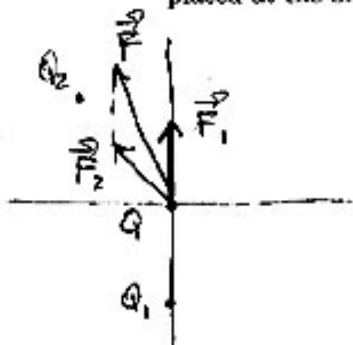


Key Pink

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 x -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 .



a. Find $|\vec{F}_1|$ and $|\vec{F}_2|$.

$$|\vec{F}_1| = \frac{k|Q_1||Q|}{r_1^2} = \frac{(9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(4 \times 10^{-9} \text{ C})(4 \times 10^{-9} \text{ C})}{(0.04 \text{ m})^2}$$

$$= 9 \times 10^{-5} \text{ N}$$

$$|\vec{F}_2| = \frac{k|Q_2||Q|}{r_2^2} = \frac{(9 \times 10^9)(6 \times 10^{-9})(4 \times 10^{-9})}{(0.05)^2}$$

$$= 8.64 \times 10^{-5} \text{ N}$$

- 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 .

$$F_x = |\vec{F}_2| \cos 132 + 0 = -5.78 \times 10^{-5} \text{ N}$$

- d. Find F_y , the y -component of \vec{F} .

$$F_y = |\vec{F}_1| + |\vec{F}_2| \sin 132 = 9 \times 10^{-5} \text{ N} + 6.42 \times 10^{-5} \text{ N}$$

$$= 15.42 \times 10^{-5} \text{ N}$$

- e. Find the angle \vec{F} makes with respect to the x -axis, and on the figure sketch the direction of \vec{F} .

$$\tan \theta = \frac{F_y}{F_x} = \frac{15.42}{-5.78} \quad (\theta \text{ in 2nd quadrant})$$

$$\tan^{-1} \left(\frac{F_y}{F_x} \right) = -69.45^\circ, \quad \theta = -69.45 + 180 = 110.5^\circ$$

- 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 .

$$F_x = |\vec{F}| \cos (110.5 - 16) = -1.292 \times 10^{-5} \text{ N}$$