Winter Quarter 1989
March 13, 1989
George Williams

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FINAL EXAM

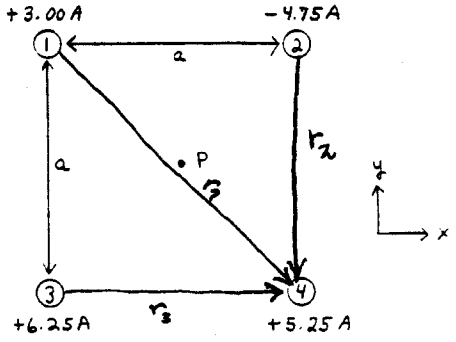
Name (print) Doug Ball Name (signed) _____

Discussion Instructor (circle one): An Chen Emerson Iguchi Stoops

Discussion Section #: _____

SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

Four long, straight wires are arranged in a square perpendicular to the paper as shown. (+ means current out of the paper, − means current into the paper.) The sides of the square have length a = 2.75 cm. Calculate the force per unit length (magnitude and direction using the coordinates shown), on wire 4.



The field from a long straight wire is:

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

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The force from this wire on a second wire (wire 2) is:

$$F = I_2 \ell \times B_1 = I_2 \ell B_1 \hat{r} \Rightarrow$$

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

or in terms of force per meter,

$$\left| \frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi r} \hat{r} \right|$$

To solve this prob. we need only apply this equation 3 times. We get:

$$\frac{\vec{F}_{14}}{\ell} = \frac{\mu_0 I_1 I_4}{2\pi r_1}\left(\frac{1}{\sqrt{2}}\hat{y} - \frac{1}{\sqrt{2}}\hat{x}\right)$$

$$\frac{\vec{F}_{24}}{\ell} = \frac{\mu_0 I_2 I_4}{2\pi r_2}(\hat{y})$$

$$\frac{\vec{F}_{34}}{\ell} = \frac{\mu_0 I_3 I_4}{2\pi r_3}(-\hat{x})$$

The net force per unit ~~length~~ length is:

$$\frac{\vec{F}_{net}}{\ell} = \frac{\mu_0 I_4}{2\pi a}\left[\left(\frac{I_1}{2} + \frac{I_2}{1}\right)\hat{y} - \left(\frac{I_1}{2} + I_3\right)\hat{x}\right]$$

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The numerical answer is:

$$\frac{\vec{F}_{net}}{\ell} = -1.24\times10^{-4}\ \frac{N}{m}\hat{y} - 2.96\times10^{-4}\ \frac{N}{m}\hat{x}$$

or

$$\left|\frac{F_{net}}{\ell}\right| = 3.21\times10^{-4}\ N/m$$

$$\theta = 3.54 \text{ radians or } 203°$$