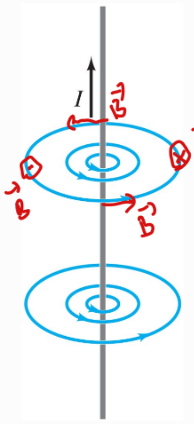
Chapter 28: Sources of Magnetic Field

magnetic field due to a straight wire:

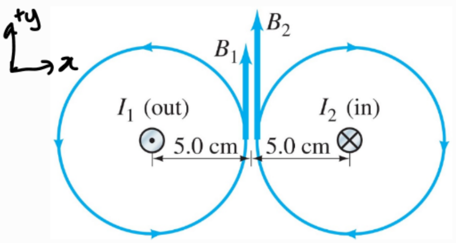


$$|B| \propto \frac{I}{r} \Rightarrow B = \frac{\mu_0}{2\pi}\frac{I}{r} \quad \text{where } \mu_0 = 4\pi \times 10^{-7}\ \text{Tm/A}$$

Example 28.1

$$B = \frac{\mu_0}{2\pi}\frac{I}{r} \Rightarrow B = \frac{4\pi\times10^{-7}\ \text{Tm/A}}{2\pi}\left(\frac{25\text{A}}{0.10\text{m}}\right) = 5.0\times10^{-5}\ \text{T}$$

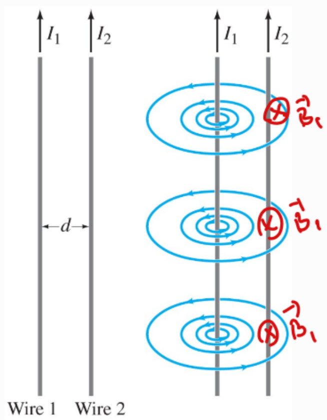
Example 28.2



$$\vec{B} = \vec{B_1} + \vec{B_2} = (B_1 + B_2)\hat{j}, \quad I_1 = 5.0\text{A},\ I_2 = 7.0\text{A},\ r = 0.05\text{m}$$

$$B = \frac{4\pi\times10^{-7}\ \text{Tm/A}}{2\pi}\left(\frac{5.0\text{A}}{0.05\text{m}}\right) + \frac{4\pi\times10^{-7}\ \text{Tm/A}}{2\pi}\left(\frac{7.0\text{A}}{0.05\text{m}}\right) = 4.8\times10^{-5}\ \text{T}$$

Force between two parallel wires:



magnetic field due to I_1: $B_1 = \frac{\mu_0}{2\pi}\frac{I_1}{d}$

Force on wire 2 due to B_1: $\vec{F_2} = I_2\vec{l_2}\times\vec{B_1}$

$$F_2 = I_2 l_2 B_1 \underbrace{\sin 90}_{1} \Rightarrow F_2 = I_2 l_2 B_1$$

$$F_2 = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} l_2 \quad \text{(toward left)}$$

Example 28.4

$$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} l_2$$

$I_1 = I_2 = 8.0\text{A}$

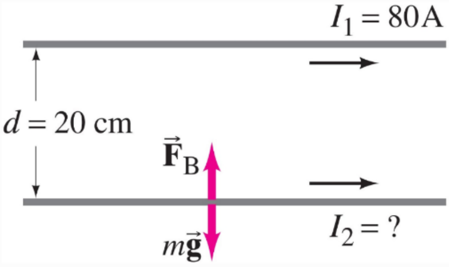
$l_2 = 2.0\text{m}$

$d = 3.0\times10^{-3}\text{m}$

$$F = \frac{4\pi\times10^{-7}\ \text{Tm/A}}{2\pi}\left(\frac{8.0\text{A}^2}{3.0\times10^{-3}\text{m}}\right)(2.0\text{m})$$

$$F = 8.5\times10^{-3}\ \text{N}$$

Example 28.5



* 1m of lower wire has the mass 0.12×10^{-3} kg.

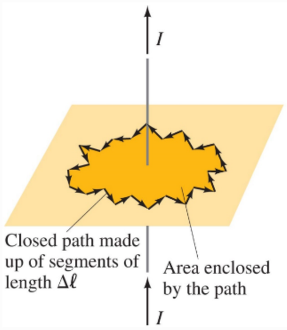
$F = mg = (0.12 \times 10^{-3} kg)(9.8 m/s^2) = 1.18 \times 10^{-3} N$

$F_B = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{d} \ell \Rightarrow F = F_B \Rightarrow I_2 = \frac{2\pi d}{\mu_0 I_1} \left(\frac{F}{\ell}\right)$ ($F \to mg$)

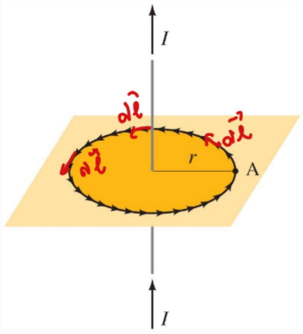
$I_2 = 2\pi(0.20 m)(1.18 \times 10^{-3} N) / (4\pi \times 10^{-7} Tm/A)(80A)(1m) = 15 A$

Ampere's Law

$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$



* let's find the magnetic field around a wire using Ampere's Law:



$\vec{B} \parallel d\vec{\ell}$ at all points on the circular loop:

$\oint \vec{B} \cdot d\vec{\ell} = \oint B\, d\ell = B \oint d\ell = B(2\pi r) = \mu_0 I$

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