

Magnetic fields of wires and forces on moving charges

AP Physics 2 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How big is the magnetic force on a wire carrying current, and can a kitchen balance measure it? By using the reaction of the magnets, you can turn a tiny force into a mass reading and determine the field strength between two poles.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 12

Aim

Investigate how the magnetic force on a current-carrying wire depends on the current, and use the results to find the field of a pair of magnets.

Equipment

- pair of bar or disc magnets on a U-shaped iron yoke, with a gap of about 4 cm
- top-pan balance reading to 0.01 g
- rigid wire, clamped on a stand so that it passes through the gap without touching the magnets
- variable d.c. supply (0–6 V) with a rheostat and an ammeter (0–6 A)
- ruler

Safety

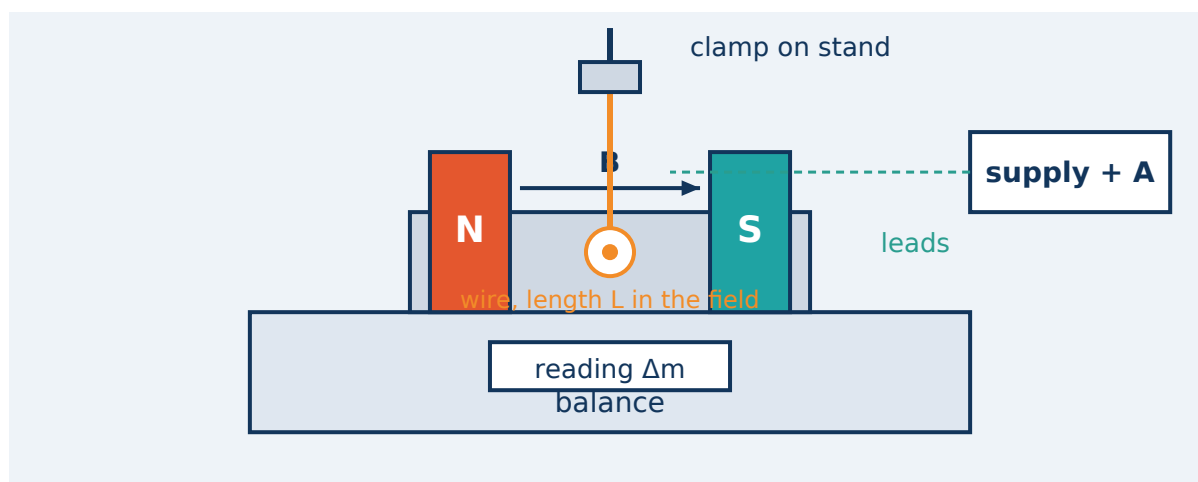
Safety

Currents of several amperes warm the wire. Switch on only while reading the balance and never hold the wire. Keep magnets away from phones and bank cards.

Method

1. Place the magnet-and-yoke assembly on the balance and tare the reading to zero.
2. Clamp the wire so that a length L of 4.0 cm lies inside the field, with no part touching the magnets. Measure L with the ruler.
3. Choose the current direction so that the force on the wire is upward (the magnets are pushed down by the reaction).
4. Set $I = 1.0$ A, switch on, read the balance change Δm , then switch off.

5. Repeat for $I = 2.0, 3.0, 4.0$ and 5.0 A.



The wire pushes up on the magnets with a reaction force, so the balance reading rises.

Results

Sample data, with $L = 4.0$ cm:

Current I (A)	Change in balance reading Δm (g)
1.0	0.50
2.0	0.98
3.0	1.46
4.0	1.95
5.0	2.44

Analysis questions

Question 1 Force from the readings

Convert $\Delta m = 1.46$ g ($I = 3.0$ A) into the force on the wire. Use $g = 9.81$ N/kg and state why the balance reading changes.

Question 2 Graph

Plot Δm (y-axis) against I (x-axis). Describe the graph and explain the shape using $F = BIL$.

Question 3 Slope of the line

Work out the slope of your best-fit line from its two end points, and state the unit of the slope.

Question 4 Magnetic field

Use the gradient, g and L to calculate the field B between the poles.

Question 5 Uncertainty

The length L is 4.0 cm with an uncertainty of ± 1 mm, and Δm has an uncertainty of ± 0.01 g. Estimate the percentage uncertainty in L and in Δm for $I = 1.0$ A. State which limits the experiment more.

Question 6 Changing the angle

The wire is turned in the horizontal plane until it makes 30° with the field, keeping the same length in the field. Predict the new reading for $I = 4.0$ A and explain.

Question 7 Improving the method

Suggest two improvements to make the value of B more reliable.