Life to the Full

Western Australian Certificate of Education
ATAR course examination, 2020

Question/Answer Booklet

12 PHYSICS

Name SOLUTIONS

Test 3 - Electromagnetism

Student Number: In figures

In words

Mark: $\frac{\quad}{41}$

Time allowed for this paper
Reading time before commencing work: five minutes
Working time for paper: fifty minutes

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens, (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers	-	-	-		
Section Two: Problem-solving	6	6	50	41	100
Section Three: Comprehension	-	-	-	-	-
				Total	100

Instructions to candidates

1. The rules for the conduct of examinations at Holy Cross College are detailed in the College Examination Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

6. Answers to questions involving calculations should be ***evaluated and given in decimal form***. It is suggested that you quote all answers to ***three significant figures***, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are ***clearly and legibly set out***.

7. Questions containing the instruction "estimate" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

8. Note that when an answer is a vector quantity, it must be given with magnitude and direction.

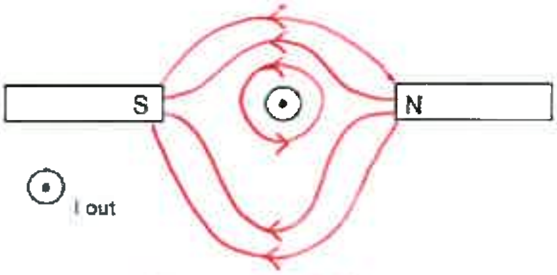
9. In all calculations, units must be consistent throughout your working.

1. Draw the field (magnetic or electric) associated with the following. (8 marks)

(a) The Earth.

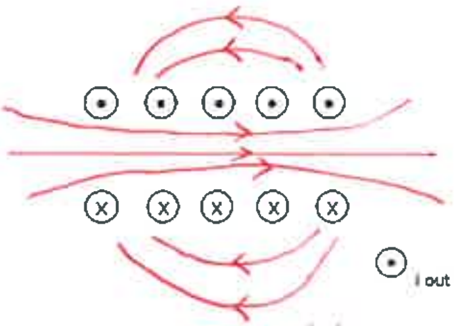
Direction (1)
Offset to N-S (1)

(b) A current-carrying wire in a magnetic field.



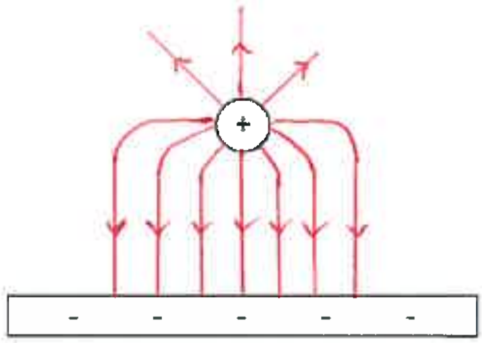
Direction (1)
Shape (1)

(c) A solenoid.



Direction (1)
Shape (1)

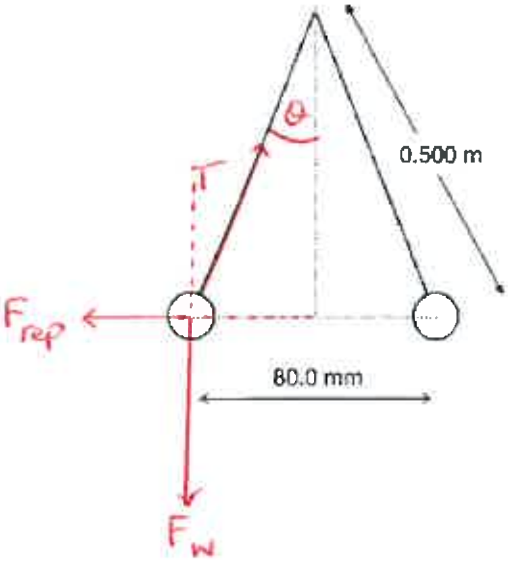
(d) Point charge near a charged plate.



Direction (1)
Shape (1)

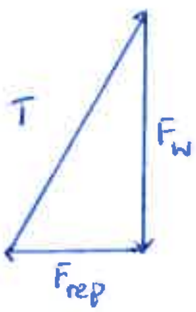
2. Two small spheres, each of mass 5.00 g, are supported from the same point by a light insulating thread 0.500 m long. When they are given equal charges, they repel each other so that the distance between is 80.0 mm. Determine the charge on each sphere.

(6 marks)



$$\sin\theta = \frac{0.0400}{0.500}$$

$$\Rightarrow \theta = 4.59° \quad (1)$$



$$\tan\theta = \frac{F_{rep}}{F_W}$$

$$\Rightarrow F_{rep} = mg\tan\theta \quad (1)$$

$$= (5.00\times10^{-3})(9.80)\tan 4.59°$$

$$= 3.934\times10^{-3}\,N \quad (1)$$

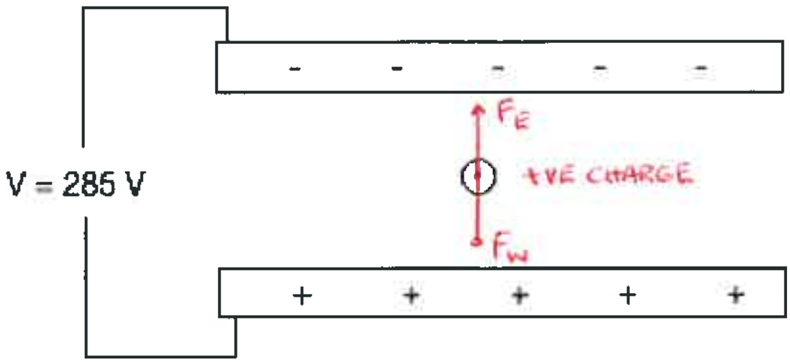
$$F_{rep} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1 q_2}{r^2}$$

$$\Rightarrow q = \sqrt{F_{rep}\,4\pi\varepsilon_0 r^2} \quad (1)$$

$$= \sqrt{(3.934\times10^{-3})\,4\pi\,(8.85\times10^{-12})(0.0800)^2} \quad (1)$$

$$= \underline{5.29\times10^{-8}\,C} \quad (1)$$

3. A small plastic sphere of mass 2.90×10^{-8} g, when introduced midway between two parallel plates 4.91 mm apart with a potential difference of 285 V across them, is found to "float". Calculate the magnitude and nature of the charge on the sphere, given the top plate is negative. (5 marks)



$$\Sigma F_v = 0$$

$$\Rightarrow \quad F_E = F_W \quad (1)$$

$$\Rightarrow \quad Eq = \frac{Vq}{d} = mg$$

$$\Rightarrow \quad q = \frac{mgd}{V} \quad (1)$$

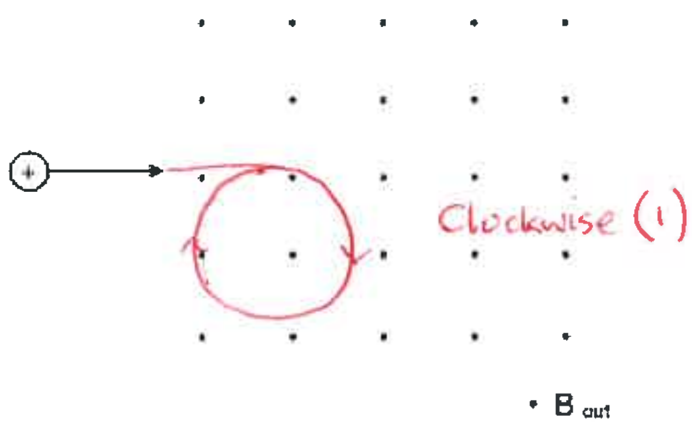
$$= \frac{(2.90 \times 10^{-11})(9.80)(4.91 \times 10^{-3})}{(285)} \quad (1)$$

$$= \underline{4.90 \times 10^{-15}\ C} \quad (1)$$

<u>The charge is +ve</u>. (1)

4. A proton enters a uniform magnetic field of 4.50×10^{-4} T directed vertically upward and moves in a horizontal circle of radius 0.633 m.

(a) In which direction (clockwise or anticlockwise) does the proton move? (1 mark)



(b) Determine the period of revolution of the proton. (4 marks)

$$r = \frac{mv}{qB} \quad \text{and} \quad v = \frac{2\pi r}{T}$$

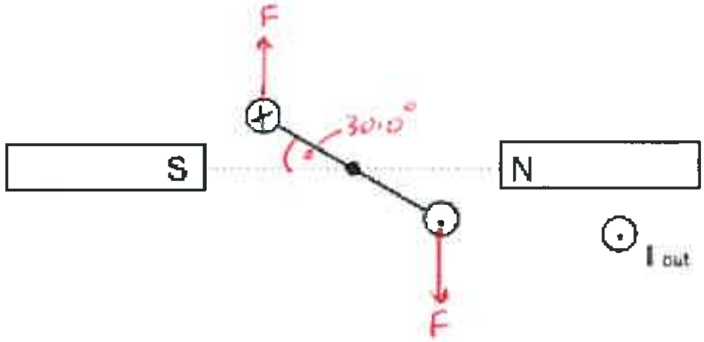
$$\Rightarrow \cancel{r} = \frac{m 2\pi \cancel{r}}{qBT} \quad (1)$$

$$\Rightarrow T = \frac{2\pi m}{qB} \quad (1)$$

$$= \frac{2\pi (1.67 \times 10^{-27})}{(1.60 \times 10^{-19})(4.50 \times 10^{-4})} \quad (1)$$

$$= \underline{1.46 \times 10^{-4}\ \text{s}} \quad (1)$$

5. A small rectangular coil 3.00 cm x 1.00 cm consists of 500 turns and is suspended in a uniform magnetic field of 0.400 T. The plane of the coil makes an angle of 30.0° to the field and the long side is at right angles to the field. A direct current of 12.0 μA flows in the coil.



(a) Find the force exerted on the long side of the coil. (3 marks)

$F = NI\ell B$ (1)

$= (500)(12.0\times10^{-6})(3.00\times10^{-2})(0.400)$ (1)

$= \underline{7.20\times10^{-5}\ \text{N}}$ (1)

(b) What is the maximum torque operating on the coil? (2 marks)

$M = 2\times F\times r$ (1)

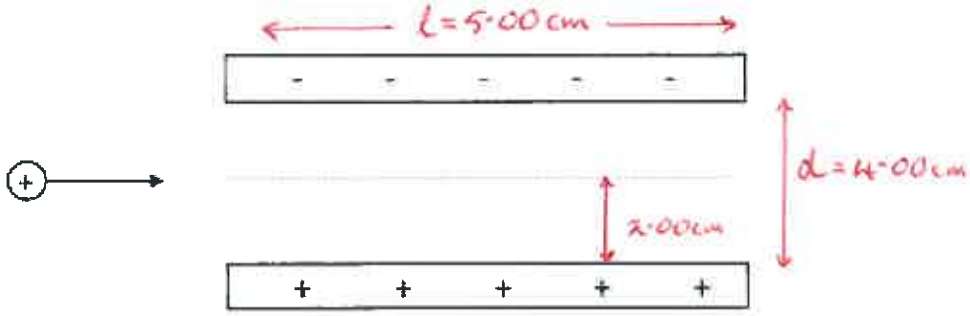
$= 2(7.20\times10^{-5})(5.00\times10^{-3})$

$= \underline{7.20\times10^{-7}\ \text{Nm clockwise}}$ (1)

(c) Describe the type of commutator required to keep the coil rotating in one direction and explain why it is necessary. (2 marks)

- Split-ring commutator. (1)
- Need to reverse the current direction every 180° of turn so the torque is in a constant direction. (1)

6. A proton is accelerated from rest in a particle accelerator by a potential difference of 2.50 kV. It then enters the region between two horizontal plates that are 4.00 cm apart, 5.00 cm long and with a potential of 5.00 x 10^2 V across them. The proton enters down the axis between the plates, equidistant from each.



(a) Calculate the horizontal velocity of the proton as it enters the field between the plates. (3 marks)

$$W = Vq = \frac{1}{2}mv^2$$

$$\Rightarrow v = \sqrt{\frac{2Vq}{m}} \quad (1)$$

$$= \sqrt{\frac{2(2{\cdot}50\times10^{3})(1{\cdot}60\times10^{-19})}{(1{\cdot}67\times10^{-27})}} \quad (1)$$

$$= \underline{6{\cdot}92\times10^{5}\ ms^{-1}} \quad (1)$$

(b) Determine the vertical displacement of the proton as a result of travelling between the plates. (7 marks)

HORIZONTALLY: $V_h = \frac{l}{t}$

$$\Rightarrow t = \frac{5{\cdot}00\times10^{-2}}{6{\cdot}92\times10^{5}} \quad (1)$$

$$= 7{\cdot}22\times10^{-8}\ s \quad (1)$$

VERTICALLY: $F_E = Eq = \frac{Vq}{d} = ma \quad (1)$

$$\Rightarrow a = \frac{Vq}{md} \quad (1)$$

$$= \frac{(5{\cdot}00\times10^{2})(1{\cdot}60\times10^{-19})}{(1{\cdot}67\times10^{-27})(4{\cdot}00\times10^{-2})}$$

$$= 1{\cdot}198\times10^{12}\ ms^{-2} \quad (1)$$

$v = ?$
$u = 0\ ms^{-1}$
$a = 1{\cdot}198\times10^{12}\ ms^{-2}$
$t = 7{\cdot}22\times10^{-8}\ s$
$s = ?$

$\uparrow$ +VE

$$s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2}(1{\cdot}198\times10^{12})(7{\cdot}22\times10^{-8})^2 \quad (1)$$

$$= \underline{3{\cdot}12\times10^{-3}\ m \text{ upwards}} \quad (1)$$