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CORPUS CHRISTI COLLEGE

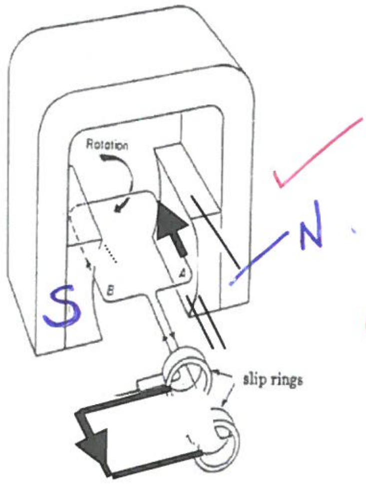
SEQUERE DOMINUM

12 ATAR Physics

EM Test 2016

Student name: Soln

1. The following diagram represents a generator with a coil of 35 loops, 15.0cm wide by 28.0cm long. The field strength between the poles is 0.0125 T and the coil is spinning clockwise at a rate of 1380 cycles per minute. The arrows show the direction of induced current in the circuit.



(a) Label the poles of the magnet shown in the diagram. **(1 mark)**

1

(b) Calculate the maximum flux passing through the coil as it spins **(3 marks)**

$$\Phi_B = BA\cos\theta = (0.0125)(0.15 \times 0.28)$$

$$= 5.25 \times 10^{-4}\ \text{Wb}\ (\text{Tm}^2)$$

3

(c) This type of generator is also known as an alternator. Explain why is it called an alternator. **(1 mark)**

- THIS TYPE OF GENERATOR PRODUCES AC CURRENT.

1

5

(d) Calculate the peak (maximum) EMF generated. **(4 marks)**

4

$EMF = 2NB\ell v = 2NB\ell 2\pi rf$

where $v = 2\pi rf$.

$= (2)(35)(0.0125)(0.28)(6.28)(0.075)\left(\frac{1380}{60}\right)$

$= \underline{\underline{2.66V}}$

(e) Calculate the effective (root mean square) voltage produced by the generator. **V_{RMS} = $V_{PEAK} \div \sqrt{2}$.** **(2 marks)**

2

$$V_{RMS} = \frac{V_{PEAK}}{\sqrt{2}}$$

$$= \frac{2.66}{\sqrt{2}} = \underline{\underline{1.88V}}$$

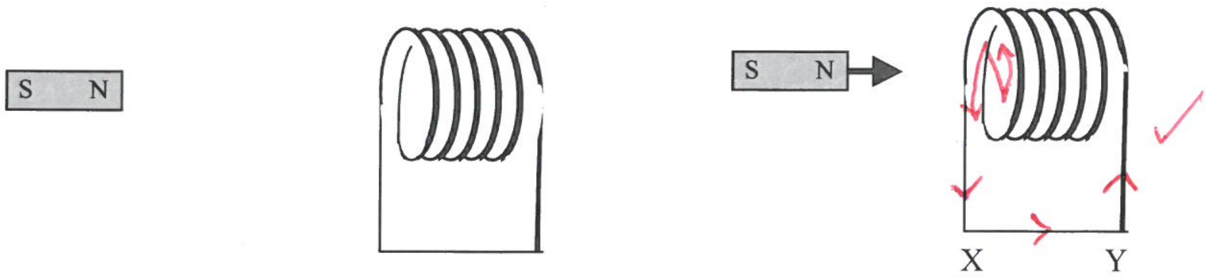
(f) What is the value of the EMF when the coil is perpendicular to the magnetic field (B). Use your knowledge of electromagnetism theory to explain your answer. **(4 marks)**

- FLUX (Φ_B) = BA cos θ ($\frac{1}{2}$)
- θ = ANGLE BETWEEN AREA OF COIL AND NORMAL TO THE AREA.
- WHEN COIL IS PERPENDICULAR θ = 0° ($\frac{1}{2}$)
- ∴ FLUX (Φ_B) = BA cos 90° = 1 = MAX
- ∴ EMF = 0V WHEN FLUX IS MAX.

4

10

2. A magnet is moved towards a coil of diameter 7.60cm and consisting of six loops. The resistance of the coil wire is 0.222 Ohms. During this time the magnetic field strength passing through the coil increases from 2.00×10^{-3} T to 9.00×10^{-3} T generating an induced current 0.0345 Amps.



1

(a) Draw an arrow on the wire XY to show the direction of the induced current as the magnet is moved towards the coil. **(1 mark)**

(b) For how long was the magnet moving toward the coil? **(4 marks)**

$$EMF = V = IR = (0.0345)(0.222)$$
$$= 0.007659\ V$$

$$EMF = V = -N\frac{d\Phi_B}{dt} = \frac{NA\Delta B}{t}$$

4

$$\therefore t = \frac{NA(B_f - B_i)}{V} \quad (A = \pi r^2)$$

$$\therefore t = \frac{NB2\pi r}{V} = \frac{(6)(7\times10^{-3})(3.14)(0.038)^2}{0.007659}$$

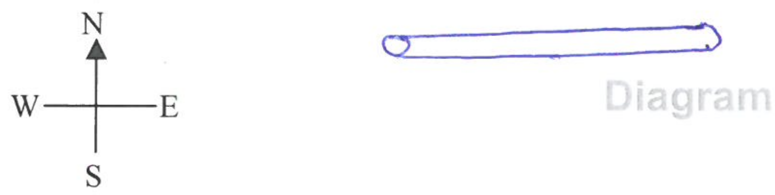
$$\therefore t = \frac{1.9043\times10^{-4}}{0.007659}$$

$$\therefore t = 0.03\ s$$

5

3. A steel rod of length 2.00 metres and diameter 15.0cm falls vertically from the top of a roof. Half way down it is travelling at 5.00ms^{-1}. The horizontal (S → N) component of the earth's magnetic field at this location is 2.88x10^{-5} T.

(a) How should the rod be oriented for a maximum EMF to be induced in it as it falls from the roof? Use a diagram to help explain your answer. **(2 marks)**



1 HORZ

1 W–E

2

(b) Which end of the rod will be positively charged? Use a diagram to help show your answer. **(1 mark)**

1

(c) Calculate the maximum EMF that would be induced in the steel rod as it falls with a speed of 5.00 ms^{-1}. **(3 marks)**

$$EMF = Bvl$$
$$= (2.88 \times 10^{-5})(5)(2)$$
$$= 2.88 \times 10^{-4}\ V$$

3

6

4. Energy consumption in our homes is measured in kilowatt-hours (kWh). Show that one kilowatt-hour is equal to 3.6 x 10^6 Joules. **(3 marks)**

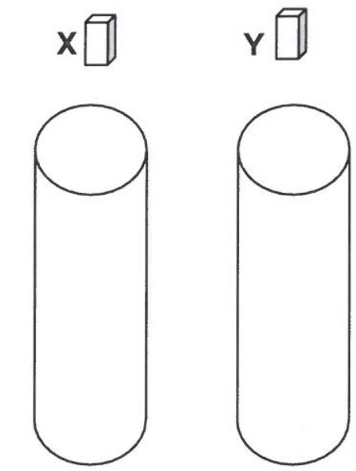
$$1\,\text{kWh} = (1000\,\text{W})(3600\,\text{s})$$
$$= (1000\,\text{J}\,\text{s}^{-1})(3600\,\text{s})$$
$$= 3.6 \times 10^6\,\text{J}.$$

(3)

5. One bar magnet (X) is dropped through an aluminium cylinder. An identical magnet (Y) is dropped through a plastic cylinder.

Which magnet will fall through its cylinder first (X, or Y)? Y

Using your knowledge of EM theory, explain your answer. **(3 marks)**



Aluminium cylinder Plastic cylinder

($\frac{1}{2}$ EA).

BY FARADAYS LAW WHEN A CONDUCTOR EXPERIENCE A CHGING MAG FLUX AN OPPOSING FIELD WILL BE INDUCED SO A TO OPPOSE THE CHG (LENZ LAW). THE OPPOSING INDUCED FIELD IN THE AL CYLINDER WILL SLOW THE FALL OF "X". NO CURRENT IS INDUCED IN THE PLASTIC CYLINDER, THEREFORE IT WILL NOT SLOW DOWN.

(3)

(6)

6. The maximum power through the primary coil of a 100% efficient transformer is 1200 W at a voltage of 240 V. The primary coil has 800 turns. The secondary current produced is 50.0 A and is used to operate an electric motor.

(a) What voltage is produced in the secondary coil? Draw a diagram to help explain your answer. **(4 marks)**

$P_s = P_p = 1200W$; $P_s = V_s I_s$

$\therefore V_s = \frac{P_s}{I_s} = \frac{1200}{50}$

$= \underline{24 V}$

4

(b) How many turns does the secondary coil contain? **(2 marks)**

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\therefore N_s = \frac{V_s N_p}{V_p} = \frac{(24)(800)}{240}$

$\therefore \underline{N_s = 80 \text{ coils}}$

2

(c) Most transformers are not 100% efficient.

(i) Identify one source of power loss in the transformer core. **(1 mark)**

EDDY CURRENTS.

1

(ii) Using your knowledge of EM theory, explain why the answer you gave for (c)(i), causes a reduction of efficiency. **(3 marks)**

- EDDY CURRENTS FORMED IN THE SOFT IRON CORE DUE TO THE CHANGING FLUX
- ENERGY IS LOST IN THE FORM OF HEAT, $E = I^2Rt$ FROM $P = I^2R$.

3

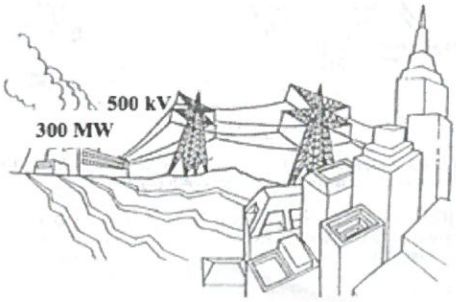
(iii) Identify one way that transformer core power loss cam be reduced. **(1 mark)**

LAMINATED CORE

1

11

7. A power station produces 300 MW of electric power for a distant city. Just outside the power station a 100% efficient transformer boosts the voltage to 500 kV. The power loss (and therefore also the voltage loss) occurring along the transmission wires is 5.50%.



(a) Calculate the power lost along the transmission wires. **(2 marks)**

$$P_{Loss} = 300\text{MW} \times 5.5\%$$
$$= \underline{16.5\text{ MW}}$$

2

(b) Calculate the current flowing in the transmission wires. **(2 marks)**

$$P = IV$$
$$\therefore I = P/V = \frac{(300\times10^6)-(16.5\times10^6)}{(500\times10^3)-(27.5\times10^3)}$$

2

$$\therefore \underline{I = 600\text{A}}$$

(c) Calculate the resistance of the transmission cables. **(2 marks)**

$$P = I^2R$$

2

$$\therefore R = \frac{P}{I^2} = \frac{1.65\times10^7}{600^2} = \underline{45.8\,\Omega}$$

(d) Calculate the voltage available at the city. **(2 marks)**

$$V = (500\times10^3) - (27.5\times10^3)$$
$$= 4.73\times10^5\text{ V}$$

2

$$= \underline{473\text{ kV}}$$

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