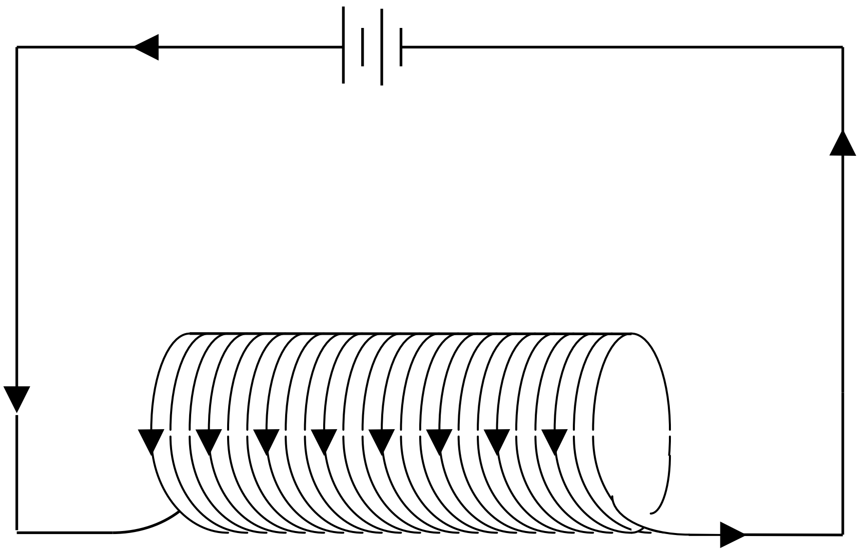
Magnetism and the Solenoid

solenoid - a long coil of wire consisting of many loops



A current sent through a solenoid will, as expected, set up a magnetic field; the shape of that field resembles that of a bar magnet!

Example #2: Using the Right-Hand-Rule, determine and draw the shape of the magnetic field both inside and around the solenoid in the above diagram.

(see Electromagnetism Ex 2 for answer)

Since a solenoid acts like a bar magnet, if an iron core is placed inside the solenoid, domains within the iron will align themselves with the external field as soon as a current flows through the solenoid coils. The magnetic field that results is the sum of that due to the current-carrying solenoid plus that produced by the suddenly magnetic iron core. This highly magnetic device is called an *electromagnet*. Most electromagnets use a 'soft' iron core (loses magnetism as soon as the current is cut).

<u>The Magnetic Field Inside a Solenoid</u>

Through experiments and mathematically, it has been proven that a solenoid produces a <u>uniform</u> magnetic field **B** almost anywhere *inside* its coils. The magnitude of **B** depends on:

- current **I**
- # of turns of wire **N**
- the length ***l*** across a section of turns

From this, we say that

$$\mathbf{B = a\ constant(\frac{N}{\ell})(I)}$$

- this constant = the magnetic permeability of the core **μ**
- in this case (no core), **μ = the permeability of free space μ_o**
- $\mu_o = 4\pi \times 10^{-7}\ \frac{\text{tesla x meters}}{\text{ampere}}$

From this we get

$$\boxed{B = \mu_o \frac{N}{\ell} I}$$

However, $\frac{N}{\ell}$ may already be calculated as *turns per meter* (**n**);

- then $\boxed{B = \mu_o n I}$

Example #3: A solenoid 15 cm long has 600 turns and carries a current of 5.0 A. What is the magnetic field strength inside this coil?

(see Electromagnetism Ex 3 for answer)