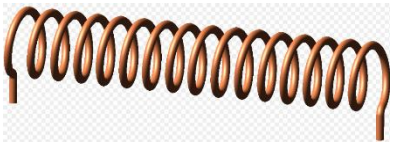
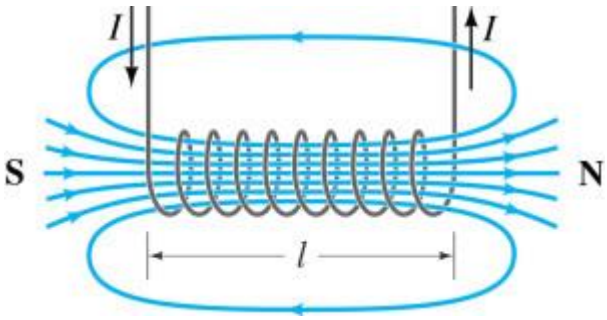
Solenoids





Solenoid consists of a **length of insulated wire coiled into a cylinder shape**.

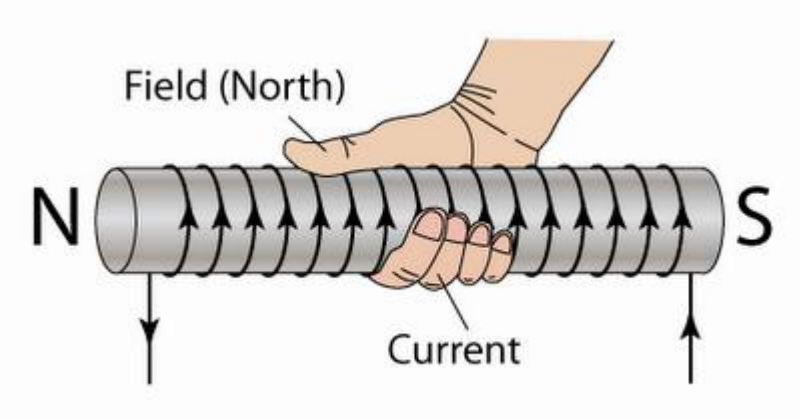
- Current in solenoid produces a stronger magnetic field inside the solenoid than outside. The field lines in this region are parallel and closely spaced showing the field is highly uniform in strength and direction.

- Field lines outside the solenoid are similar to that of a bar magnet, and it behaves in a similar way – as if it had a north pole at one end and south pole at the other end. Strength of the field diminishes with distance from the solenoid.

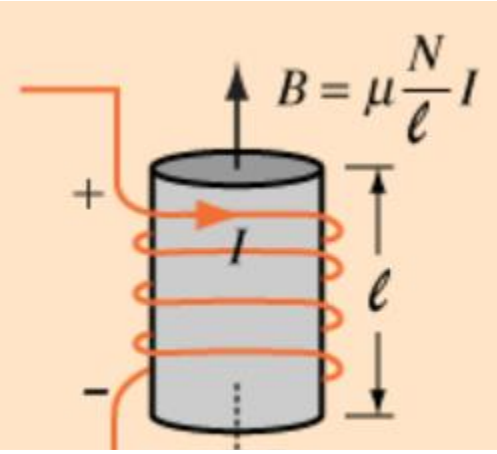
Strength of the magnetic field can be increased by:

1. Increasing the current in the coil
2. Increasing the number of coils in the solenoid; and
3. Using a soft iron core within the solenoid.

- Reversing the direction of the current reverses the direction of the magnetic field.



Right-hand rule can be used to find the direction of the magnetic field. In this case, point the wrapped fingers (along the coil) in the direction of the conventional current. Then, the thumb will point to the direction of magnetic field within the solenoid.



B – Magnetic Field Created (Teslas –T)

μ - Permeability of free space $4\pi \times 10^{-7}$

N – Number of coils

I – current in conductor (Amps)

L – Length of Solenoid (m)

SAMPLE problem 2

What is the magnitude of the magnetic field in the core of a solenoid 5.0 cm long, with 300 turns and a current of 8.0 A?

Solution

$L = 5.0 \text{ cm} = 5.0 \times 10^{-2} \text{ m}$

$N = 300$

$I = 8.0 \text{ A}$

$B = ?$

$$B = \mu_0\left(\frac{NI}{L}\right)$$

$$= \frac{(4\pi \times 10^{-7} \text{ T·m/A})(300)(8.0 \text{ A})}{5.0 \times 10^{-2} \text{ m}}$$

$$B = 6.0 \times 10^{-2} \text{ T}$$

The magnitude of the magnetic field is 6.0×10^{-2} T.

Practice

Understanding Concepts

6. A 14-gauge copper wire has a current of 12 A. How many turns would have to be wound on a coil 15 cm long to produce a magnetic field of strength 5.0×10^{-2} T?
7. Calculate the magnitude of the magnetic field strength in the core of a coil 10.0 cm long, with 420 turns and a current of 6.0 A.
8. A coil 8.0 cm long, with 400 turns, produces a magnetic field of magnitude 1.4×10^{-2} T in its core. Calculate the current in the coil.

Figure 3
Cross-section of a s

Answers

6. 5.0×10^{2}
7. 3.2×10^{-2} T
8. 2.2 A