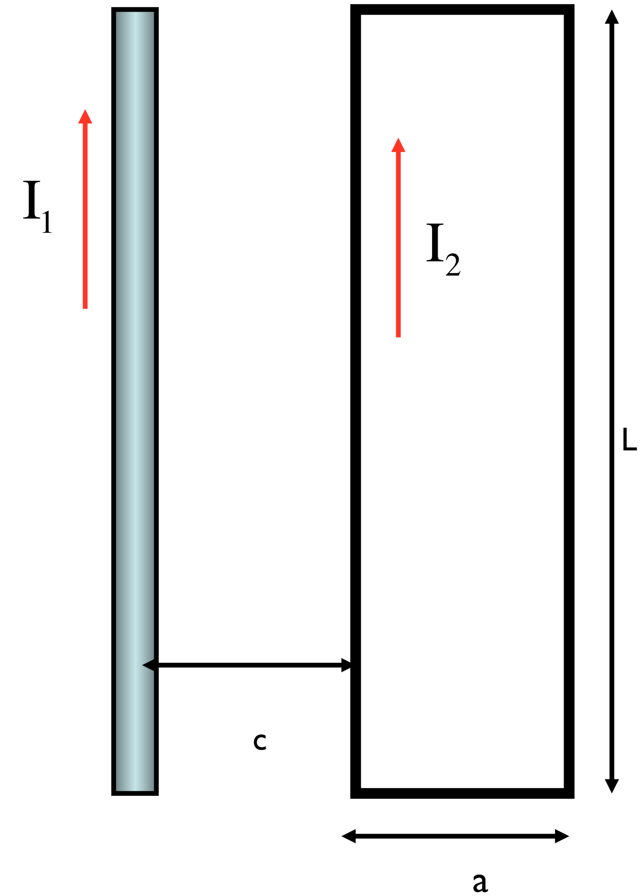
Problem19.58

If the left wire current is 5 amps and the loop current is 10 amps, what is the magnitude and direction of the force exerted on the loop by the wire, assuming that a=.15 meters, c = .1 meters and L=.45 meters?



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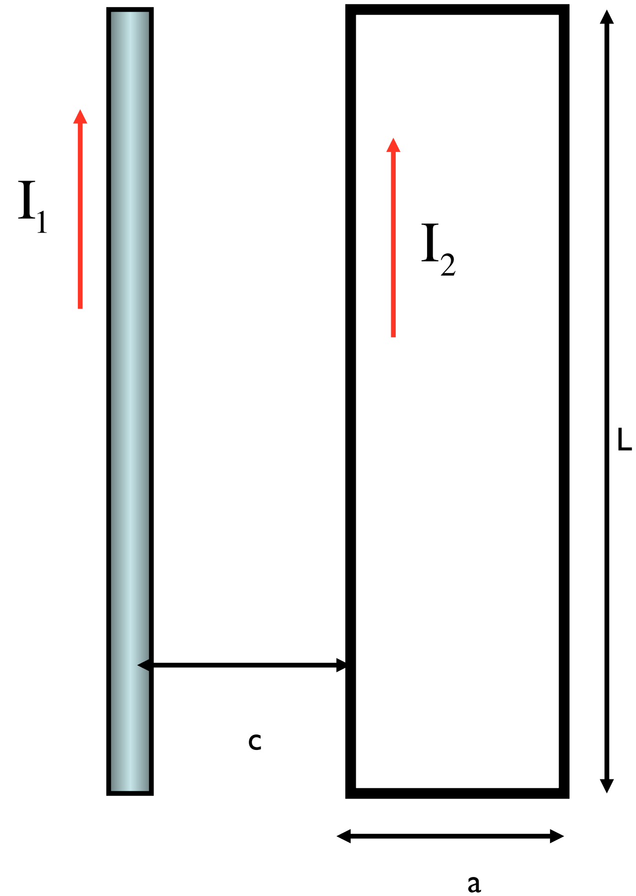
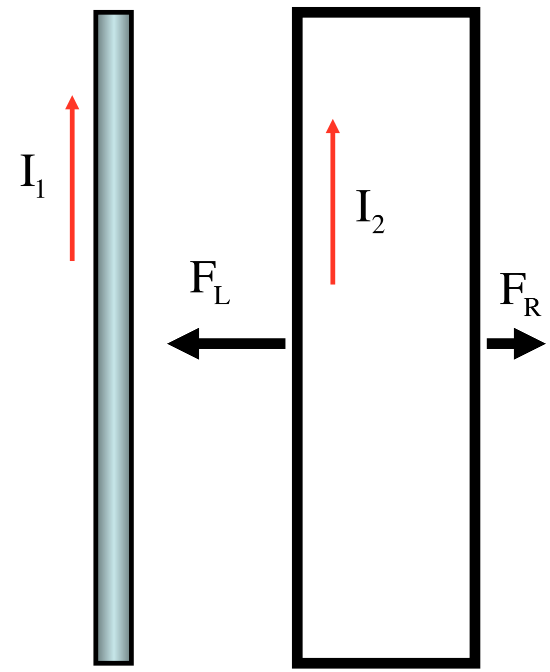
The current in the straight wire baths the coil in a magnetic field. The current in the near stretch of coil wire (the section on the left) feels a force due to the presence of that field (you should be able to tell in what direction that force is). The far stretch of coil wire (the section on the right) also feels a force, but it will be smaller as that section of wire is farther from the straight wire that produces the field. Adding (or subtracting) those fields will give you the net force (note that any force on the horizontal stretches of coil wire will cancel one another out).



The long wire's magnetic field, using the right thumb rule, is into the page on the right side of that wire. Using the right-hand rule (iLxB), the force directions are shown in the sketch.



$$
\begin{aligned}
F_{net} &= F_L - F_R \\
&= I_2\vec{L}_2 x\vec{B} - I_2\vec{L}_1 x\vec{B} \\
&= I_2 L\left(\frac{\mu_o}{2\pi}\frac{I_1}{c}\right) - I_2 L\left(\frac{\mu_o}{2\pi}\frac{I_1}{(c+a)}\right) \\
&= I_2 L\left(\frac{\mu_o}{2\pi}I_1\right)\left(\frac{1}{c}-\frac{1}{(c+a)}\right) \\
&= (5\ \text{A})(.45\ \text{m})\left(\frac{\left(4\pi x10^{-7}\right)}{2\pi}(10\ \text{A})\right)\left(\frac{1}{(.1\ \text{m})}-\frac{1}{(.1\text{m}+.15\text{m})}\right) \\
&= 2.7x10^{-5}\ \text{nts}
\end{aligned}
$$