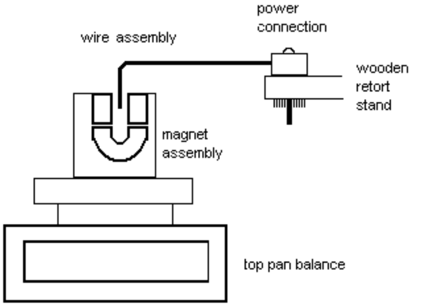
The force on a current carrying conductor (F = BIL)

While conducting this experiment, you will be assessed for CPAC1: Following written instructions, including your ability to set up the circuit. Your lab report will be assessed for CPAC4: Correctly tabulating sufficient data and CPAC5: Calculating percentage uncertainties.

Apparatus

Large smoothed power pack with continuous adjustment
Wire assembly
Ammeter
Wires
Wooden retort stand
Top pan balance
Magnet assembly



Theory

A current carrying conductor in an external magnetic field experiences a force that depends on the strength of the magnetic field, the current flowing in the conductor and the length of the conductor in the field. This force can be calculated from the corresponding mass reading on the top pan balance.

The magnet assembly consists of a number of magnets. If we assume that the flux density varies uniformly with the number of magnets, then the force is given by:

$$F = nBIl$$

where n is the number of magnets and B is the field due to one magnet.
B is a constant and there are three variables:

If n and l are kept constant then a plot of F against I should be a straight line.
If n and I are kept constant then a plot of F against l should be a straight line.
If I and l are kept constant then a plot of F against n should be a straight line.

In each case, you should be able to find a value for B, the field due to one magnet, from the gradient of the line.

Method

There are three sections to the experiment and each will require a separate results table. The common pole of the horseshoe magnets is marked with black – make sure that you insert all magnets into the arrangement the same way round! **The balance should be zeroed before every reading**. First connect the balance in a circuit with the power pack. N.B. Be careful to set the power pack to zero output.

Ask your teacher to check your circuit before proceeding – do not switch on the supply until checked.

Variation of current.
Use all 5 magnets and use the maximum length of wire. Measure this length. Vary the current I from about 0.5 A to 2.5 A. (The power pack has a meter on the front showing the voltage, which can be varied smoothly.) Determine the force and record this for each current. Obtain at least 8 readings.

Variation of length.
Next use all 5 magnets and keep the current constant at the maximum of 2.5 A. Record it. Vary l by adjusting the relative position of the wire assembly and the magnet assembly. Record the force and the length of the conductor each time.

Variation of magnetic field strength.
Keep l at its maximum value and make a note of it. Keep I constant at the maximum value of 2.5 A and note its value. Vary B by changing the number of magnets. Try to keep the magnets evenly distributed. You should be able to obtain 5 readings.

Results

Use the following table formats to record your readings. The force is calculated from F = m g, where the mass is in kg and g = 9.81 m s^{-2}.

Variation of current.

Current I/A	Balance Reading/g	Magnetic Force F/N

Variation of length.

l/mm	Balance Reading/g	F/N

Variation of magnetic field strength.

Number of magnets (n)	Balance Reading/g	F/N

Analysis

Analyse each part separately, plotting an appropriate graph for each section.

If B and l are constant then a plot of F against I should be a straight line. The gradient of this line is nBl. Use the gradient to calculate the field due to a single magnet. The unit of B is the tesla (T).

If B and I are constant then a plot of F against l should be a straight line. The gradient of this line is nBI. Use the gradient to calculate the field due to a single magnet.

If I and l are constant then a plot of F against the number of magnets should be a straight line. The gradient of this graph will be BIl. Calculate a third value for the field due to a single magnet.

Are the graphs straight lines as expected? Is there evidence of random and systematic errors?

Using a middle value from each table, calculate a percentage uncertainty for each value of B.

Are the three values for the field due to a single magnet of the same order of magnitude? If not check for errors. Calculate an average value and discuss the associated uncertainty.

What assumption has been made about the magnets used in this experiment?