VICTORIAN CERTIFICATE OF EDUCATION

2019

STUDENT NAME	MARK
	………….../41 …………...%
TEACHER CODE:	

PHYSICS

SAC 3: How do things move without contact?
Data analysis

Reading time: 5 minutes
Writing time: 55 minutes

QUESTION AND ANSWER BOOK

Section	*Number of questions*	*Number of marks*
Part A -	11	33
Part B -	1	8
Total	**12**	**41**

● Students are permitted to bring into the examination room: one single sided A4 sheet of notes, pens, pencils, highlighters, erasers, sharpeners, rulers, and one scientific calculator.

● Students are NOT permitted to bring into the examination room: blank sheets of paper, white out liquid/tape or a CAS calculator.

Materials supplied

● Question and answer book, MC answer sheet and a formula sheet.

Instructions

● Write your **name** in the space provided above on this page.

● Unless otherwise indicated, the diagrams in this paper are **not** drawn to scale.

● All written responses must be in English and in **blue or black pen.** Diagrams and graphs may be drawn in pencil.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices (watches) into the test room.

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2}mv^2 = qV$
field of a point charge	$E = \frac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \frac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current	$F = IlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G\frac{M_1M_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$

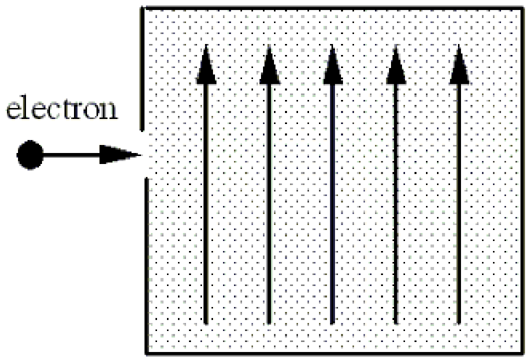
Prefixes/Units

p = pico = 10^{-12}	n = nano = 10^{-9}	μ = micro = 10^{-6}	m = milli = 10^{-3}
k = kilo = 10^{3}	M = mega = 10^{6}	G = giga = 10^{9}	t = tonne = 10^{3} kg

$k = 9.0 \times 10^9 Nm^2C^{-2}$

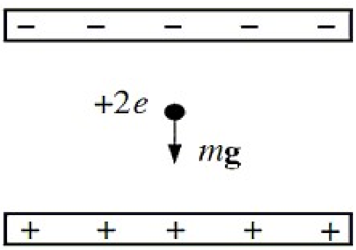
Part A:

1. An electron traveling horizontally enters a region where a uniform magnetic field is directed upward. What is the direction of the force exerted on the electron once it has entered the field?



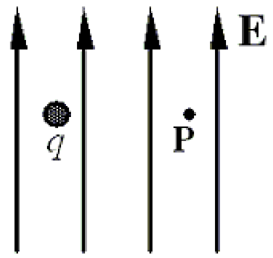
1 marks

2. An ion is located between the plates of a parallel-plate capacitor as shown. The ion has a charge of +2e. The magnitude of the electric field between the plates is $2 \cdot 10^{-7}\,\frac{V}{m}$. What is the mass of the ion if the electric force exactly balances the weight of the ion so that it remains stationary? $e = 1.6 \times 10^{-19}C$



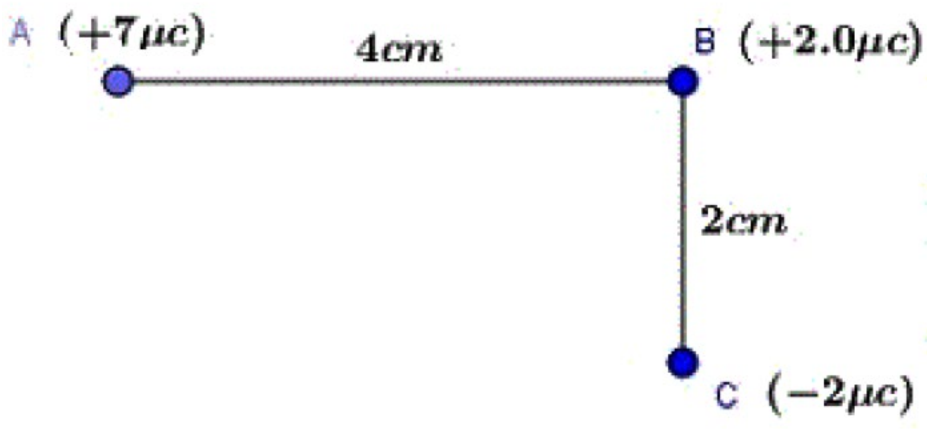
3 marks

3. An object electrically charged with the charge $q = 20\ nC$ is moved 2.0 m horizontally across the electric field in the picture below. The electric field strength is $2.1 \cdot 10^3\ \frac{V}{m}$. Calculate the work done by the electric force on the object.



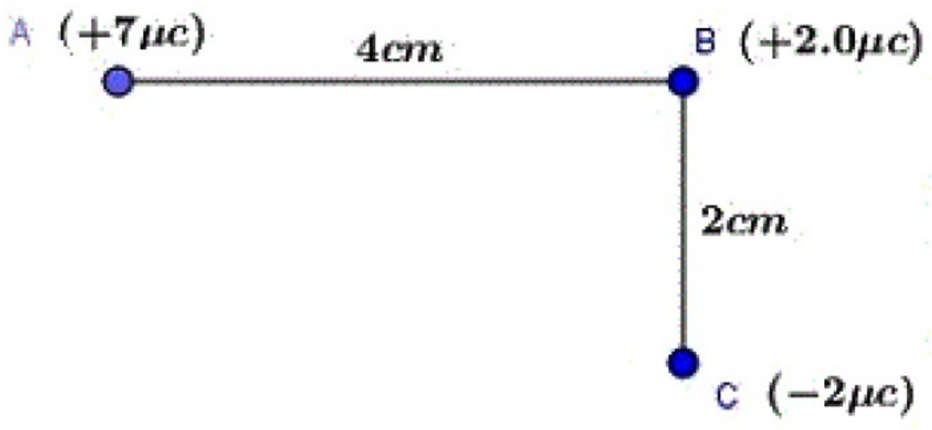
2 marks

4. What is the magnitude of the electric field generated by charge A at point B? What is the direction of this field?



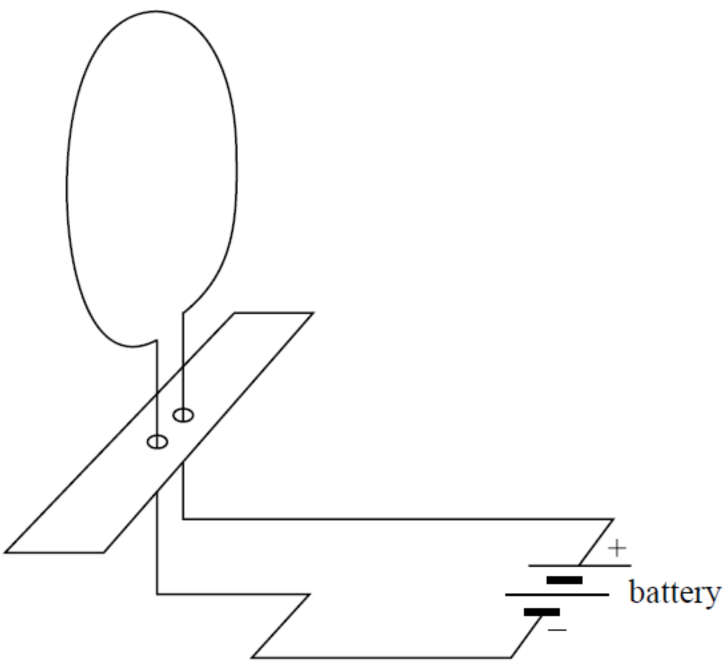
2 marks

5. What is the magnitude of the resultant electric force acting on charge B?



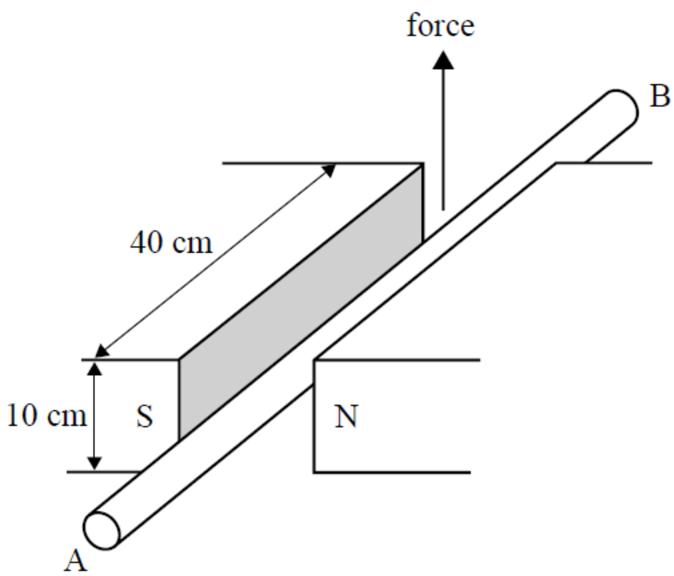
3 marks

6. Draw five magnetic field lines to show the magnetic field through the coil. You should include arrows to show direction.



2 marks

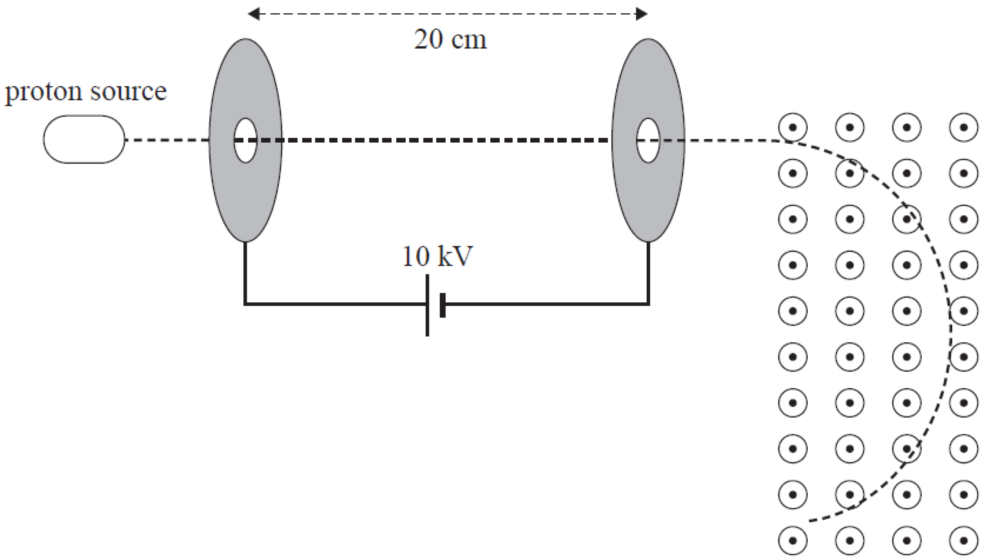
7. In the picture below, a current carrying wire AB is placed in a region with a magnetic field of $20 \cdot mT$. The force acting on the cable upwards is 0.008 N. What is the size and the direction of the electric current passing through the wire?



3 marks

6

8. A beam of protons is accelerated at 10 KV. After exiting the electric field the protons enter a region of magnetic field of $2.0 \cdot 10^{-2} T$. $m_{proton} = 1.6 \cdot 10^{-27} kg$



a. What is the speed of the protons after they exit the region of electric field?

2 marks

b. What is the radius of the circular trajectory described by the electrons in the magnetic field?

2 marks

9. In the table below you will find the period of revolution of the planets in the solar system and their distance from the Sun. Graph R^3-T^2 and find the mass of the Sun using the graph.

R(m)	T(s)	R^3	T^2
5.83×10^{10}	6.31×10^{6}		
1.08×10^{11}	1.89×10^{7}		
1.50×10^{11}	3.16×10^{7}		
2.28×10^{11}	6.00×10^{7}		

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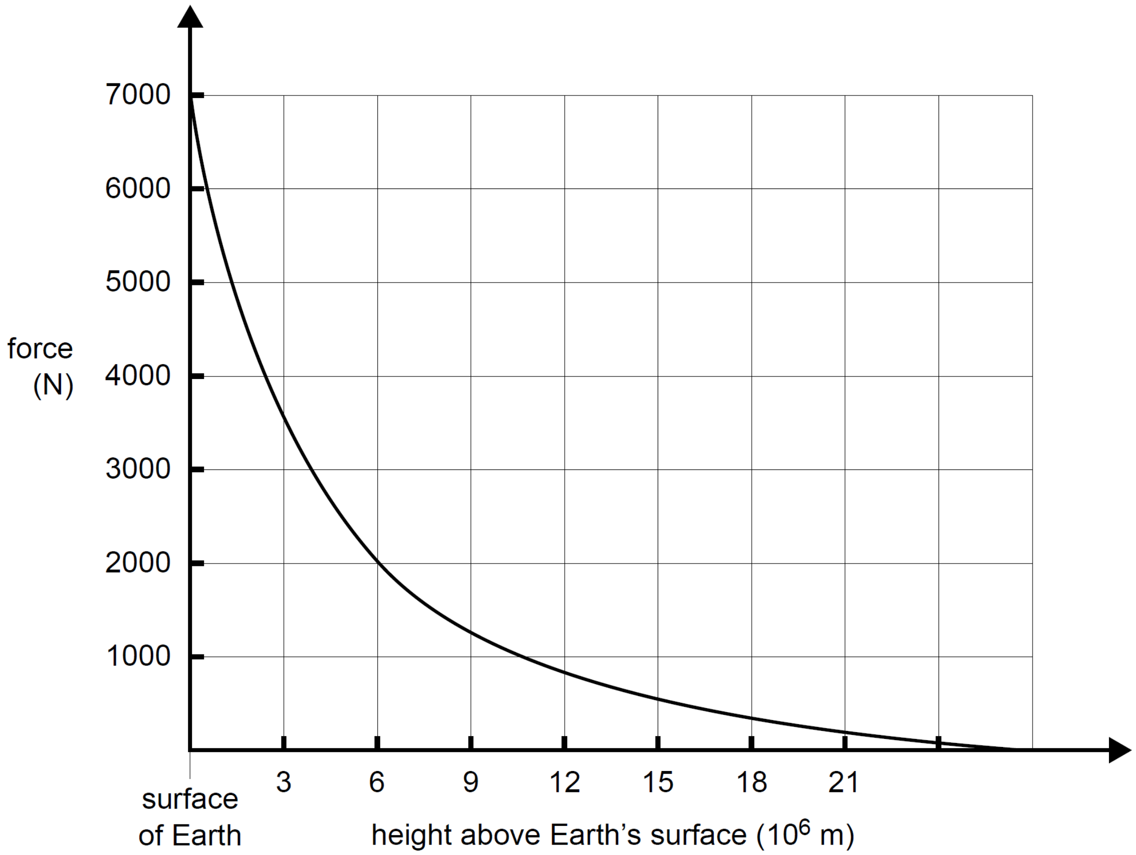
4 marks

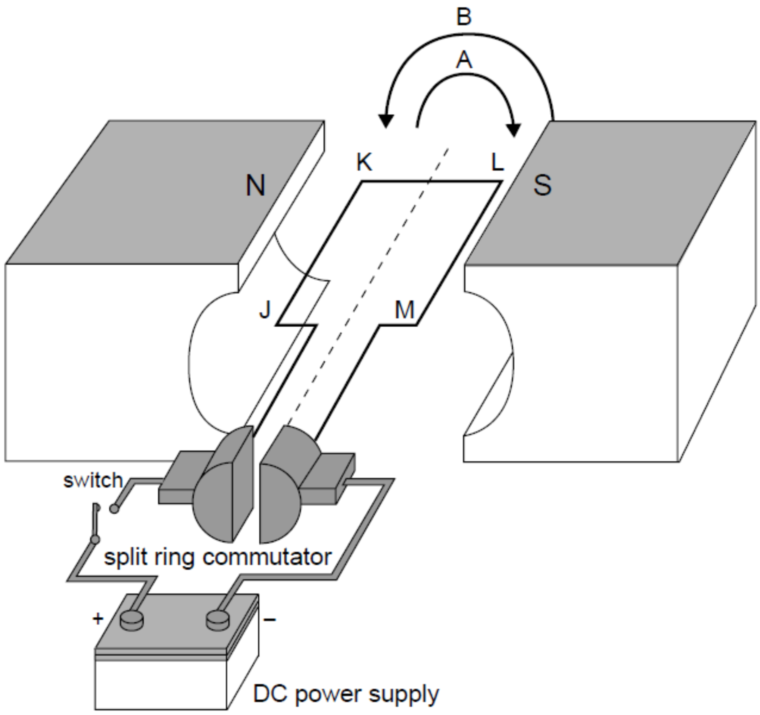
8

10. A 700 kg asteroid is plunging towards the Earth. At 6,000 km altitude the asteroid is moving at 50 km/s. Using the graph below find the kinetic energy of the asteroid at the impact with our planet.



3 marks

11. A DC electric motor has a 100 turns coil (JKLM), spinning in a magnetic field of 0.50 T. The size of the coil is 40 cm (JK) by 20 cm (KL). The power supply provides an electric current of 2.0 A.



a. In which direction, A (clockwise) or B (anticlockwise), will the motor rotate when the switch is closed?

1 mark

b. What is the magnitude of the magnetic force acting on side LM?

2 marks

c. What is the magnitude and direction of the magnetic force acting on side KL?

1 mark

d. Explain is the role of the split ring commutator in the good functioning of the motor?

2 marks

<u>END OF SECTION A</u>

12

Part B:

Question 1 (8 marks)

Figure 1

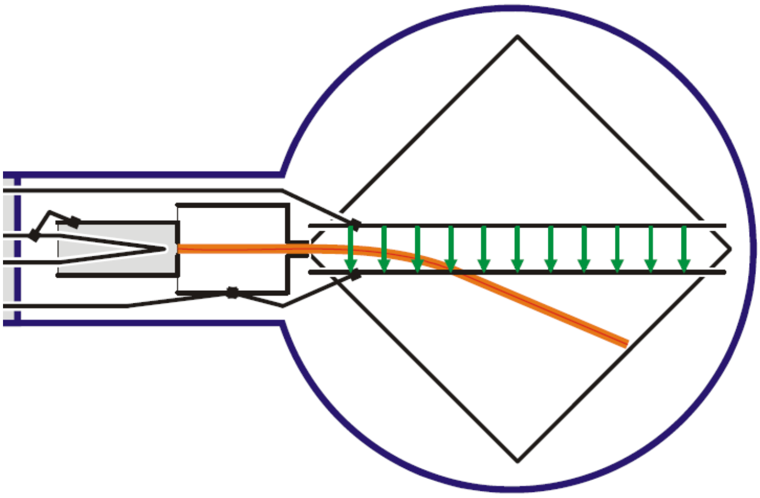


Figure 2

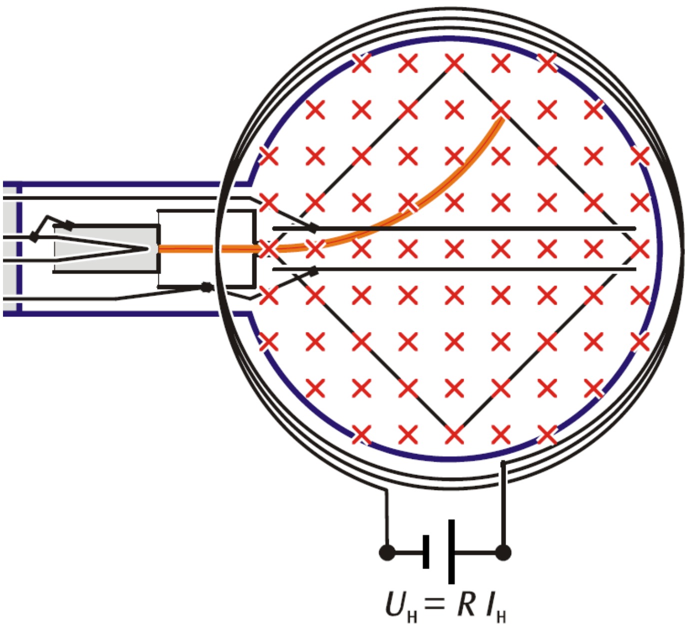


Figure 3

13

In the Thomson tube above, electrons are accelerated by a voltage between 0 V and 5000 V. The beam of electrons can be seen on the square fluorescent screen as blue light.

The electrons beam can be deflected by electric or magnetic fields as seen in the pictures above.
The aim of the experiment is to measure the specific charge of the electron, the ratio $\frac{e}{m}$.

The electrons are accelerated at a voltage U_A.

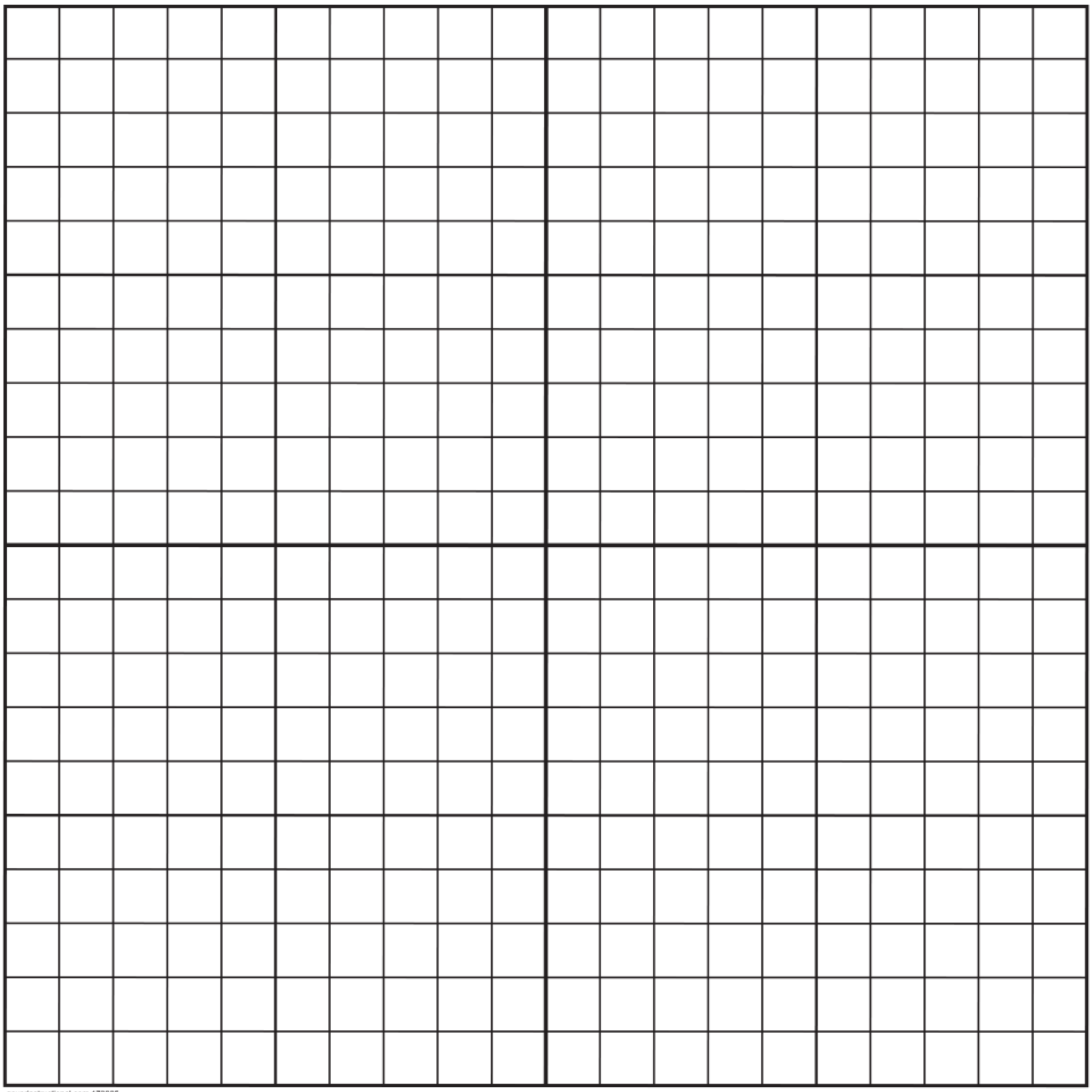
The velocity of the electrons can be measured using a velocity filter. To measure velocities using a velocity filter, students apply applies simultaneously equal electric and magnetic forces on the electrons. The electric and magnetic forces act in opposite directions such that the trajectory of the electrons remains straight.

During the experiment students have measured the velocity of the electrons using the velocity filter, for different accelerating voltages. The data is presented in the table below:

$U_A(10^3$ V)	v(10^7m/s)	$v^2(10^{14}$ m/s)
1.0	1.875	
2.0	2.543	
3.0	3.455	
4.0	3.755	
5.0	4.162	

Table 1

a. Graph v^2-U_A and determine the specific charge of the electron $\frac{e}{m}$ from the graph.



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5 marks

15

b. Explain the shape of the orange trajectories of the electrons presented in Fig 2 and 3.

3 marks

END OF SECTION B

END OF SAC

Year 12 Physics SAC - Fields - 21st May 2019

Data analysis

Part A

1.

Direction of the force - into the page

1 mark

2.

$$mg = F_e \quad \text{or} \quad mg = qE$$

1 mark

$$mx9.8 = 1.6x10^{-19} x2x10^{-7}$$

```
In[9]:= Solve[m * 9.8 == 1.6 * 10^-19 * 2 * 10^-7, m]
Out[9]= {{m → 3.26531 × 10^-27}}
```

---

1 mark

$$m = 3.3\,x10^{-27}\text{kg}$$

---

1 mark

3.

W=q V=0 J as V=0 V

2 marks

OR

W=Fxdxcos(α)=0 J as α=90^o

2 marks

W=0 J

I mark only

4.

$$E=k\ \frac{q}{r^2}$$

$9 * 10^9 * \frac{7*10^{-6}}{0.04^2}$

I mark

$E = 4\text{x}10^7\ V/m$

I mark

5.

$$F_{AB}=k\ \frac{q_A\, q_B}{r^2}$$

In[10]:=
```
9 * 10^9 * (7 * 10^-6 * 2 * 10^-6)/0.04^2
```
Out[10]= 78.75

I mark

$$F_{CB}=k\,\frac{q_C\, q_B}{r^2}$$

In[11]:= $9 * 10^{9} * \frac{2 * 10^{-6} * 2 * 10^{-6}}{0.02^{2}}$

Out[11]= 90.

1mark

$$F_{\text{total}} = \sqrt{F_{AB}{}^{2} + F_{CB}{}^{2}}$$

In[13]:= `Sqrt[78.75^2 + 90^2]`

`119.5891403932648` N

1 mark

6.

five field lines

1 mark

correct direction

1 mark

7.

F=IxLxB

$0.008 = I \times 0.4 \times 20 \times 10^{-3}$

1 mark

I=1A

1 mark

Direction - from A to B

1 mark

8.

a.

$\Delta E_K = qV$

$\frac{1}{2} mv^2 = eV$

$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 10000}{1.6 \times 10^{-27}}}$

1 mark

In[14]:= $\text{Sqrt}\left[\frac{2 * 1.6 * 10^{-19} * 10000}{1.6 * 10^{-27}}\right]$

Out[14]= 1.41421×10^{6}

$v = 1.4 \times 10^{6}$ m/s

1 mark

b.

$r = \frac{mv}{qB} = \frac{1.6 \times 10^{-27} \times 1.4 \times 10^{6}}{1.6 \times 10^{-19} \times 2 \times 10^{-2}}$

In[19]:= $\frac{1.6 * 10^{-27} * 1.4 * 10^{6}}{1.6 * 10^{-19} * 0.02}$

Out[19]= 0.7

R = 0.7 m
1 mark

9.

R^3 (10^{32} m)
1.99
12.7
33.5
119

0.5 marks

T^2 (10^{13} s)
3.98

35.9
99.6
360

0.5 mark
s
Symbols and units

0.5 marks

Scales

0.5 marks

Correct points

0.5 marks

line of best fit

0.5 marks

k = gradient

$3.3 \times 10^{18}\ m^3/s^2$
Range $(2.5 - 4.5 \times 10^{18}\ m^3/s^2)$

0.5 marks

$$M = \frac{k\,4\,\Pi^2}{G} = 2 \times 10^{30}\ kg$$
Range $(1.5 - 2.5 \times 10^{30}\ kg)$

0.5 marks

10.

$E_{k\,Final} = \Delta E_{P\,G} + E_{k\,Initial}$

1 mark

$\Delta E_{P\,G}$ = Area = 8.7 squares x 1000 x3×10^{6} J = 2.61×10^{10} J

1 mark

$$E_{k\,Initial} = \frac{700 \times 50000^2}{2} = 8.75 \times 10^{11}\ J$$

0.5 marks

In[20]:= $\frac{700 * 50\,000^2}{2}$

Out[20]= 875 000 000 000

```
In[21]:= ScientificForm[N[875 000 000 000, 12]]
```

Out[21]//ScientificForm=

$8.75000000000 \times 10^{11}$

$$E_{k\,Final} = 2.61 \times 10^{\wedge}10\ J + 8.75 \times 10^{\wedge}11\ J = 9.0 \times 10^{11}\ J$$

0.5 marks

11.

a. B - anticlockwise

1 mark

b. F=NBIL=100x0.50x2x0.4

1 mark

F=40 N

1 mark

c.

F=0 N

1 mark

d.

The SRC reverses the direction of the input current every half period and therefore reverses the direction of the forces on the coil every half period

1 mark

This preserves the torque in the same direction so the coil keeps spinning.

1 mark

Part B

Question 1

a.

$v^2(10^2\ m^2/s^2)$

3.52

6.47

11.94

14.10

17.32

0.5 marks

Symbols and units

1 mark

Correct scales

1 mark

Correct points

1 mark

line of best fit

0.5 marks

gradient=3.4x$10^{11}$$m^2/s^2$V
range - (2.9-4.0x$10^{11}$$m^2/s^2$V)

0.5 marks

$e/m = \frac{\text{grad}}{2}$=1.7x$10^{11}$$m^2/s^2$V OR C/kg
range - (1.2-2.2 x10^{11}) m^2/s^2V OR C/kg

0.5 marks

b.
in figure 2 there is a vertical electric force acting on the electrons.

1 mark

the trajectory in fig 2 is parabolic.

0.5 marks

in figure 3 there is a magnetic force acting on the electrons, perpendicular to their velocity

1 mark

the trajectory is circular.

0.5 marks