Magnetic Field of a Solenoid*

Object

To study the magnetic field inside and outside a solenoid.

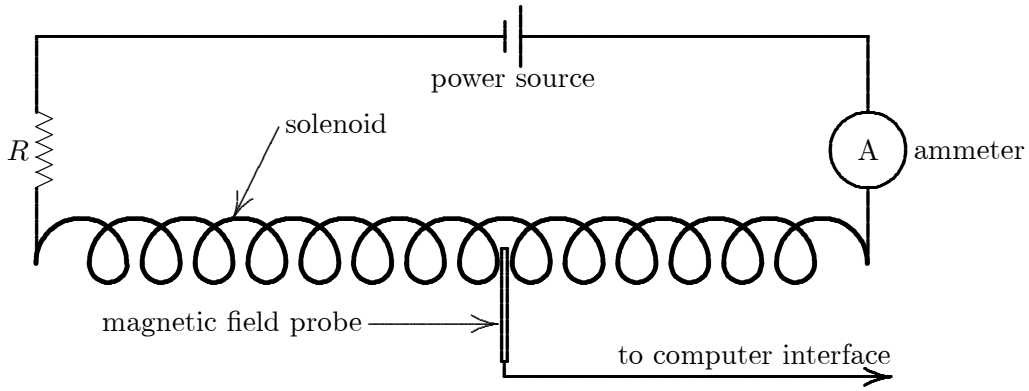
Theory

The magnetic field inside a long straight solenoid is known to be given by the following.

$$B = \mu_0 n i$$

where $\mu_0 = 4\pi \times 10^{-7}$ Tm/A, n is the number of turns/meter of the solenoid and i is the current in it. This can be tested by measuring B in the middle of a long solenoid for various currents and checking how closely the above formula is satisfied. The long solenoid approximation is expected to be invalid near the ends of the solenoid. This can also be tested.

The measurement method



The above setup is used to make the measurements. **Do not let the current rise above 2.0 A.** The computer continuously monitors the magnetic field measured by the probe. The direction of the field measured is marked on the probe. For a given orientation of the probe, its measurement must be zeroed with the current set at zero. This makes sure other sources of magnetic field (in particular the Earth) do not interfere.

To test the above formula for the solenoid magnetic field one may record the magnetic field for several values of current. Then the slope of the B vs. i curve can be compared to the value of $\mu_0 n$.

You may plot your own graphs or use the available LabPro software.

Some trials

Check how closely experiment verifies the theoretical formula for magnetic field in a long solenoid. For best approximation of a long solenoid, measure the field near the middle.

For a fixed current (say 2.0 A), the position dependence of the field along the axis can be found. Around the middle of the solenoid no position dependence is expected. So, you may start about 10 cm. inside the solenoid from the end and work outwards measuring the field about every 2 cm.. Continue to measure the field beyond the end of the solenoid upto a point where measurements are not accurate enough to record.

See if you can estimate the direction of the field away from the solenoid axis. The direction in which the field component becomes zero is perpendicular to the field. It is easier to locate this zero field direction rather than the maximum field direction. The measurement is complicated by the fact that changing the orientation of the probe requires zeroing it again for zero current.