

TAP 412-3: Force on a current-carrying wire

Here you measure the force on a current-carrying wire placed in a uniform magnetic field. This is the origin of the 'motor force'.

You will need:

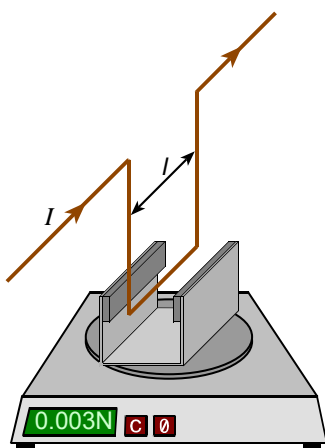
- ✓ two mild steel yokes
- ✓ four slab magnets
- ✓ rheostat rated at least at 4 A, 6 A is better
- ✓ digital multimeter, used as an ammeter
- ✓ power supply, 0–12 V
- ✓ leads, 4 mm; three are required, two need to be at least 0.5 m long
- ✓ mass balance, electronic, 0–2 kg, ± 10 mg
- ✓ two retort stands with boss and clamp
- ✓ metre rule (used for holding wire in position)
- ✓ shaped bare wire, six samples



Safety

Large currents will heat the wires and care should be taken when handling them

What to do



The 'top pan balance' is a straightforward way of investigating the factors affecting the force on a wire carrying a current in a magnetic field. The 'wire' is clamped so that it remains stationary and the balance measures the 'change in weight' of the Magnadur magnets placed on its pan.

The balance will probably be calibrated in grams and milligrams. One gram is equivalent to a weight of 0.0098 N (0.01 N will probably be accurate enough). The balance should also be capable of being 'tared' or zeroed with the magnets in place, so that when there is no force the reading is zero.

1. A single straight wire, connected to a dc power supply in series with an ammeter and rheostat, is taped to a metre rule and clamped horizontally at right angles to the field. Vary the current gradually up to about 5 or 6 A. (This will depend on your power supply.)
2. How does the force on the wire (or the change in weight of the magnets) depend on the current in the wire?
3. Plot a graph of force against the current in the wire.
4. To investigate how the length of wire in the field affects the force, the single wire can be replaced by wires of different length. These wires have been shaped so that a short horizontal section can be placed in the field. Investigate how changing the length affects the force on the wire. Make sure that the current is the same each time.
5. There are forces acting on the vertical sections of the wire. Why don't these affect the reading on the balance?
6. Plot a graph of force against the length of the wire in the field.

If magnets of different strength are available, you should be able to determine how the force depends on the magnetic field strength, although a quantitative relationship may be very difficult to establish.

Outcomes

1. The two graphs should show that the force is proportional both to the current in the wire and to the length of wire in the field.
2. The force is also proportional to the magnetic field strength, although without measurement you may not be convinced.

Practical advice

Several lengths of shaped bare wire are required, about 0.56 mm diameter or thicker. Bare or tinned copper will do. All apart from one should be shaped so that a known length can be inserted into the field between the magnets ranging from 10 mm up to 60 mm. The ends of these wires could be fitted with 4 mm sockets for ease of use.

This is a slick and easy way to do an experiment that has appeared in different forms, primarily as a current balance, which we want to avoid. We do not think the students' or teacher's time is rewarded by the effort that is often necessary to get results. The top pan balance provides a simple way of measuring force.

It is well worth preparing a set of wires beforehand, although, if time allows, teachers may wish their students to make them. This will mean that suitable tools, good pliers and possibly a small vice, will need to be available as well as the apparatus listed.

Investigating length and current are straightforward and should not cause too many problems. It would be wise to check what range of currents will provide suitable results.

Changing the magnetic field will be less satisfying, unless you have a wide range of suitable magnets with different, known strengths.

There may be a problem with a 100 Hz ripple affecting either the ammeter or the balance; if this is the case a good smoothing unit should be used.

Alternative approaches

We strongly recommend this method: it allows us to concentrate on the relevant physics and avoids the practical intricacies that other methods introduce. This method also gives good accuracy and reliability.



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External reference

This activity is taken from Advancing Physics chapter 15, 300E