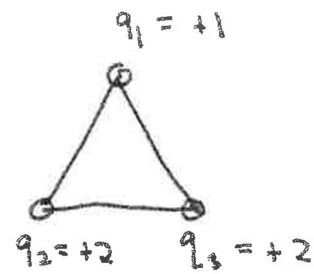
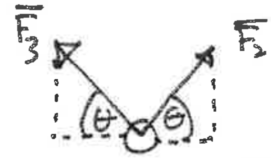
(Force addition)

EX 6.2 Net force on each charge?



I will solve this problem for each charge. First, consider charge q_1.

The forces acting on this charge are as follows:



$$\bar{F}_{NET} = \bar{F}_3 + \bar{F}_2$$

We need to add the forces $\bar{F}_2$ and $\bar{F}_3$ vectorially, that is, by breaking them into x-direction and y-direction components, and adding them accordingly. First, consider the x-direction forces

$$F_{3x} = F_3 \cos\theta = \left(\frac{k q_1 q_3}{d^2}\right) \cos(60°) = \frac{1}{2} \frac{k(1)(2)}{d^2}$$

$$F_{2x} = F_2 \cos\theta = \frac{1}{2} k \frac{(1)(2)}{d^2}$$

But since these are equal in size and opposite in direction, they cancel, and there is no net x-direction force on q_1. How about y-direction forces?

$$F_{3y} = F_3 \sin\theta = \frac{k(1)(2)}{d^2} \frac{\sqrt{3}}{2}$$

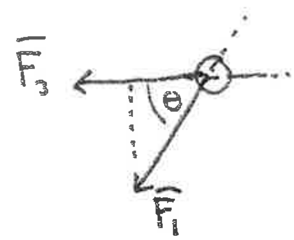
$$F_{2y} = \frac{k(1)(2)}{d^2} \frac{\sqrt{3}}{2}$$

So the net force in the y-direction is

$$\boxed{F_y = \frac{2\sqrt{3}\,k}{d^2}} = \boxed{3.1e16\ N}$$

This is the total force on q_1, and it is directed $\boxed{\text{straight upward.}}$

What about the force on charge 2? There are forces arising from charge 1 and 3. These, too, can be decomposed into x-direction and y-direction forces



$$F_{3x} = F_3 = \frac{k(2)(2)}{d^2}$$

$$F_{3y} = 0$$

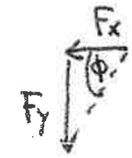
$$F_{1x} = F_1 \cos\theta$$
$$= \frac{k(1)(2)}{d^2}\,\frac{1}{2}$$

$$F_{1y} = F_1 \sin\theta$$

$$= \frac{k(1)(2)}{d^2}\,\frac{\sqrt{3}}{2}$$

So the total forces on charge 3 are

$$F_x = \frac{k}{d^2}(1+4) = \frac{5k}{d^2}$$



$$F_y = \frac{\sqrt{3}\,k}{d^2}$$

The strength of this force is $F = \frac{k}{d^2}\sqrt{5^2+3} = \frac{2\sqrt{7}\,k}{d^2} = \boxed{4.8e\ N}$

The direction of this force is $\phi = \arctan\left(\frac{F_y}{F_x}\right)$

$$\phi = \arctan\left(\frac{\sqrt{3}}{5}\right) = \boxed{19.1^\circ}$$

The force on charge 2 is the same, but pointing down and right, instead of down and left.