Electromagnetic induction

Name & set

1. An aeroplane of wingspan 40 metres flies horizontally at a speed of 1200 km hr^{-1}. If the flux density of the vertical component of the earth's field is 4×10^{-5} T., what is the p.d. set up between the wing tips?

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_____

_____ [4]

2. A bicycle wheel 0.80 m in diameter is spun at 180 rpm in a vertical plane at right angles to the magnetic meridian.

(i) If the horizontal component of the earth's field is 1.8×10^{-5} T, at what rate does a spoke cut flux?

_____

_____ [2]

(ii) What is the emf set up between the ends of the spoke?

_____

_____ [2]

3. A solid metal wheel 1.2 m in diameter spins in a vertical plane at right angles to the magnetic meridian at a rate of 4.0 Hz. It is found that there is a p.d. between the centre and the rim of the disc of 85 μV. What is the horizontal component of the earth's field?

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_____ [2]

4 A car aerial is 1.5 m long. Calculate the e.m.f. induced across it when the car is travelling at 30ms^{-1} in an East-West direction. The horizontal component of the earth's field is 18 μT. Assume that the aerial is vertical.

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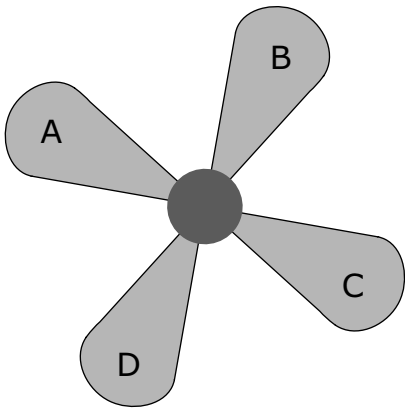
_____

_____ [2]

5 An electric fan is placed so that the axis about which the blades rotate is parallel to the earth's magnetic field lines. The magnetic flux density of the earth's field is 60 μT. The fan has four blades each adjacent blade is perpendicular to its neighbours.



If the fan rotates at 3600 r.p.m., calculate the e.m.f. induced

(a) between the tip of any one of the blades and the axle,

_____

_____ [2]

(b) between the tips of two blades directly opposite to one another (e.g. A & C),

_____

_____ [2]

(c) between tips of adjacent blades (e.g. D & C).

_____

_____ [2]

6 A bicycle wheel is rotated in a horizontal plane at a place where the total magnetic flux density of the earth's magnetic field is 60 μT. If the radius of the wheel is 35 cm and it is rotating at 100 rev/min in a plane *perpendicular* to the magnetic field, calculate the voltage generated between the axle and rim of the wheel.

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_____ [3]

7 (a) (i) State Lenz's law of electromagnetic induction

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_____ [2]

(ii) Describe an experiment which demonstrates the truth of this law. Illustrate your description with a suitable diagram.

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_____ [4]

(b) Discuss the consequences, in the experiment which you describe, if the direction of the induced e.m.f. were other than that which the law predicts.

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_____

_____ [3]

8 A small fan, having blades 15.0 cm long, rotates at 3000 rev min^{-1}.

(a) How should the axis of rotation of the fan be orientated so that the maximum e.m.f. is induced between the tips of the blades and the axel if the only magnetic field present is that of the earth?

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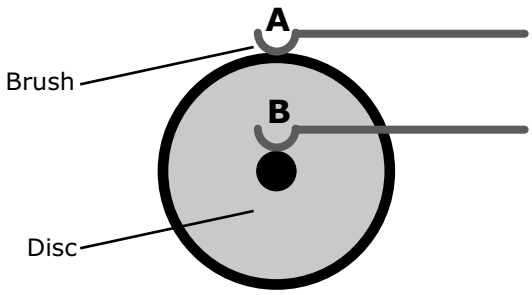
_____ [2]

(b) What would be the value of this e.m.f. if the magnetic flux density of the earth is 60 μT?

_____

_____ [2]

9 A metal disc rotates anticlockwise at an angular velocity ω in a uniform magnetic field that is directed into the paper in the diagram, and covers the whole of the disc. A and B are the brushes.



(a) By considering an electron between the brushes show that a potential difference exists between A and B.

_____

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(b) Explain what changes, if any, will be needed in the torque required to keep the disc rotating at the same angular velocity w if A and B are connected by a resistor

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_____

_____

_____

10 (a) Diagram 1 shows an electron of charge *e* moving with velocity *v* at right angles to a magnetic field of strength B.

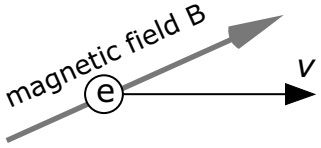

diagram 1

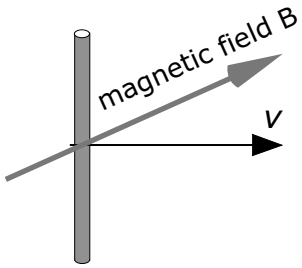

diagram 2

Write down a formula for the force on the electron *and* add an arrow to diagram 1 to indicate the direction of this force.

_____ [2]

(b) A straight wire is now moved with a velocity *v*, at right angles to the magnetic field, of strength *B*, as shown in diagram 2 above:

(i) How is this situation similar to that in part (a)?

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_____ [1]

(ii) Explain how this leads to an induced e.m.f. across the wire.

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_____ [3]

(iii) What additional information do you need in order to calculate the induced e.m.f.?

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_____ [1]

(iv) Write down the formula for the induced e.m.f..

_____

_____ [1]

(c) An aeroplane with a wingspan of 20m flies horizontally at a speed of 300ms^{-1}.

If the Earth's vertical component of magnetic flux density is 5.2×10^{-5} T, calculate the e.m.f. induced between its wingtips.

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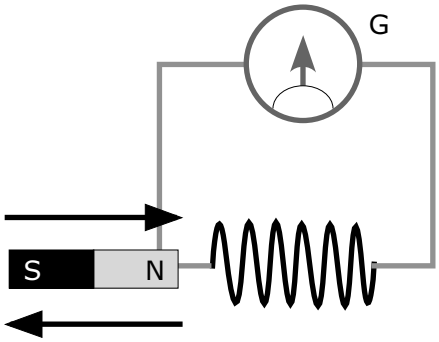
_____ [2]

11 A solenoid is connected to a sensitive galvanometer, G. A bar magnet is pushed quickly into the solenoid and then removed at the same speed.



(a) State the effect you would expect this action to have on the galvanometer.

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_____

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_____ [4]

(b) Explain these observations.

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_____ [5]

(c) The action is now repeated at a higher speed. State and explain what difference you would expect to see in the response of the galvanometer.

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_____ [2]

12 (a) Calculate the magnetic flux density of the magnetic field inside a 150 turn air cored solenoid of length 60 cm, carrying a current of 1.2 A.

(permeability of free space $\mu_o = 4\pi \times 10^{-7}$ Hm^{-1}.)

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_____ [3]

(b) A second coil of 50 turns and diameter 5 cm is wound tightly on the solenoid.

The current in the solenoid is switched off and falls to zero in 0.1s.

(i) Calculate the e.m.f. induced across the second coil.

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_____

_____

_____

_____ [4]

(ii) What assumption did you make in this calculation?

_____

_____

_____ [1]

(c) In another experiment the current in the solenoid is reversed rapidly. The e.m.f. across the second coil is found to be the same as in (b). How long did it take to reverse the current?

_____

_____

_____

_____

_____ [4]

13 (a) State Lenz's Law of electromagnetic induction.

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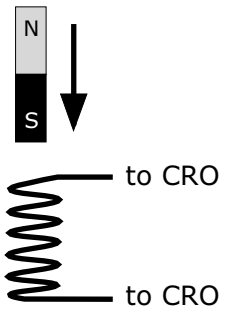
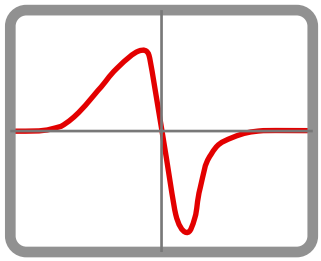
_____ [2]

(b) A magnet is dropped vertically through a coil of wire. A CRO connected to the coil displays a trace of the e.m.f. induced in the coil.





Explain the following features of the trace:

(i) The positive peak

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_____

_____ [3]

(ii) The negative peak

_____

_____

_____

_____ [2]

(iii) The relative magnitudes of the two peaks

_____

_____

_____ [2]

(iv) The duration in time of the two peaks

_____

_____ [1]

14 A long straight vertical wire has a direct current of 2A flowing in it.

(a) Describe how a Hall probe could be used to investigate the magnetic field at different distances from the wire. Include in your description:

(i) Other apparatus you would require.

(ii) A diagram of how the apparatus is set up.

(iii) The measurements you would take.

(iv) Three sources of error in the measurements.

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_____ [10]

(b) When the measurements are completed, they are plotted on a graph of field strength against distance from the wire. Make a sketch of the shape of this and state the relationship between field and distance that it indicates. [2]

(c) Taking μ_o as $4\pi \times 10^{-7}\ Hm^{-1}$, calculate the value of the field you would expect to find at a distance of 10cm

_____

_____

_____ [2]

15 (a) (i) State the relationship between magnetic field strength, B, and magnetic flux, ϕ

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_____

_____ [2]

(ii) State the SI units of each quantity.

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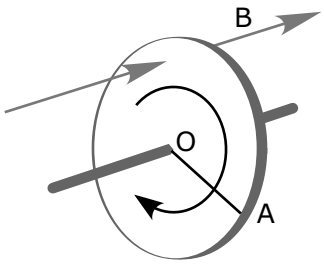
_____ [2]

(b) A conducting disc of diameter 5cm is mounted with its plane perpendicular to a uniform magnetic field of 0.1T. It rotates at 25 revolutions per second.



(i) Calculate the flux cut by a radial line AO as the disc makes one revolution.

_____

_____

_____ [2]

(ii) Hence calculate the emf induced between the centre of the disc and a point on its rim.

_____

_____

_____ [2]

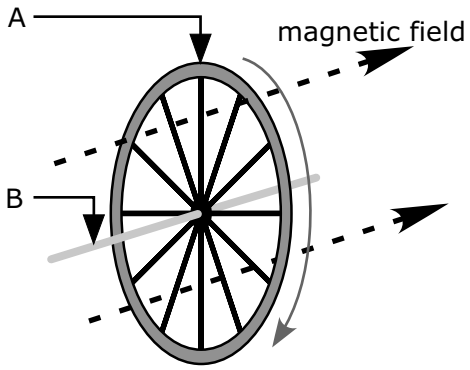
(iii) What is the emf induced between the end points of a diameter of the disc?

_____

_____

_____ [1]

16 A bicycle wheel is mounted vertically on a metal axle in a horizontal magnetic field.
Sliding contacts are made to the metal rim of the wheel and the axle.
The wheel is set to rotate freely.



(a) (i) Explain why an e.m.f. is generated between the contacts.

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_____

_____ [2]

(ii) State two ways in which this e.m.f. could be varied.

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_____

_____ [2]

(b) A small light bulb is connected between the contacts. State and explain what you would observe about:

(i) The light bulb

_____

_____ [2]

(ii) The rotation of the wheel

_____

_____

_____ [2]

(c) A second wheel is mounted in the same way at the same orientation to the field and rotated at same angular speed. The emf measured is 1/4 that of the first wheel.

What do you conclude about this wheel?

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_____

_____ [3]

17 (a) Describe an experiment to demonstrate Lenz's Law using a bar magnet and a solenoid.
What other equipment would you need?

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_____ [4]

(b) Describe the energy changes that take place during the experiment and show that Lenz's Law is consistent with energy conservation.

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_____ [6]