Year 12
Physics 3AB

Electricity and Magnetism
Unit Test
2015

Name: Solutions

Mark: / 54

= %

Time Allowed: 50.0 Minutes

Notes to Students:

1. You must include **all** working to be awarded full marks for a question.
2. Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
3. **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(9 marks)**

A set of transmission lines have a resistance of 1.00 Ω. A generator supplies the lines with 500 kW and the potential difference across the lines is 600 V.

(a) Calculate the power loss in the lines.

(4 marks)

$P = VI$ (0.5) $P = I^2R$ (0.5)

$500 \times 10^3 = (600)(I)$ (0.5) $= (833^2)(1)$ (0.5)

$I = 833\ A$ (1) $= 694 \times 10^3\ W$ (1)

The power loss in (a) would make the transmission of power along these lines very uneconomical.

(b) State what could be included to the transmission line system to minimise the power loss.

(1 mark)

- Step Up Transformer

(0.5) (0.5)

(c) Explain why your answer to (b) would make the transmission line system more efficient.

(4 marks)

- The step-up transformer would increase the voltage across the power lines.
- Increase in voltage will lead to a decrease in the current in the transmission lines as P=VI.
- A decrease in current means the resistive heating due to the current will decrease (as $P=I^2R$).
- There will be less voltage drop across the lines, V=IR, meaning more voltage at the final destination.

Question 2 **(4 marks)**

A 15.0 m long wire is held vertically and a current of 10.0 A runs from the top to the bottom of it. If the wire is in Perth, where the Earth's magnetic field is 5.50×10^{-6} T at 66.0° to the horizontal, calculate the force on the current-carrying wire.

$$F = I\ell B \quad (1)$$
$$= (10)(15)(5.50\times10^{-6}\cos 66) \quad (1)$$
$$= 3.36\times10^{-4}\ N \quad East$$

(1) (1)

-1 mark is sin66° is used

Question 3 **(3 marks)**

A transformer used to operate a fluorescent light has 260 coils on the primary winding and 65 coils on the secondary winding. If the transformer is plugged into a 240 V household circuit, calculate the potential difference required to operate the fluorescent light.

$$\frac{N_S}{N_P} = \frac{V_S}{V_P}$$ (1)

$$\frac{65}{260} = \frac{V_S}{240}$$ (1)

$$V_S = 60.0\ V$$ (1)

Question 4 **(4 marks)**

A proton moving at 3.00 x 10^6 ms^{-1} through a uniform magnetic field experiences a maximum force of 5.20 x 10^{-12} N directly upwards when it is travelling due East. Calculate the magnitude and direction of the magnetic flux density.

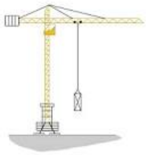
$$F = qvB$$ (1)

$$5.2 \times 10^{-12} = (1.6 \times 10^{-19})(3 \times 10^{6})(B)$$ (1)

$$B = 10.8\ T \quad North$$

(1) (1)

Question 5 **(8 marks)**



A motor is used to drive a large crane on a worksite.

(a) Describe and explain the changes that occur in the motor as it is turning without a light load.

(5 marks)

- When the coil in the motor turns there is a changing magnetic flux through the coil.
- This induces an emf which is proportional to the rate of change of magnetic flux (Faraday's Law).
- The direction of the emf will be such as to oppose the change that caused it (Lenz's Law).
- The induced emf will therefore be in the opposite direction to the applied emf.
- This reduces the net emf in the circuit and hence the current flowing.

The crane operator decides to finish his jobs quickly and uses the crane to lift a greater load than the operating manual specifies.

(b) Explain why the crane operator is at risk of overheating the crane motor.

(3 marks)

- When carrying too great a load, the motor will slow and the rate of change of magnetic flux and therefore induced emf will decrease.
- This will mean more net emf and a greater current flowing through the motor
- which will mean more resistive heating ($P=I^2R$)

Question 6 **(6 marks)**

A long length of wire is wound 200 times onto a square frame of side 20 cm. The wire carries a current of 1.25 A and is located in a uniform, 0.500 T magnetic field.

(a) Calculate the maximum magnitude of force that can be exerted on one side of the coil.

(3 marks)

$F = I\ell B$ (1)

$= (200)(1.25)(0.2)(0.5)$ (1)

$= 25.0\ N$ (1)

(b) Calculate the maximum magnitude of torque that can be exerted on the coil.

(3 marks)

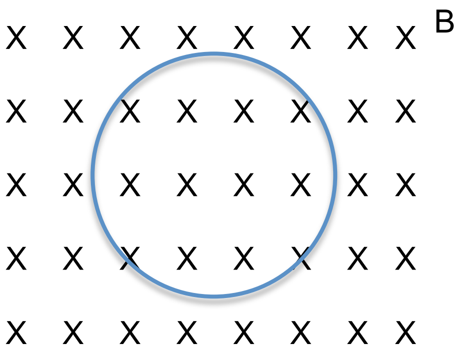
$\tau = rF$ (1)

$= (2)(0.1)(25)$ (1)

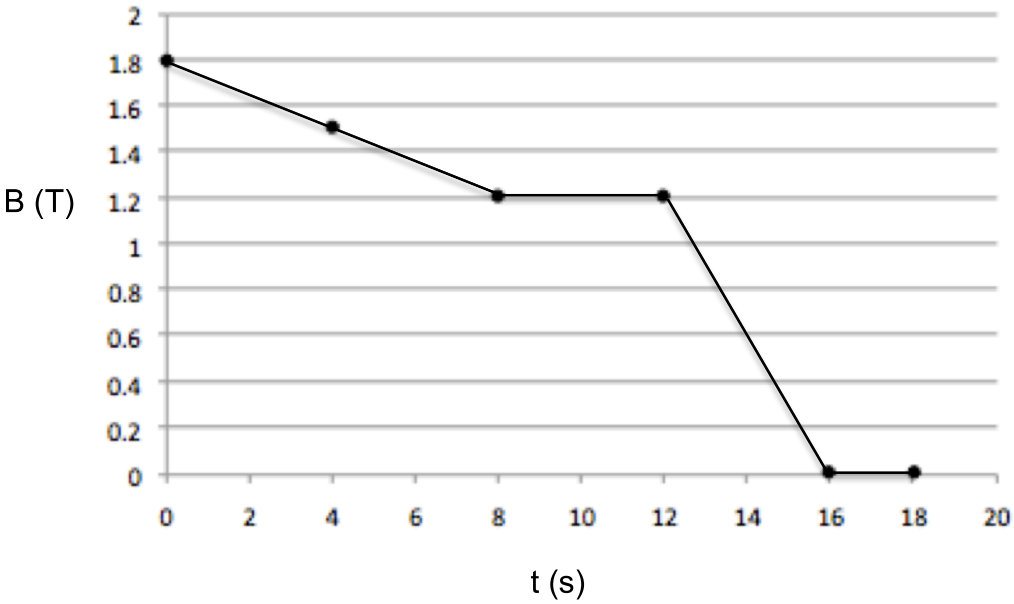
$= 5.00\ Nm$ (1)

Question 7 **(11 marks)**

The diagram below shows a circular loop of area 2.50 x 10^3 cm^2 and resistance 12.0 Ω that lies in the plane of the page. A magnetic field of magnitude B is directed into the page.



The value of B varies with time as shown in the graph below.



(a) Calculate the magnitude of the induced emf in the loop from t = 0 to t = 8s.

(3 marks)

(0.5) $\varepsilon = -\dfrac{\Delta\Phi}{\Delta t}$ $\Phi = BA$ (0.5)

$= -\dfrac{(0.25)(1.2-1.8)}{(8-0)}$ (1)

$= 18.8 \times 10^{-3}\ V$ (1)

(b) Calculate the total energy dissipated in the first 8 seconds.

(4 marks)

$$P = \frac{V^2}{R} \quad (0.5)$$
$$= \frac{(18.8\times10^{-3})^2}{12} \quad (0.5)$$
$$= 2.95\times10^{-5}\ W \quad (1)$$

$$P = \frac{E}{t} \quad (0.5)$$
$$E = (2.95\times10^{-5})(8) \quad (0.5)$$
$$= 2.36\times10^{-4}\ J \quad (1)$$

(c) State the direction of the induced current in the coil from t = 0 s to t = 8 s.

(1 mark)

- clockwise

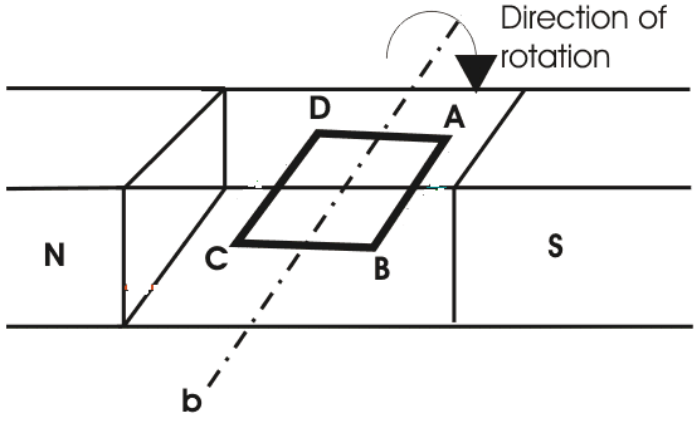
(d) Explain the reasoning behind your choice of direction for (c).

(4 marks)

- Lenz's law states that the direction of the induced emf will be such as to oppose the change that caused it.
- The magnetic flux inside the coil is decreasing from t = 0 s to t = 8 s.
- The induced current will be in such a direction so that the magnetic field associated with it will be directed into the page.
- A clockwise current will produce a magnetic field directed into the page.

Question 8 **(8 marks)**

An engineer wishes to design an AC generator using an armature on which is wound a flat tight rectangular coil, 8.00 cm (AD) x 20.0 cm (AB), of 150 turns, as shown in the diagram below. The generator output is to have a peak voltage of 20.0 V and a frequency of 50.0 Hz



(a) Calculate the required rotational speed of the generator if it is to meet these specifications.

(3 marks)

$v = 2\pi rf$ (1)
$= (2\pi)(0.04)(50)$ (1)
$= 12.6\ ms^{-1}$ (1)

Can use v = (2πr)/T and T = 1/f for full marks

(b) Calculate the magnetic flux density required for the generator to meet these specifications.

(3 marks)

$\varepsilon = 2Nv\ell B$ (1)
$20 = (2)(150)(12.6)(0.2)(B)$ (1)
$B = 0.0265\ T$ (1)

Can use emf = vLb as long as 2N is shown in working

(c) State which of A, B, C and D will be at the higher potential when the coil turns.

(2 marks)

- B and D

End of Test