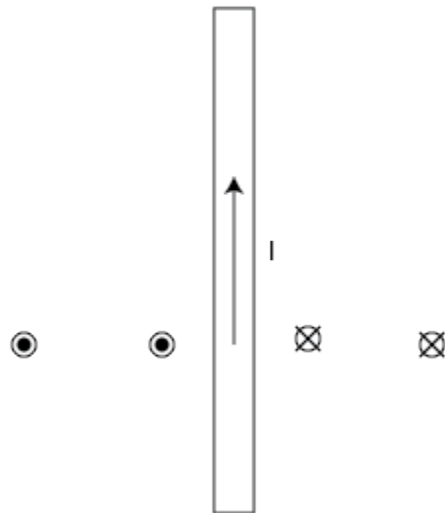


Preparation PHYS2425 Magnetism lab.

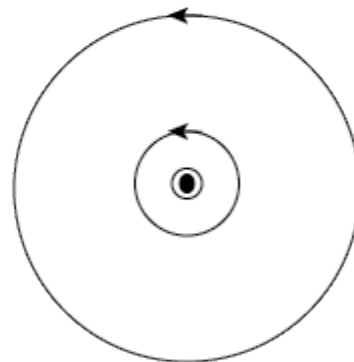
Charges cause electric fields. We saw in the first part of the semester that electric field lines start at positive charges and end up at negative charges. We say in physics positive charges are the sources of the electric field lines and negative charges are the sinks. So electric charges create a star-like electric field pattern.

In the lecture we learned that magnetic fields which exist around permanent magnets or electromagnets are caused by currents or moving charges. So a wire that conducts a current will have a magnetic field around it. The magnetic field lines caused by currents are not star-like pattern, but they are twisters. So magnetic field lines close upon themselves. The magnetic field is always perpendicular to the current that creates the field. So a straight wire will create a magnetic field twister perpendicular to the wire. So the field lines are circles that lay in a plane perpendicular to the wire. To find the direction of the magnetic field you use the right hand rule. Please explain and then ask several people in the lab to show it for a wire (use a ruler stick for the wire and indicate the direction of the current and ask the students to use the right hand rule to indicate the direction of the magnetic field twister. Note that the ruler provides you with different questions as you can keep it horizontally, vertically, or towards them, and you can also vary the current (right left, left right, top bottom, bottom top, towards them away from them, etc.).

Side View



View from above

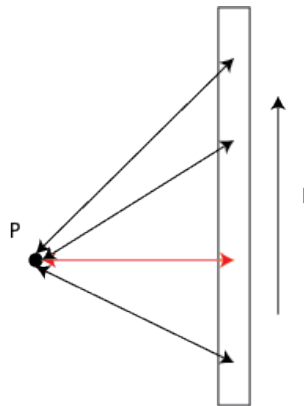


Spend some time in explaining the notation of vectors that are perpendicular to the blackboard. The circle with the cross identifies a vector going into the black board, notice that this looks like the back of a rocket. The circles with the dark dot identifies a vector that is coming out of the black board. In the left picture that notation is used to identify the direction of the magnetic field at four different locations left and right from the straight wire. In the right figure this notation is used to identify the direction of the current through the wire.

The farther you are away from the wire the smaller the magnetic field will be. So the magnitude of the magnetic field depends on the distance from the current carrying wire. It is not an inverse square law as for electric fields but varies with the reciprocal distance to the wire:

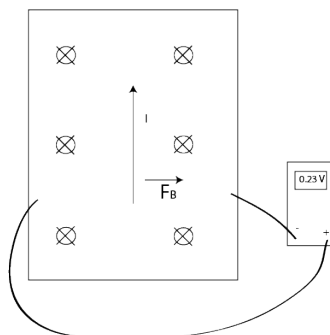
$$B = \mu_0 \frac{i}{2\pi r}$$

Where μ_0 is the permeability constant, i.e. $4\pi \cdot 10^{-7} \text{ Tm/A}$, i is the current through the wire, and r is the distance to the wire. Explain what the distance from a point P to the current carrying wire means, i.e. the shortest distance from P to the wire. The figure below shows that only the red line has the shortest length. So the length of the red line is the distance from P to the wire.



Magnetic field is measured with a Hall sensor. In a Hall sensor the moving charges are deflected by the magnetic field. This deflection causes an electric voltage perpendicular to the current, which can be measured with a voltmeter.

Note that in class you learned that a current carrying conductor placed in an external magnetic field will feel a force acting on it. The direction of this force is perpendicular to the current through the wire and also perpendicular to the external magnetic field at the position of the wire. So the voltage perpendicular to the current is linear proportional to the magnitude of the magnetic field. Draw the figure below on the black board. The magnetic field is perpendicular to the black board, ask the students whether the B-field goes into the black board or comes out of the black board. In class you will learn or have already learned a method to determine the direction of the magnetic force on the moving charges in the Hall sensor. This is another right hand rule.



A magnetic field will not only exert a force on a current carrying wire, but also on a small permanent magnet. You saw in class the effect a magnetic field has on a compass needle. Also you might have seen demonstrations of iron filings used to show the magnetic field line pattern. The small magnetic particles line up with the magnetic field lines and accumulate in areas where the magnetic field is largest.

Use provided toner to visualize the magnetic poles on a credit card.