

TAP 411- 4: Fields near electric currents

Magnetic fields due to electric currents are investigated. The fields will need to be measured carefully.



Turn power supplies off when not taking readings. Large current may be used, wires can get hot!

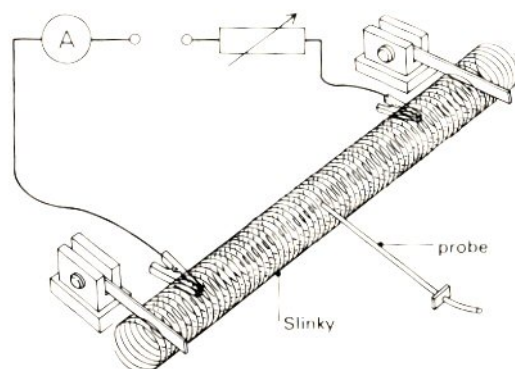
Magnetic flux density B for a solenoid

You will need:

- ✓ large Slinky
- ✓ 2 slotted bases
- ✓ 2 wood strips or rulers (to support the slinky)
- ✓ 2 crocodile clips with insulating covers
- ✓ transformer + $15\ \Omega$ rheostat or variable ac power supply
- ✓ oscilloscope
- ✓ search coil
- ✓ leads
- ✓ ruler
- ✓ 10 A ac ammeter

Set-up:

Switch off equipment when not taking measurements



Use the equipment to investigate the following:

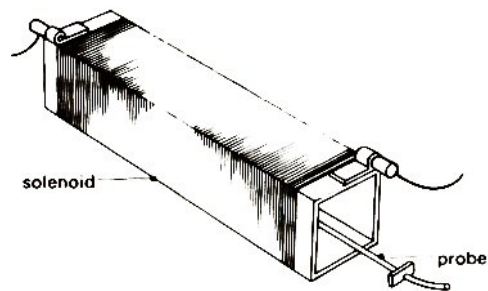
- How does the field vary along the axis? (Current and N/L constant)
- How does the field at the centre vary with current? (N/L constant)
- How does the field vary with number of turns per unit length (N/L)? (Current constant.)

Set of solenoids

You will need:

- ✓ Set of solenoids
- ✓ oscilloscope and search coil if using ac
- ✓ leads
- ✓ ruler
- ✓ transformer + $15\ \Omega$ rheostat or variable ac power supply + 5 A ac ammeter
- ✓ Alternative: smoothed dc power supply (or car battery) + rheostat, 5 A dc current meter and Hall probe

Set up



Use the equipment to investigate the following:

- How does the field vary along the axis? How does the field at the end compare to the centre?
- How does the field vary with current? (N/L constant)

- How does the field vary with number of turns per unit length? (N/L) (Current constant.) {Use a solenoid with closely wound turns and one with loose turns and compare results.}

Switch off equipment when not taking measurements.

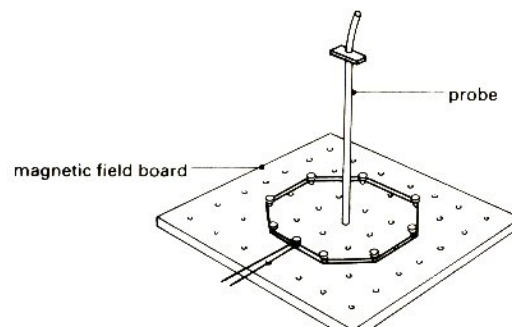
Magnetic field board

You will need:

- ✓ Magnetic field board and 0.45 mm PVC covered wire or similar
- ✓ oscilloscope and search coil if using ac
- ✓ leads
- ✓ ruler
- ✓ transformer + 15 Ω rheostat or variable ac power supply + 5 A ac ammeter
- ✓ Alternative: smoothed dc power supply (or car battery) + rheostat, 5 A dc current meter and Hall probe

Set up

Wind circular coils on the board.



Use the equipment to investigate the following:

- How does the field at the centre vary with radius of coil? (constant current and number of turns)
- How does the field vary with current? (Radius and number of turns constant, measure the field at the centre of the coil)

Switch off equipment when not taking measurements

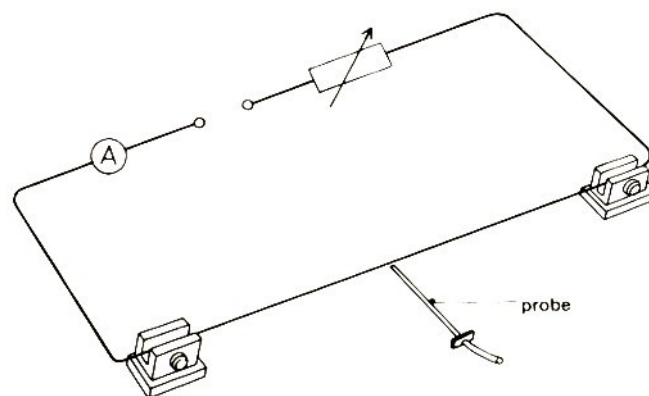
Make suitable notes and graphs of your results.

Straight wire

You will need:

- ✓ 0.45 mm PVC covered wire or similar
- ✓ 2 slotted bases
- ✓ 2 crocodile clips
- ✓ transformer + 15 Ω rheostat or variable ac power supply
- ✓ oscilloscope
- ✓ search coil
- ✓ leads
- ✓ ruler
- ✓ 5 A ac ammeter

(Alternative: use a signal generator with a high ac frequency rather than a power supply, but take care to limit the current so that the signal generator is not damaged.)



The longer the wire between the slotted bases the better. Make sure the rest of the equipment is some distance away.

Use the equipment to investigate the following:

- How does the field vary with distance from the wire? (constant current)
Hint try $1/\text{distance}$
- How does the field vary with current? (Have the probe close to the wire))

Remember to turn off equipment when it is not be used to take measurements

Practical advice

Search coils and Hall probes will need to be introduced as devices that give a reading proportional to field size

The set of coils and Slinky are alternative experiments

It is suggested that students report back on their experiment rather than carry out each task.

The straight wire is best with a signal generator set at a fixed high ac frequency together with the search coil. This allows smaller currents to be used and an easier experiment for students.



Turn power supplies off when not taking readings. Large current may be used, wires can get hot!

Slinky solenoid This offers the chance to vary the number of turns per unit length and to explore the field along a line at right angles to the axis of the coil (both within and without). A current of 3 A is suggested.

Set of solenoids The solenoids require currents of about 2 A. The set of four includes two different cross-sectional areas and two different numbers of turns per unit length.

Coils The magnetic field board enables coils of various shapes to be made. Each should have about ten turns with 5 A flowing. Alternatively, a coil such as that with 120 + 120 turns may be used.

A straight wire This has rather a weak field so the current should be 10 A if possible. If a 10 A rheostat is not available, try using two 5 A ones in parallel, ensuring that each takes half the total current. It is also possible to use several parallel wires each carrying several amperes, provided that the return circuit is kept well away. In any case, students should switch off as soon as a measurement has been made.

In all cases, the plane of the probe should be such as to give a maximum reading.

The advice for a straight wire above is for use with a Hall probe and dc.

External reference

This activity is taken from an adaptation of Revised Nuffield Advanced Physics experiment H7.