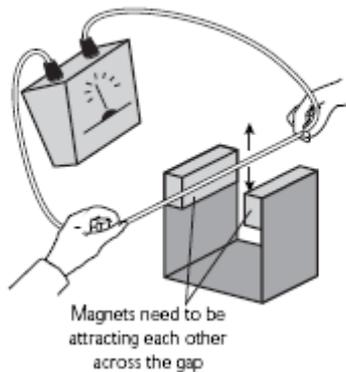


## TAP 414-2: Electromagnetic induction

Use the apparatus shown below to show how a current can be induced in a wire using magnetism. Explore the factors that affect the size of the induced emf and current.

### Straight wire in a field



### Apparatus

- ✓ steel yoke
- ✓ Magnadur magnets (2) (as in Westminster Electromagnetic kit)
- ✓ 26 swg PVC-covered copper wire
- ✓ wire strippers
- ✓ cathode-ray oscilloscope or centre-zero galvanometer (Philip Harris Y19360/7 or similar)

### What to do:

Connect a long wire to a sensitive galvanometer or cathode-ray oscilloscope.

Note the effect on the meter or CRO as you do each of the following:

Move the wire into a strong magnetic field as shown above

Hold the wire at rest within the field.

Remove the wire from the field.

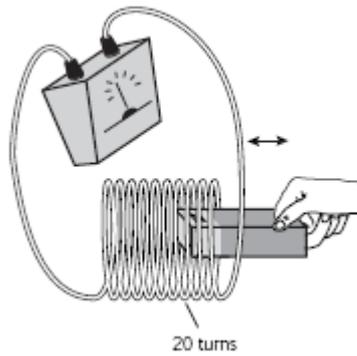
Repeat, but move the wire more quickly or more slowly.

Reverse the field and repeat.

Make a loop in the wire and pass it over one of the magnetic poles so that two thicknesses of wire move through the field together.

Keep the wire still and move the magnet.

### Magnet and coil:



## Apparatus

- ✓ cathode-ray oscilloscope or centre-zero galvanometer (Philip Harris Y19360/7 or similar)
- ✓ C-cores (2)
- ✓ 1.5 V cell
- ✓ 26 swg PVC-covered copper wire
- ✓ wire strippers

## Set up:

Connect a loosely coiled solenoid of about 20 turns to a sensitive galvanometer or a CRO.

Note the effect on the meter or CRO as you do each of the following:

Move the bar magnet as shown in Figure A12.2, north pole end first, into the solenoid.

Hold the magnet at rest within the solenoid.

Remove the magnet from the solenoid.

Repeat the previous steps, moving the magnet more quickly or more slowly.

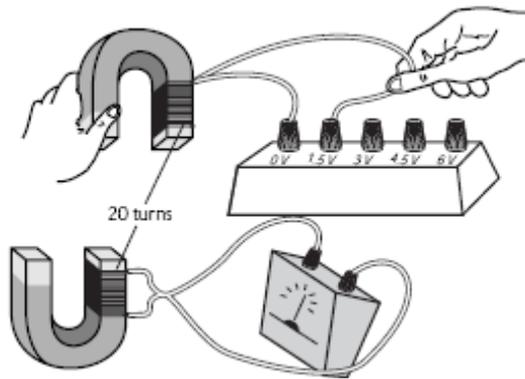
Reverse the magnet so that the south pole points towards the coil.

Repeat the above steps.

Increase the number of turns of wire in the coil and repeat the previous steps.

Keep the magnet still and move the solenoid.

## Two C-cores



### Apparatus

- ✓ Two C-Cores with 20 turns each or with specialised 120-120 turn coils (not shown)
- ✓ cathode-ray oscilloscope or centre-zero moving-coil galvanometer/ microammeter
- ✓ 1.5 V cell
- ✓ ammeter
- ✓ leads

### What to do:

One C-core and coil is used to set up a magnetic field. The second C-core and coil is connected to galvanometer, as shown above.

Note the meter reading as you do each of the following:

Connect the 'magnetic field' solenoid to a single cell.

Leave the 'field' solenoid connected.

Disconnect the 'field' solenoid from the cell.

Change the separation of the solenoids and repeat.

What can you do to increase the size of the meter reading?

## Dynamo

### Apparatus

- ✓ cathode-ray oscilloscope
- ✓ bicycle dynamo (mounted version that can be turned by hand)
- ✓ leads

### What to do

Connect a bicycle dynamo to a CRO and observe the output as you rotate the dynamo at various speeds.

**Note**

Not all parts of this activity are equally reliable for quantitative results but you should be reasonably confident to say whether the induced emf increases or decreases with any or all of the variables.

## **Practical advice**

If time permits, we recommend that this is a class practical, but it could be a demonstration. These classic demonstrations are a little remote from the context, but they are nevertheless useful and thought-provoking and provide a useful lead in to a quantitative treatment of electromagnetic induction.

There is quite a lot of theory at this point, involving the key ideas of flux and flux linkage and leading up to Faraday's law. To introduce Lenz's law, an energy argument is used; we recommend discussing with students the consequences if the induced emf was in the reverse direction.

The case of an isolated straight wire moving in a magnetic field can be treated as a special case of Faraday's law (i.e. rate of change of flux linkage), rather than in terms of 'cutting' field lines, since the latter approach obscures the fact that there is really only one law underlying electromagnetic induction, irrespective of how it is brought about.

Fleming's right-hand rule could make an appearance here, following an argument in terms of Lenz's law. One way to remember which hand to use is to note that (in the UK) motors drive on the left, so the left-hand rule applies to motors – and the other hand is for dynamos.

## **External reference**

This activity is taken from Salters Horners Advanced Physics, section TRA, activity 12