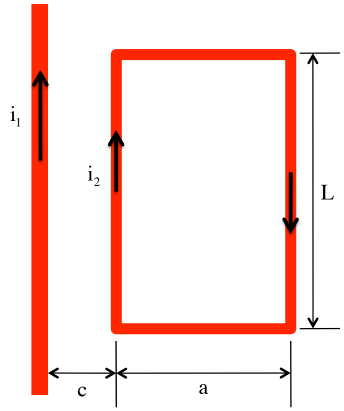
Problem 30.23

If we didn't know the magnetic field function for the long wire, we would probably use Ampere's Law to determine it. We do know it, though, so we can evaluate that function "c" and "c +a" units from the long wire to determine the magnitude of the B-fld at those points. With that information, we can determine the magnitude of the force (due to current in a magnetic field) on the left vertical section of wire and the right vertical section of wire. The difference between the two will give us the net force on the loop.

All that follows:



--The long wire's field at "c":

$$B_c = \frac{\mu_o i_1}{2\pi c}$$

--The long wire's field at "c+a":

$$B_{c+a} = \frac{\mu_o i_1}{2\pi(c+a)}$$

--The force on the right section of the loop:

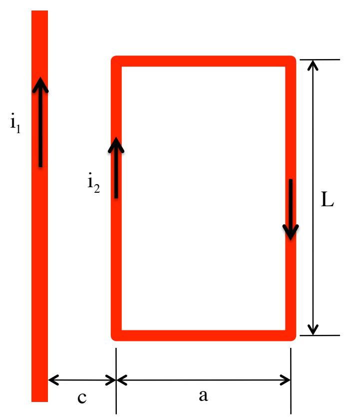
$$\left|\vec{F}_{left}\right| = \left|i_2\vec{L}x\vec{B}_c\right|$$

$$= i_2 L B_c \sin 90^o$$

$$= i_2 L\left(\frac{\mu_o i_1}{2\pi c}\right)$$

$$= (10\ A)(.45\ m)\left(\frac{(\overset{2}{\cancel{4}}\cancel{\pi}x10^{-7}\ T\bullet m/A)(5\ A)}{\cancel{2}\cancel{\pi}(.1\ m)}\right)$$

$$= (45x10^{-6}\ N)$$



Note that as the direction of the magnetic field on the right side of the long wire is *into* the page, and as the L vector is directed upward (along the current flow) in the left vertical section of the loop, the cross product iLxB suggests that the direction of the force on the left vertical section of the loop will be to the left. That means:

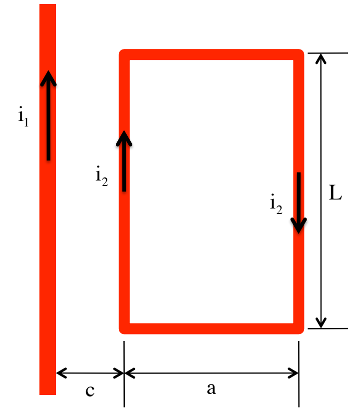
$$\vec{F}_{left} = (45x10^{-6}\ N)(-\hat{i})$$

--Similarly, the magnitude and direction of the force on the right vertical section of the loop is:

$$\vec{F}_{right} = i_2\vec{L}x\vec{B}_{c+a}$$

$$= (10\ A)(.45\ m)\left(\frac{(\overset{2}{\cancel{4}}\cancel{\pi}x10^{-7}\ T\bullet m/A)(5\ A)}{\cancel{2}\cancel{\pi}[(.1\ m)+(.15\ m)]}\right)$$

$$= (18x10^{-6}\ N)(\hat{i})$$



The net force due to the two forces yields:

$$\vec{F}_{net} = \vec{F}_{left} + \vec{F}_{right}$$

$$= (45x10^{-6}\ N)(-\hat{i}) + (18x10^{-6}\ N)(\hat{i})$$

$$= (27x10^{-6}\ N)(-\hat{i})$$