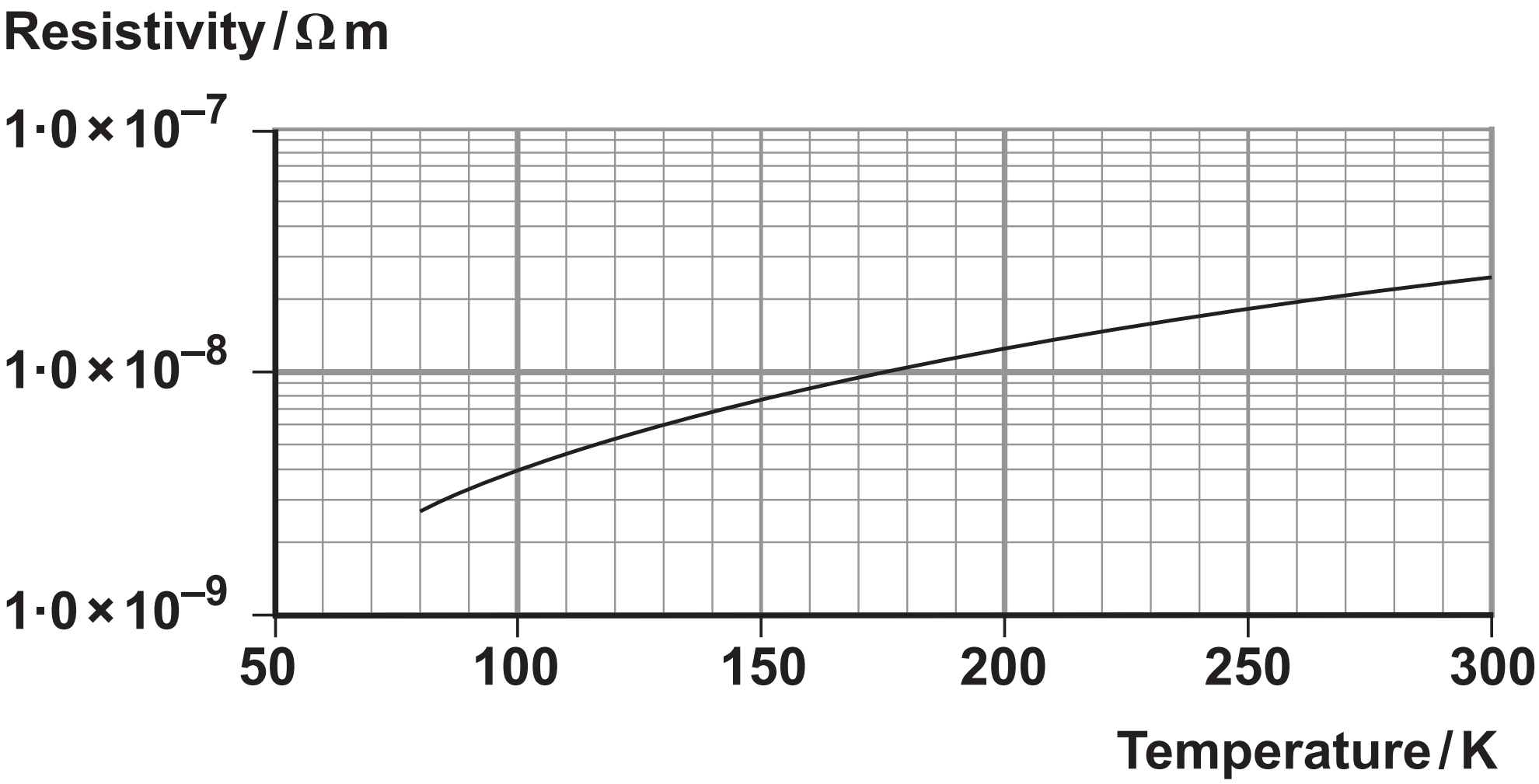
Explain how a higher p.d. is produced across the secondary coil. (4 marks)

(Question continues on next page)

(b) Efficient electrical transmission systems are being developed using superconductors. Superconductors have zero resistance at low temperatures, and therefore no power is wasted by transfer to thermal energy unlike copper cable systems.

In one project a 1·05 km length of copper cable at a temperature of 270 K has been replaced by a superconductor. The superconductor has a cooling system which requires power.

The graph shows the variation of resistivity with temperature for copper.



(Question continues on next page)

Deduce whether the power requirement of the superconductor cooling system is less than the power losses in the copper cable. (5 marks)

transmission power = 40 MW

transmission potential difference = 110 kV

cross-sectional area of copper cable = 145 mm^2

power requirement of cooling system for the superconductor = 7 kW

(Continue your answer on next page)

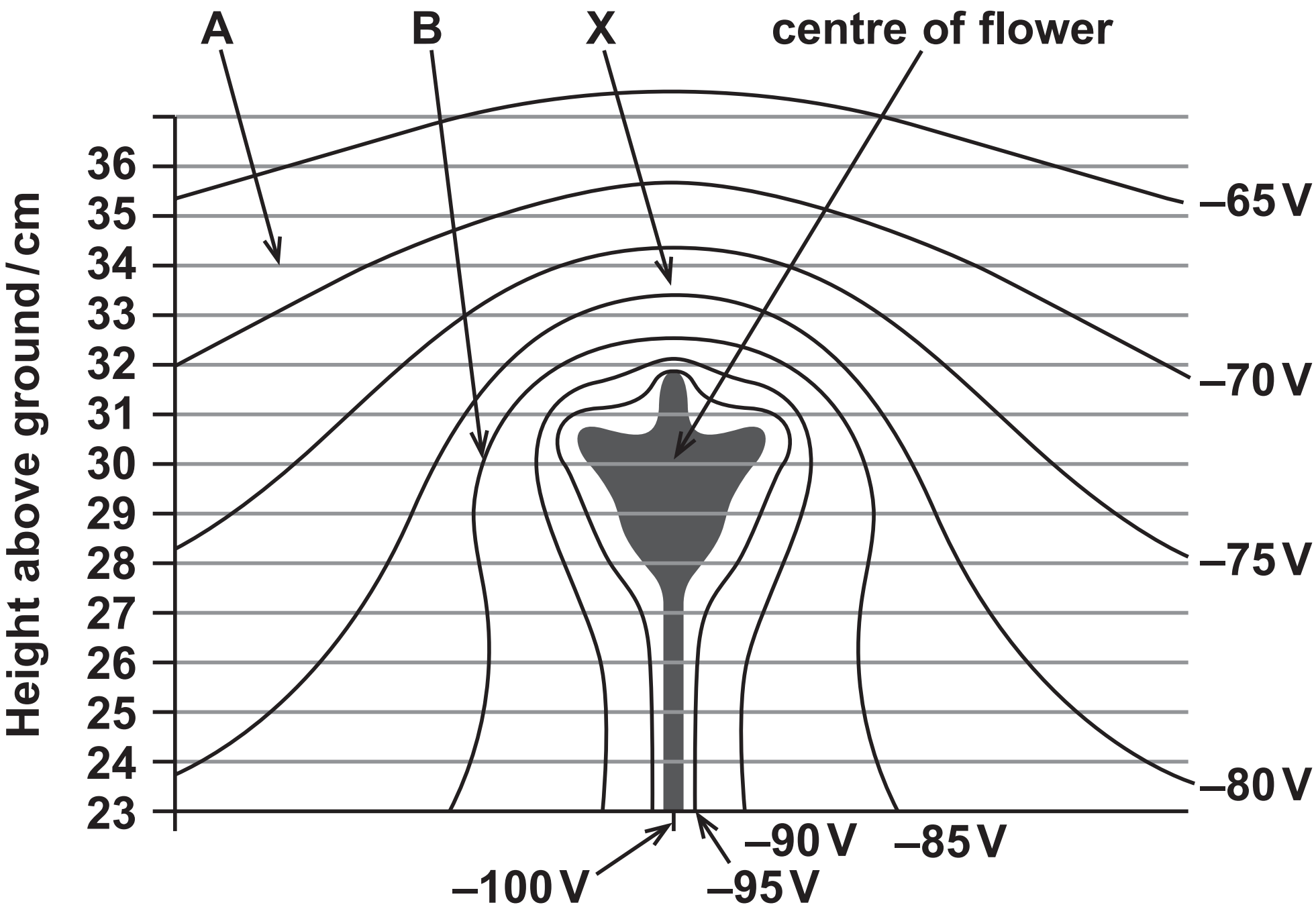
(TOTAL FOR QUESTION 12 = 9 MARKS)

(Questions continue on next page)

13 Some flowers are negatively charged and surrounded by an electric field. This helps to attract bees.

(a) State what is meant by an electric field. (1 mark)

(b) The diagram shows lines of equipotential surrounding a flower.



(Question continues on next page)

(i) Determine the electric field strength at X.
(3 marks)

Electric field strength at X = _____

(Question continues on next page)

(ii) Draw the electric field line between point A and point B on the diagram. (2 marks)

(iii) An equation for electric potential V is

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

This applies to a radial field.

Deduce whether the electric field in the region directly above the flower is radial.
You should take values from the diagram.
A graphical method is not required. (3 marks)

(c) A bee has short hairs which are thought to carry charge.

State how the bee might use this to detect the electric field of a flower. (1 mark)

(d) When the bee is collecting nectar from the plant, the electric field strength decreases. It is thought that this warns other bees that the nectar supply is low.

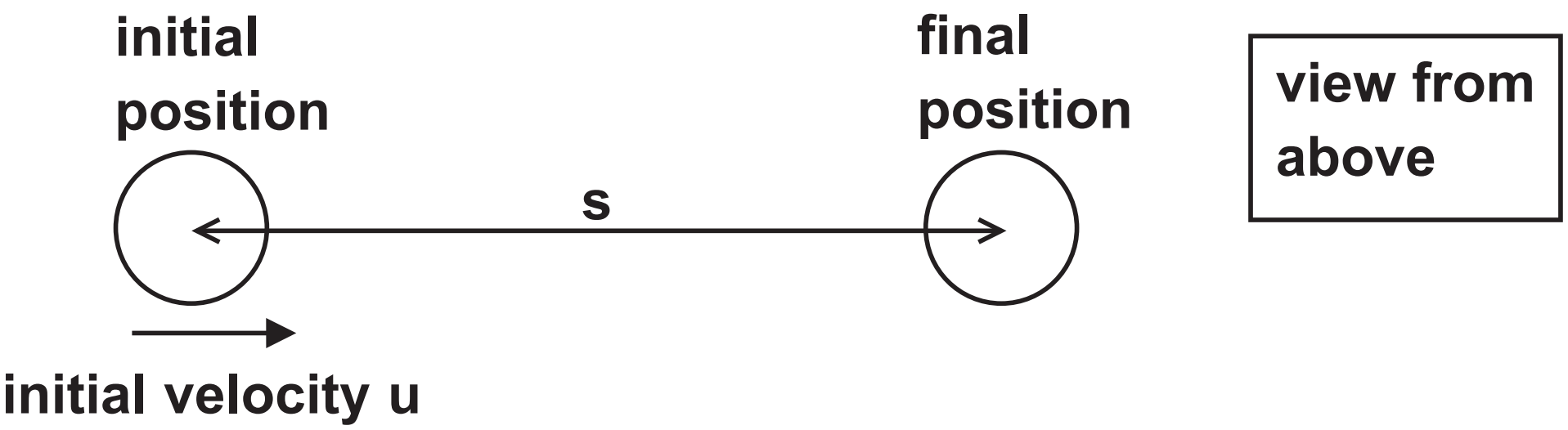
State the effect of a decreased electric field strength on the equipotential lines. (1 mark)

(TOTAL FOR QUESTION 13 = 11 MARKS)

(Questions continue on next page)

14 A student carried out an experiment with coins.

(a) She gave a 2p coin a sharp tap, so that it slid along a horizontal surface and came to rest as shown.



The student recorded the distance s moved by the coin.

She then replaced the 2p coin with a 1p coin and repeated the process.

The student read that the frictional force between an object and a surface is directly proportional to the mass of the object. She suggested that, in her experiment, u is directly proportional to $\sqrt{s}$ and is independent of the mass of the coin.

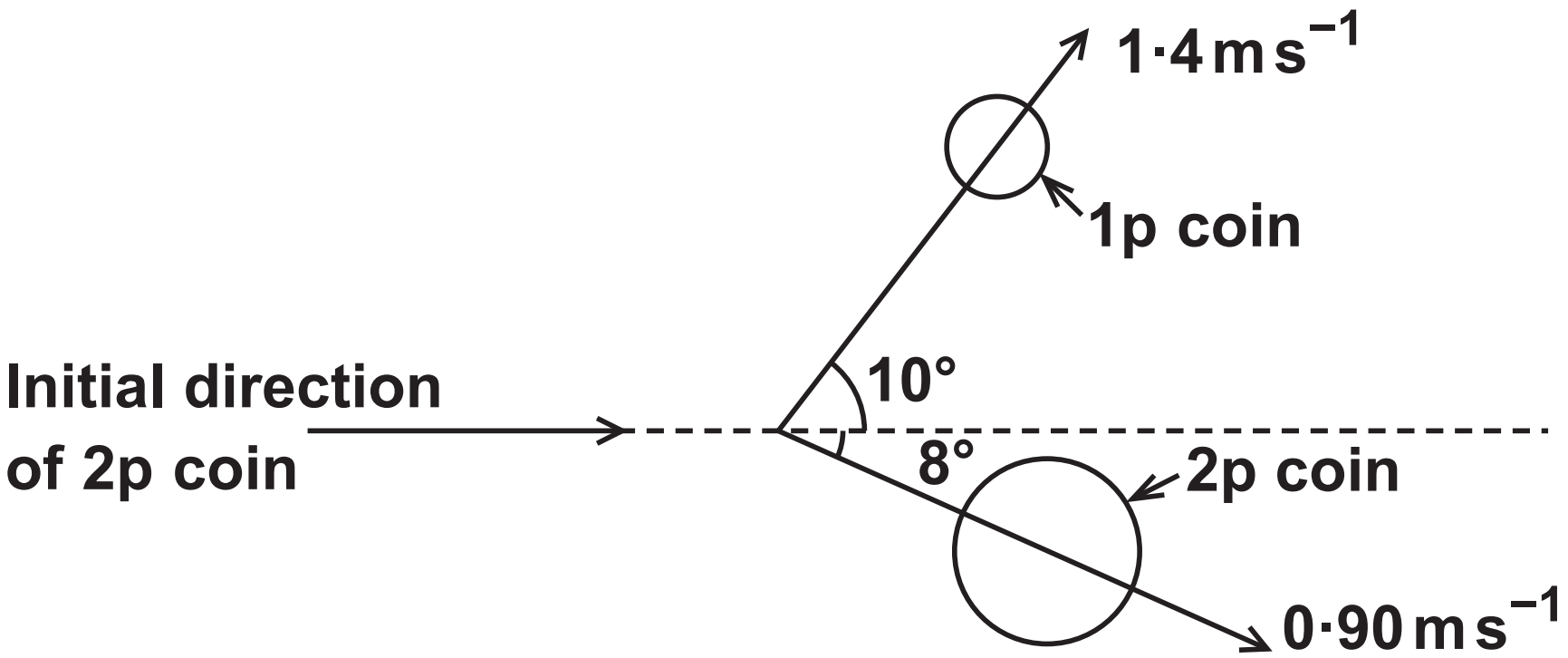
(Question continues on next page)

Discuss the validity of this suggestion. (6 marks)

(Continue your answer on next page)

(Question continues on next page)

(b) She arranged a collision between a 2p coin and a stationary 1p coin. She noted the directions in which the coins moved after the collision and determined their velocities.



(i) Show that the velocity of the 2p coin just before the collision was about 2 m s^{-1}.
(4 marks)

mass of 2p coin = 7·1 g

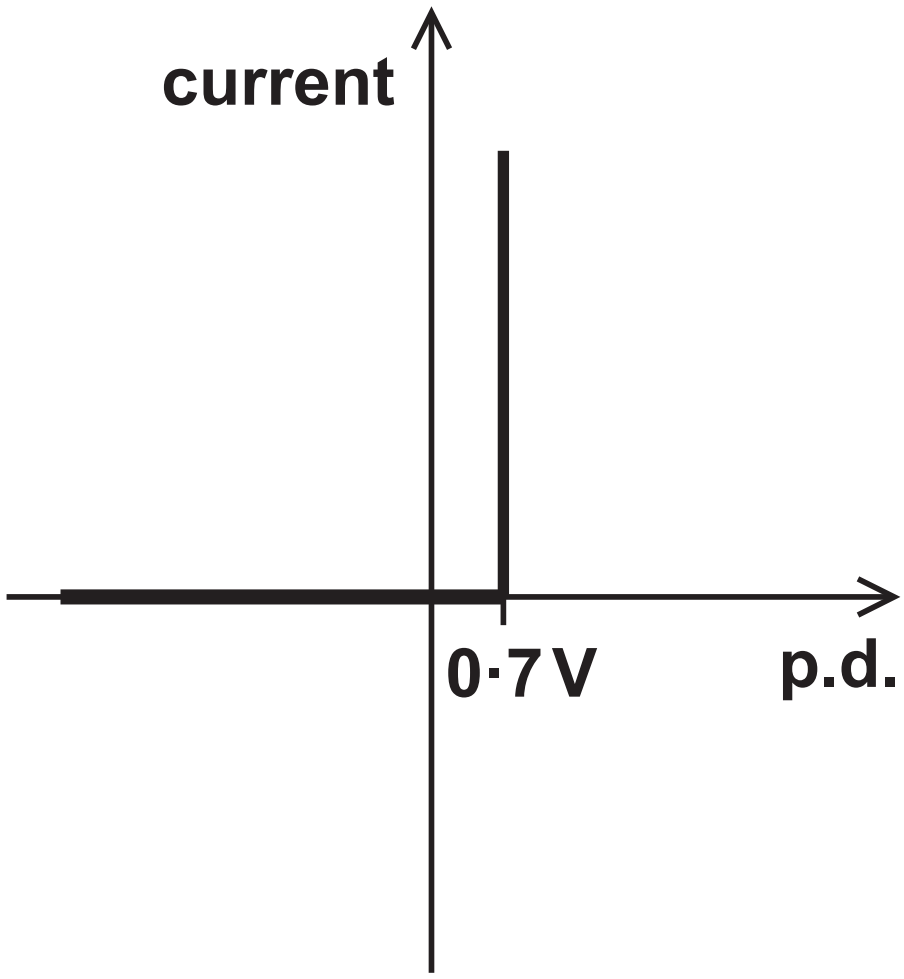
mass of 1p coin = 3·6 g

(ii) Show that the collision was inelastic.
(2 marks)

(TOTAL FOR QUESTION 14 = 12 MARKS)

(Questions continue on next page)

15 The graph shows how current varies with potential difference (p.d.) for an ideal diode.



(a) Describe how the current through this diode varies for positive p.d.s and negative p.d.s. (2 marks)

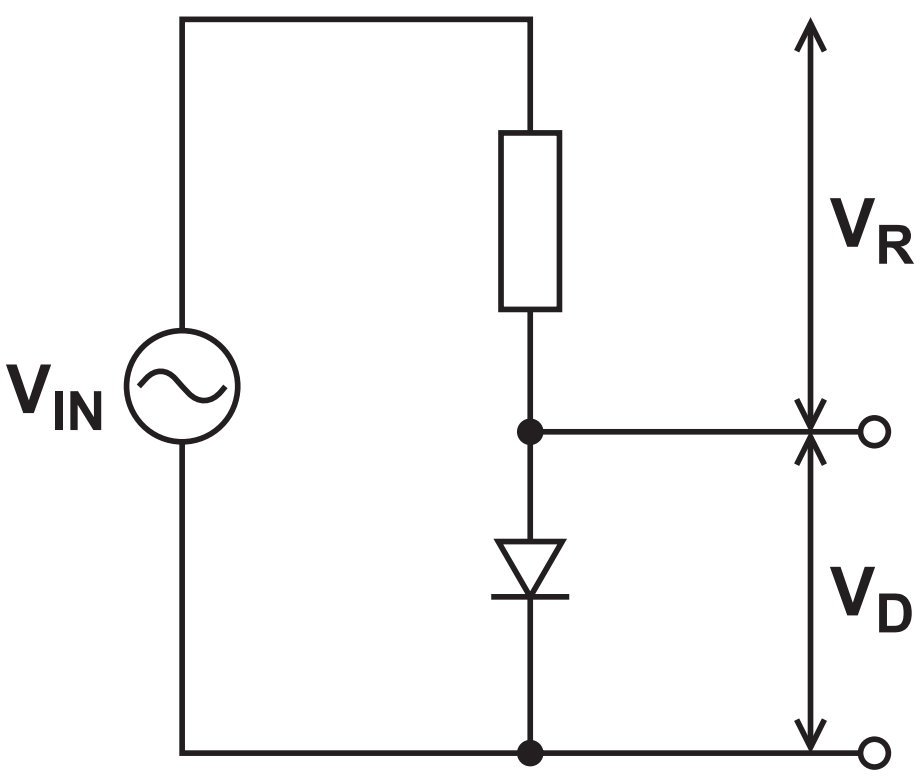
(Question continues on next page)

(b) An alternating p.d. V_{IN} has a peak value of 3·4 V.

(i) Calculate the r.m.s. value. (2 marks)

r.m.s. value = _____

(ii) V_{IN} is applied to a diode and resistor as shown.



The p.d. across the resistor is V_R and the p.d. across the diode is V_D. V_D is the output.

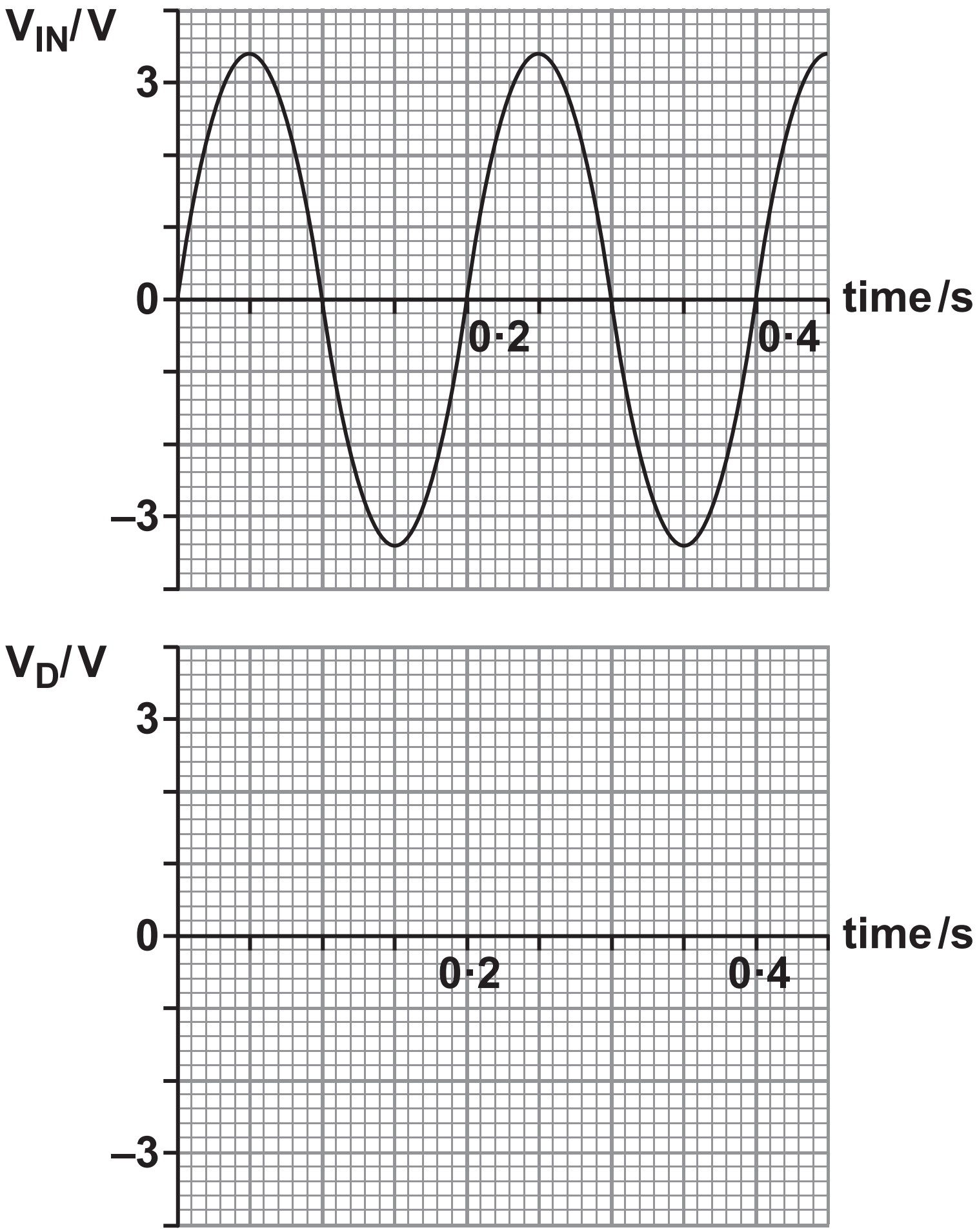
(Question continues on next page)

Explain why $V_{IN} = V_R + V_D$ at any given time. (2 marks)

(Question continues on next page)

(iii) The graph shows how V_{IN} varies with time.

Sketch a graph of V_D against time using the axes provided below. (3 marks)



(TOTAL FOR QUESTION 15 = 9 MARKS)

(Questions continue on next page)

(Turn over)

16 A muon (μ) is a lepton with a mass of 106 MeV/c^2.

(a) Calculate the mass of a muon in kg. (3 marks)

Mass of muon = _____ kg

(b) Muons are produced from the decay of pions in the upper atmosphere.

An example of this decay is given by the equation

$$\pi^- \longrightarrow \mu^- + \bar{\nu}_\mu$$

(Question continues on next page)

(i) Explain how this decay obeys the laws of conservation of charge, baryon number and lepton number. (3 marks)

(Question continues on next page)

(ii) The masses of these three particles, in MeV/c^2, are given below.

π^-	μ^-	$\bar{\nu}_\mu$
140	106	≈0

Explain why the total kinetic energy of the products of this decay is approximately 34 MeV. Assume the π^- is stationary. (2 marks)

(Question continues on next page)

(iii) State which two conservation laws could be used to calculate the kinetic energy of the μ^- and the $\bar{\nu}_\mu$ just after the decay of the π^-. (2 marks)

*(iv) The muons are produced at a height of 10 km in the atmosphere. The velocity of the muons is 0·99 c. The average lifetime for muons is normally 2·2 μs and yet muons produced in the upper atmosphere are found in significant numbers at sea level.

Discuss this apparent anomaly. (6 marks)

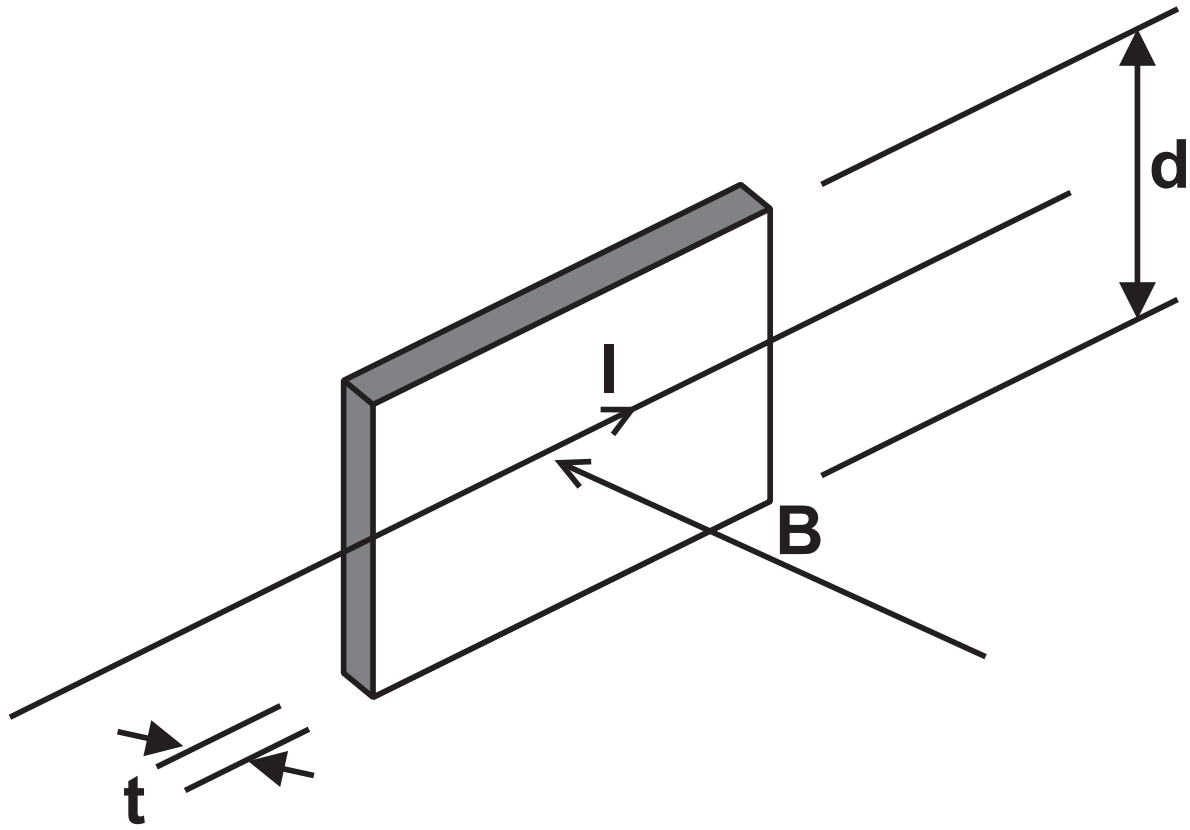
(Continue your answer on next page)

(TOTAL FOR QUESTION 16 = 16 MARKS)

(Questions continue on next page)

17 Tiny sensors in smartphones could be used to determine the position of the phone on the Earth's surface by measuring the Earth's magnetic flux density.

A current I and a magnetic field of flux density B are applied to a slice of semiconductor as shown. The slice has thickness t and depth d.



Electrons collect at the top edge of the slice and the bottom edge becomes positively charged. As a result a potential difference known as a Hall voltage V_{HALL} develops.

(Question continues on next page)

(a) Explain why electrons will collect at the top edge of the slice. (2 marks)

(b) Add to the diagram to show clearly two points between which V_{HALL} develops. (1 mark)

(Question continues on next page)

(c) Electrons continue to collect at the top edge of the slice, until the force on a moving electron due to the magnetic field is equal to the force on the electron due to the electric field.

Derive the following equation for V_{HALL}:

$$V_{HALL} = \frac{BI}{nte}$$

where n is the number of charge carriers per unit volume of the semiconductor. (4 marks)

(Continue your answer on next page)

(d) Show that the units are the same on each side of the equation (3 marks)

$$V_{HALL} = \frac{BI}{nte}$$

(e) The table gives the values of n and t for a number of material samples.

material	n / m^{-3}	t / m
copper	$8{\cdot}47 \times 10^{28}$	110×10^{-6}
germanium	$2{\cdot}25 \times 10^{19}$	$1{\cdot}10 \times 10^{-6}$
silicon	$1{\cdot}44 \times 10^{16}$	120×10^{-6}

Deduce which sample would result in the largest Hall voltage for a particular current and magnetic field. (2 marks)

(Question continues on next page)

(f) Two sensors in the smartphone were used to determine the horizontal component B_H and the vertical component B_V of the Earth's magnetic flux density.

Calculate the angle of the Earth's magnetic field to the horizontal. (2 marks)

$B_H = 19{\cdot}0\,\mu T$

$B_V = 49{\cdot}0\,\mu T$

Angle = _____

(TOTAL FOR QUESTION 17 = 14 MARKS)

TOTAL FOR PAPER = 90 MARKS

END