



VCE PHYSICS UNITS 3&4 [2020]

Unit 3 AOS 1 - How do things move without contact? - Topic Exam 1

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STRUCTURE OF EXAM

Section A - Multiple Choice	4 questions	9 marks
Section B - Short Answer	9 questions	34 marks
		43 marks

WHEN YOU FINISH

Get your marks, and view solution videos that explain the answer to each question at:

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SECTION A – MULTIPLE CHOICE

Question 1 (2 marks)

Figure 23 shows a coil placed next to a straight wire. When both the coil and the wire carry an electric current, there is a force exerted on the wire. The directions of the currents are shown by arrows on the diagram. The point X lies on the axis of the coil.

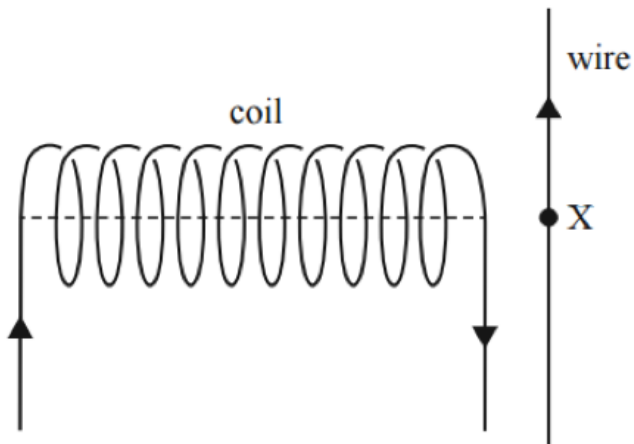


Figure 23

Question 1.a (1 mark)

Which one of the following best describes the direction of the **magnetic field** of the coil at point X?

- A left
- B right
- C up
- D down
- E out of the page
- F into the page

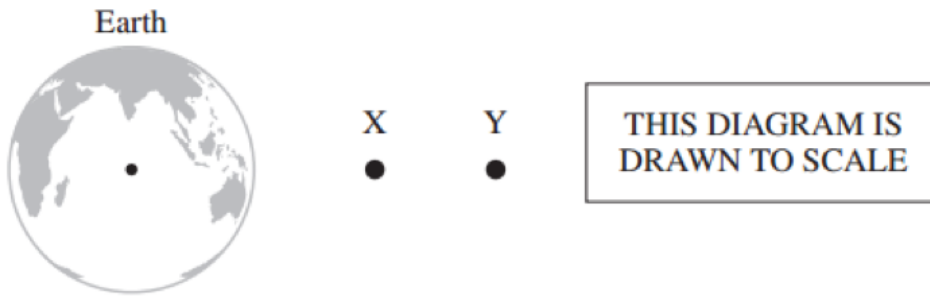
Question 1.b (1 mark)

Which one of the following best describes the direction of the **force on the wire** at point X?

- A left
- B right
- C up
- D down
- E out of the page
- F into the page

Question 2 (1 mark)

The gravitational force, due to Earth, on a mass positioned at X is F_x and on the same mass positioned at Y is F_y . The diagram is drawn to scale.



What is the value of $\frac{F_x}{F_y}$?

- A 1.5
- B 2.0
- C 2.25
- D 4.0

Question 3 (2 marks)

The first stage of the electrons' path through the synchrotron is the electron-gun injector, in which stationary electrons are initially accelerated by an electric field, E .

In a particular synchrotron, the electric field in the injector is 200 kV m^{-1} .

Which one of the following best gives the force on a single electron while it is in the field of the injector?

- A $9.1 \times 10^{-31} \text{ N}$
- B $1.6 \times 10^{-19} \text{ N}$
- C $3.2 \times 10^{-14} \text{ N}$
- D $1.8 \times 10^{-25} \text{ N}$

Question 4 (4 marks)

An electron gun is used to inject electrons into the linac of a synchrotron.

Figure 1 shows a schematic diagram of the electron gun.

The mass of the electron is 9.1×10^{-31} kg, and the charge on the electron is 1.6×10^{-19} C.

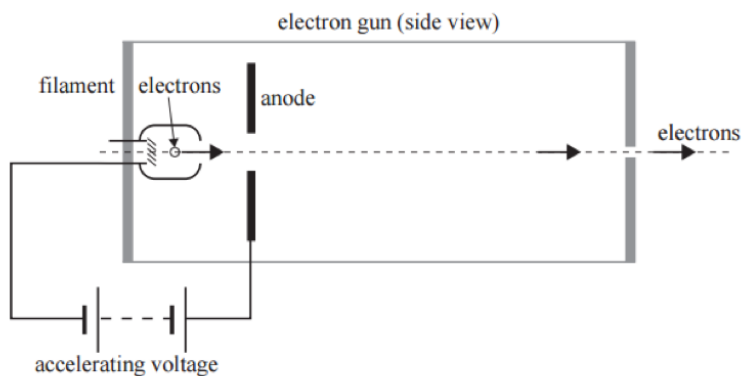


Figure 1

The electron gun is tested by first operating it at a low voltage. Using this voltage the acceleration of the electrons is $1.8 \times 10^{15} \text{ m s}^{-2}$.

An electron with a speed of $4.6 \times 10^7 \text{ m s}^{-1}$ then enters a uniform magnetic field and moves in a circular path. The radius of the path is 0.40 m. This is shown in Figure 2.

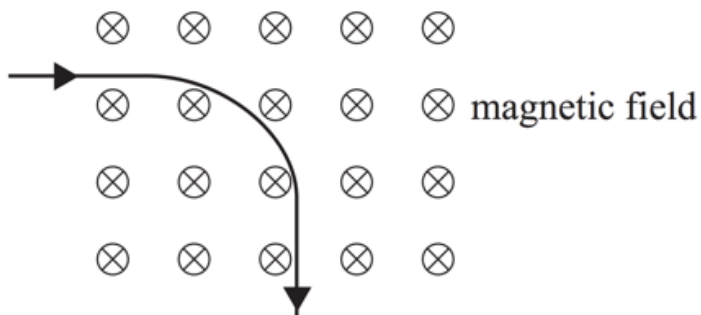


Figure 2

Question 4.a (2 marks)

What is the magnitude of the magnetic field required to achieve this path?

- A** $4.2 \times 10^{-3} \text{ T}$
- B** $6.5 \times 10^{-4} \text{ T}$
- C** $1.5 \times 10^3 \text{ T}$
- D** $3.0 \times 10^4 \text{ T}$

Question 4.b (2 marks)

The magnetic field is now adjusted to 5.0×10^{-4} T.

Which of the following now best gives the magnetic force on the electron?

- A** 4.80×10^{-17} N
- B** 3.68×10^{-15} N
- C** 2.40×10^{-14} N
- D** 3.68×10^{-7} N

SECTION B – SHORT ANSWER**Question 1**

2 marks

An electric field is produced between two charged parallel plates, M and N .

M

N

The plates, M and N , are 1.0 cm apart and have an electric field of 15 V m^{-1} . Calculate the potential difference between the plates.

Question 2 (5 marks)

Two parallel metal plates have a potential difference across them of 24 V. The distance between these two plates is 1.0 mm.

Question 2.a

3 marks

What is the electric field strength between the plates? You need to provide an appropriate unit for your answer.

Question 2.b

2 marks

What would be the work done on a charge of $+8.2 \mu\text{C}$, if it was moved from just in front of the negative plate to the positive plate?

Question 3

2 marks

If 2 point charges are separated in air by a distance of 25 cm.

Find the size of the electric force between them if both charges are $+3.2 \times 10^{-19} \text{ C}$.

Take Coulomb's Law constant to be $9.0 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$

Question 4

3 marks

An electron is projected at 90° into a magnetic field of $7 \times 10^{-4} \text{ T}$, at a speed of $1.5 \times 10^7 \text{ m s}^{-1}$. This results in the electron undergoing uniform circular motion.

Calculate the radius of the electron's path.

The mass of the electron is $9.1 \times 10^{-31} \text{ kg}$, and the charge on the electron is $1.6 \times 10^{-19} \text{ C}$.

Question 5 (4 marks)

A diagram of a DC motor is shown in Figure 21.

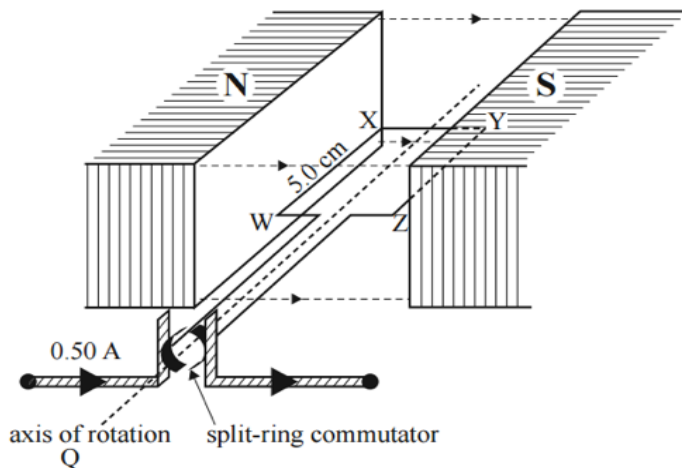


Figure 21

Question 5.a

2 marks

The motor is operating and the rectangular coil is rotating about the axis of rotation. Mary views the operating motor from point Q. Is the direction of rotation clockwise or anticlockwise? Give a reason for your answer.

Question 5.b

2 marks

While in the position shown in the diagram, a current of 0.50 A is flowing in the rotating coil. The coil has 20 turns and the magnetic field at the side labelled WX has a strength of 500 mT. The side WX has a length of 5.0 cm. Calculate the magnitude of the force on the side WX.

Question 6

2 marks

Explain the difference between F_g and F_N when considering the forces acting on a cat who is traveling in a satellite which is in a stable circular orbit around Earth. In your answer you should communicate whether these are zero or not.

Question 7

4 marks

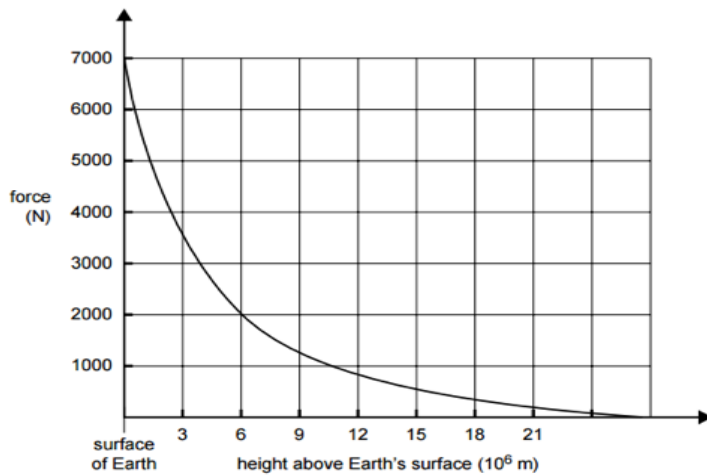
A distant star has a planet orbiting it. The period of the planet's circular orbit is 1200 hours. The radius of the planet's orbit is measured to be 7.0×10^{10} m.

Use the data above to calculate the mass of the star in kg. Show your working.

Question 8

3 marks

The Mars Odyssey spacecraft was launched from Earth on 7 April 2001 and arrived at Mars on 23 October 2001. Figure 1 is a graph of the gravitational force acting on the 700 kg Mars Odyssey spacecraft plotted against height above Earth's surface.

**Figure 1**

Estimate the minimum launch energy needed for Mars Odyssey to escape Earth's gravitational attraction.

Question 9 (9 marks)

Figure 3 below shows a diagram of a simple DC motor. The single square loop coil **TUVW**, of side 0.0090 m, is free to rotate about the axis XY. Current is supplied from a battery via the split-ring commutator.

The two permanent magnets provide a uniform magnetic field **B** of magnitude 0.25 T in the region of the coil.

The current flowing in the coil is 2.0 amp.

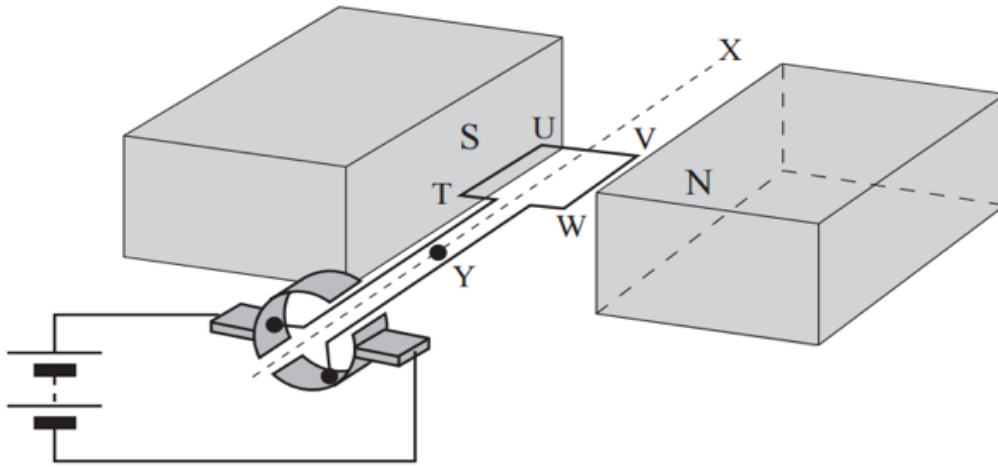


Figure 3

Question 9.a

2 marks

Indicate with an arrow the direction of *the force on side TU* of the coil in Figure 3.

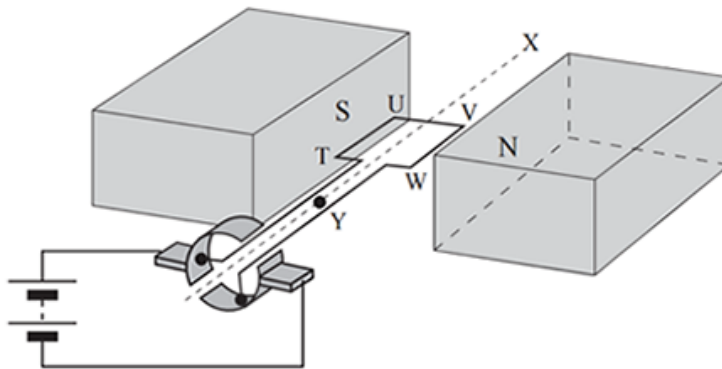


Figure 3

Question 9.b

2 marks

Calculate the magnitude of the force on the side **TU** of the coil. Show your working.

Question 9.c

2 marks

What is the magnitude of the force acting on side **UV** of the coil when in the position shown in Figure 3?

Question 9.d

3 marks

Explain the purpose of the split-ring commutator.
