Shenton College

Physics 3A

Electric Power Test

SHENTON
COLLEGE

Name____

Instructions

1 Answer ALL questions in the spaces provided.

2 This test consists of 3 sections

	Number of questions	Total marks	Mark obtained
A	4	20 marks	
B	4	25 marks	
C	1	10 marks.	
	TOTALS	55 marks	

3 Time allowed: **55 minutes**

4 Only supplied Curriculum Council Formulas and Constants Sheet can be used.

5 Only calculators approved by the C.C. may be used.

6 Borrowing of calculators or any other materials is NOT permitted.

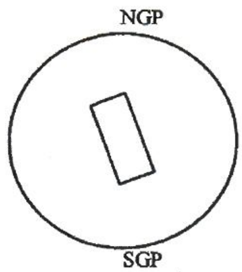
7 Give all numerical answers to 3 significant figures.

ALL CURRENT DIRECTIONS GIVEN ARE FOR CONVENTIONAL CURRENT

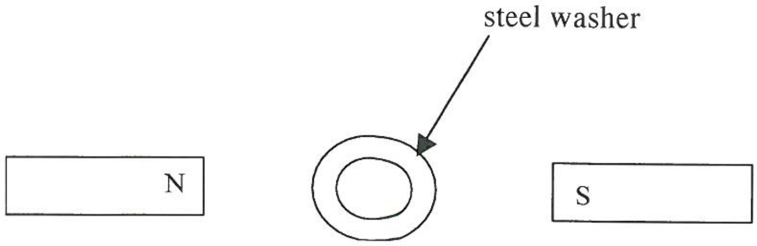
SECTION A Short Answer Questions (20 marks)

1 On the diagrams shown below sketch the shape and direction of the magnetic fields produced.

i) Earth's Magnetic Field



ii)



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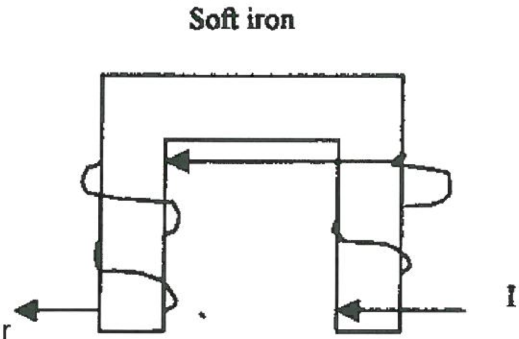

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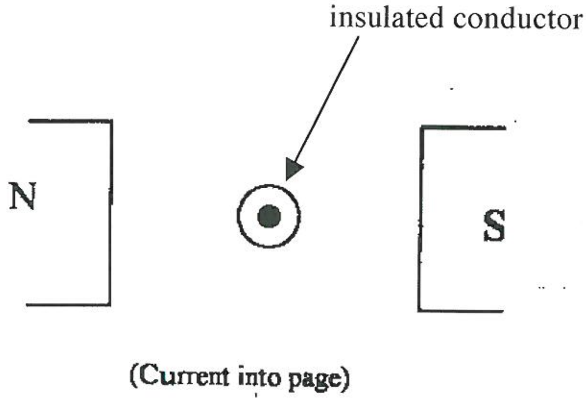
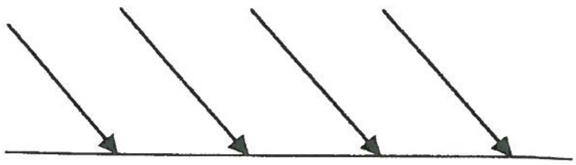
iv)



2 The sketch below shows some magnetic field lines near the surface of the earth.



Town X Town Y

a Given that the vertical component of the earth's magnetic field in this area is 4.00mT and you are driving a truck at 88 kmh^{-1} from Town Y towards Town X, calculate the emf across the front axle of length 1.52m.

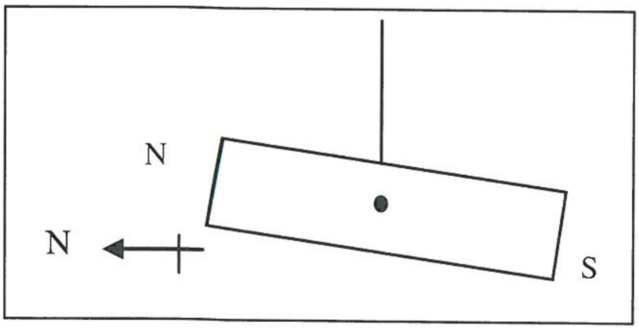
(3 marks)

3. Give clear explanations for each of the following.

(a) All ferromagnetic substances are believed to contain domains. What are domains and what evidence suggests their existence?

(2 marks)

(b) Explain why the magnet in the diagram, which is free to swing both horizontally and vertically, attains the position shown.



(2 marks)

4

(a) Which way would the coil need to be rotated (clockwise or anticlockwise) for the current to flow in the direction indicated?

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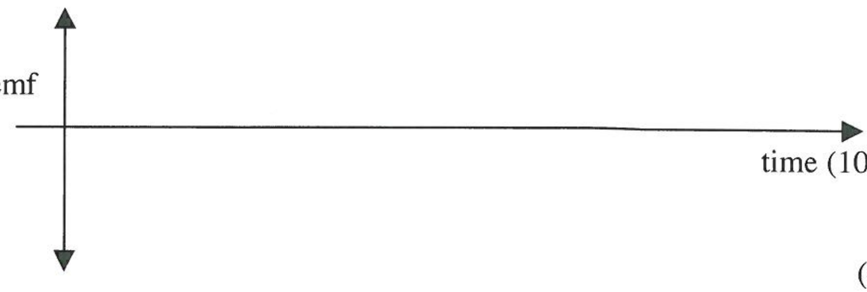
(1 mark)

(b) Sketch a graph to show the variation of emf with time during one complete, 360°, revolution of the coil from its current position.

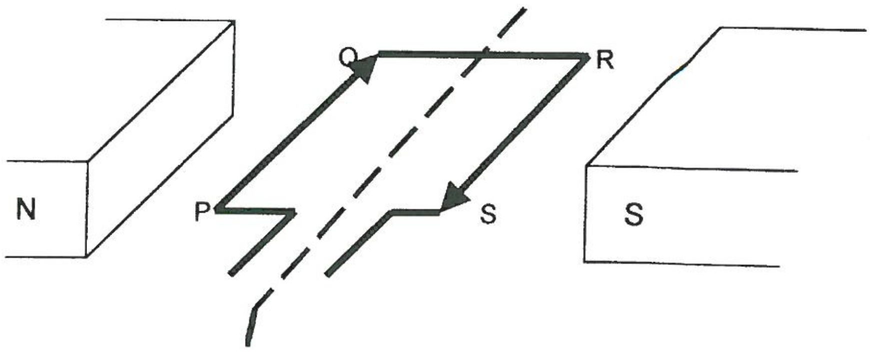


(4 marks)

SECTION B: Problem solving **(25 marks)**

This section contains 3 questions. **All of questions 1 to 3 must be answered.**

1 To investigate the performance a simple DC electrical **motor**, Marilyn winds 20 turns of copper wire into a rectangular coil of length 0.050m and width 0.040m. A schematic diagram of the arrangement is shown below.



At the instant shown, the plane of the coil is lying parallel to the uniform magnetic field of flux density 6.00 x 10^{-1} T when a current of 3.50 A flows as shown.

a) Calculate the force on the coil at PO.

(3marks)

b) In which position will the coil have zero torque?

(1 mark)

c) What is the maximum torque on the coil?

2 **Earth Leakage Protection**

Earth-leakage protection is designed as a means for protecting people against electrical shock which results from touching something connected to the active wire. The sketch below shows a typical earth leakage protection circuit which is designed to trip whenever the current flowing through the neutral wire drops below that flowing through the active wire.

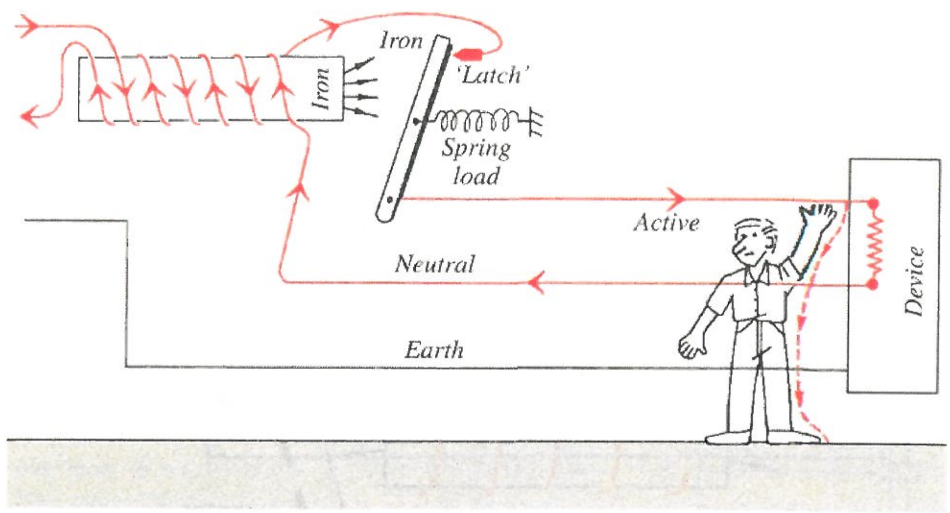


Figure 9 Earth-leakage protection circuit.

(a) Under **normal operating circumstances**, what would be

(i) the effect on the **iron** core by the current in the active wire?

(ii) the effect on the **iron** core by the current in the neutral wire?

(iii) the net effect on the **iron** core?

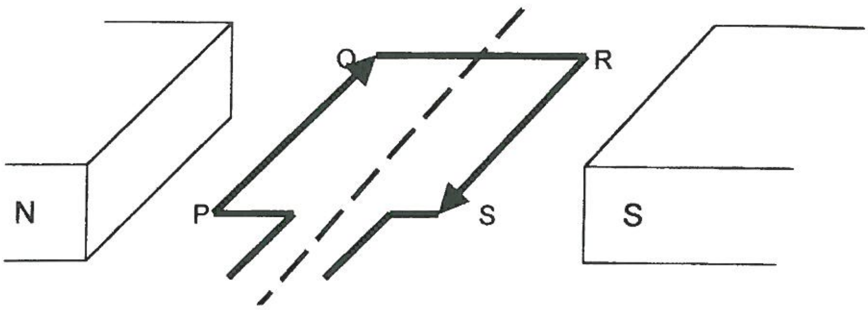
(3 marks)

(b) Explain what would occur if the current through the active wire was **greater than** the current through the neutral wire, (i e a short circuit to earth occurs)?

(3 marks)

3 To investigate the performance of a simple **AC generator**, Marilyn winds 20 turns of copper wire into a rectangular coil of length 0.050m and width 0.040m. The total resistance of the wire was measured as 1.03Ω.

(a) Complete the schematic diagram of the arrangement to show how the current is transferred from the coil to an external circuit.



(1 mark)

At the instant shown, the plane of the coil is lying parallel to the uniform magnetic field of flux density 6.00×10^{-1} T when a current of 3.50 Amps flows as shown.

(b) Determine the magnitude and direction of the minimum force required to spin the coil to produce a current of 3.50A.

(3 marks)

(c) What is the emf induced in the coil when a current of 3.50A flows?

(2 marks)

(d) How long does it take for the emf to go from a maximum to zero?

(3 marks)

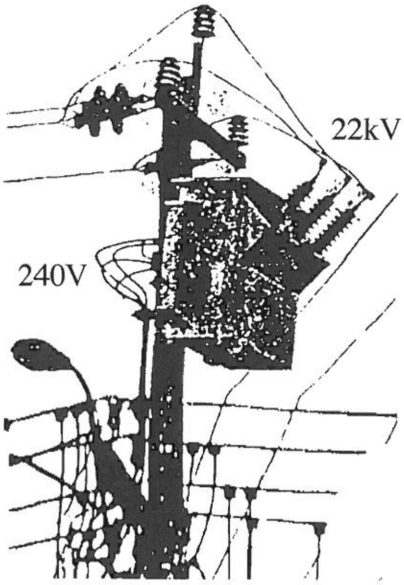
(e) What is the frequency of rotation of Marilyn's coil?

(2 marks)

4 The photograph is of a transformer mounted on a street pole in a suburban area.

(a) Is the transformer a step up or a step down?

(1 mark)



(b) Electric power lines carry energy over large distances. Explain why very high voltages are used to do this.

(2 marks)

(d) Eddy currents contribute to significant power losses in commercial transformers. What causes an eddy current and what method is used to minimise the effect?

(2 marks)

SECTION C: Comprehension (10 marks)

Read the passage carefully and answer all questions. Candidates are reminded of the need for clear and concise presentation of the answers.

EXPLOSIONS FROM MAGNETIC EFFECTS

When steel is poured from the furnace and solidifies in flat sheets, the iron atoms are lined up by the Earth's weak magnetic field. Not only does the sheet of steel have a slight magnetism, but also its magnetic field has the dip of the location where it is formed. In the northern hemisphere, the north end of the magnet points down, while in the southern hemisphere, the south end points down.

Magnetic mines were commonly used during World War II. They were placed on the bottom of the entrances to harbours and exploded when ships passed overhead. The magnetic mines responded to the weak magnetic field in the steel plate of the ship. The mine's mechanism was a magnet suspended at its centre so that the ends could move up or down. The magnet would align with the dip of the magnetic field at that latitude. Springs attached to the magnet held it in place. The magnet was part of a switch in an electric circuit which would ignite the explosive in the mine once the switch was closed. When a steel ship passed overhead, the mine's magnet and the alignment of the steel's magnetic field forced the magnet down and closed the switch.

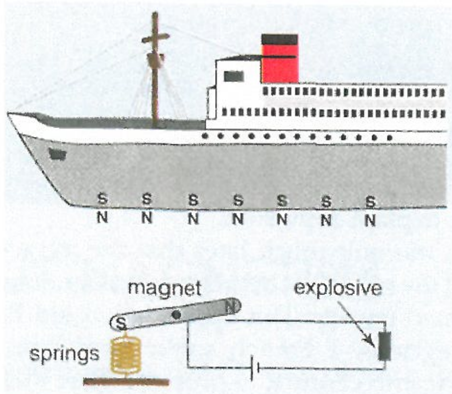


Figure 1: The magnetic field in the steel plate in the bottom of the ship pushes the magnet down on the switch which ignites the explosive.

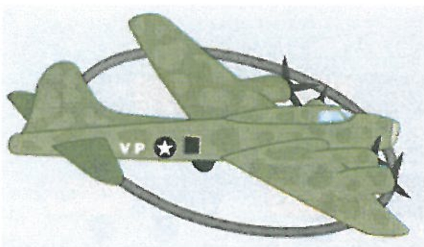


Figure 2: Specially adapted planes were used to explode the mines.

Allied shipping was initially devastated by this device. Two strategies were used to combat it. One was to revert to using wooden ships; the other was to use Australian ships which had been constructed from steel produced in the southern hemisphere.

But, eventually, the magnetic field of the Allied ships had to be changed. This was done by wrapping enormous electric cables around the middle of the ship and supplying a very large current to re-align the ship's magnetic field. This process was called **degaussing** after the word *gauss,* which is the old unit for magnetic field strength.

Another means of dealing with this problem was to use special aircraft to explode the mines. Such planes had attached to their under-body a huge circular coil of wire, through which a large current, generated by a dynamo, was passed. This action generated sufficient magnetic effect to explode the mines.

1 Use the domain theory to explain the mechanism by which steel hulls of ships become magnetised during construction in the northern hemisphere.

(3 marks)

2 In which hemisphere of the Earth is the mine in Figure 1 is located? Explain your answer. (2 marks)

3 Explain how the Australian made ships affect these mines. (2 marks)

4 The "degaussing" process was used to remove the magnetism in the ship hulls. Outline the principles that enabled this to occur. (2 marks)

5 In which direction, when viewed from above, would the current in the circular coil on the plane need to flow to ensure the mines explode. (1 mark)

END OF TEST CHECK YOUR WORK