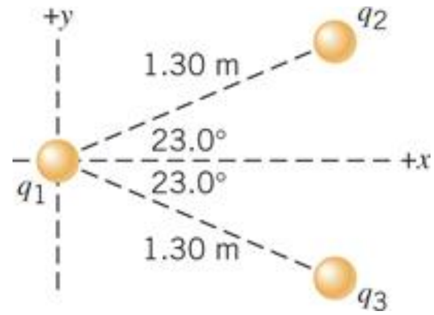
12. The drawing shows three point charges fixed in place. The charge at the coordinate origin has a value of q_1 = +8.00 μC; the other two charges have identical magnitudes, but opposite signs: q_2 = -5.00 μC and q_3 = +5.00 μC. **(a)** Determine the net force (magnitude and direction) exerted on q_1 by the other two charges. **(b)** If q_1 had a mass of 1.50 g and it were free to move, what would be its acceleration?



$$\overrightarrow{F_{Net\to 1}} = \overrightarrow{F_{2\to 1}} + \overrightarrow{F_{3\to 1}}$$

$$\overrightarrow{F_{2\to 1}} = k\frac{q_1 q_2}{r_{12}^2} \text{ @ } 23.0° \text{ } above \text{ } \widehat{+x}$$

The direction is above $\widehat{+x}$ because the signs are opposite so the force is attractive.

$$F_{2\to 1} = k\frac{q_1 q_2}{r_{12}^2} = \left(8.99 \; x \; 10^9 \; {Nm^2}/{C^2}\right)\frac{(8.00 \; x \; 10^{-6} C)(5.00 \; x \; 10^{-6} C)}{(1.30 \; m)^2} = 0.2128 \; N$$

$$\overrightarrow{F_{2\to 1}} = 0.2128 \; N \text{ @ } 23.0° \text{ } above \text{ } \widehat{+x}$$

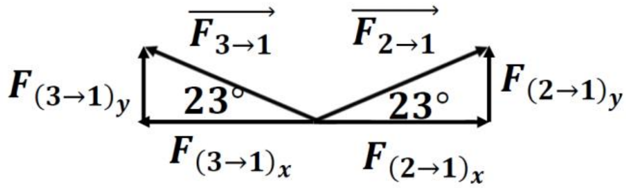
$$\overrightarrow{F_{3\to 1}} = k\frac{q_1 q_3}{r_{13}^2} \text{ @ } 23.0° \text{ } above \text{ } \widehat{-x}$$

The direction is above $\widehat{-x}$ because the signs are same so the force is repulsive.

$$F_{3\to 1} = k\frac{q_1 q_3}{r_{13}^2} = \left(8.99 \; x \; 10^9 \; {Nm^2}/{C^2}\right)\frac{(8.00 \; x \; 10^{-6} C)(5.00 \; x \; 10^{-6} C)}{(1.30 \; m)^2} = 0.2128 \; N$$

$$\overrightarrow{F_{3\to 1}} = 0.2128 \; N \text{ @ } 23.0° \text{ } above \text{ } \widehat{-x}$$

So the two force vectors are the same magnitude and look like this



So we find the x and y components and then add or subtract them. Since the magnitude of $\overrightarrow{F_{2\to1}}$ and $\overrightarrow{F_{3\to1}}$ is both 0.2128 N, and the x vectors point opposite, the net x component will be zero. Moreover since both the y components point towards $\widehat{+y}$, the final value will be twice this.

$$F_{(2\to1)_x} = F_{2\to1}\cos(23.0°) = (0.2128\ N)\cos(23.0°) = 0.1959\ N$$

$$F_{(2\to1)_y} = F_{2\to1}\sin(23.0°) = (0.2128\ N)\sin(23.0°) = 0.0831\ N$$

$$F_{(3\to1)_x} = -F_{3\to1}\cos(23.0°) = -(0.2128\ N)\cos(23.0°) = -0.1959\ N$$

$$F_{(3\to1)_y} = F_{3\to1}\sin(23.0°) = (0.2128\ N)\sin(23.0°) = 0.0831\ N$$

$$\begin{aligned}\overrightarrow{F_{Net\to1}} &= \overrightarrow{F_{2\to1}} + \overrightarrow{F_{3\to1}} \\ &= \left(0.1959\ N(\widehat{+x}) + 0.0831\ N(\widehat{+y})\right) \\ &\quad + \left(-0.1959\ N(\widehat{+x}) + 0.0831\ N(\widehat{+y})\right)\end{aligned}$$

$$\begin{aligned}\overrightarrow{F_{Net\to1}} &= \left(0.1959\ N(\widehat{+x}) - 0.1959\ N(\widehat{+x})\right) + \left(0.0831\ N(\widehat{+y}) + 0.0831\ N(\widehat{+y})\right) \\ &= 0.1662\ N(\widehat{+y})\end{aligned}$$

$$\overrightarrow{F_{Net\to1}} = m_1\overrightarrow{a_1}$$

Solve for acceleration

$$\overrightarrow{a_1} = \frac{\overrightarrow{F_{Net\to1}}}{m_1} = \frac{0.1662\ N(\widehat{+y})}{(1.50\ g)\left(\frac{10^{-3}kg}{g}\right)} = 110.8\ {}^{m}/_{s^2}\,(\widehat{+y})$$

$$\boxed{\begin{aligned}\overrightarrow{F_{Net\to1}} &= 0.166\ N(\widehat{+y}) \\ \overrightarrow{a_1} &= 111\ {}^{m}/_{s^2}\,(\widehat{+y})\end{aligned}}$$

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Please send any comments or questions about this page to ddonovan@nmu.edu

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