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:

\[
B = \frac{\mu_0 I}{2\pi r}
\]

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

\[
F = I_2 l \times B_1 = I_2 l B_1 \hat{r}
\]

\[
F = \frac{\mu_0 I_1 I_2}{2\pi r}
\]

or, in terms of force per meter.

\[
\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}
\]

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

\[
\frac{F_{net}}{l} = \frac{\mu_0 I_1 I_3}{2\pi r_1} \left( \frac{1}{2} \hat{y} - \frac{1}{2} \hat{z} \right)
\]

The net force per unit length length is:

\[
\frac{F_{net}}{l} = \frac{\mu_0 I_1 I_3}{2\pi r_1} \left[ \left( \frac{I_1}{2} + \frac{I_3}{2} \right) \hat{y} - \left( \frac{I_1}{2} + \frac{I_3}{2} \right) \hat{z} \right]
\]

The numerical answer is:

\[
\frac{F_{net}}{l} = -1.24 \times 10^{-4} \text{ N/m} - 2.96 \times 10^{-4} \text{ N/m} \hat{z}
\]

\[
\frac{1}{l} \frac{F_{net}}{l} = 3.21 \times 10^{-5} \text{ N/m} \]

\[
\theta = 3.54 \text{ radians or 203°}
\]