4. (35 pts) A point charge \( Q_1 = -4.0 \times 10^{-9} \) C is on the negative y-axis at \( r_1 = 4 \) cm from the origin. A point charge \( Q_2 = 6.0 \times 10^{-9} \) C makes a counterclockwise angle \( \theta = 132^\circ \) to the positive z-axis, at \( r_2 = 5 \) cm from the origin. A charge \( Q = -4.0 \times 10^{-9} \) C is placed at the origin. \( Q_1 \) and \( Q_2 \) act on \( Q \) with forces \( \vec{F}_1 \) and \( \vec{F}_2 \).

\[ \vec{F}_1 = \frac{k |Q|}{r_1^2} \]

\[ \vec{F}_2 = \frac{k |Q| |Q_2|}{r_2^2} \]

\[ |\vec{F}_1| = \frac{9 \times 10^{-5} \text{N}}{ \text{C}^2} \]

\[ |\vec{F}_2| = \frac{8.64 \times 10^{-5} \text{N}}{ \text{C}^2} \]

b. On the figure, draw \( \vec{F}_1 \) and \( \vec{F}_2 \) with their tails on \( Q \), and in relative proportion.

c. Find \( F_x \), the x-component of the total force \( \vec{F} \) on \( Q \).
\[ F_x = |\vec{F}_2| \cos 132^\circ + 0 = -5.78 \times 10^{-5} \text{N} \]

d. Find \( F_y \), the y-component of \( \vec{F} \).
\[ F_y = |\vec{F}_1| + |\vec{F}_2| \sin 132^\circ = 9 \times 10^{-5} \text{N} + 6.42 \times 10^{-5} \text{N} = 15.42 \times 10^{-5} \text{N} \]

e. Find the angle \( \vec{F} \) makes with respect to the x-axis, and on the figure sketch the direction of \( \vec{F} \).
\[ \tan \theta = \frac{F_y}{F_x} = \frac{15.42}{-5.78} \]
\[ \theta = -69.45^\circ \] (\( \theta \) in 2nd quadrant)

f. Find \( |\vec{F}| \).
\[ |\vec{F}| = \sqrt{F_x^2 + F_y^2} = \sqrt{(-5.78)^2 + (15.42)^2} \times 10^{-5} \text{N} = 16.47 \times 10^{-5} \text{N} \]

g. \( Q_1 \) and \( Q_2 \) are rotated clockwise by 16 degrees about the origin. From parts e) and f) find the new \( F_x \).
\[ F_x = |\vec{F}| \cos (110.5^\circ - 16^\circ) = -1.292 \times 10^{-5} \text{N} \]