 Physics 12

Electromagnetism Test

|  |  |
| --- | --- |
| Student Name |  |
| Teacher |  |

**Time allowed for this paper**

Working time for paper: 60 minutes

**To be provided by the supervisor:**

This Question/answer booklet;

Formulae and constants sheet

**To be provided by the candidate**

Standard items: Pens, pencils, eraser or correction fluid, ruler, highlighter

Special items: Drawing instruments or templates.

A **scientific** (i.e. non graphics) calculator satisfying curriculum council requirements.

**Structure of this paper**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Section | Number of questions available | Suggested working time  (minutes) | Your Mark | Marks available | Percentage of test |
| Section One:  Short answer | 9 | 18 |  | 15 | 30 |
| Section Two:  Extended | 5 | 32 |  | 27 | 54 |
| Section Three  Comprehension | 1 | 10 |  | 8 | 16 |
|  |  | **Total** |  | 50 | 100 |



Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Instructions: Answer all questions in the spaces provided. Marks may be awarded for correct or incorrect solutions even though the final answer may be wrong, but only if full working is shown. Marks will be deducted for lack of precision in final answers, lack of directions for vector quantities & appropriate use of units. No resources may be used, apart from general stationary items & the provided data & formula sheet.

**Section A**: Short Answer Section.

1. A 7m long wire carries a current of 10.0A to a back yard shed. Calculate the force on the wire if it carries the current in an East – West direction and the horizontal component of the Earth's magnetic field is 2.5 x 10-5 T.

3 marks

2. Kathy has a model train with an AC motor. The engine in the train set operates on 12V maximum AC, but the source is mains 240V AC electricity. Explain how the voltage is lowered by a transformer to the voltage needed for the engine.

3 marks

3. In each of the four diagrams below, a wire is between two magnetic poles. Which way will the conductor move in each case when the current flows in the direction shown?

Write your answer under each diagram and choose from;

up, down, left, right, into page, out of page or no force.

(a)

N

S

N

S

S

N

S

N

(c)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

S

N

S

N

(d)

(b)

**N**

S

N

S

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4 marks

4. A small bar magnet is moved along the axis of a long solenoid from left to right, as shown in the diagram:

S

N

N

S

N

S

On the diagram, sketch the direction of the force exerted on the magnet due to the presence of the coil, when it is at:

a) left of the solenoid.

b) in the centre of the solenoid

c) exiting the solenoid on the right. 3 marks

5. Two magnets fall from the same height. One passes through a metal ring on the way down. Which magnet reaches the ground first? Clearly explain your answer.

3 marks

6. Sketch the magnetic field produced in the following examples:

a)

N

S

b)

4 marks



**Section B**: Calculations and Extended Answers.

1. A laboratory investigation required Tania to build a simple DC motor. She wound a rectangular coil of 20 turns to make a rectangular coil of length 0.050 m and width 0.040 m, and pivots it so it can rotate around the axis shown by the dashed line in the diagram below.

R

Q

S

P

**-**

**+**

N

S

At the instant shown the coil is lying parallel to the plane of the magnetic field. The field in this region is of uniform strength 6.00 x 10-1 T. A current of 3.50 A is passing through the coil in the direction PQRS.

a) On the side RS of the coil indicate the direction of the force by drawing an arrow on the

diagram. Calculate the magnitude of the force.

4 marks

b) The coil is stationary in the position shown in the diagram.

When the current is turned on the coil begins to rotate.

Explain how this happens when the total force acting on the coil is 0 N.

2 marks

c) Tania wants to make the coil turn faster. For each of the alternatives below, describe the

effect, if any, that the change would produce.

(i) Replace the original coil with a new coil with 40 turns.

(ii) Decrease the current to 2.00 A.

(iii) Use different magnets which increase the strength of the magnetic field.

(iv) Reduce the friction in the pivots.

4 marks

2. a) Calculate the magnitude and direction of the EMF induced in a 6.0m tall, aluminium mast on a sailing boat travelling at 9.0 ms-1 towards the West. The horizontal component of the Earth's magnetic field in this region is 2.5 x 10-5 T.

3 marks

b) Could this induced EMF be useful on the sailing boat? Explain.

2 marks

3. An important part of a generator is the type of commutator used.

Explain fully why a split ring commutator might be used instead of a slip ring commutator.

5 marks

4. A single loop of wire is passed through the iron core of a transformer as shown below.

This loop forms the primary circuit. The secondary winding has 50 turns. A steady current of 10.0 mA is shown in the primary circuit in the direction shown by the arrow.



a) The current in the primary is steadily increased over 0.05 s, causing the magnetic flux

threading the loops to increase by 0.005 Wb. What is the EMF induced in the secondary

circuit ?

4 marks

b) Draw on the diagram an arrow to indicate the direction of the induced current in the

secondary coil during the change in the primary current.

2 marks

c) Explain how this type of transformer works.

3 marks

d) What type of transformer is the one above?

1 mark

5 A 250.0 MW power station steps up its output voltage from 16kV to 330kV for transmission

using a step up transformer.

a) Explain why the voltage is stepped up to 330kV for long distance transmission.

3 marks

A 330kV transmission line connected to the power station is 150km long and has a total

resistance of 40Ω.

b) What power loss is experienced in this transmission line?

4 marks

c) What voltage is delivered at the end of the line?

3marks

**Extended response question (part C)**

Marks Allotted: 15

This section contains 1 question. Answer the question in the space provided and show full working.

**Using a Mass Spectrometer for a crime scene investigation.**

Australian Federal Police have isolated an element found at a crime scene. They think the element may be sodium or potassium so they have asked the forensic laboratory to run tests on the element to identify it. The laboratory is able to ionise the element to give it a single positive charge. They then accelerate the ions through a potential difference (Vd) and by use of a velocity filter are able to send ions that have reached their maximum kinetic energy into a mass spectrometer. When the ions enter the mass spectrometer they are acted on by a uniform magnetic field and follow a semi -circular path.

Technicians conduct a series of tests and measure the radius of circular motion for different values of potential difference used to accelerate the charged ions.

*Schematic diagram of mass spectrometer*

Positive ion beam follows semicircular paths

Magnetic flux density B within chamber fixed at 3.50 🞩 10-2 T

Ionisation

Accelerating Voltage

*Adjustable Vd*

Faraday plates detect ion strikes

Velocity filter

The table below shows the results obtained when the magnetic flux density B in the mass spectrometer was fixed at 3.50 🞩 10-2 T. Measurements of radius have been expressed with an uncertainty of ±5% and radius squared with an uncertainty ±10%.

|  |  |  |
| --- | --- | --- |
| Potential difference Vd  (volts) | Radius of circular path (metres) | Radius squared  (metres squared) |
| 200 | 0.270 ± 0.014 | 0.073 |
| 400 | 0.370 ± 0.019 |  |
| 600 | 0.490 ± 0.025 |  |
| 800 | 0.530 ± 0.053 |  |
| 1000 | 0.620 ± 0.027 |  |
| 1200 | 0.670 ± 0.034 | 0.449 |

Masses of a potassium K+ ion = 6.49 × 10-26 kg and of sodium Na+ ion = 3.82 × 10-26 kg

It can be shown that the radius **r** of circular motion for an ion of mass **m** and charge **q**, entering the mass spectrometer at speed **v** and being deflected by a magnetic field of flux density **B** is as follows:

Answer the following questions

1. Use the equation and other equations on the formulae and constant sheet that link the kinetic energy in (joules) attained by a mass of charge **q** (coulombs) in a potential difference **Vd** (volts) and derive the following expression:

[3 marks]

The equation follows the format **y = mx + c** for values of r2 plotted against Vd

1. Complete the table by filling in the values of radius squared r2. Two values have been done for you.

[1 mark]

1. Plot the graph of r2 (vertical axis) versus **Potential difference V**d (horizontal axis) on the graph paper next page. Include a line of best fit.

4 marks]

If you need to make a second attempt, spare graph paper is at the end of this question. Indicate clearly if you have used the second graph and cancel the working on the first graph.

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1. Calculate the gradient of your line of best fit from your graph showing all working. Include units.

[3 marks]

1. Use the value of the gradient that you obtained to calculate the mass of the charged ions. (If you could not obtain a gradient use the numerical value 4.00 × 10-4)

[3 marks]

1. Based on the results you have calculated, what is the identity of the charged ion?

[1 mark]

