Chapter 21. Electromagnetic Induction

Contents:

4.5.1 Electromagnetic induction

Core

1 Know that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an e.m.f. in the conductor

2 Describe an experiment to demonstrate electromagnetic induction

3 State the factors affecting the magnitude of an induced e.m.f.

Supplement

4 Know that the direction of an induced e.m.f. opposes the change causing it

5 State and use the relative directions of force, field and induced current

4.5.2 The a.c. generator

Core

Supplement

1 Describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings and brushes where needed

2 Sketch and interpret graphs of e.m.f. against time for simple a.c. generators and relate the position of the generator coil to the peaks, troughs and zeros of the e.m.f.

4.5.6 The transformer

Core

1 Describe the construction of a simple transformer with a soft iron core, as used for voltage transformations

2 Use the terms primary, secondary, step-up and step-down

3 Recall and use the equation

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

where p and s refer to primary and secondary

4 Describe the use of transformers in high-voltage transmission of electricity

5 State the advantages of high-voltage transmission

Supplement

6 Explain the principle of operation of a simple iron-cored transformer

7 Recall and use the equation for 100% efficiency in a transformer

$$I_p V_p = I_s V_s$$

where p and s refer to primary and secondary

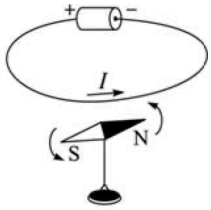
8 Recall and use the equation

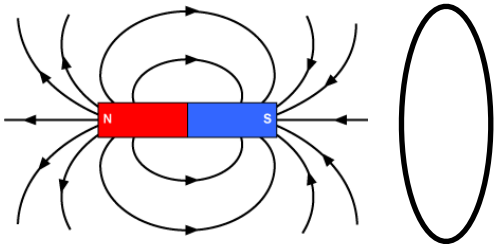
$$P = I^2 R$$

to explain why power losses in cables are smaller when the voltage is greater

20.1 Generating Electricity

Introduction





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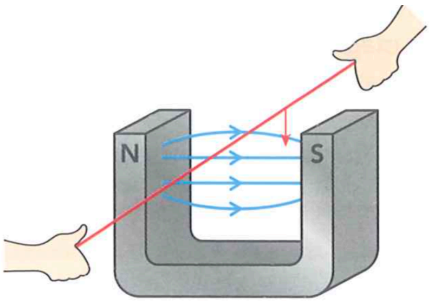
The principles of electromagnetic induction

Electromagnetic induction:

1. **Induction by** _____

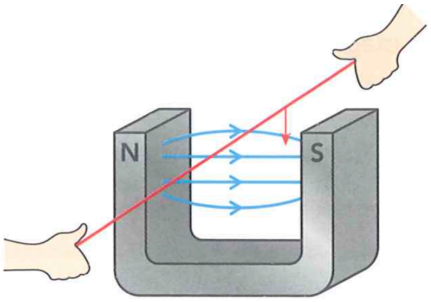
What kind of motion can induce a current?

How to increase the induced current?

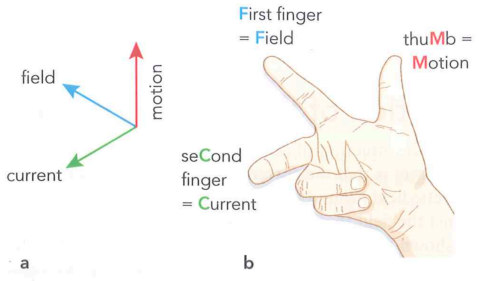


Why cutting filed lines can induce a current/e.m.f.?

According to the explanation above can you draw the direction of current of following situation?



Determine direction of current (high potential -> low potential) =>



Exercise 21.0:

Fig. 9.1 shows a thin, straight rod XY placed in the magnetic field between the poles of a magnet. The wires from the ends of XY are connected to a centre-zero voltmeter.

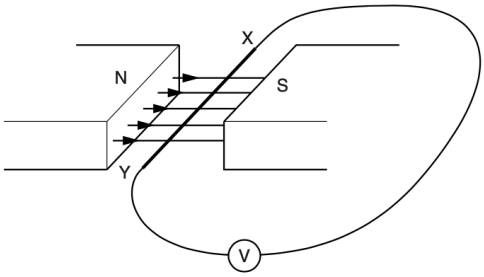


Fig. 9.1

(a) When XY is moved slowly upwards the needle of the voltmeter shows a small deflection.

(i) State how XY must be moved to produce a larger deflection in the opposite direction.

.....

..... [2]

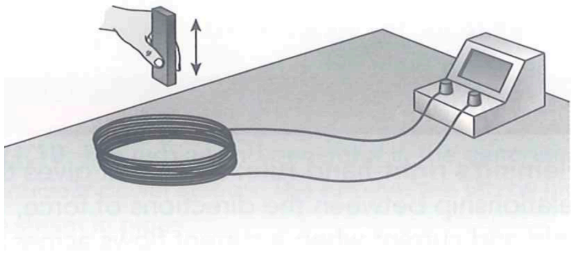
(ii) XY is now rotated about its central point by raising X and lowering Y. Explain why no deflection is observed.

.....

.....

..... [2]

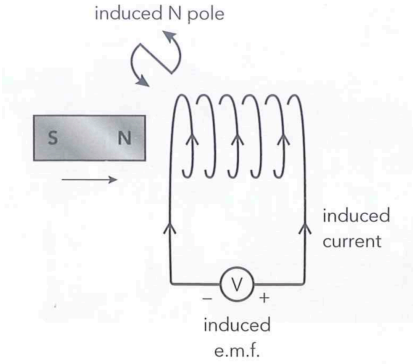
2. Induction by _____



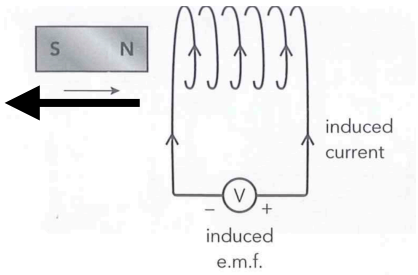
What kind of motion can induce a current?

Increase the induced current e.m.f?

Determine direction of current =>



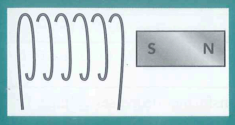
What if the magnet now moving away?



Understanding Lenz's law in the point of view of **Energy:**

Exercise 21.1:

4 The diagram shows a coil and a magnet. When the magnet is moved away from the coil, current flows.



Which one of the following describes what happens? [1]

A Current flows clockwise in the coil, creating a north pole which attracts the south pole of the bar magnet.

B Current flows anticlockwise, creating a north pole which repels the south pole of the bar magnet.

C Current flows anticlockwise, creating a south pole which repels the south pole of the bar magnet.

D Current flows anticlockwise, creating a north pole which attracts the south pole of the bar magnet.

5 a Which statement describes electromagnetic induction? [1]

A the production of an e.m.f across an electrical conductor when there is relative movement between the conductor and a magnetic field

B the production of an e.m.f across an electrical conductor when there is no movement between the conductor and a magnetic field

C the production of an e.m.f across an electrical conductor when there is relative movement between the conductor and an induced current

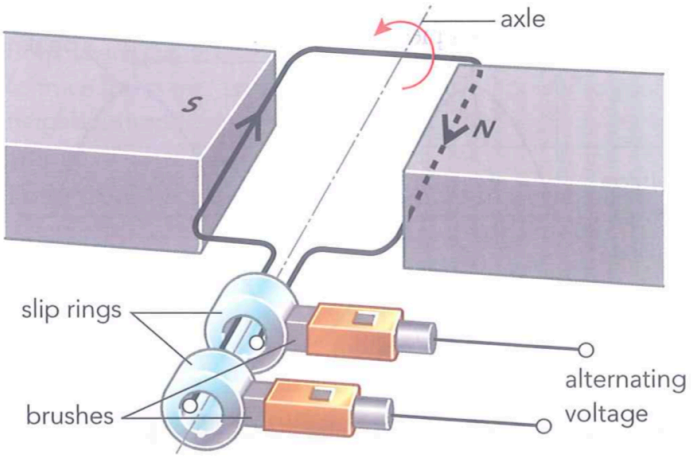
D the production of an e.m.f across an electrical conductor when there is no movement between the conductor and an induced current

b **Describe** an experiment to demonstrate electromagnetic induction using a horseshoe magnet, a piece of copper wire and a sensitive ammeter. You may include a diagram in your answer. [3]

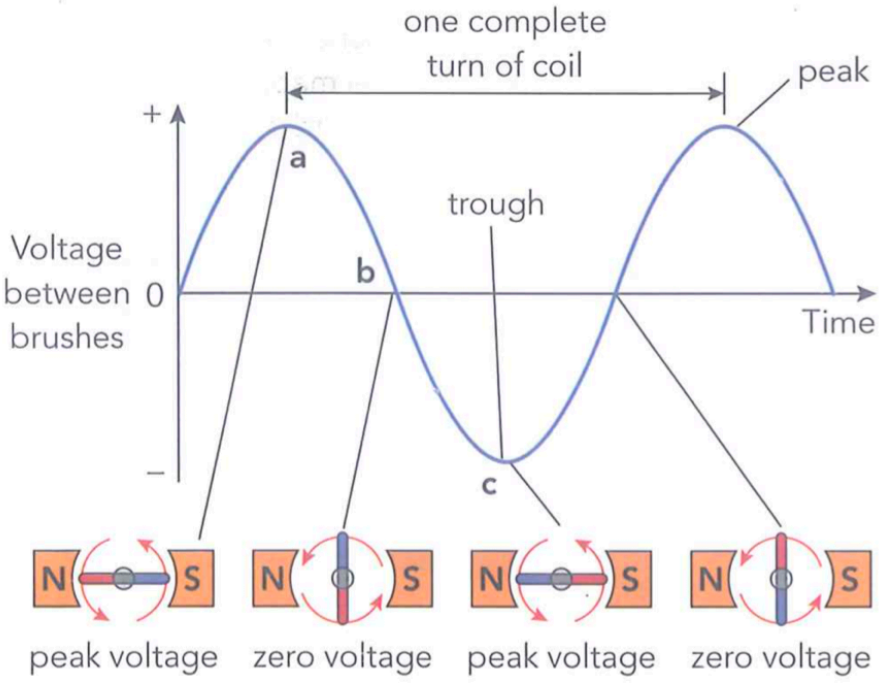
c **State two** factors which affect the size of the current induced in this experiment. [2]

[Total: 6]

a.c. generator



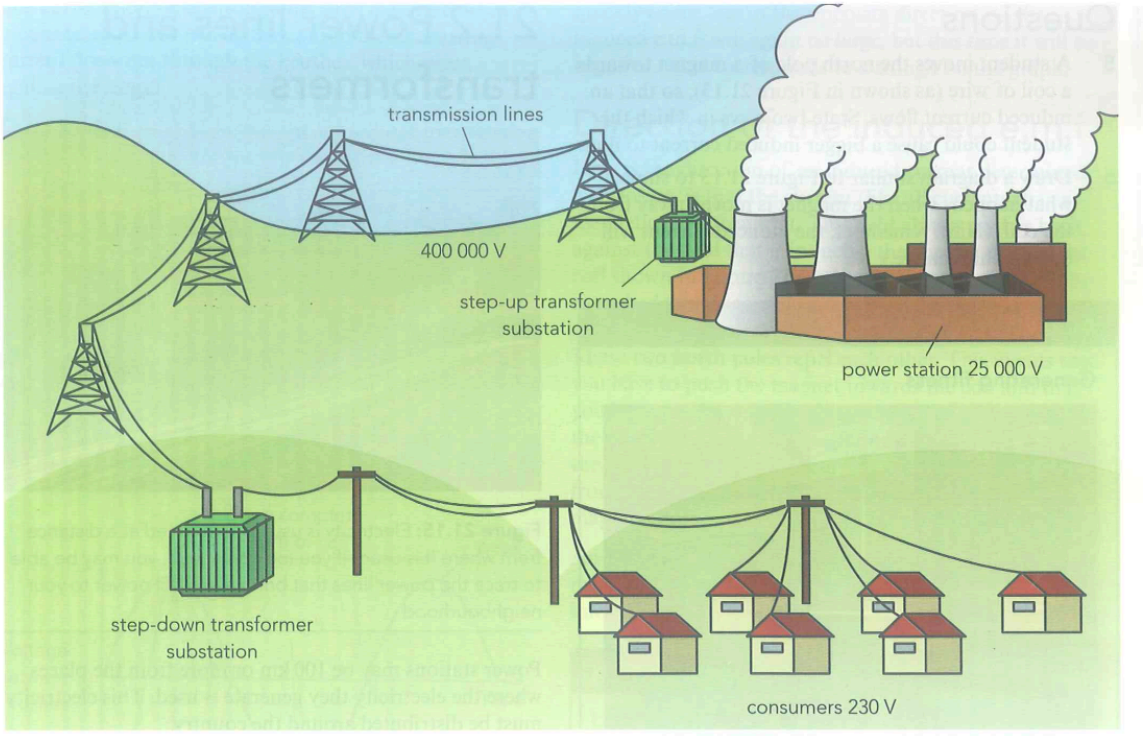
Why generator produces alternating current?



Increasing the e.m.f. generated by a.c. generator

20.2 Power lines and Transformers

National grid:



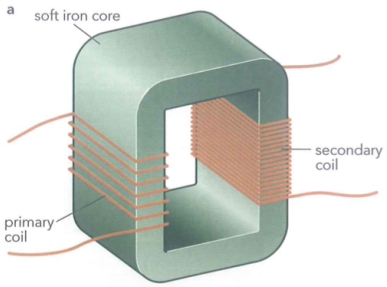
Why use high voltage?

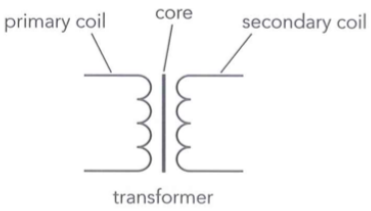
Power loss:

Exercise 21.2:

A 20kW generator gives an output of 500V. This is transmitted to a workshop by cables with a resistance of 20 ohms. Calculate:
A. the power loss in the cables.
B. If the output is increased somehow to 20kV, calculate the power loss in this case.

How to get high/low voltage => transformers

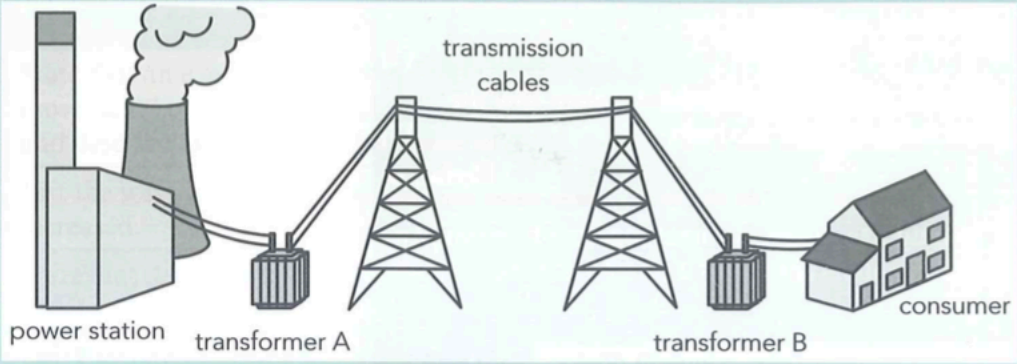




Step-up transformer:
Step-down transformer:

Exercise 21.3:

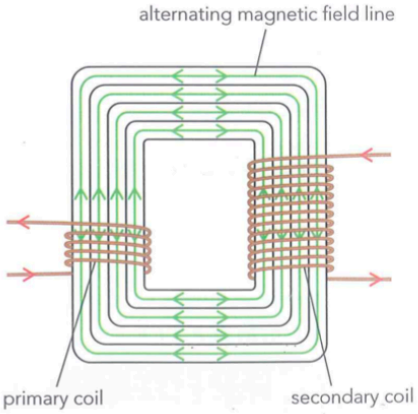
7 a Transformers are used in the national grid to change the voltage of the supply. For transformers A and B, state whether the transformer is step-up or step-down, and explain why the voltage change is necessary. [4]



b A transformer in the national grid has 800 turns on the primary coil and 16 000 on the secondary. The primary voltage is 25 kV. Calculate the secondary voltage. [2]

[Total: 6]

How transformers work?



Power in transformer

Exercise 21.4:

A school power pack has an output voltage of 9 V. It is plugged in to the 230 V mains supply. The power pack contains a transformer. The output current of the power pack is 3 A. Calculate the current supplied to the primary coil of the transformer in the power pack. Assume there are no energy losses in the transformer.