Biot-Savart Law

The magnetic field $d\vec{B}$ at a point P associated with a length element $d\vec{s}$ of a wire carrying a steady current I:

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{s} \times \hat{r}}{r^2}$$

where $d\vec{s}$ points in the direction of the current and $\hat{r}$ is the unit vector directed from $d\vec{s}$ towards P.

Magnetic Field due to a wire

See example 30.1 on your book

The magnitude of the magnetic field at a distance r from a long, straight wire carrying an electric current I is:

$$B = \frac{\mu_0 I}{2\pi r} \tag{1}$$

Magnetic Force Between Two Parallel Conductor

The field $\vec{B}_2$ due to the current in wire 2 exerts a magnetic force of magnitude $F_1 = I_1 l B_2$

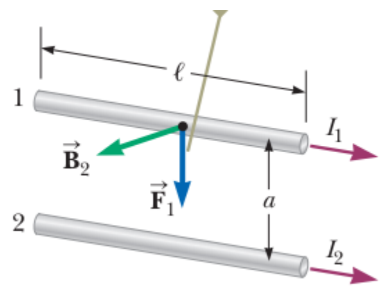

Figure 1:

$$F_1 = I_1 l B_2 = I_1 l (\frac{\mu_0 I_2}{2\pi a}) = \frac{\mu_0 I_1 I_2}{2\pi a} l$$

Exercises

A long, straight wire carries a current I. A right-angle bend is made in the middle of the wire. The bend forms an arc of a circle of radius r. Determine the magnetic field at point P, the center of the arc.

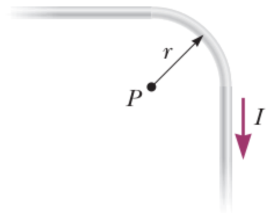

Figure 2:

2) In the figure below the current in the long, straight wire is I_1 and the wire lies in the plane of a rectangular loop, which carries a current I_2. The loop is of lenght l and width a. Its left end is a distance c from the wire. Find the magnitude and direction of the net force exerted on the loop by the magnetic field created by the wire.

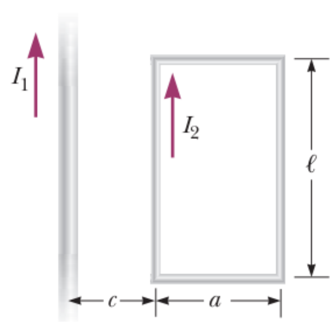

Figure 3:

3) Proof equation (1) by finding the magnetic field of a wire by direct integration of Biot-Savart law. Hint: Find the magnetic field due to a wire of **finite** lenght then take the limit as the length of the wire goes to infinity.