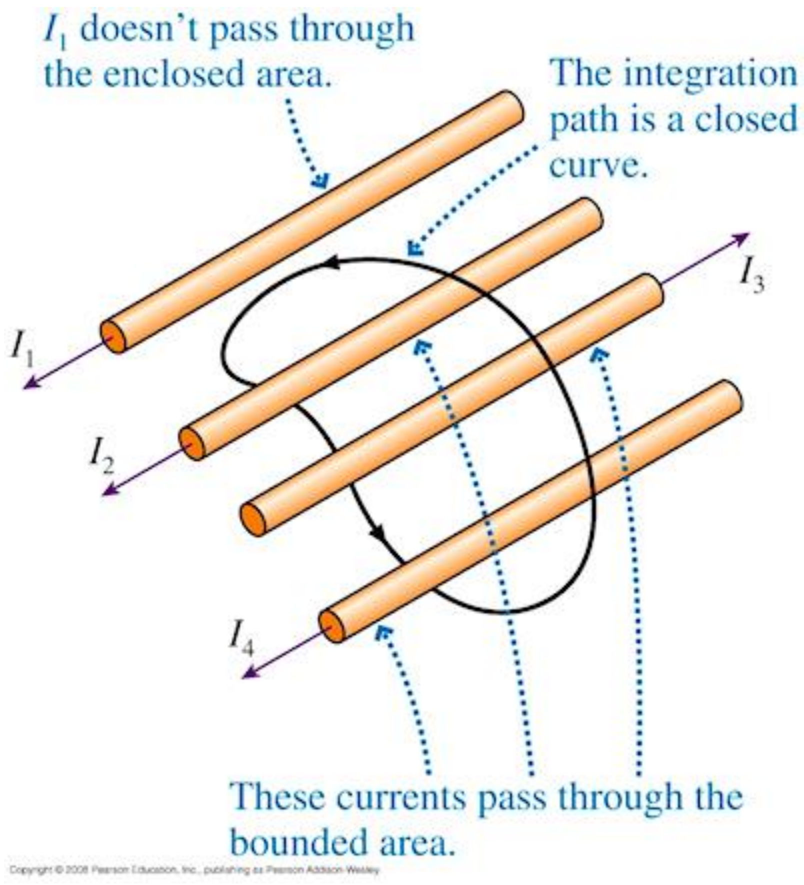
Ampere's Law

Consider an arbitrary closed loop (for instance, a circle). Ampere's Law states that the integral of magnetic field along that loop is proportional to the total current enclosed by it:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \sum_{\text{inside the loop}} I$$



Note that the integral contains "dot" product that depends on the angle between vector B and the local direction of the integration path:

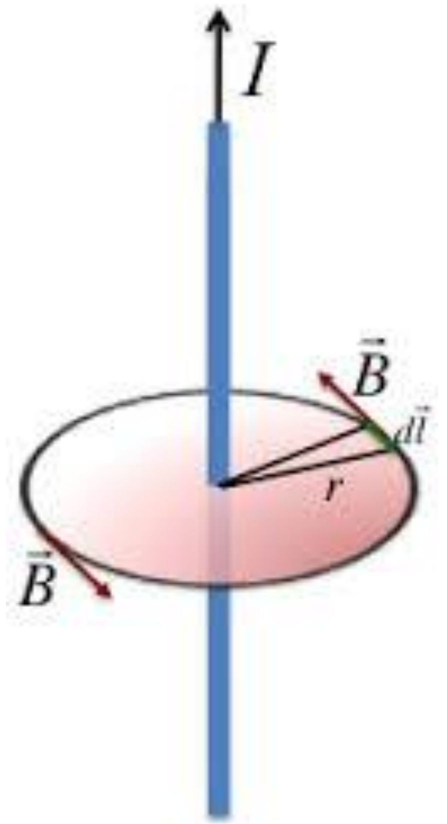
$$\vec{B} \cdot d\vec{l} = \left|\vec{B}\right|\left|d\vec{l}\right| \cos\alpha$$

$$\mu_0 = 4\pi \cdot 10^{-7}\, T \cdot m / A$$

Using Ampere's Law: Infinite Wire

Consider a straight infinite wire carrying current I. As an integration loop we choose a circle of radius r around the wire. At any point of the loop, B is constant and directed along the path, therefore cos (α)=1.

$$\oint \vec{B} \cdot d\vec{l} = 2\pi r B$$



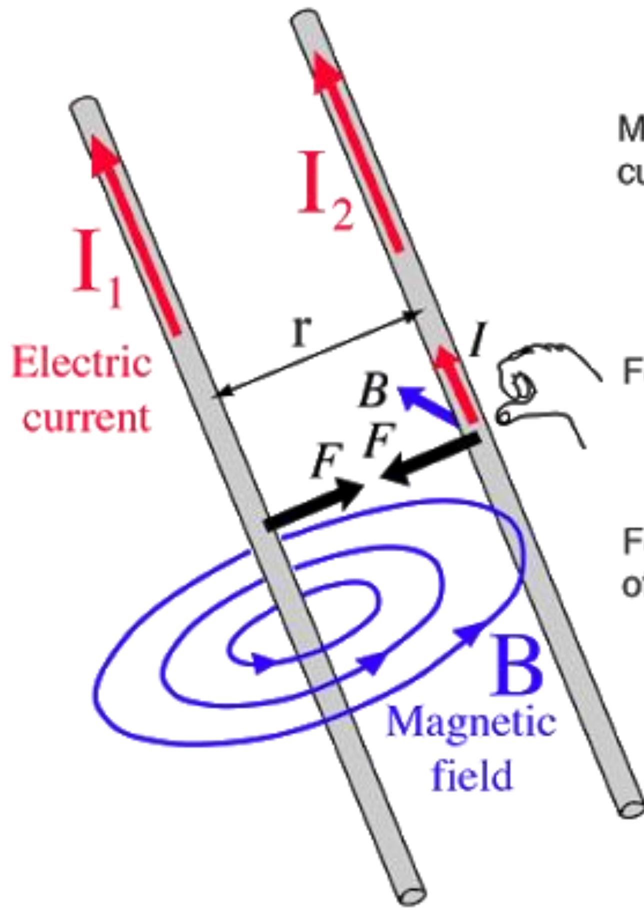
By using Ampere's Law, we obtain:

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

Direction of B is determined by the right hand rule.

Magnetic Force Between Wires

We combine Ampere's Law with Lorenz Force, ***F=I∆LB:***



Magnetic field at wire 2 from current in wire 1:

$$B = \frac{\mu_0 I_1}{2\pi r}$$

Force on a length ΔL of wire 2:

$$F = I_2 \Delta L B$$

Force per unit length in terms of the currents:

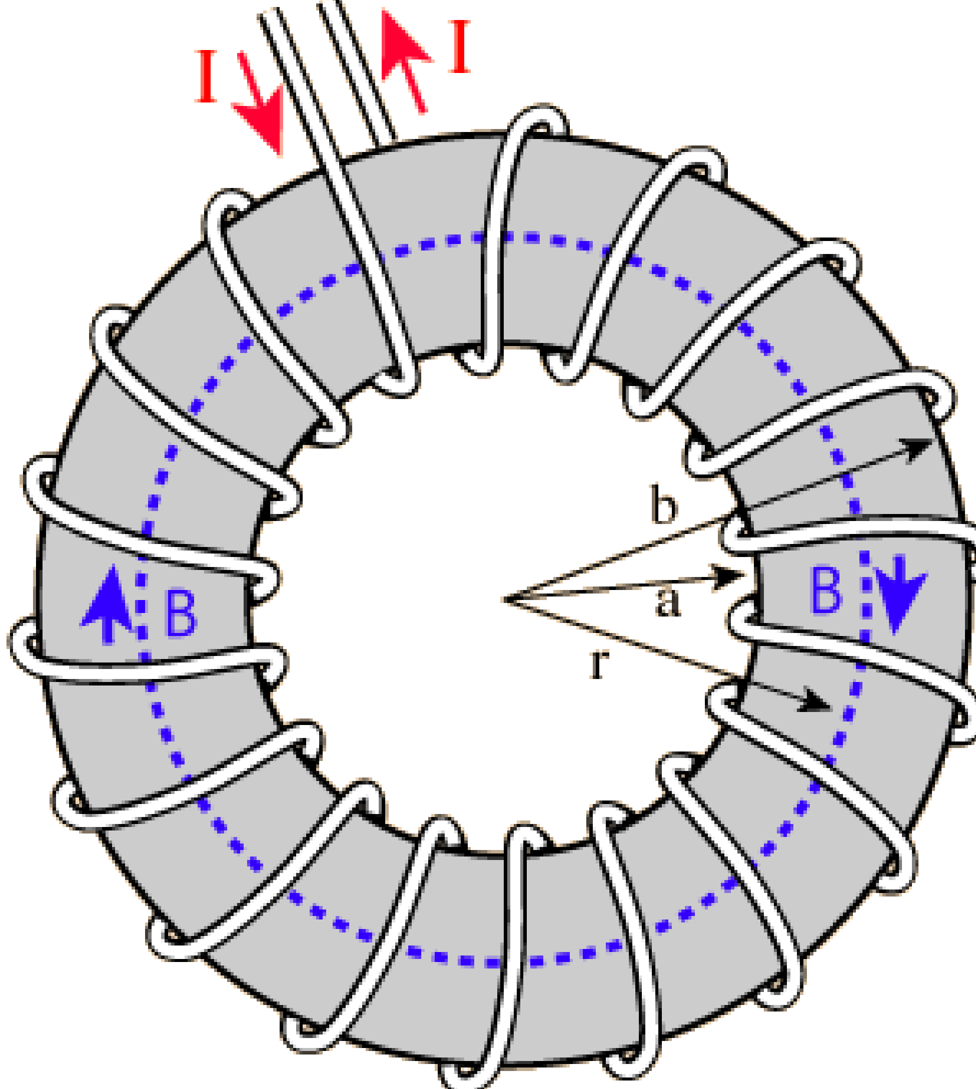
$$\frac{F}{\Delta L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

Homework

Problem 1

Two parallel wires of radius ***r=0.1 mm*** each, are placed right next to each other (i. e. distance between their centers is 2r). The same current ***I*** is run through each wire. Find the value of ***I***, at which the magnetic force between the wires is equal to the weight of each of them. Density of cupper is ***9000 kg/m³***.

Homework



Problem 2

Torus is a mathematical term for a bagel- like shape. Torroidal magnets have been used in tape recorders, and other devices. Find the magnetic field B inside of the torroidal magnet, near its centerline that has a shape of a circle of radius r (shown in the Figure as blue dashed line)). The wire makes N turns around the torus, and the current is I.
How many turns do you need to produce 1 T magnetic field in a torus of radius r=30 cm, if current is I=1A?