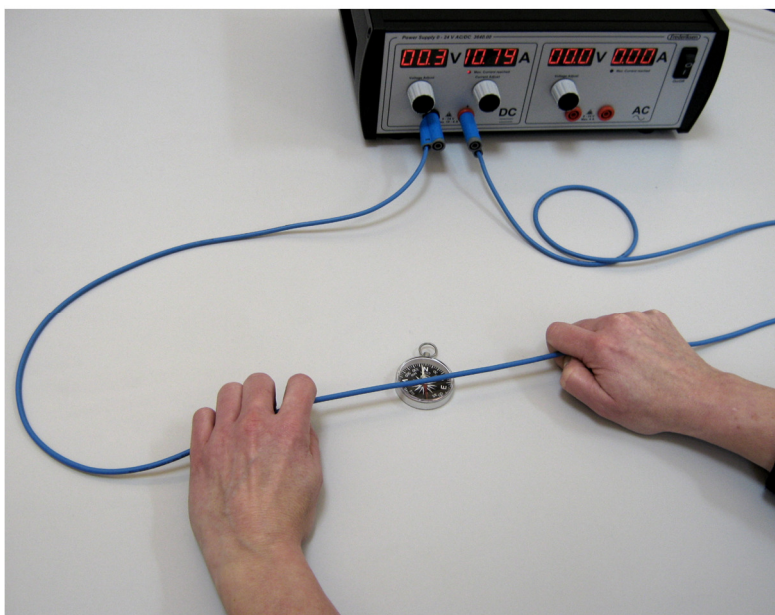


Number	137110-EN	Topic	Electromagnetism		
Version	2016-04-27 / HS	Type	Student exercise	Suggested for	Grade 8, 9, (10) p. 1/4



Objective

We will examine the magnetic field around a current-carrying wire.

The observations are compared to an easy to remember rule of thumb.

Principle

The direction of the magnetic field at a given position can be found by a small compass. The north pole of the compass needle points in the direction of the field.

In this experiment we examine the magnetic field below and above a horizontal wire (Oersted's classical experiment) as well as around a vertical wire.

Equipment

(Detailed equipment list on last page)

Compass

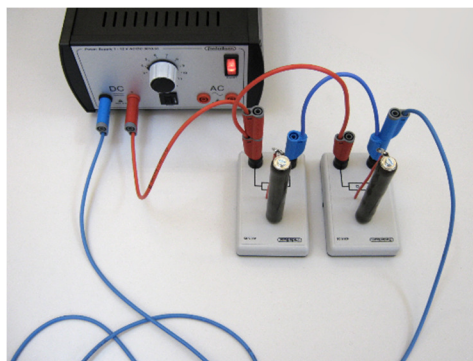
Lab lead, (preferably:) 2 m

Power supply, 10 A, with current limiter
(like Frederiksen no. 364000, 363000 or the older models: 362060, 362050).

Alternative power supply

If the power supply *doesn't* have a current limiter you must insert a series resistor in the circuit. As this resistor carries a high current, use two 1 Ω , 50 W resistors in parallel – see photo below.

Your instructor can advise how far to turn up the voltage.



Alternative setup (see text)

Procedure

This experiment is best performed with a good distance to iron or other magnetic materials as these can have an unwanted influence on the compass. Unfortunately, lots of lab furniture has steel frames so have a look at the underside of the table to see if there are areas of the table top that you should avoid.

Place the compass on the table. The north pole of the compass needle is **RED**. Turn the housing to fit the direction of the needle – we call this the *rest direction* of the needle.

Connect the wire to the power supply. Turn the voltage up a bit. Make sure the current limiter is turned fully up – we should ideally use 10 A or more in this experiment.

Notice the direction of the current. The current in the wire goes from plus (red socket) to minus (black).

Now, hold the wire closely over the compass, running parallel to the rest direction. Note what happens. Make a sketch showing the compass, the wire, the rest direction of the needle, and the direction when the wire is close by. Put an arrow on the wire to show the direction of the current.

Rearrange the wire to make the current run in the directly opposite direction above the compass. Draw the new situation also.

Try to explore the difference between having the wire close to the compass and a bit longer away. Move the wire slowly to allow the needle to come to rest.

Keep the direction of the wire but place it directly on top of the table. Place the compass above the wire. Once more, make a sketch of the situation. Try again to vary the distance between wire and compass.

Now, try to run the wire double. This can be done in two different ways – see figure to the right.

Try both ways with the parallel parts of the wire as close to each other as possible.

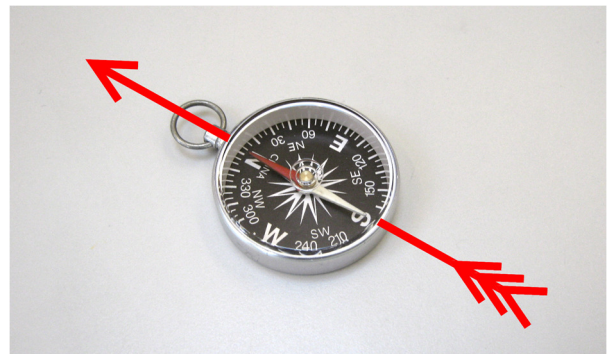
Before you do it: Guess what will happen!

How does the effect depend on the distance? – compare with the same experiment with the single wire.

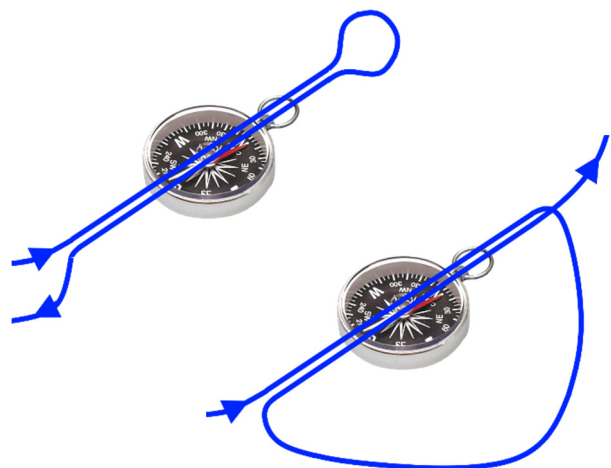
Finally help each other two by two: One holds part of the wire vertically. Notice as before which way the current runs (up or down).

The other one of you takes the compass a tour around the wire – as close as possible; let the compass touch the wire. Take care to hold the compass horizontal for the needle to swing freely

Keep an eye on the direction of the needle along the way. Draw the situation seen from above.



First, turn the compass to follow the rest position of the needle



Double wire – two different ways

Theory

The direction of the magnetic field at a given position can be found by a small compass placed there.

The north pole of the compass needle points in the direction of the field.

(Here, we imagine a "Super 3D compass" in which the needle is free to rotate in three dimensions.)

The magnetic field around a straight, current-carrying wire can be described by field lines, running in circles around the wire.

In order to remember the direction you can make a *grip rule*:

Grip the wire with the thumb pointing in the direction of the current – then the remaining fingers will show the direction of the field.

This rule can naturally only be valid for **either the right or the left hand!** (Consider why!)

In the next paragraph, you will decide which.

Discussion and evaluation

From your sketches of the experiment, decide whether the grip rule is valid for the right or the left hand.

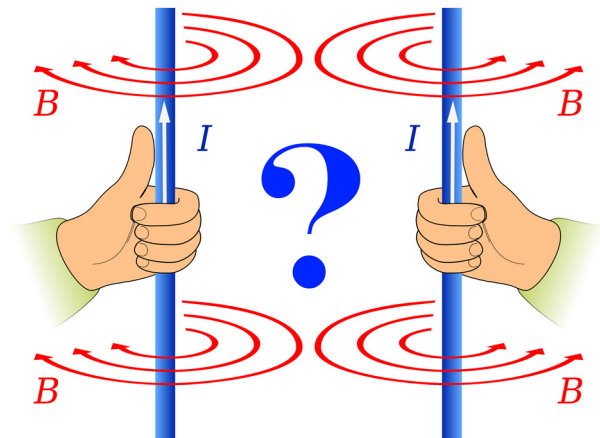
Write down the answer – preferably as a re-phrased grip rule than explicitly mentions the hand.

Check that *all* parts of the experiment agree with your rule.

Explain the difference between the two situations with the wire running double.

Which other magnetic fields (i.e. apart from the field from the wire) will influence the compass in practical situations?

How could the experiment be improved if you want to demonstrate the magnetic field from the current carrying wire more clearly?



Grip rule – which hand?

The current is called I . The direction of the current is shown with the white arrow. The magnetic field is called B , its direction is shown with red arrows.

Only one side of the figure can be correct!

Teacher's notes

About the equipment

It is important that the compass isn't larger than the one recommended here. When measuring with the wire in a vertical position, the distance will be at least the radius of the compass, and if the distance is more than about 20 mm the magnetic field of the earth will dominate the result.

Quite a large current is needed to get a significant reaction from the needle. The precise size of the current is less important.

Frederiksen's power supplies type 364000 or 353000 are built to handle large currents into very small resistances.

Alternative power supplies

As mentioned on page 1, you can use other power supplies by inserting a series resistor in the circuit. But at 10 A, the resistor quickly gets hot. By coupling two in parallel, the power is distributed evenly.

In case the power supply has no ammeter, the current can be found by measuring the voltage across the resistors and using Ohm's law. Even if your multimeter has a 10 A range, it will not necessarily tolerate this large current for an extended time.

Caution: The resistors get hot!

The parallel connection has a resistance of 0,5 Ω .

When carrying a total of 10 A, this will cause a 5 V voltage drop across the resistors. Each of them will therefore dissipate 25 W. (If *one* 1 Ω resistor is used instead, the voltage drop raises to 10 V and the single resistor will have to dissipate 100 W.)

Apart from the series resistor, there will be resistance in the wires and the connectors. The power supply must be adjusted for a larger voltage in order to deliver 10 A.

Investigate this in advance, so you can instruct the students simply to turn up to a certain voltage.

Detailed equipment list

Specifically for this experiment

340505 Pocket Compass with ring \varnothing 40 mm
(Other small compasses can also be used)

Standard lab equipment

364000 Power supply
105753 Safety cables, silicone, 200 cm, blue
or:
105743 Safety cables, silicone, 100 cm, blue (2pcs)
... or similar

Alternative power supplies

As mentioned: When using power supplies without a current limiter, add a series resistor in the form of two large power resistors, coupled in parallel:

420505 Resistor 1 ohm 50 W 5% (2pcs)
105711 Safety cables, silicone, 25 cm, red
105713 Safety cables, silicone, 25 cm, blue
105721 Safety cables, silicone, 50 cm, red