Edexcel

A Level

A Level Physics

Electromagnetism 2 (Answers)

Name:

Mathsmadeeasy.co.uk

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]

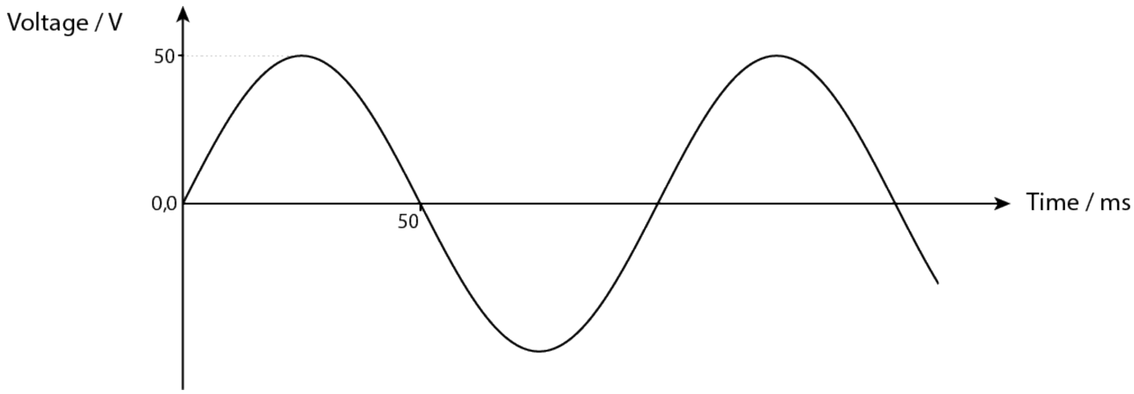
Solution: The direction of the induced emf/current opposes the action that caused it.
If Faraday's law did not have the minus sign then electrical energy would be created when a magnet and coil of opposite polarity were brought together i.e. when no work is done on the magnet.

(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 voltage varies sinusoidally as a square coil is rotated in a uniform magnetic field.

Total for Question 2: 12



(a) In the UK, the peak voltage of mains electricity is about 325 V. Why, then, is mains electricity frequently referred to as having a voltage of 230 V? Support your answer using simple calculations. [3]

Solution: The voltage and current both vary sinusoidally for an AC power supply. The power supplied by a $V_{peak} = 325$ V AC source will not be the same as that supplied by a 325 V DC source. For comparison purposes, it is useful to know the nominal DC-equivalent voltage of a AC supply. This is the RMS voltage, which for a sinusoidal variation is $V_{peak}/\sqrt{2}325/\sqrt{2} = 230$ V.

(b) The AC supply above is used to power a circuit with a resistance of 40.0 Ω. Calculate the following:

i. The frequency of the supply. [2]

Solution: 10 Hz

ii. The peak current in the circuit. [2]

> **Solution:** 1.25 A

iii. The time taken to dissipate 800 J of energy in the circuit. [2]

> **Solution:** 25.6 s

To minimise energy losses, power in the national grid is transmitted at very high voltages. Transformers are used to reduce the transport voltages to safer domestic voltages. In a typical transformer, a current is supplied to the primary coil, which is linked to a secondary coil by an iron core. The ratio of the input voltage to the output voltage depends on that of the coils.

(c) If the secondary coil is to continually have a non-zero current, why must the primary coil's supply have an alternating current? [3]

> **Solution:** If it were DC, when initially switched on the primary coil would produce a magnetic field. This flux is linked to the secondary coil so we would see a sudden increase in the voltage of the secondary coil. However, once the magnetic field stabilises there will no longer be any change in the flux linkage and so, by Faraday's law, there will be no induced emf in the secondary coil.
> In contrast, as the AC current varies, so too will the induced magnetic field. Therefore, the flux linkage will be constantly changing and a constantly varying, non-zero emf will be induced in the secondary coil.