Christ Church
Grammar School

Science Department
Year 12 2020

# ATAR PHYSICS
# UNIT 3: ELECTROMAGNETISM
# TOPIC TEST 2020

Teacher: JRM HKR
(Please circle)

**Time allowed for this paper** **NAME:** ______________________________

Working time for paper: 50 minutes.

**Instructions to candidates:**

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

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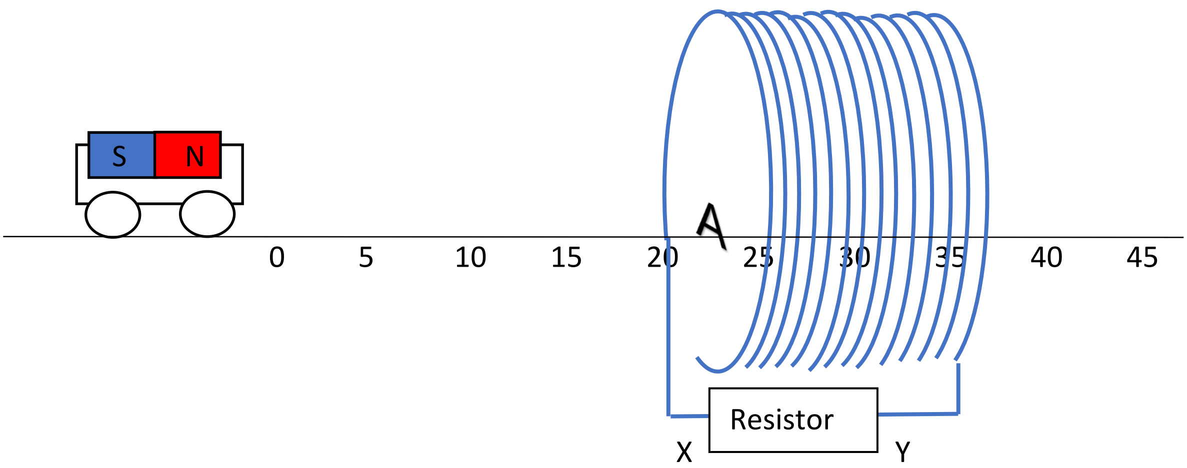
|---|---|
| Mark: | / 55 |
| = | % |

**Question 1** **(10 marks)**

A 5.00 cm magnet on a motorised cart rolls at a constant speed into a 15.0 cm long solenoid of radius 3.00 cm and attached to a resistor. When the north pole enters the first coil, the magnetic field passing through the area bounded by the coil changes from 155 mT Right to 35.0 mT Left in a time period of 0.150 s. The coil is placed at 20 to 35 cm along the horizontal section of the track.




(a) State which direction the conventional current passes through the resistor when the north pole **enters** the coil and include a detailed explanation as to why this direction was chosen.

(4 marks)

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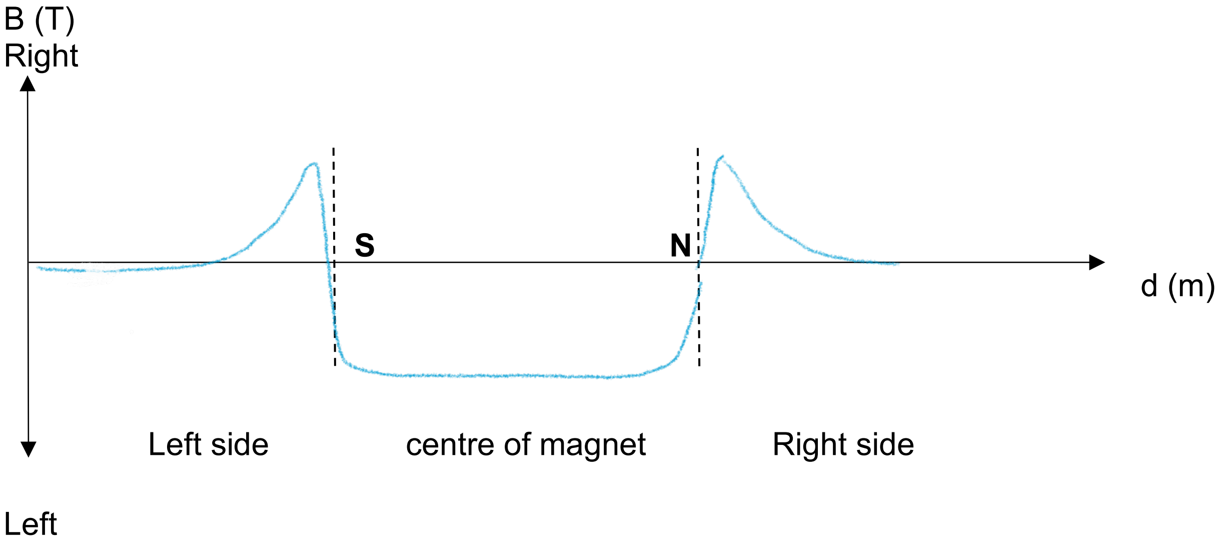
(b) Calculate the magnitude of the induced EMF across the first coil when the north pole enters the solenoid.

(3 marks)

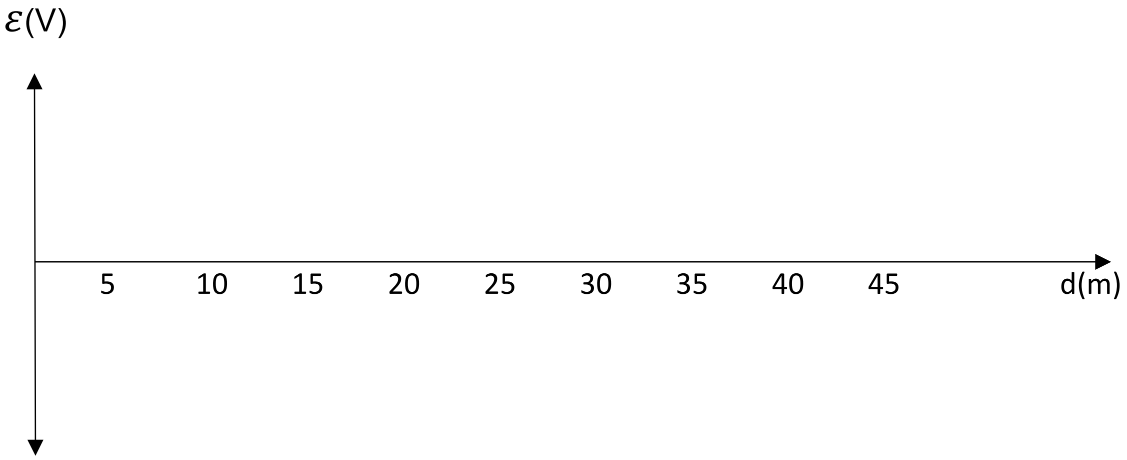
**Question 1 continued**

The graph below shows how the magnetic field strength changes along the dimensions of the magnet.



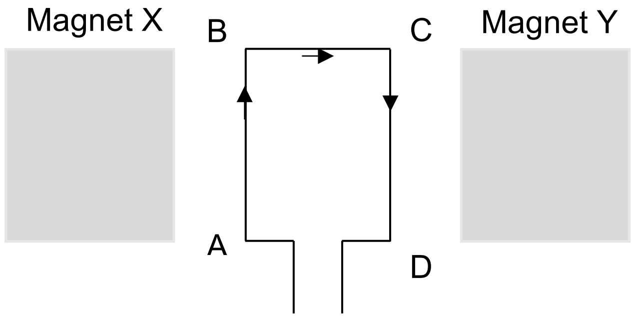

On the graph below sketch the induced EMF across the solenoid as the north face of the magnet rolls along the horizontal section of the track.

(3 marks)



**Question 2** **(6 marks)**

The diagram below shows the structure of a simple DC Motor. A rectangular coil (ABCD) consisting a single loop is sitting in a magnetic field created by the poles of two bar magnets (X and Y).




(a) As shown by the arrows on the coil, at a particular instant in time, conventional current flows from A to D. At this instant, side AB experiences a force out of the page and side CD experiences a force into the page. In the spaces provided below, write down the polarity (North or South) of Magnets X and Y that would create these forces.

(1 mark)

MAGNET X: _________ MAGNET Y: _________

The dimensions of the coil are AB = CD = 20.0 cm; BC = AD = 10.0 cm.
The current flowing is equal to 1.50 A and the strength of the magnetic field is 0.400 T.

(b) Calculate the magnitude of the torque acting on the coil when it is in the position shown in the diagram.

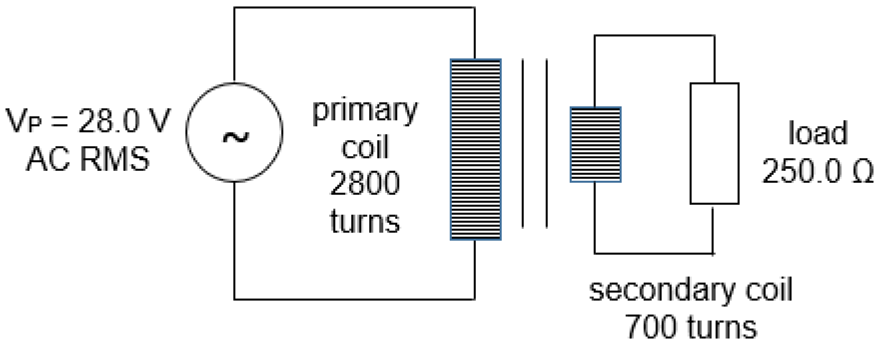
(3 marks)

(c) On the set of axes below, sketch the torque curve of this simple DC motor over the course of two full rotations. Assume that a commutator is present in the motor and the coils starts in the position shown in the diagram above.

(2 marks)

**Question 3** **(9 marks)**

A transformer has an input voltage of 28.0 V RMS AC. For the questions that follow, assume the transformer is 100% efficient.




(a) Calculate the output voltage for this transformer.

(2 marks)

(b) Calculate the current flowing through the load in the secondary circuit.

(2 marks)

(c) Hence, calculate the power generated in the primary coil of this transformer.

(2 marks)

(d) In reality, transformers are not 100% efficient; they experience energy losses through a combination of factors. State one type of energy loss experienced in a transformer and describe how it is reduced via its design.

(3 marks)

**Question 4** **(12 marks)**

A group of students conducted an investigation measuring the force between two parallel current-carrying wires. Diagram 1 below shows conducting wires with current flowing through them. During the investigation, the students kept ‘r’ constant at a value of 5.00 cm and the values of $I_1$ and $I_2$ were kept at 5.00 A.

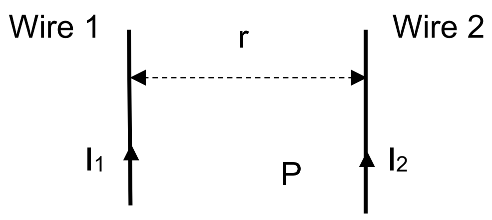



Diagram 1.

Diagram 2 below illustrates this experiment from a bottom-up view.

Diagram 2.


(a) On diagram 2, draw the net magnetic field around the two wires.

(2 marks)

(b) On Diagram 1, draw vectors representing the forces that each conductor would experience due to the currents $I_1$ and $I_2$.

(1 marks)

(c) Calculate the magnetic field strength at Point P which is 2.00 cm from wire 2.

(4 marks)

**Question 4 continued.**

The resultant force on each conductor was then measured with very sensitive force probes. The equation for calculating the *resultant force* acting between the two parallel current-carrying wires in this investigation is given by the formula below:

$$\frac{F}{L} = \frac{\mu_0 I^2}{2\pi r}$$

(d) Show the derivation of the *resultant force* equation.

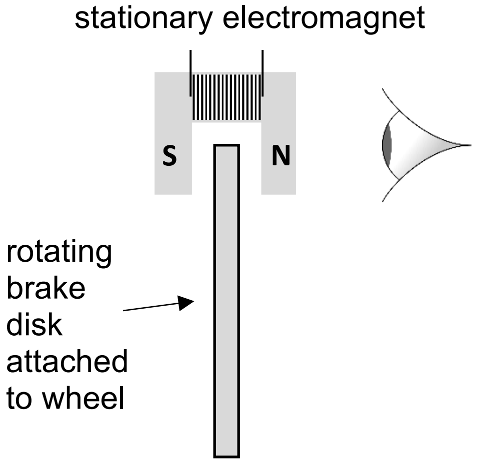
(3 marks)

(e) Calculate magnitude of the force acting on a 10.0 cm length of wire.

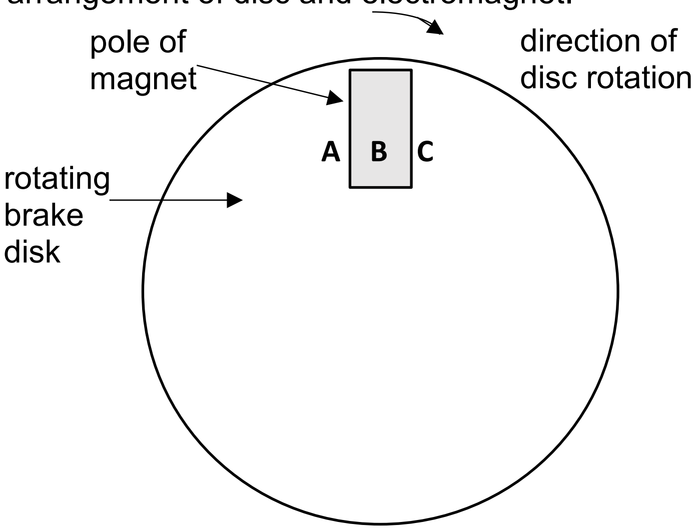
(2 marks)

**Question 5** **(10 marks)**

Eddy currents can be used to apply 'magnetic braking' to a vehicle like a train. Like conventional 'friction brakes', the wheels of the train have a 'brake disc' attached to them that rotates with the wheel as the train is moving. Around the top of the disc, but without touching it, is an iron core electromagnet. When the brakes are applied, the electromagnet is switched on and the train is decelerated. The figures below show the arrangement of disc and electromagnet.




FRONT VIEW




SIDE VIEW (viewed from right)

(a) Referring to the 'SIDE VIEW' diagram, state the direction, if any, of the induced eddy currents generated at points A, B and C by the rotating disc and electromagnet.

(3 marks)

A: ___________________ B: ___________________ C: ___________________

(b) Explain how the movement of the disc causes the braking effect.

(4 marks)

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**Question 5 continued**

(c) Explain the effect, if any, of the speed of the train on the strength of the magnetic brake.

(3 marks)

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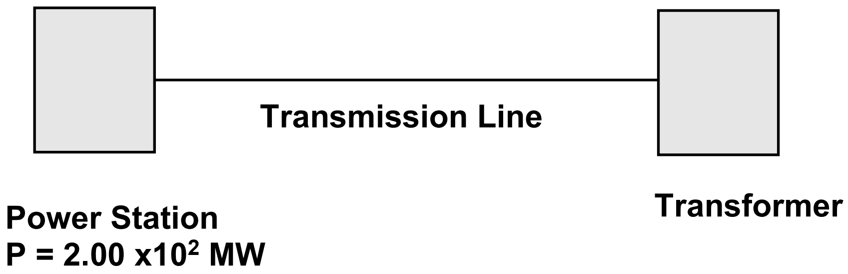
**Question 6** **(3 marks)**

Two positively charged point charges of magnitude (in Coulombs) $q_1$ and $q_2$ are separated by a distance $d$ and experience an electrostatic force $F$.
The charge sizes are changed to $2q_1$ and $3q_2$ and the distance is reduced to $0.50d$. Calculate an expression for the electrostatic force between these two charges in terms of $F$.

**Question 7** **(5 marks)**

A power station generates electric power at a rate of 2.00 x $10^2$ MW. The power is transmitted along a 40.0 km long transmission line to a transformer at voltage of 220 kV. The line has a resistance rating of 0.15 Ω $km^{-1}$. Calculate the voltage delivered to the primary coil of the transformer at the end of this transmission line. Show working.




**END OF TEST**