AQA, OCR

A Level

A Level Physics

Electromagnetism 2 (Answers)

Name:

MME
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Total Marks: /30

1. This question explores the implications of Faraday's law.

Total for Question 1: 18

(a) State the requirement for an emf to be induced in a circuit that lacks a power supply. [2]

Solution: A change in the flux linking the circuit i.e. a change in B, A or $\cos\theta$.

(b) A coil with 500 turns as a core with a radius of 2 cm. It is placed in a field of 0.6 T such that there is an angle of 30°between the field and the normal to the cross-sectional area. Calculate the magnetic flux and the magnetic flux linkage. [4]

Solution: $\phi = 6.5 \times 10^{-4}$ Wb
$N\phi = 0.33$ Wb

(c) State Faraday's law, both in words and mathematically. [2]

Solution: The induced emf is proportional to the rate of change of flux linkage.
$\epsilon \propto \frac{\Delta(N\phi)}{\Delta t}$

(d) A search coil has 4000 turns and a cross-sectional area of 1 cm^2. Given that it induces an emf of 2 V when removed from the field in 1 ms, calculate the flux density. [4]

> **Solution:** 5 mT

(e) State Lenz's law and explain why it is a statement of energy conservation. [3]

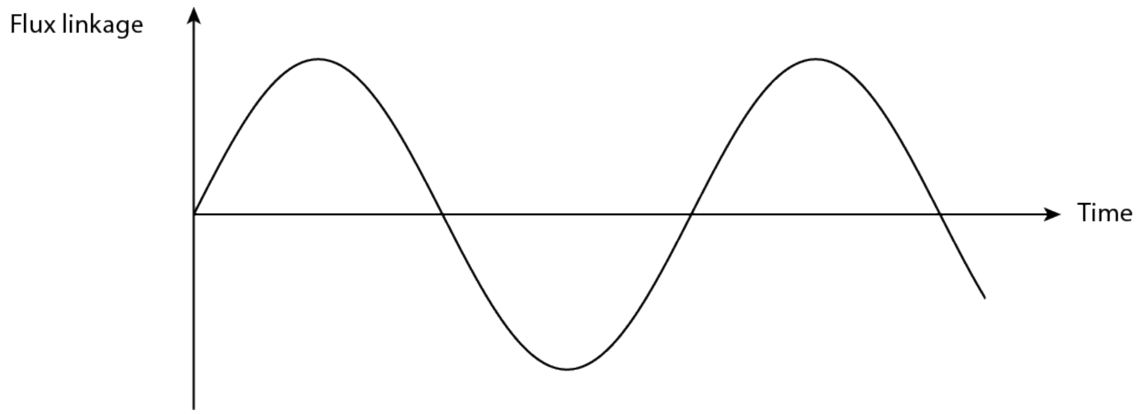
> **Solution:** The direction of the induced emf/current opposes the action that caused it.
> If Faraday's law did not have the minus sign then electrical energy would be created when a magnet and coil of opposite polarity were brought together i.e. when no work is done on the magnet.

(f) Explain, using Faraday's law, why large current-carrying coils can be dangerous if the current is suddenly switched off. [3]

> **Solution:** Large coils are linked by their own field. If the current is switched off then the magnetic field collapses, creating a large change in the flux linkage over a short time interval.
> $\epsilon \propto \frac{\Delta(N\phi)}{\Delta t}$; if t is very small the backward emf is very large.

2. AC generators can be understood using Faraday's law. The graph below shows how the flux linkage varies sinusoidally as a square coil with 1000 turns and a side length of 20 cm is rotated in a uniform field of flux density 0.8 T.

Total for Question 2: 6



(a) On the same set of axes, sketch the variation of the induced emf. [3]

Solution: $-\cos\theta$ plot.

(b) The coil rotates by 15° in 2 s. Calculate the induced emf. [3]

Solution: 15 V

3. Without transformers the national grid would be much less efficient. However, they are not complex and can be understood using ideas developed above.

Total for Question 3: 6

(a) State two mechanisms of undesirable power dissipation in a transformer. [2]

> **Solution:** Heat from eddy currents in the core.
> Heat due to resistance in the coil.

(b) State the purpose of the core. [1]

> **Solution:** To ensure that all flux in the primary coil is links the second coil.

(c) Design a transformer that steps down the voltage by a factor of four. [1]

> **Solution:** Any transformer with four times as many primary coils as secondary coils.

(d) An ideal transformer has 100 primary coils and 400 secondary coils. Given that the current in the secondary coil is 3 A, calculate the current in the primary coil. [2]

> **Solution:** 12 A