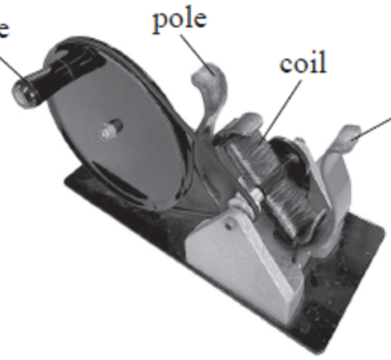
Questions

Q1.

The photograph shows a demonstration a.c. generator used in a school.



The handle is used to rotate the coil between the magnetic poles.
When a light emitting diode (LED) is connected across the coil, the LED flashes on and off as the coil rotates.

(a) Explain this observation.

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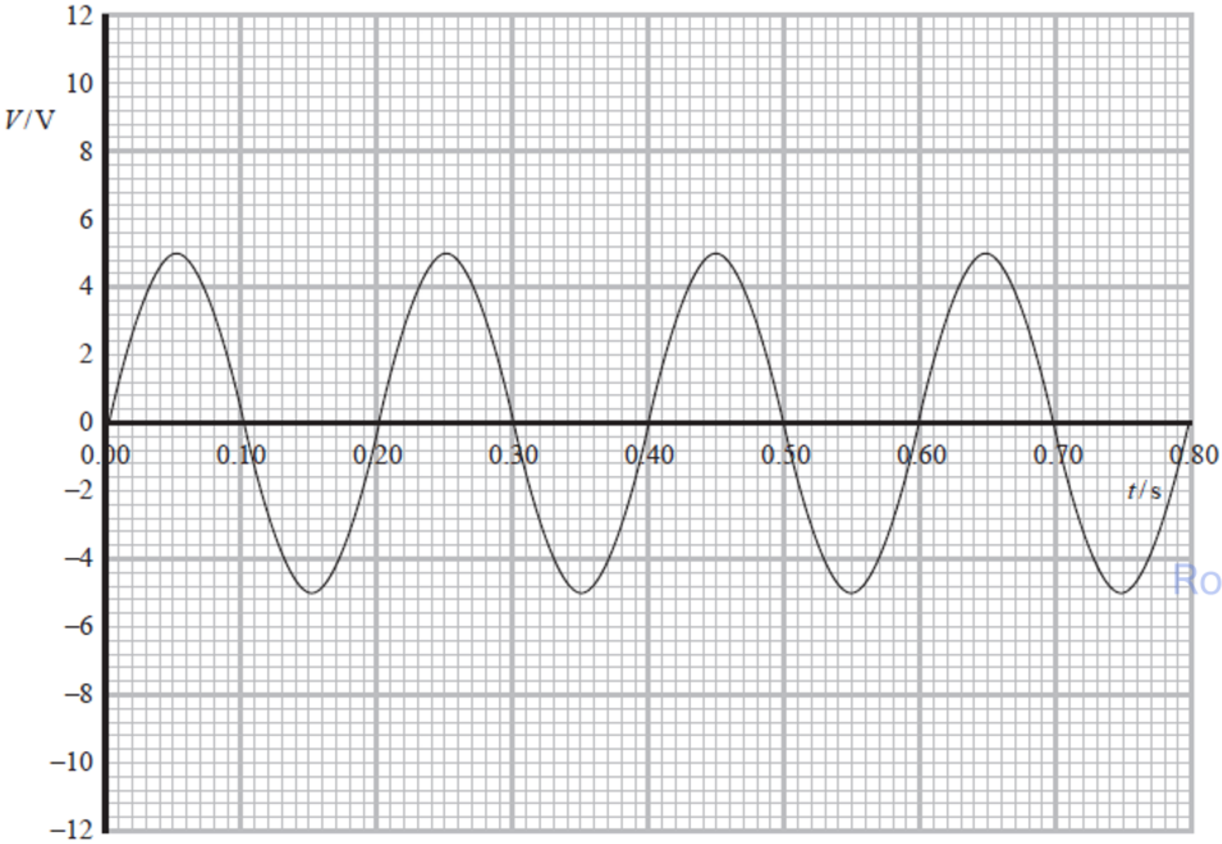
(b) The output potential difference V for the generator is recorded using a data logger and a graph is produced of V against time t.



(i) Add to the graph to show the output if the angular velocity of the generator coil is halved.

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(ii) Explain the changes in the graph when the angular velocity of the coil is halved.

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(iii) The coil rotates in a uniform magnetic field at the original angular velocity.
The average magnitude of *V* is 3.2 V.

Determine the number of turns in the coil.

magnetic flux density = 0.083 T

cross-sectional area of coil = 0.0048 m^2

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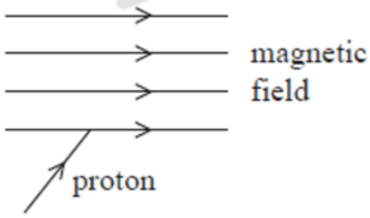
Number of turns = ...

(Total for question = 12 marks)

Q2.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

A proton enters a magnetic field at an angle as shown.



Which of the following gives the direction of the force on the proton as it enters the magnetic field?

☐ **A** in the plane of the page at 90° to the direction of the magnetic field

☐ **B** in the plane of the page at 90° to the proton velocity

☐ **C** into the page

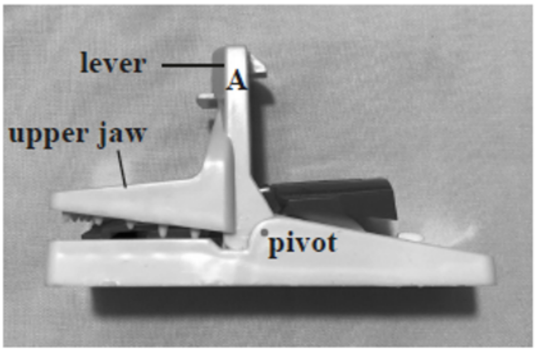
☐ **D** out of the page

(Total for question = 1 mark)

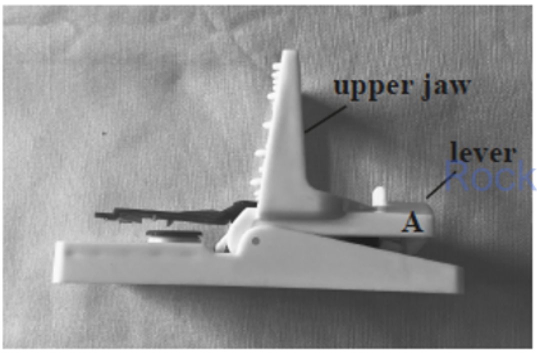
Q3.

A student carried out an investigation to compare the energy stored in a mechanical mouse trap with the energy stored in an electronic mouse trap.

(a) The photographs show the mechanical version trap before and after it is set to trap a mouse.



Before being set



After being set

The trap was set by applying a force on the lever at point A. The lever rotated through an angle of 90°, stretching a spring. The force was applied at right angles to the lever throughout the process.

The initial force applied was 2.6 N and the force increased steadily to a final value of 9.6 N when the trap was set.

Show that the work done setting the trap was about 0.5 J.

length of lever = 4.9 cm

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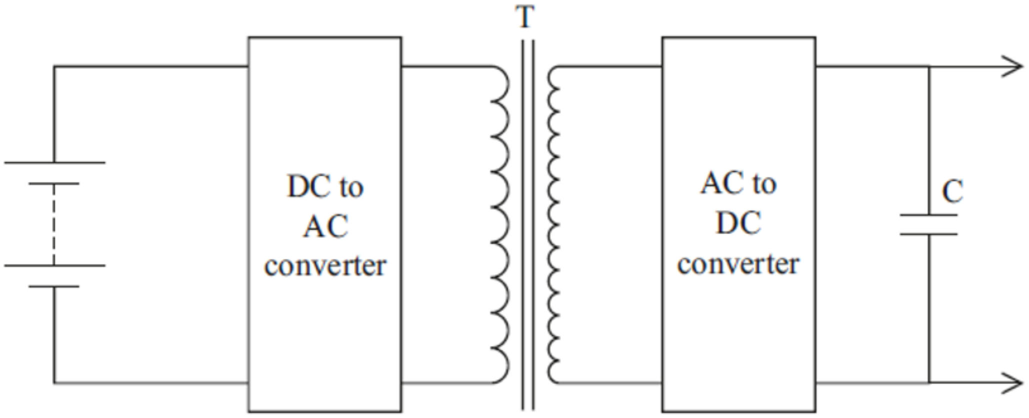
(b) The electronic mouse trap works by applying a large potential difference (p.d.) across two metal plates. The diagram shows part of the circuit for the electronic mouse trap.



* (i) The transformer T consists of two coils wound around a single iron core. An alternating p.d. is applied to the input coil and the output coil is connected, through a diode, to a capacitor.

Explain how applying a p.d. across the input coil causes the capacitor to charge.

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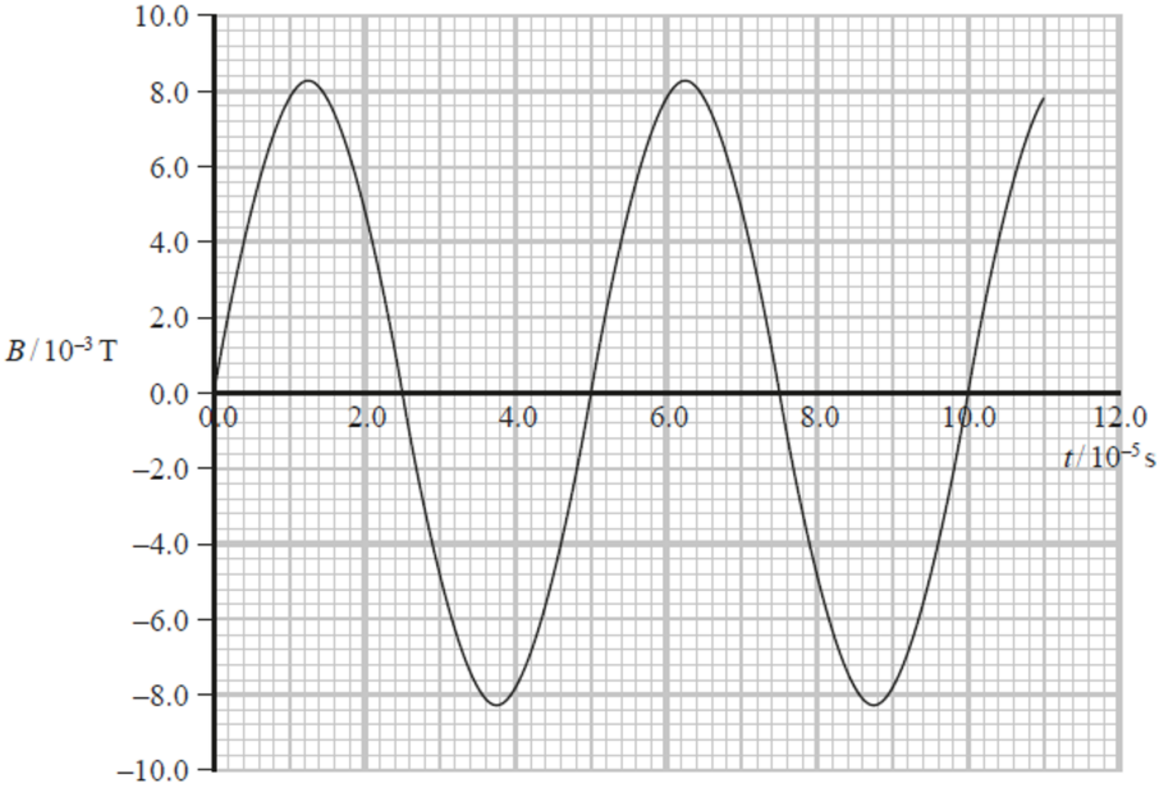
(ii) The graph shows how the magnetic flux density B in the iron core varies with time.



Show that the maximum p.d. across the output coil is about 600 V.

number of turns on coil = 1700

cross-sectional area of coil = 3.5×10^{-4} m^2

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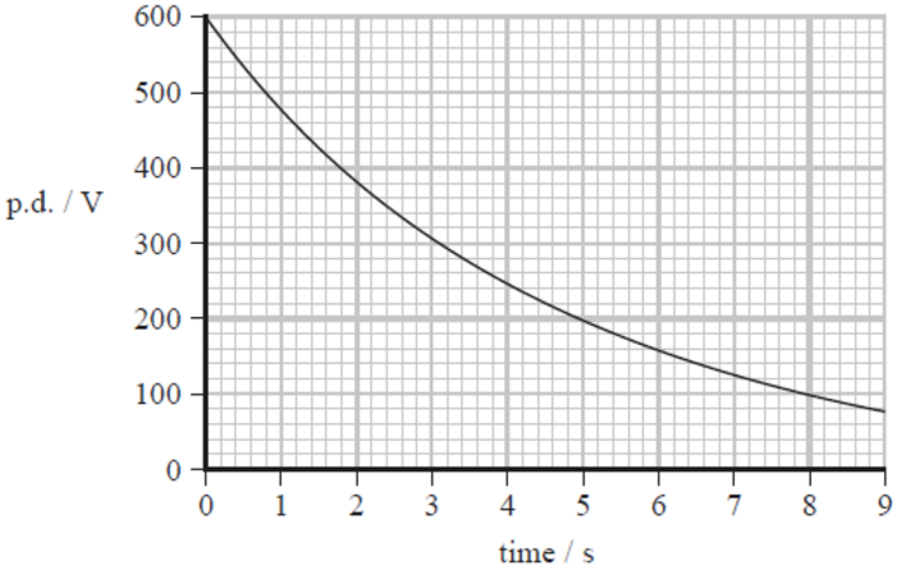
(c) The student tested the capacitor by charging it until the p.d. across the capacitor was 600 V and recording the p.d. as it was discharged through a resistor of resistance 3000 Ω.

The following graph was obtained.



Determine whether the mechanical or the electric mouse trap stores the most energy.

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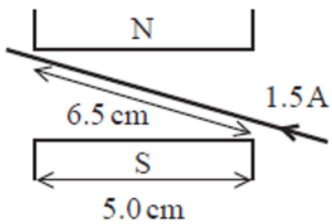
(Total for question = 16 marks)

Q4.

A current-carrying wire is placed between two magnetic poles as shown. The magnetic flux density in the region between the poles is 0.070 T.



Which of the following gives the magnitude of the force on the wire, in newton, and its direction?

☒ **A** $0.070 \times 1.5 \times 0.050$ into page

☒ **B** 0.070 × 1.5 × 0.065 into page

☒ **C** 0.070 × 1.5 × 0.050 out of page

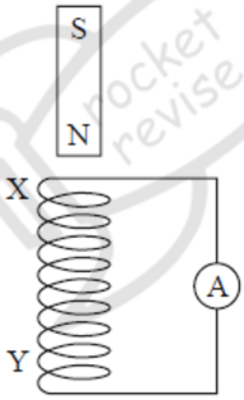
☒ **D** 0.070 × 1.5 × 0.065 out of page

(Total for question = 1 mark)

Q5.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

A magnet is dropped vertically through a coil, producing a current in the coil which creates a magnetic field around it.



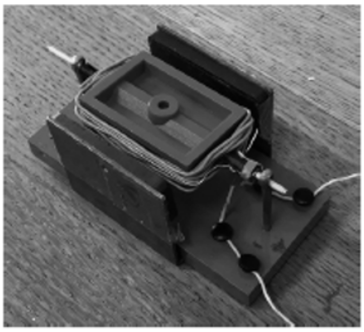
Which line of the table correctly shows the pole at X when the magnet enters the coil, and the pole at Y when the magnet leaves the coil?

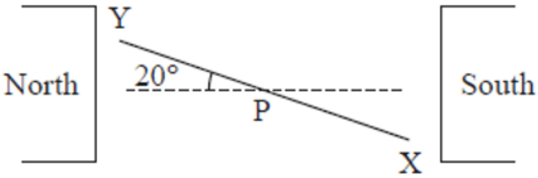
		pole of field due to coil at X	pole of field due to coil at Y
☒	**A**	north	north
☒	**B**	north	south
☒	**C**	south	north
☒	**D**	south	south

(Total for question = 1 mark)

Q6.

The photograph shows a model electric motor.





A coil of wire is mounted between two magnets. When there is a current in the coil, it rotates.

The diagram shows the position of the coil, viewed from one end, when it is at an angle of 20° to the horizontal. The current is into the page at X and out of the page at Y.

There are 10 turns on the coil and the current in the coil is 6.9 A.

Determine the resultant moment about P of the magnetic forces acting on the coil.

length of coil = 5.0 cm

width of coil = 3.5 cm

current = 6.9 A

number of turns = 10

magnetic flux density = 0.07 T

(4)

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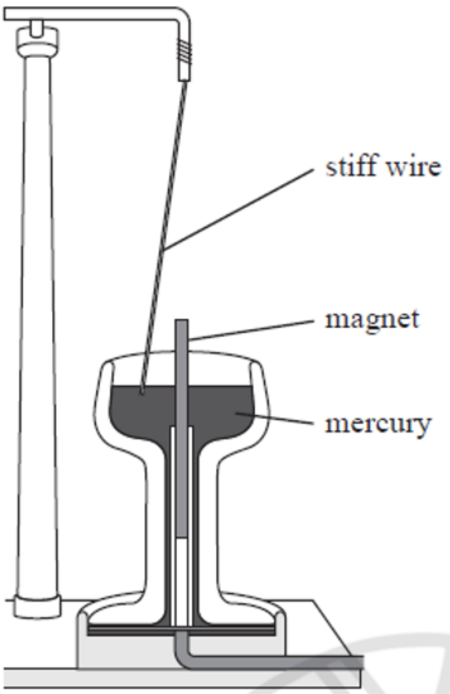
Moment about P = ...

(Total for question = 4 marks)

Q7.

In 1821, Michael Faraday made what is believed to be the first electric motor.



The stiff wire was suspended freely from a stand. The mercury completed an electrical circuit, which included the wire. When there was a current in the wire, the wire moved around the magnet.

(a) The wire made 10 complete revolutions around the magnet in a time of 8.3 s.

Calculate the angular velocity of the wire.

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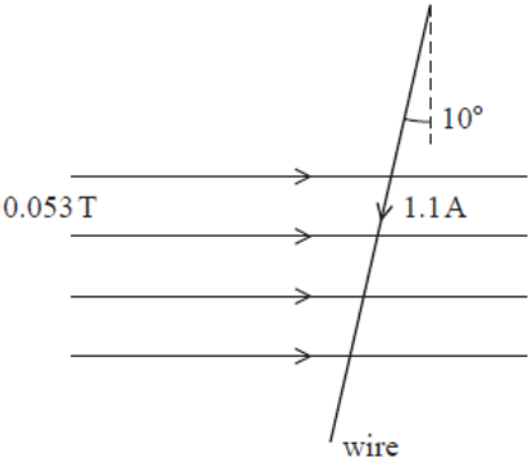
Angular velocity = ...

(b) When the current in the wire is 1.1 A, the wire is at an angle of 10° to the vertical.
The length of the wire in the horizontal magnetic field is 3.5 cm.



Determine the force on the wire.

magnetic flux density = 0.053 T

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Magnitude of force on wire = ...

Direction of force on wire = ...

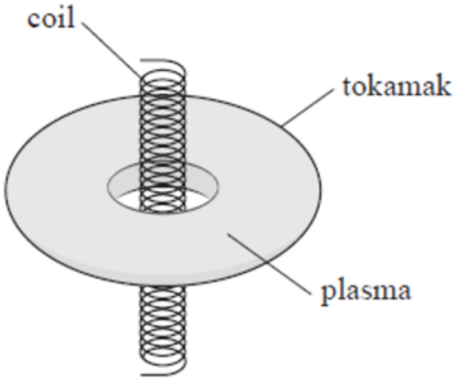
(Total for question = 6 marks)

Q8.

At the Culham Centre for Fusion Energy (CCFE), experiments are carried out on plasmas.

A plasma is an ionised gas which is an electrical conductor. The plasma at CCFE is contained in a doughnut-shaped vessel known as a tokamak.

A current in the plasma is produced by steadily increasing a current in a coil passing through the hole at the centre of the tokamak.



The plasma in the tokamak acts as a single conducting loop around the central coil.

(a) Explain how steadily increasing the current in the central coil produces a current in the plasma.

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(b) The plasma can be considered to be a cylinder of length 13.2 m and cross-sectional area 2.30 m^2.

(i) Show that the resistance of the plasma is about $1.9 \times 10^{-7}\ \Omega$.

resistivity = $3.30 \times 10^{-8}\ \Omega$ m

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(ii) In a particular experiment, the current in the central coil is increased steadily from zero to its maximum value in a
time of 25.0 s.

When the current in the central coil reaches its maximum, the magnetic flux linkage with the plasma loop
is 16.9 Wb.

Calculate the heating power produced in the plasma.

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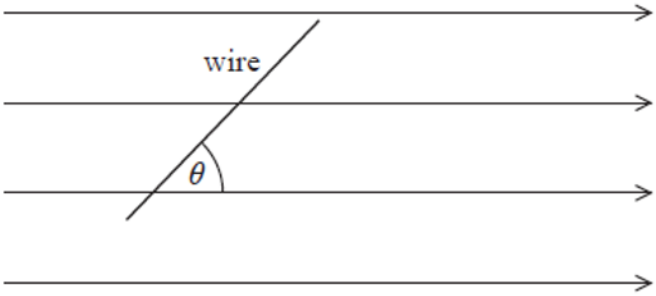
Heating power = ...

(Total for question = 10 marks)

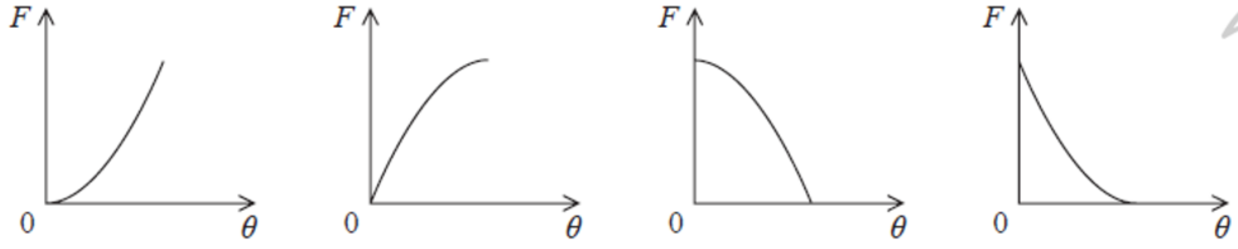
Q9.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows a current-carrying wire at an angle θ to a uniform magnetic field.



Which of the following graphs shows how the force F on the wire varies as θ is increased from 0 to 90°?



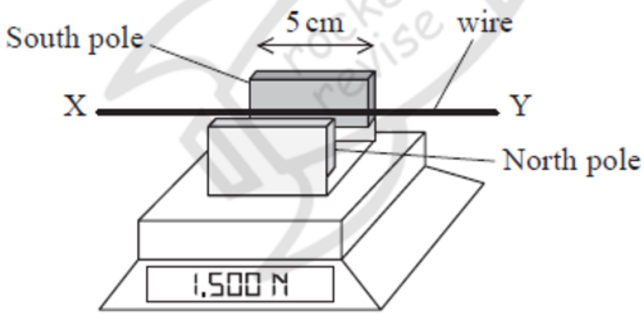
A ☒ **B** ☒ **C** ☒ **D** ☒

(Total for question = 1 mark)

Q10.

A wire is held firmly in place between two magnets mounted on top of an electric balance as shown.

The reading on the balance is 1.500 N.



The magnetic flux density between the magnets is 0.07 T.
When the wire is connected to a circuit so there is a current in the wire, the reading on the balance is 1.503 N.

Which of the following gives the current in the wire in ampere and its direction?

☒ **A** $\dfrac{0.003}{0.07 \times 0.05}$ from X to Y

☒ **B** $\dfrac{0.003}{0.07 \times 0.05}$ from Y to X

☒ **C** $\dfrac{0.07 \times 0.05}{0.003}$ from X to Y

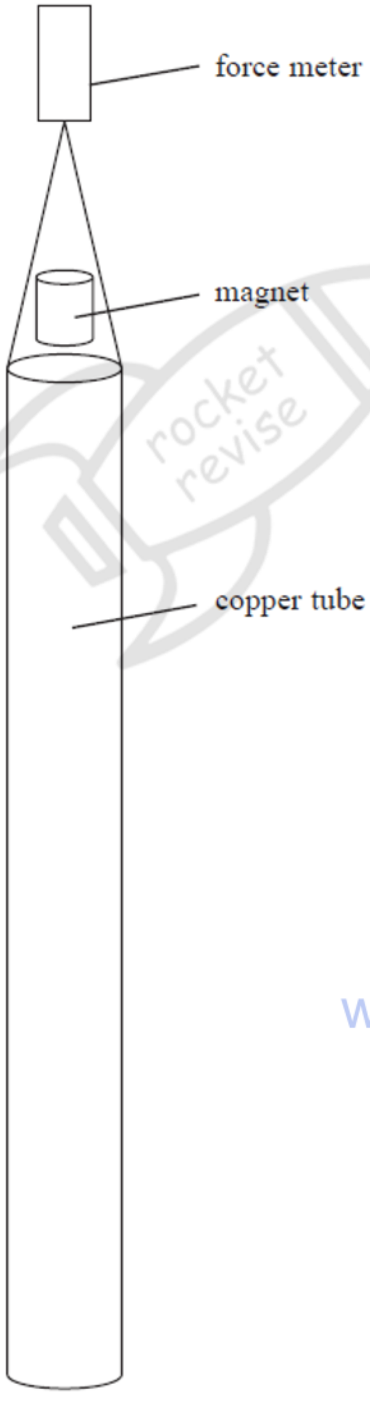
☒ **D** $\dfrac{0.07 \times 0.05}{0.003}$ from Y to X

(Total for question = 1 mark)

Q11.

* A student carried out an investigation of Lenz's law. A copper tube was suspended from a force meter, as shown.

A magnet was released at the top of the tube. When the magnet was falling through the tube, there was an increased reading on the force meter.



Explain why there was an increased reading on the force meter.

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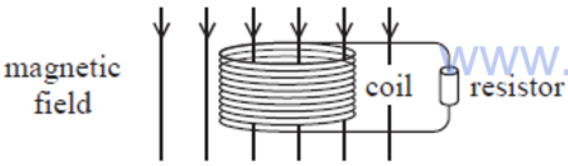
(Total for question = 6 marks)

Q12.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A coil of wire is connected to a resistor as shown.



The magnetic flux density of the field through the coil is increased steadily from zero to a maximum value.

Which of the following single changes would result in a smaller current in the resistor?

☐ **A** increasing the area of the coil in the magnetic field

☐ **B** increasing the maximum flux density

☒ **C** increasing the number of turns on the coil

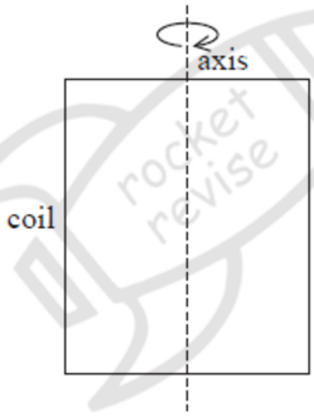
☒ **D** increasing the time taken to reach the maximum flux density

(Total for question = 1 mark)

Q13.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows a rectangular coil of *N* turns. The coil rotates around an axis as shown. A magnetic field acts perpendicular to the plane of the coil in the position shown.



The magnetic flux linkage with the coil is $N\phi$. The coil is rotated through an angle of π radians.

Which of the following is equal to the change in magnetic flux linkage with the coil?

☒ **A** 0

☒ **B** $N\phi/2$

☒ **C** $N\phi$

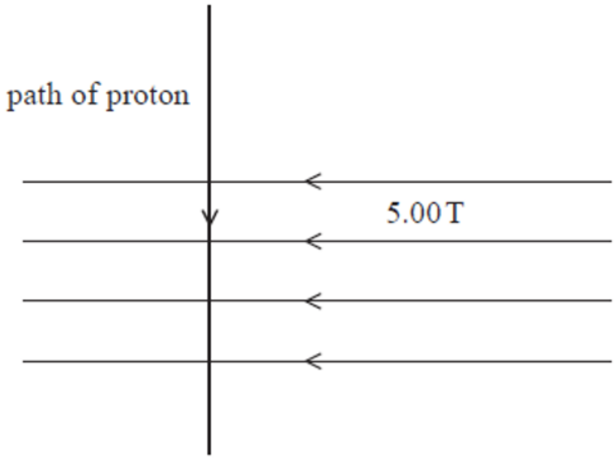
☒ **D** $2N\phi$

(Total for question = 1 mark)

Q14.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A proton travelling at speed *v* enters a magnetic field of magnetic flux density 5.00 T, as shown.



A force of 1.20×10^{-11} N is exerted on the proton.

Which of the following gives the speed of the proton in m s^{-1}?

☐ **A** $\dfrac{1.20\times10^{-11}}{5.00\times1.67\times10^{-27}}$

☐ **B** $\dfrac{1.20\times10^{-11}}{5.00\times1.60\times10^{-19}}$

☐ **C** $\dfrac{5.00\times1.67\times10^{-27}}{1.20\times10^{-11}}$

☐ **D** $\dfrac{5.00\times1.60\times10^{-19}}{1.20\times10^{-11}}$

(Total for question = 1 mark)

Q15.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following statements does **not** help to explain why electrons can be used to probe the nuclei of atoms?

☒ **A** Electrons can be accelerated to high energies.

☒ **B** Electrons can be part of an atom.

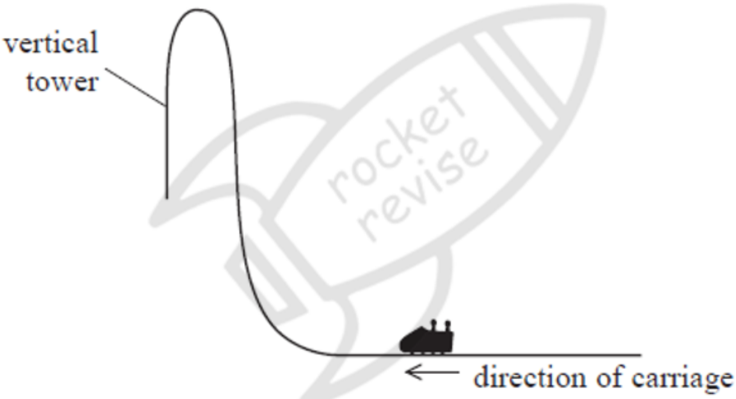
☒ **C** Electrons can exhibit diffraction effects.

☒ **D** Electrons can have wavelengths similar in size to nuclear diameters.

(Total for question = 1 mark)

Q16.

A carriage on a roller coaster ride travels along a horizontal track towards a vertical tower, as shown.



(a) The carriage starts from rest. A force of 109 kN acts on the carriage for 2.9 s. The carriage then moves up a vertical tower of height 81 m.

(i) Show that the velocity of the carriage is about 40 m s^{-1} as it leaves the horizontal track.

total mass of carriage and people = 7500 kg

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(ii) Deduce whether this velocity is enough for the carriage to reach the top of the tower.

Assume that resistive forces are negligible.

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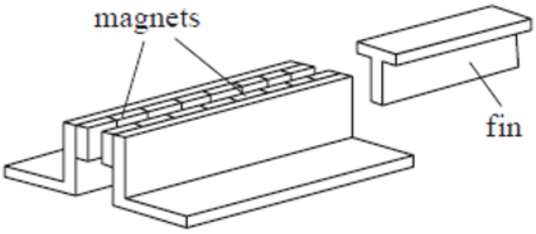
(b) Just before the carriage reaches the end of the ride it is slowed by an electromagnetic brake. Powerful magnets are attached to the track. An aluminium fin is attached to the carriage. The fin moves through a narrow gap between the magnets.



(Source: © MAGNETAR TECHNOLOGIES CORP)

Explain why the fin will leave the gap with a much slower speed than it entered the gap.

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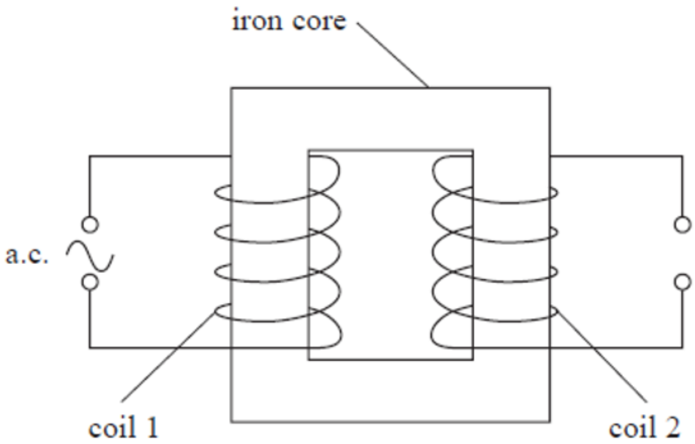
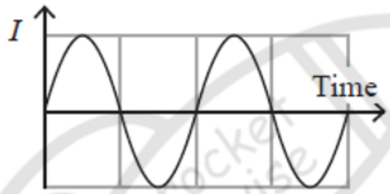
(Total for question = 10 marks)

Q17.

Two coils are linked by an iron core as shown. Coil 1 carries an alternating current *I*.

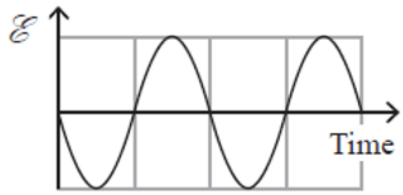


The graph shows the variation of *I* with time for two complete cycles.

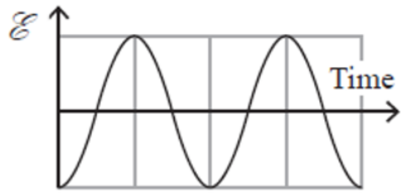


Which of the following graphs gives the corresponding induced e.m.f. $\mathscr{E}$ across coil 2?

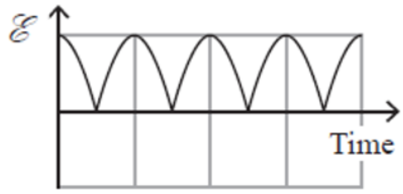
☒ **A**



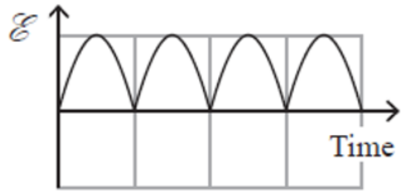
☒ **B**



☒ **C**



☒ **D**

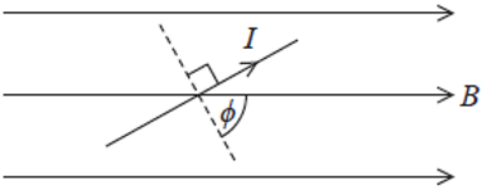


(Total for question = 1 mark)

Q18.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A wire is in the same plane as a magnetic field of magnetic flux density *B* as shown.
The wire is of length *l* and carries a current *I*.



Which row of the table gives the magnitude and direction of the force on the wire?

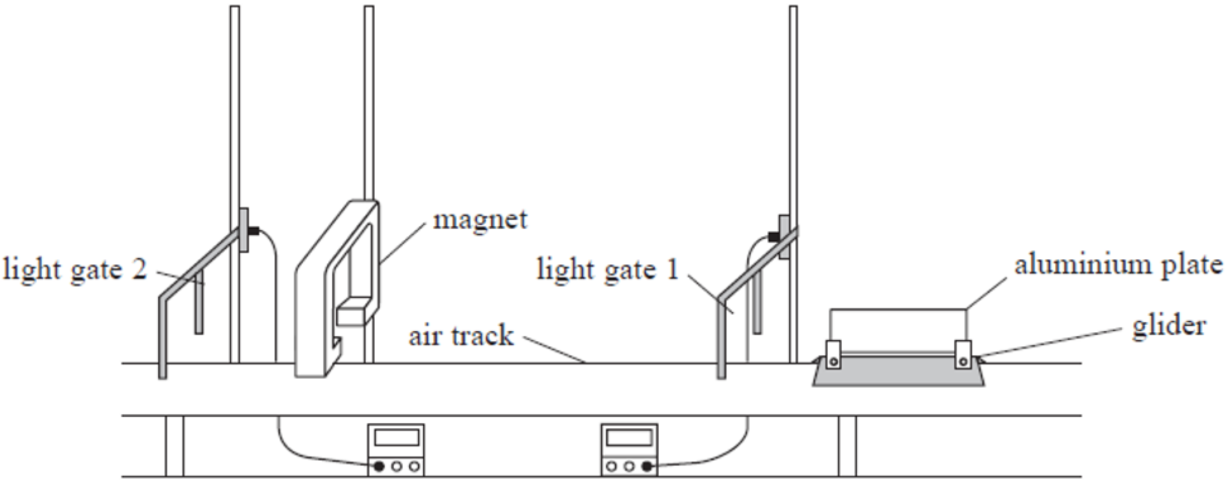
		Magnitude	Direction
☒	**A**	$BIl\cos\phi$	into page
☒	**B**	$BIl\cos\phi$	out of page
☒	**C**	$BIl\sin\phi$	into page
☒	**D**	$BIl\sin\phi$	out of page

(Total for question = 1 mark)

Q19.

A student investigated electromagnetic braking using the apparatus shown.

A vehicle consisting of a glider and aluminium plate was placed on an air track. A powerful magnet was positioned between the two light gates so that the aluminium plate could pass between the poles of the magnet. The air resistance on the vehicle was negligible.



(a)(i) The vehicle was given a push. The aluminium plate took 0.19 s to pass through light gate 1.

Show that the momentum of the vehicle was about 0.3 N s.

length of plate = 15.0 cm
mass of vehicle = 0.40 kg

(3)

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(ii) The vehicle then moved between the poles of the magnet before passing through light gate 2.

The magnet caused the kinetic energy of the vehicle to reduce by 10%.

Calculate the velocity of the vehicle at light gate 2.

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Velocity = ...

(b) (i) Explain why a current was produced in the aluminium plate as it passed between the poles of the magnet.

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(ii) The kinetic energy of the vehicle decreased as the aluminium plate moved between the poles of the magnet.

Explain why.

(2)

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(c) The investigation was repeated using different aluminium plates with the same length but different thicknesses. The vehicle was given the same approximate initial velocity each time. The table shows the thickness of each aluminium plate and the corresponding percentage reduction in the kinetic energy of the vehicle.

	Thickness / mm	Percentage reduction in kinetic energy
Initial plate	0.50	10
Second plate	0.80	16
Third plate	1.1	22

(i) Show that the percentage reduction in kinetic energy is proportional to the thickness of the plate.

(2)

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(ii) Suggest why the percentage reduction in kinetic energy increases as the thickness of the plate increases.

(3)

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(Total for question = 15 marks)

Q20.

Faraday's law can be written as $\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

(a) State the name of the term $N\phi$ and its unit.

(2)

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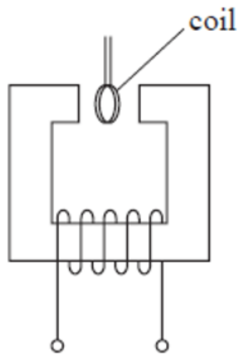
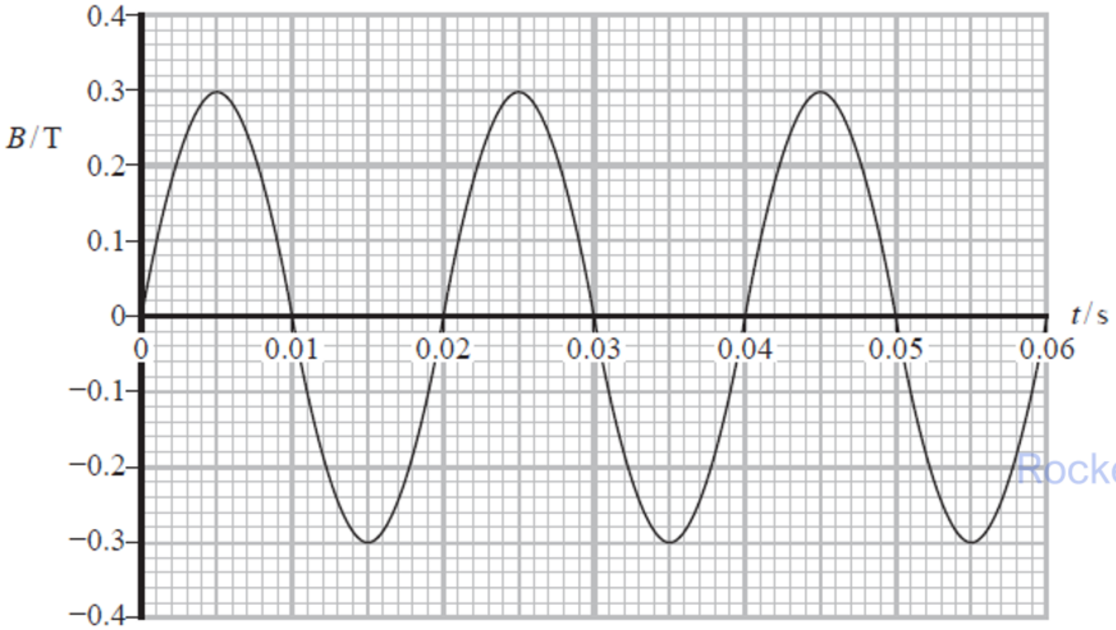
(b) A coil of 500 turns and radius 3.0 mm is placed between two poles of an electromagnet as shown. The terminals are connected to an a.c. power supply.



The magnetic flux density *B* perpendicular to the plane of the coil varies with time *t* as shown below.



Determine the maximum e.m.f. across the coil.

(6)

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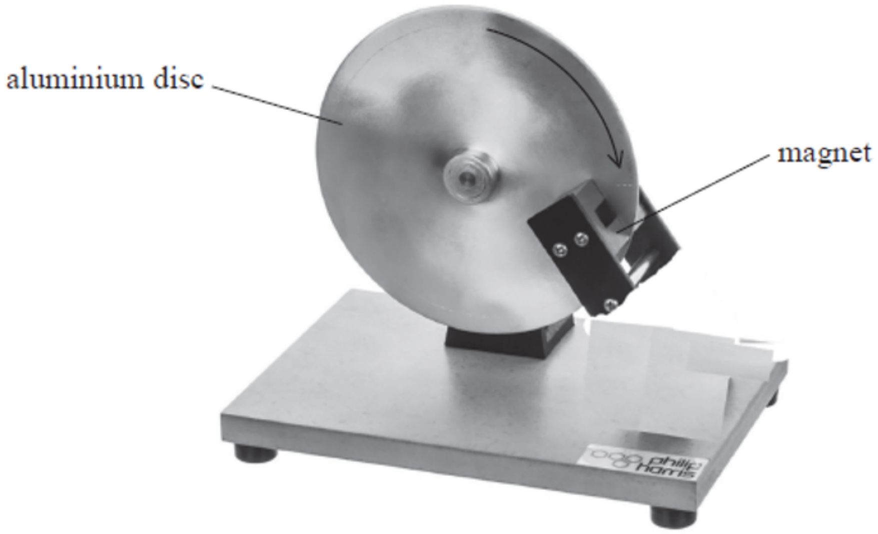
Maximum emf = ...

(c) Some electric motor designs rely on electromagnetic induction.

A laboratory demonstration of the principle of an induction motor is shown. An aluminium disc is free to rotate and is initially stationary. A powerful magnet is moved around the disc in the direction of the arrow, without touching the disc.



(Source: https://www.philipharris.co.uk/product/physics/electricity-and-electromagnetism/magnetism/eddy-current-unit/b8h79908)

A student suggests that the disc will start to rotate as the magnet is moved and that the disc will rotate in the same direction as the movement of the magnet.

Discuss this suggestion.

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(Total for question = 14 marks)

Q21.

The surface of a balloon can become charged by rubbing it against clothing. The charge on the surface of the balloon can be assumed to act as if it was concentrated at the balloon's centre.

Two balloons are suspended by cotton threads so that they just touch each other as shown in diagram 1. The two balloons are then given an equal negative charge and repel as shown in diagram 2. The dots represent the centre of each balloon.

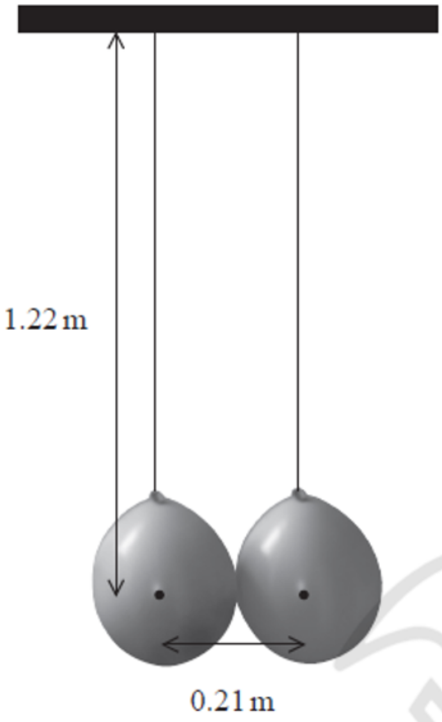

Diagram 1

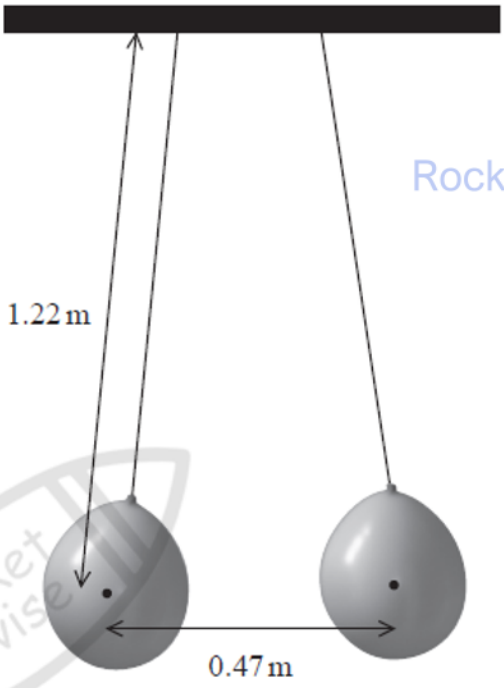

Diagram 2

(a) (i) Show that the force of repulsion between the balloons in diagram 2 is about 1×10^{-3} N.

mass of each balloon = 1.1 grams

(4)

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(ii) Show that the charge on each balloon is about 2×10^{-7} C.

(2)

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(b) One balloon is removed and the remaining balloon returns to its original position.

Calculate the electric potential at a distance of 0.30 m from the centre of the remaining balloon.

(2)

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Electric potential = ...

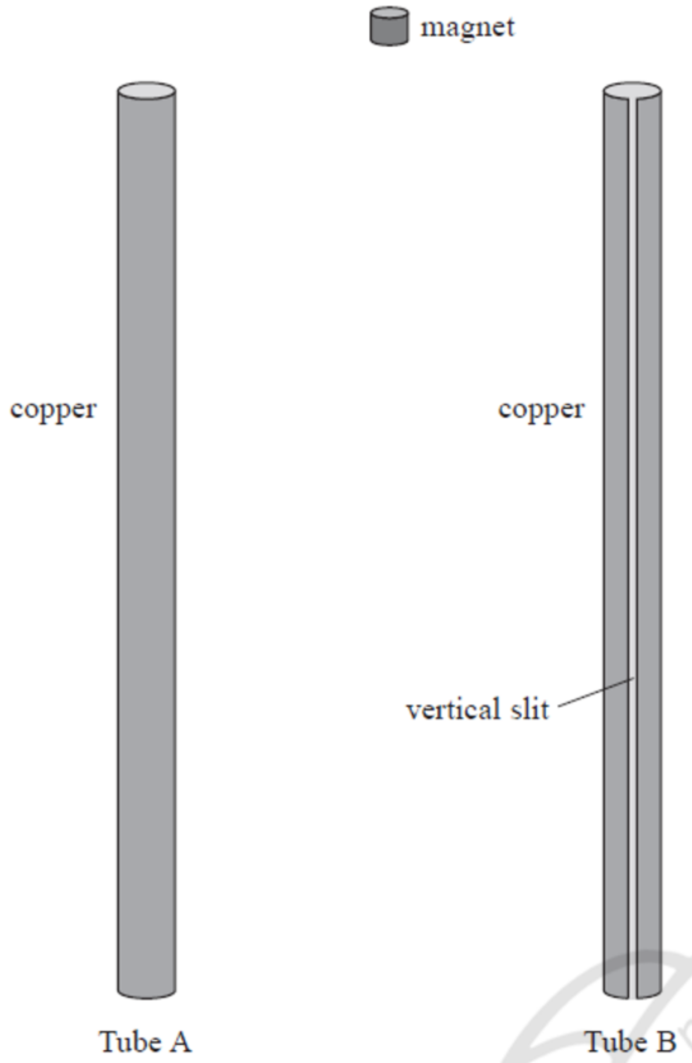
(Total for question = 8 marks)

Q22.

* A student uses a strong, cylindrical magnet to investigate Lenz's law.

The student records the time taken for the magnet to fall through two hollow tubes of copper, tube A and tube B.

The two tubes have the same length and cross-sectional area. Tube B has a vertical slit cut into it, as shown.



Discuss the differences in the time taken for the magnet to fall through each tube.

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(Total for question = 6 marks)

Q23.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The SI unit of magnetic flux density is the tesla.

Which of the following gives the base units of the tesla?

☐ **A** $N\ A^{-1}\ m^{-1}$

☐ **B** $N\ C^{-1}\ m^{2}$

☐ **C** $kg\ A^{-1}\ s^{-2}$

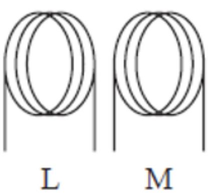
☐ **D** $kg\ C^{-1}\ s^{-1}$

(Total for question = 1 mark)

Q24.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Two coils, L and M, are placed next to each other as shown.



An alternating e.m.f. is induced across coil M.

Which of the following could produce this?

☒ **A** an alternating current in coil L

☒ **B** a constant current in coil L

☒ **C** a decreasing current in coil L

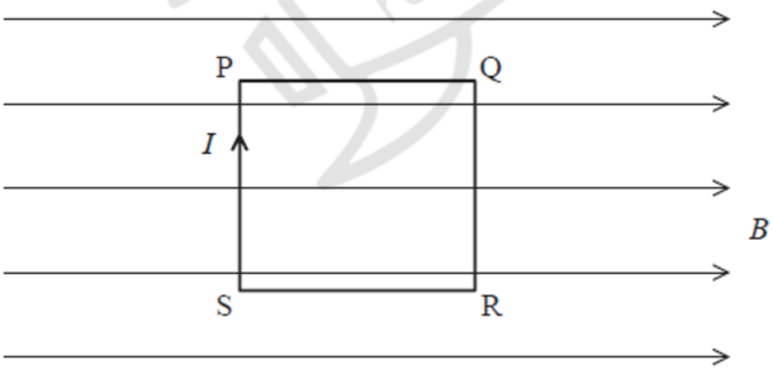
☒ **D** an increasing current in coil L

(Total for question = 1 mark)

Q25.

Select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A square coil PQRS has sides of length *l*. There is a clockwise current *I* in the coil as shown. The plane of the coil is parallel to a magnetic field of magnetic flux density *B*.



Which row of the table is correct?

	Side of coil	Magnetic force
☒ **A**	PQ	0
☒ **B**	QR	0
☒ **C**	RS	BIl into page
☒ **D**	SP	BIl out of page

(Total for question = 1 mark)

Q26.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following is a possible unit for magnetic flux?

☐ **A** T m^2

☐ **B** T m^{-2}

☐ **C** Wb m^2

☐ **D** Wb m^{-2}

(Total for question = 1 mark)

Q27.

A student placed two magnets on a holder so that the north pole of one magnet faced the south pole of the other magnet. The arrangement was placed on a sensitive balance, calibrated to measure force.

The student held part of a closed loop of wire between the magnets, as shown in the photograph.

* (a) When the student moved the wire quickly downwards between the magnets, the reading on the balance changed.

Explain how the reading on the balance changed.

(6)

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(b) A voltmeter was connected across the ends of a second wire.
The student moved this wire vertically downwards between the magnets at a constant speed.

A potential difference (p.d.) was observed on the voltmeter while the wire was moving.

Calculate the maximum p.d. that could have been measured.

length of each magnet = 34 mm
height of each magnet = 20 mm
magnetic flux density between magnets = 0.35 T
vertical speed of wire = 2.2 m s^{-1}

(5)

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Maximum p.d. = ...

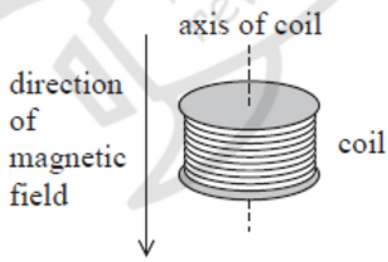
(Total for question = 11 marks)

Q28.

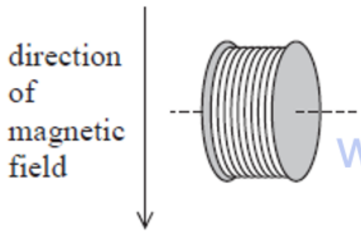
A search coil is used to investigate magnetic fields.

The search coil consists of a coil of thin copper wire connected to two output terminals, as shown.

A student placed the coil in a magnetic field with the axis parallel to the direction of the field, as shown.



The coil was rotated through 90° so the axis was perpendicular to the direction of the field, as shown.



As the coil was rotated, a potential difference (p.d.) was detected across the terminals.

(a) Explain why a p.d. was produced as the coil was rotated.

(2)

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(b) Show that the initial value of magnetic flux in the coil is about 9×10^{-5} Wb.

diameter of coil = 25 mm
magnetic flux density = 0.18 T

(3)

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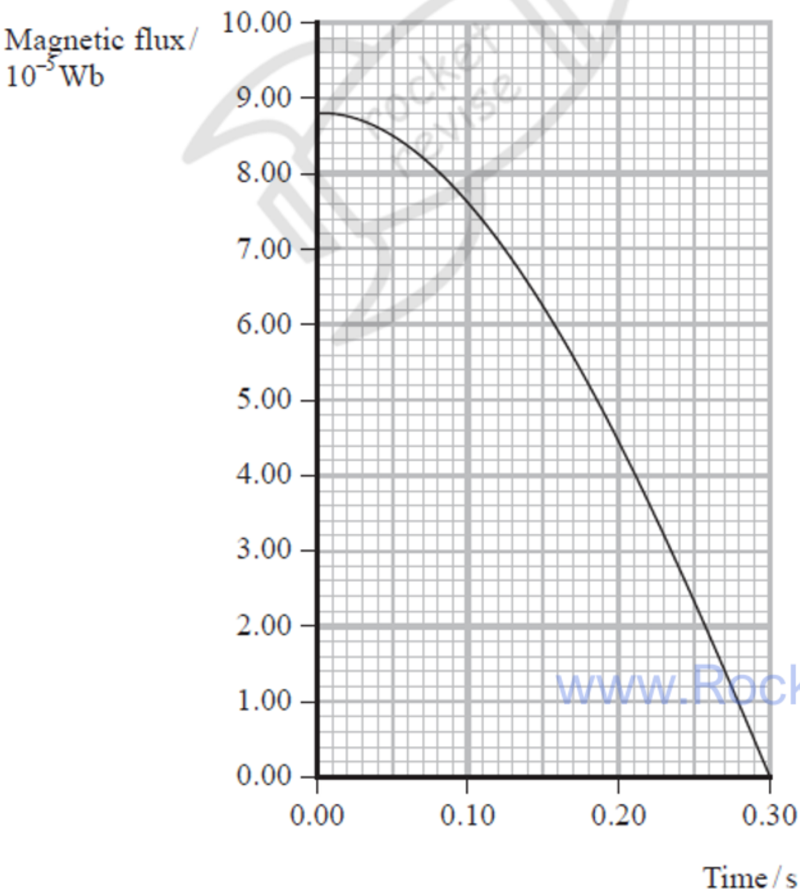
(c) The graph shows the magnetic flux in the coil while the coil was being rotated.



Determine the maximum p.d. produced across the terminals.

number of turns on coil = 5000

(4)

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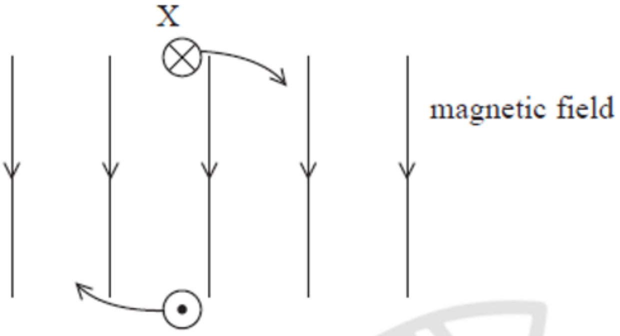
Maximum pd = ...

(d) The output terminals of the coil are connected together, while the coil is in the magnetic field. The diagram shows a cross-section through one turn of the coil. X is on one side of the coil.



The coil is rotated clockwise in the magnetic field, causing a current in the coil.
The student states that the current at X is into the page.

(4)

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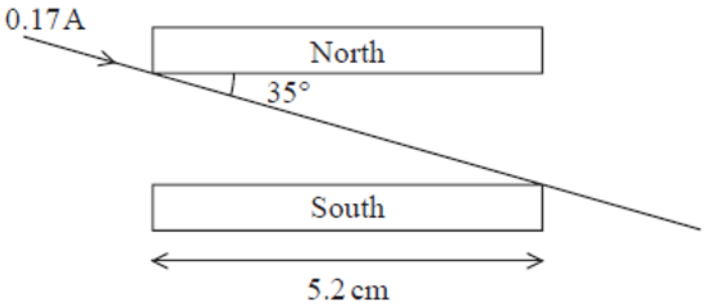
(Total for question = 13 marks)

Q29.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows a current-carrying wire between two magnetic poles.



The magnetic flux density between the poles is 0.85 T.

Which of the following gives the force on the wire in newtons?

☒ **A** 0.085 × 0.17 × 0.052 into the page

☒ **B** 0.085 × 0.17 × 0.052 × sin 35° into the page

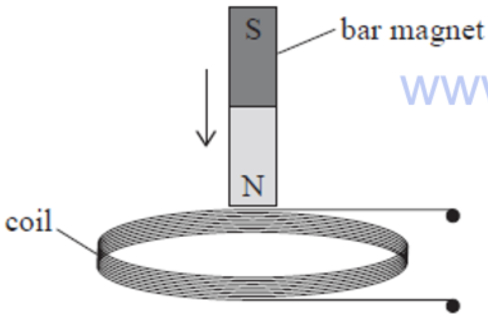
☒ **C** 0.085 × 0.17 × 0.052 out of the page

☒ **D** 0.085 × 0.17 × 0.052 × sin 35° out of the page

(Total for question = 1 mark)

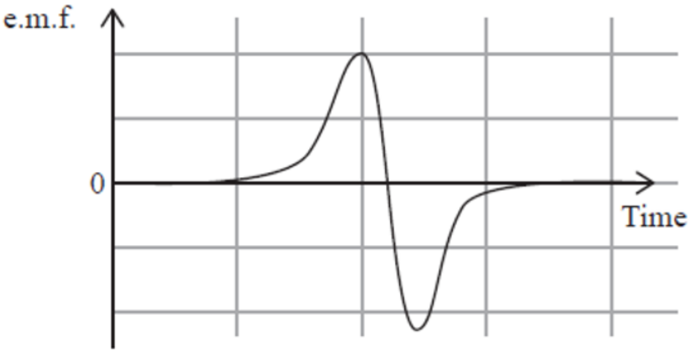
Q30.

* A bar magnet was dropped vertically through a small coil, as shown.



The coil was attached to a data logger. The data logger recorded the variation of e.m.f. across the coil with time.

The output from the data logger is shown below.



Explain the variation of e.m.f. with time.

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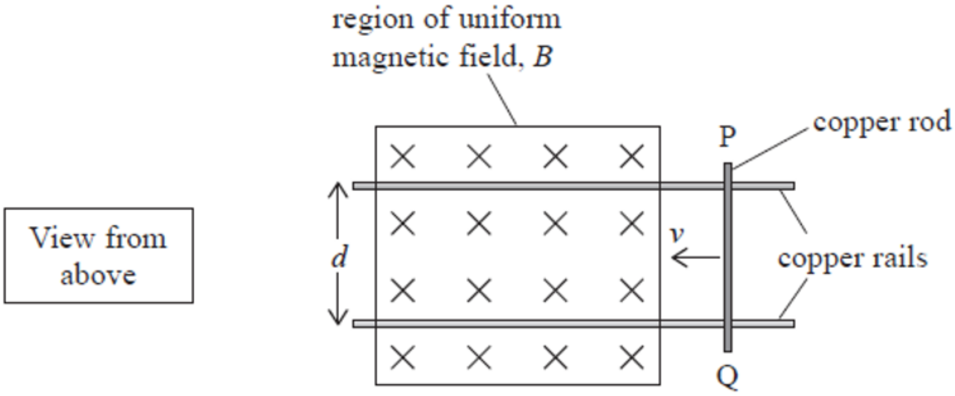
(Total for question = 6 marks)

Q31.

A copper rod, *PQ*, is moved with a velocity *v* along a pair of copper rails, as shown.
The rails are a distance *d* apart.



The rod and rails are in a uniform magnetic field that is directed vertically downwards.

(a) Calculate the e.m.f. induced across the copper rod.

B = 150 mT
$v = 3.5 \times 10^{-2}$ m s^{-1}
d = 7.5 cm

(3)

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Induced e.m.f. = ...

(b) Explain the direction of the induced e.m.f.

(3)

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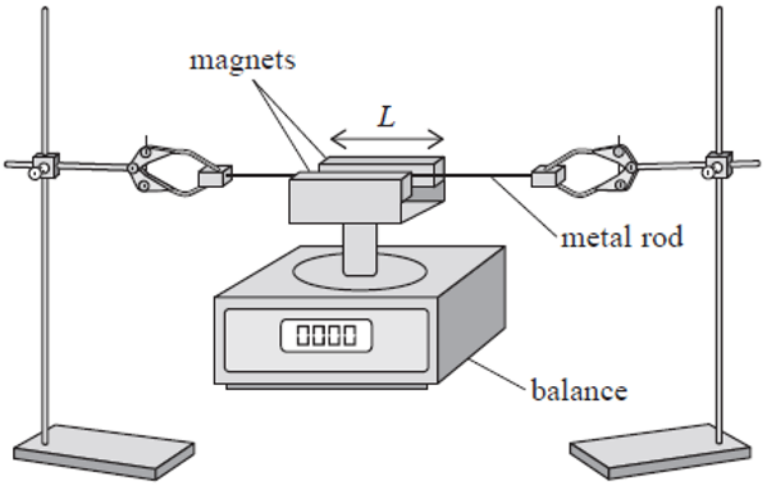
(Total for question = 6 marks)

Q32.

A student clamped a metal rod horizontally in a uniform magnetic field as shown.

The student connected the ends of the metal rod to a power supply, an ammeter and a switch in a series circuit. When the student closed the switch there was a current in the metal rod.



When the switch was closed, the reading on the balance increased by 2.8 g. The reading on the ammeter was 3.6 A.

The flux density of the magnetic field was 120 mT.
The length of the rod in the magnetic field was *L*.

Calculate *L*.

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L = ...

(Total for question = 3 marks)