On electromagnetic induction

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Warm-up problems

1. Explain the terms *magnetic flux* and *flux linkage*, using diagrams to help you explain these concepts as appropriate.

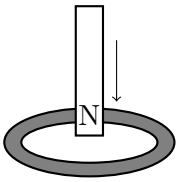
2. State carefully in words how a voltage can be electromagnetically induced across the ends of a conductive bar of copper (*do not draw a diagram for this*).

3. How can an emf be induced in a coil of wire, and what equation could be used to calculate the emf? Make sure you define the terms in the equation carefully!

Regular problems

4. The flux passing though a coil of 3 turns drops from 5 mT to zero in 8s. What is the EMF induced? Show your calculation carefully.

5. The north pole of a magnet is thrust downward into a horizontally oriented copper ring as shown.



   (a) Does the ring experience a force under these circumstances? If so, in what direction? Explain your reasoning.

   (b) Does the magnet experience a force? If so, in what direction? Explain your reasoning.

6. A straight wire of length 50 cm is moved at a speed of $15\,\mathrm{m\,s^{-1}}$ through a field of flux density of $2 \times 10^{-3}\,\mathrm{T}$. What voltage is induced between its ends?

7. The axle of a railway carriage is 1.5 m long, and cuts the vertical component of the Earth's magnetic field of flux density $4 \times 10^{-5}\,\mathrm{T}$ as it travels at $10\,\mathrm{m\,s^{-1}}$. Calculate the emf induced between the ends of the axle.

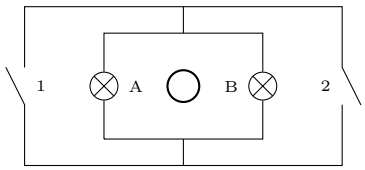
Extension problems

8. A circular metal disk of area $3.0 \times 10^{-3}\,\mathrm{m^2}$ is rotated at $50\,\mathrm{rev\,s^{-1}}$ about an axle through its centre, and perpendicular to its plane. The disk is in a uniform magnetic field of flux density $5.0 \times 10^{-3}\,\mathrm{T}$ in the direction of the axle.

   (a) Between which two points is the maximum emf?

   (b) What is the value of this emf?

9. A long coil of wire, axis perpendicular to the paper, carries a steadily increasing current, so there is a steadily changing magnetic field in the coil. With both switches open, a resulting current flows in the loop of wire surrounding the coil and the two identical bulbs shown light up:



(a) What happens to the brightness of bulb B if bulb A is unscrewed from its socket wilst the current in the magnetic field is still increasing? Explain your answer.

(b) Suppose now that with both bulbs in their sockets, switch 1 is closed and switch 2 is left open. What happens to the brightness of each bulb?

(c) Suppose that now switch 1 is opened and switch 2 is closed. What happens to the brightness of each bulb?