HOLY CROSS COLLEGE
Life to the Full

Western Australian Certificate of Education
ATAR course examination, 2018

Question/Answer Booklet

12 PHYSICS

Name SOLUTIONS

Test 4 - Electromagnetism

Student Number: In figures | | | | | | | | |

Mark: ___/59

In words _____

_____

Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: seventy 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	12	12	70	59	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***.

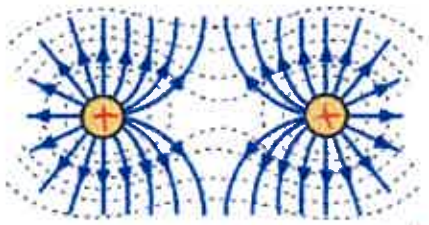
7. Questions containing the instruction "estimate" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

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

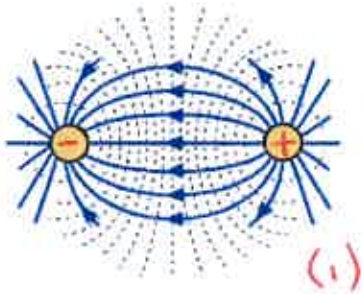
9. In all calculations, units must be consistent throughout your working.

1. On the diagrams shown below, write the ***polarity*** of each charge shown.

[2 marks]



(1)



(1)

2. Calculate the number of electrons in 1.00 nC of charge? **[2 marks]**

$$\#\text{electrons} = \frac{1.00\times10^{-9}}{1.60\times10^{-19}} \quad (1)$$

$$= 6.25\times10^{9} \quad (1)$$

3. The colour that shows on the touch screen of most modern mobile devices is determined by the charge that is delivered to the pixel. The charge specification for colour pixels of an iPhone or iPad tablet is shown in the table below.

Red	0.40 pC
Yellow	0.80 pC
Blue	1.20 pC
Violet	1.60 pC

If a high-energy cosmic particle with a charge equivalent of 7.50 million electrons strikes the touch screen, what colour pixel will be seen?

Use calculations to explain your answer. (**Note: no marks will be given for guessing.**)

[5 marks]

(1) (1)

$$q = (7.50\times10^{6})(1.60\times10^{-19})$$

$$= 1.20\times10^{-12}\ \text{C} \quad (1)$$

$$= 1.20\ \text{pC} \quad (1)$$

∴ Blue will be seen. (1)

4. A charge of 4.00 μC placed inside an electric field experiences a force of 0.120 N. Calculate the electric field intensity. **[3 marks]**

$$E = \frac{F}{q}$$

$$= \frac{0.120}{4.00 \times 10^{-6}} \quad (1)$$

$$= 3.00 \times 10^{4} \ NC^{-1} \quad (1) \quad (1)$$

5. An alpha particle (He^{2+}) with a mass of 6.40×10^{-27} kg is placed in a uniform electric field of strength 50.0 NC^{-1}. Calculate the acceleration of the particle inside the field region. **[4 marks]**

$$F = Eq = ma$$

$$\Rightarrow a = \frac{Eq}{m} \quad (1)$$

$$= \frac{(50.0)(2 \times 1.60 \times 10^{-19})}{(6.40 \times 10^{-27})} \quad (1) \quad (1)$$

$$= 2.50 \times 10^{9} \ ms^{-2} \quad (1)$$

6. What potential difference is required between two electrodes in an electron gun to accelerate an electron from rest to a speed of 1.00×10^{6} ms^{-1}? **[4 marks]**

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

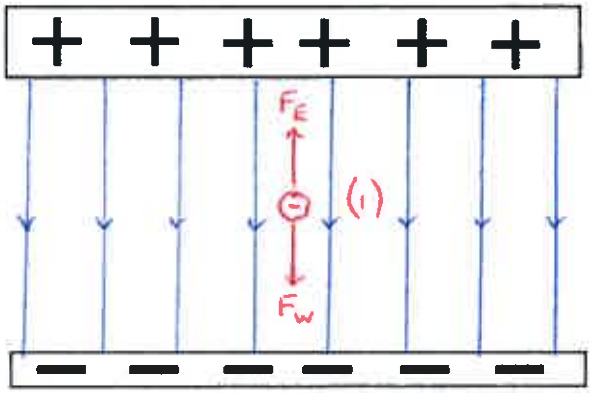
$$\Rightarrow V = \frac{mv^{2}}{2q} \quad (1)$$

$$= \frac{(9.11 \times 10^{-31})(1.00 \times 10^{6})^{2}}{2(1.60 \times 10^{-19})} \quad (1)$$

$$= 2.85 \ V \quad (1)$$

7. Consider the following parallel plate arrangement.

(a) Complete the diagram showing the electric field that exists between the plates. **[1 mark]**



Uniform field ($\frac{1}{2}$)
Direction ($\frac{1}{2}$)

(b) Draw an electron situated between the plates and show the forces acting on it. **[1 mark]**

(c) Calculate the electric field strength if the plates are 1.00 cm apart and connected by a 12.0 volt battery. **[1 mark]**

$$E = \frac{V}{d}$$
$$= \frac{12.0}{1.00 \times 10^{-2}}$$
$$= 1.20 \times 10^{3}\ V m^{-1} \quad (1)$$

(d) What voltage would have to be placed onto the plates for the electron to hover in the one spot between the plates? **[3 marks]**

$$\Sigma F_v = 0$$
$$\Rightarrow F_E = F_W$$
$$\Rightarrow Eq = mg$$
$$\Rightarrow \frac{Vq}{d} = mg \quad (1)$$
$$\Rightarrow V = \frac{mgd}{q}$$
$$= \frac{(9.11 \times 10^{-31})(9.80)(1.00 \times 10^{-2})}{1.60 \times 10^{-19}} \quad (1)$$
$$= 5.58 \times 10^{-13}\ V \quad (1)$$

8. One tiny metal ball carries a charge of +3.00 nC and a second ball, with identical shape, size and electrical properties, has a charge of -12.0 nC. What force exists between the charges if they are placed 30.0 mm apart? **[4 marks]**

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

Conversion (1)

$$= \frac{1}{4\pi(8.85\times10^{-12})} \cdot \frac{(3.00\times10^{-9})(12.0\times10^{-9})}{(30.0\times10^{-3})^2} \quad (1)$$

$$= \underset{(1)}{3.60\times10^{-4}}\ \underset{(1)}{\text{N attraction}}$$

9. A girl finds that her clothes are clinging together when she takes them from the hot air dryer. She finds that she needs to exert a force of 0.500 N to pull the clothing apart. If we assume that the charges on the pieces of clothing is equal and that they are 0.800 mm apart, calculate the charge being carried by each piece of clothing. **[4 marks]**

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

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

Conversion (1)

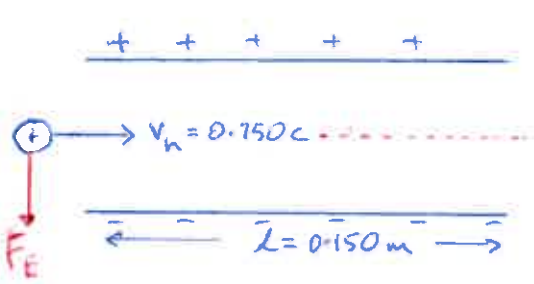
$$= \sqrt{4\pi(8.85\times10^{-12})(0.500)(0.800\times10^{-3})^2} \quad (1)$$

$$= \underset{(1)}{5.97\times10^{-9}\ \text{C}}$$

10. A nucleus of lead with a mass of 3.45×10^{-27} kg, is fired horizontally, between two parallel plates that are 4.00 cm apart, with a speed of 0.750c. If the plates are 15.0 cm long, and the potential difference across the plates is 50.0 kV, does the lead ion emerge on the opposite side of the plates?

(Hint - draw a diagram to show the forces acting on the ion as it moves between the plates.)

Note: all working must be shown. **[10 marks]**



Charge on nucleus $= 82 \times 1.60 \times 10^{-19}$ (1)

$= 1.31 \times 10^{-17}$ C (1)

VERTICALLY

$F_E = Eq = \frac{Vq}{d} = ma$

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

$= \frac{(50.0 \times 10^3)(1.31 \times 10^{-17})}{(3.45 \times 10^{-27})(4.00 \times 10^{-2})}$

$= 4.75 \times 10^{15}\ ms^{-2}$ (1)

HORIZONTALLY

$v_h = \frac{l}{t}$

$\Rightarrow t = \frac{0.150}{(0.750)(3.00 \times 10^8)}$ (1)

Conversion (1) →

$= 6.67 \times 10^{-10}$ s (1)

VERTICALLY

$v = ?$

$u = 0\ ms^{-1}$

$a = 4.75 \times 10^{15}\ ms^{-2}$

$t = 6.67 \times 10^{-10}$ s

$s = ?$

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

$= 0 + \frac{1}{2}(4.75 \times 10^{15})(6.67 \times 10^{-10})^2$ (1)

$= 1.06 \times 10^{-3}$ m (1)

$< 2.00 \times 10^{-2}$ m

$\therefore$ Nucleus makes it through (1)

11. Charged particles move in a circular path when travelling through a magnetic field.

(a) By equating the centripetal force and Lorentz force (magnetic force) experienced by the particle, show that the radius of the resultant circle is directly proportional to the ***momentum*** of the particle. **[3 marks]**

$F_B = F_C$ (1)

$\Rightarrow qvB = \frac{mv^2}{r}$

$\Rightarrow r = \frac{mv}{qB}$ (1)

$= \frac{p}{qB}$ (1)

$\Rightarrow r \propto p$

(b) A beam of particles with a charge of -1 is beamed across a magnetic field of strength 2.50×10^{-2} T. The beam bends into a circular path of radius 22.0 cm. If the particles are moving at 2.30×10^4 ms^{-1}, determine the mass of the particles.

[4 marks]

$r = \frac{mv}{qB}$ (1)

$\Rightarrow m = \frac{qBr}{v}$ (1)

$= \frac{(1.60 \times 10^{-19})(2.50 \times 10^{-2})(0.220)}{(2.30 \times 10^4)}$ (1)

$= 3.83 \times 10^{-26}$ kg (1)

12. An alpha particle enters a velocity selector with magnetic field of strength 3.70×10^{-2} T and at a velocity of 3.50×10^{5} ms^{-1}.

(a) What is the charged carried by the alpha particle? **[1 mark]**

$q = 2(1.60 \times 10^{-19})$

$= 3.20 \times 10^{-19}$ C (1)

(b) What is the electric field experienced by the alpha particle? **[2 marks]**

$F_E = F_B$

$\Rightarrow Eq = qvB$ (1)

$\Rightarrow E = (3.50 \times 10^{5})(3.70 \times 10^{-2})$

$= 1.29 \times 10^{4}$ Vm^{-1} (1)

(c) The alpha particle leaves the velocity selector (travelling to the right) and enters a mass spectrometer with a uniform horizontal magnetic field strength of 2.50×10^{-2} T, directed into the page. Calculate the force the magnetic field exerts on the particle as it passes through the mass spectrometer. **[3 marks]**

$F_B = qvB$

$= (3.20 \times 10^{-19})(3.50 \times 10^{5})(2.50 \times 10^{-2})$ (1)

$= 2.80 \times 10^{-15}$ N up the page

(1) (1)

(d) In the space provided below, draw the path of the alpha particle, as well as the path an electron would take. **[2 marks]**