Christ Church Grammar School

Science Department
Year 12 2021

ATAR PHYSICS
UNIT 3: ELECTROMAGNETISM
TEST 1 2021

Student Name: ______________________________

Teacher: CJO JRM PCW
(Please circle)

Time allowed for this paper
Working time for paper: 50 minutes.

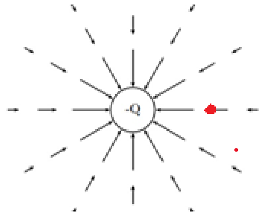
Instructions to candidates:

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Mark:	/ 53
=	%

Question 1 **(3 marks)**

Calculate the magnitude and direction of the electric field 12.5 cm East of a negative point charge of magnitude 5.30 µC.



Description	Marks
$E_{of\ q1} = \frac{F}{q_2}$ $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ $E_{of\ q1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r^2}$	1
$E = \frac{1}{4\pi(8.85\times10^{-12})}\frac{5.30\times10^{-6}}{(0.125)^2}$ = 3.05×10^6 NC^{-1} (or Vm^{-1})	1
WEST	1
Total	3

Question 2 **(5 marks)**

A student finds a piece of soft iron. Using a compass needle he is able to determine that the iron has no net external magnetic field.

(a) Describe two ways he could turn this piece of iron into a permanent magnet.

(2 marks)

Description	Marks
Exposing it to a strong existing permanent magnet for a reasonable period of time	1
Using a solenoid (coil of wire) and running an electrical current through this to produce an electromagnet. Inserting the iron inside this solenoid or placing it near this field for a reasonable period of time.	1
Total	2

The student is successful in magnetising the iron, much to the dismay of the laboratory technician.

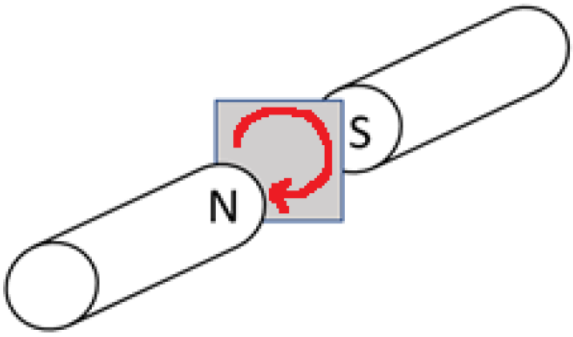
(b) Explain, with reference to domain theory, two ways that the technician could return the iron to a demagnetised state.

(3 marks)

Description	Marks
Hitting or dropping the soft iron with some force	1
Heating up the iron to above its Curie Temperature	1
This will cause the domains of the iron to become misaligned, returning the net magnetic moment of the substance to zero.	1
Total	3

Question 3 **(6 marks)**

A sheet of copper is placed between the opposite poles of a strong magnet with the magnetic field perpendicular to the sheet, as shown in the diagram below. A large force is required to pull the copper sheet out.



(a) Will the force required (circle your chosen response):

(1 mark)

A. Decrease when the speed of the pull is increased?

B. Increase when the speed of the pull is increased?

C. Not be affected by the speed of the pull?

(b) Explain the reasoning for your answer to (a) below

(4 marks)

Description	Marks
Faraday's law states that the magnitude of the induced EMF is proportional to the rate of change of magnetic flux with respect to time.	1
Lenz's law states that the direction of the induced EMF will oppose the change in magnetic flux that induced it	1
When the sheet is pulled through the metal, eddy currents are induced in the sheet, creating a drag force opposing motion OR The induced eddy currents create a magnetic field that interacts with the external magnetic field to produce and opposing force.	1
When the speed increases, the induced EMF increases, hence drag force is larger. A larger force is therefore required to pull the sheet through.	1
Total	4

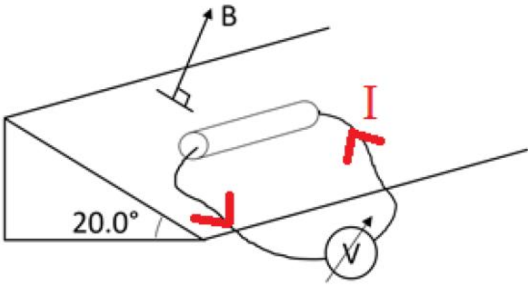
(c) Indicate on the diagram the direction of rotation of the induced eddy currents when the copper sheet is pulled to the right.

(1 mark)

Description	Marks
CLOCKWISE (Indicated on diagram)	1
Total	1

Question 4 **(8 marks)**

A straight piece of conducting metal of mass 100.0 g and length 20.0 cm is placed on a frictionless incline tilted at an angle of 20.0° to the horizontal. There is a uniform, 0.500 T magnetic field, B, perpendicular to the incline and directed out of the incline at all points, as shown in the diagram below.



To keep the metal from rolling down the incline, an adjustable voltage source is attached to the ends of the wire. When the correct amount of current flows through the metal it remains at rest.

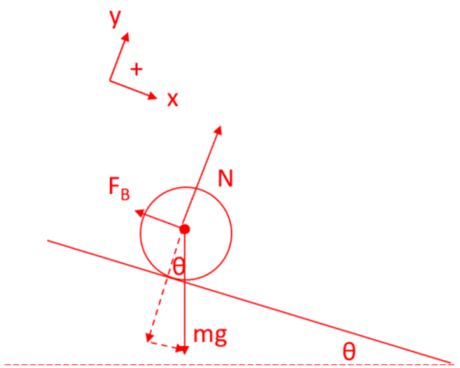
(a) On the diagram above indicate the direction of the current required to keep the metal at rest.

(1 marks)

Description	Marks
As indicated on diagram	1
Total	1

(b) Determine the magnitude of the current required to keep the metal at rest.

(4 marks)

<table>
<tr><td colspan="2">Description</td><td>Marks</td></tr>
<tr><td rowspan="2">
</td><td>$\sum F_x = 0$
$F = BIl$
$mg\ sin\theta - F_B = 0$</td><td>1</td></tr>
<tr><td>$I = \frac{mgsin\theta}{Bl}$
$I = \frac{(0.100)(9.80)sin20.0}{0.500(0.200)}$</td><td>2</td></tr>
<tr><td colspan="2">3.35 A</td><td>1</td></tr>
<tr><td colspan="2">Total</td><td>3</td></tr>
</table>

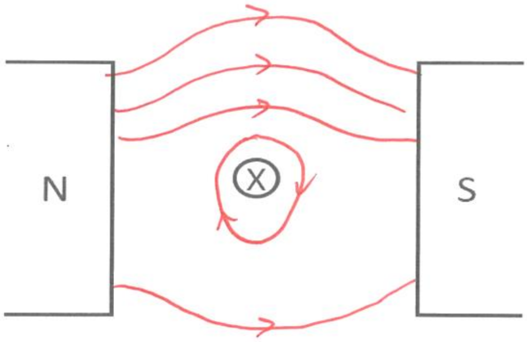
(c) If the magnetic field is now altered to point upwards in a vertical direction, would the amount of current required to keep the wire at rest, increase, decrease or stay the same? Explain your reasoning.

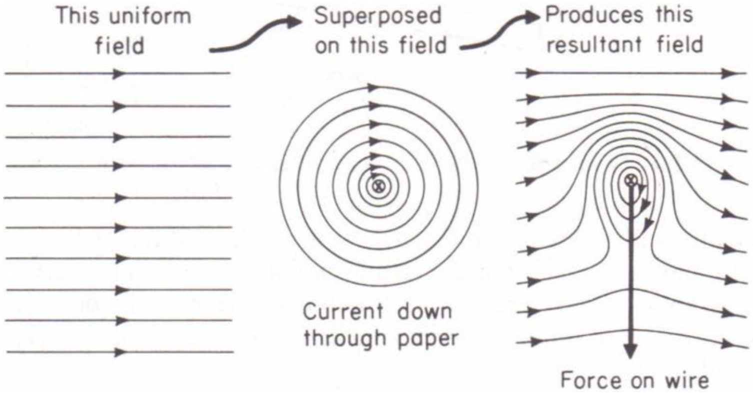
(3 marks)

Description	Marks
B and I are no longer perpendicular, only a component of B acts perpendicularly to I,	1
As F=BIl perpendicular, and B is reduced, the magnitude of force would reduce	1
Hence current would need to increase	1
Total	3

Question 5 **(3 marks)**

Draw the resultant magnetic field when a wire carrying current into the page is placed between two permanent magnets as shown.





Description	Marks
Direction of field lines between N and S magnet	1
Direction of field line around conductor	1
Overall shape. Density of lines above conductor is higher than below	1
Total	3

Question 6 **(4 marks)**

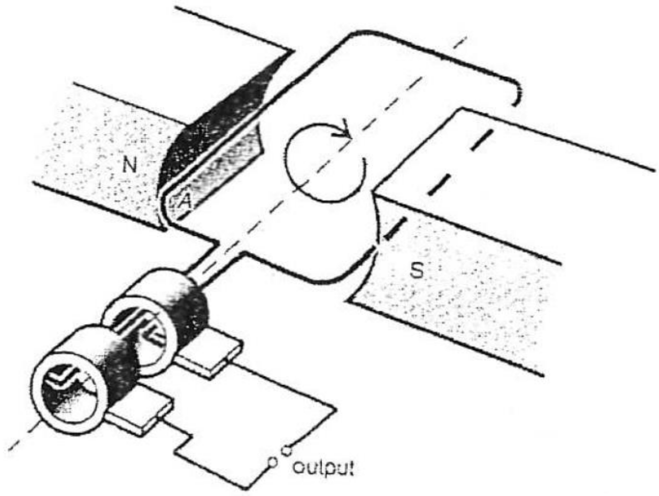
A generator at a power station produces electricity with a current of 1.10 x 10^2 A at 4.35 x 10^3 V. The voltage is stepped up to 2.55 x 10^4 V by a transformer before being sent across a high voltage transmission line across a rural area to a town. Assume the total resistance of the transmission lines are 32.0 Ω and that the transformers are ideal.

Calculate the power lost in the transmission lines.

Description	Marks
$P_{IN} = P_{OUT}$ P=VI V=IR $I_{OUT} = \frac{V_{IN} I_{IN}}{V_{OUT}}$	1
$I = \frac{4350(110)}{25500} = 18.8A$	1
P=I^2R = 18.8^2(32)	1
= 11,300 W	1
Total	4

Question 7 **(13 marks)**

A simple single phase generator has a coil of 200 turns. The coil is 14.0 cm long and 9.00 cm wide. The magnetic field in the generator has a strength of 0.150 T. The generator coil is turned at a rate of 3000 rpm.



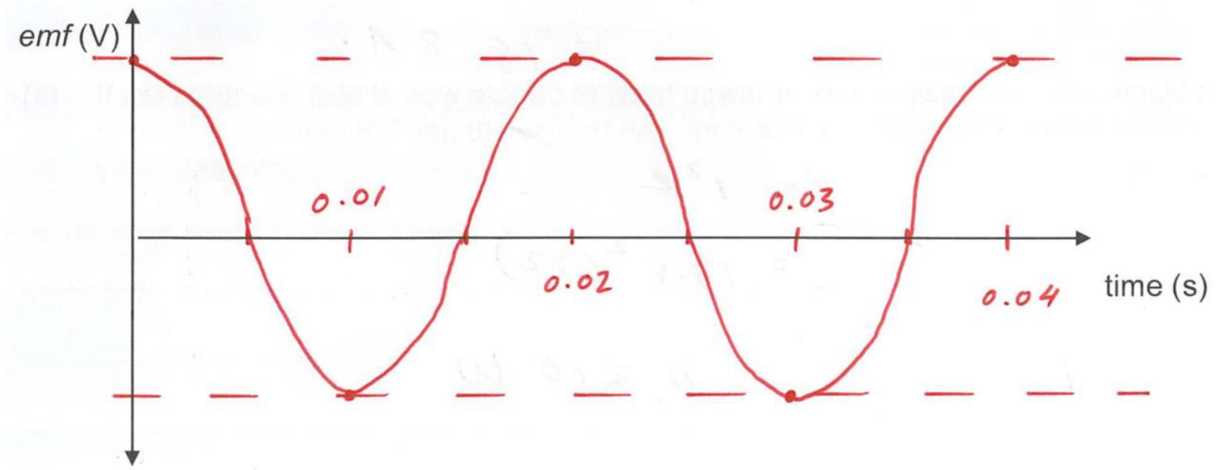
(a) Explain the purpose of the slip rings in the generator

(2 marks)

Description	Marks
Provides a constant connection to an external circuit, allowing current to be drawn (and used)	1
As the EMF across the armature alternates, so does output, hence produces AC power	1
Total	2

(b) On the following axes, draw a graph of the emf produced by the generator for at least two complete rotations from a starting position as shown in the diagram. Show the scales on the time axis and label all intercepts. You do not need to label the magnitudes on the vertical axis. (Working space for calculations is provided underneath)

(2 marks



Description	Marks
Period = 0.02s	1
Sinusoidal shape. Starts at maximum.	1
Total	2

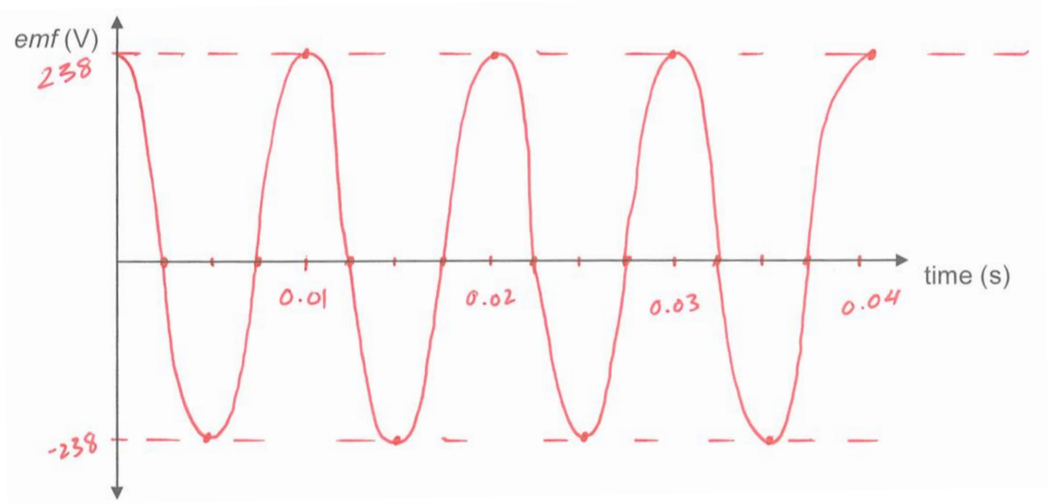
(c) Calculate the emf produced by this generator and state whether your calculated value is a maximum or average.

(3 marks)

Description	Marks
$\varepsilon_{max} = 2\pi BANf$	1
$\varepsilon_{max} = 2\pi(0.15)(0.14)(0.09)(200)(50)$	1
119 V MAXIMUM	1
Total	3

(d) On the following axis, draw a graph of the emf produced if the generator were turned at 6000 rpm instead of 3000 rpm. Using your answer to part (c) provide an approximate scale on the vertical axis.

(2 marks)



Description	Marks
Period is halved. 0.01s	1
Emf is doubled.	1
Total	2

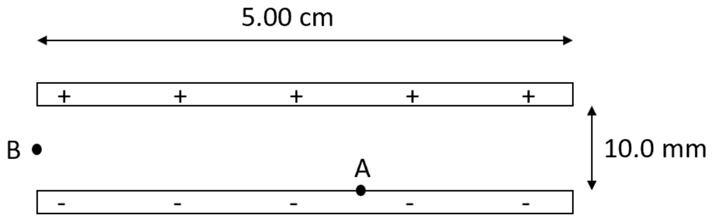
(e) State and explain two ways (other than frequency) in which the construction of the generator could be modified to increase the emf generated.

(4 marks)

Description	Marks
2 of the following: • Increase magnetic field strength (stronger magnet, soft iron core etc) • Increase Area (or either r or l) • Increase no of turns • Radial field magnets (increases perpendicular component of B) • Increased number of armatures (increases perpendicular component of B)	2
Explanation for each referring to $\varepsilon_{max} = 2\pi BANf$ Or fully justified with theory (rate of change of flux increased)	2
Total	4

Question 8 **(11 marks)**

Two parallel metal plates are separated by a distance of 10.0 mm with a potential difference of 9.00 V across them as shown.



(a) An electron is placed at Point A and released from rest. Calculate its velocity as it passes through the half way distance between the plates.

(3 marks)

Description	Marks
W=Vq W=E_K	1
½ mv^2 = Vq $v = \sqrt{\frac{2(4.5)(1.6\times10^{-19})}{9.11\ x\ 10^{-31}}}$	1
1.26 x 10^6 m s^{-1} UP	1
Total	3
Alternative methods acceptable. If v = 1.78x10^6 maximum 2 marks as the full 9 volt potential has been used instead of 4.5	

Another electron is fired horizontally through the midway point of the plates and released at point B with an initial velocity of 8.60 x 10^6 m s^{-1}.

(b) Calculate the electron's acceleration as it passes through the plates. Assume any effects of gravity are negligible.

(4 marks)

Description	Marks
$E = \frac{V}{d} = \frac{9}{10\times10^{-3}}$=900 N C^{-1}	1
$E = \frac{F}{q}$ $F = ma$ $E = \frac{ma}{q}$ $a = \frac{Eq}{m}$	1
$a = \frac{(900)(1.6\times10^{-19})}{9.11\ x\ 10^{-31}}$	1
1.58 x 10^{14} m s^{-2} UP	1
Total	4

(c) Calculate the electron's displacement from the positive plate as it leaves the field. (If you could not solve part (b) use a = 9.60×10^{13} m s $^{-2}$)

(4 marks)

Description		Marks
$t = \frac{s}{v} = \frac{(0.05)}{(8.60 \times 10^7)}$ = 5.81×10^{-9} s		1
$s = ut + \frac{1}{2}at^2, \quad u = 0$ s = ½ $(1.58 \times 10^{14})(5.81 \times 10^{-9})^2$		1
= 2.67×10^{-3} m	(alternative 1.62 mm)	1
Distance from plate = 5 - 2.67 = 2.33 mm	(alternative 3.38 mm)	1
	Total	4

END OF TEST