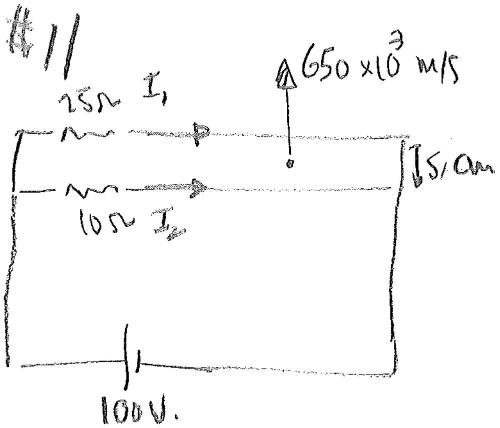
HW solns #11

28.54



$I_1 = 4$ A.

$I_2 = 10$ A.

$B_1 = \frac{\mu_0 I_1}{2\pi r}$ into page

$B_2 = \frac{\mu_0 I_2}{2\pi r}$ out of page

} long wire.

$B = \frac{\mu_0 (I_2 - I_1)}{2\pi r}$ out of page

$r = 0.025$ m.

$= \frac{.2}{0.025} \cdot 10^{-7} \cdot 6 = 4.8\times10^{-5}$ T.

Force on proton:

$F = qv\times B$ $\boxed{\vec{F} \text{ is right.}}$

$v \perp B$ so

$F = qvB =$

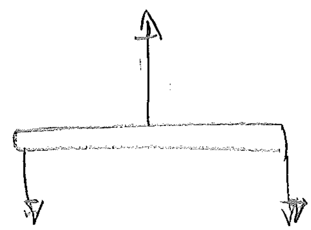
$1.6\times10^{-19} \cdot 650\times10^3 \cdot 4.8\times10^{-5} = \boxed{5\times10^{-18}\ \text{N.}}$

28.62 Using ∞ wire formula:

$\frac{F_{mag}}{L} = \frac{\mu_0 I^2}{2\pi r}$

so $F_{mag} = \frac{\mu_0 I^2 L}{2\pi r} = 2kr$ (2 springs!)

$\boxed{r = \sqrt{\frac{\mu_0 I^2 L}{4\pi k}}}$

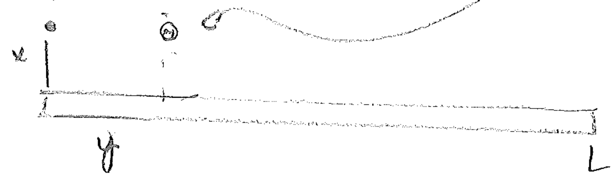


F.B.D. for upper rod.

You might worry about using the ∞ wire approximation. I did, so I did the full calculation.

$$B = \frac{\mu_0 I}{4\pi} \frac{L}{x\sqrt{x^2+L^2}}$$

$$B = \frac{\mu_0 I}{4\pi}\left(\frac{y}{x\sqrt{x^2+y^2}} + \frac{L-y}{x\sqrt{x^2+(L-y)^2}}\right)$$



$$F = \int dF = \int I\,dy \cdot B = \frac{\mu_0 I^2}{4\pi x}\left\{(x^2+y^2)^{1/2}\Big|_0^L - (x^2+(L-y)^2)^{1/2}\Big|_0^L\right\}$$

$$F = \frac{\mu_0 I^2}{4\pi x}\left\{\left(\sqrt{x^2+L^2} - x\right) - \left(x - \sqrt{x^2+L^2}\right)\right\}$$

$$= \frac{\mu_0 I^2}{2\pi r}\left\{\sqrt{r^2+L^2} - r\right\} \qquad (r = x)$$

$$= \frac{\mu_0 I^2 L}{2\pi r}\left\{\sqrt{1+\frac{r^2}{L^2}} - \frac{r}{L}\right\}$$

So error in approximation is $\lesssim \frac{r}{L}$.