It is very important to keep in mind that Coulomb's law, Eq. 16–1 or 16–2, gives the force on a charge due to only *one* other charge. If several (or many) charges are present, the *net force on any one of them will be the vector sum of the forces on that charge due to each of the others*. This **principle of superposition** is based on experiment, and tells us that electric force vectors add like any other vector. For example, if you have a system of four charges, the net force on charge 1, say, is the sum of the forces exerted on charge 1 by charges 2, 3, and 4. The magnitudes of these three forces are determined from Coulomb's law, and then are added vectorially.

Superposition principle: electric forces add as vectors

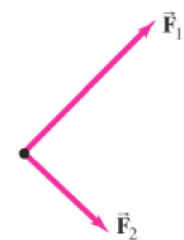
16–6 Solving Problems Involving Coulomb's Law and Vectors

The electric force between charged particles at rest (sometimes referred to as the **electrostatic force** or as the **Coulomb force**) is, like all forces, a vector: it has both magnitude and direction. When several forces act on an object (call them $\vec{\mathbf{F}}_1$, $\vec{\mathbf{F}}_2$, etc.), the net force $\vec{\mathbf{F}}_{\text{net}}$ on the object is the vector sum of all the forces acting on it:

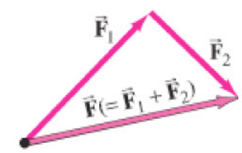
$$\vec{\mathbf{F}}_{\text{net}} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2 + \cdots.$$

As we just saw, this is the principle of superposition for forces. We studied how to add vectors in Chapter 3; then in Chapter 4 we used the rules for adding vectors to obtain the net force on an object by adding the different vector forces acting on it. It might be a good idea now to review Sections 3–2, 3–3, 3–4, as well as Section 4–9 on general problem-solving techniques. Here is a brief review of vectors.

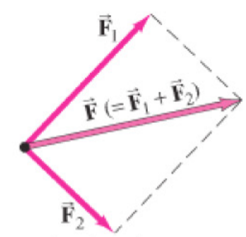
FIGURE 16–18 Review of vector addition.



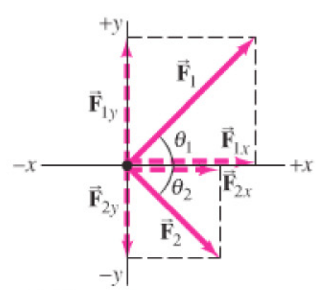
(a) Two forces acting on an object.



(b) The total, or net, force is $\vec{\mathbf{F}} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2$ by the tail-to-tip method of adding vectors.



(c) $\vec{\mathbf{F}} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2$ by the parallelogram method.



(d) $\vec{\mathbf{F}}_1$ and $\vec{\mathbf{F}}_2$ resolved into their x and y components.

Vector Addition Review

Suppose two vector forces, $\vec{\mathbf{F}}_1$ and $\vec{\mathbf{F}}_2$, act on an object (Fig. 16–18a). They can be added using the tail-to-tip method (Fig. 16–18b) or by the parallelogram method (Fig. 16–18c), as discussed in Section 3–2. These two methods are useful for *understanding* a given problem (for getting a picture in your mind of what is going on), but for *calculating* the direction and magnitude of the resultant sum, it is more precise to use the method of adding components. Figure 16–18d shows the components of our forces $\vec{\mathbf{F}}_1$ and $\vec{\mathbf{F}}_2$ resolved into components along chosen x and y axes (for more details, see Section 3–4). From the definitions of the trigonometric functions (Figs. 3–11 and 3–12), we have

$$F_{1x} = F_1 \cos\theta_1 \qquad F_{2x} = F_2 \cos\theta_2$$
$$F_{1y} = F_1 \sin\theta_1 \qquad F_{2y} = -F_2 \sin\theta_2.$$

We add up the x and y components separately to obtain the components of the resultant force $\vec{\mathbf{F}}$, which are

$$F_x = F_{1x} + F_{2x} = F_1\cos\theta_1 + F_2\cos\theta_2,$$
$$F_y = F_{1y} + F_{2y} = F_1\sin\theta_1 - F_2\sin\theta_2.$$

The magnitude of the resultant (or *net*) force $\vec{\mathbf{F}}$ is

$$F = \sqrt{F_x^2 + F_y^2}.$$

The direction of $\vec{\mathbf{F}}$ is specified by the angle θ that $\vec{\mathbf{F}}$ makes with the x axis, which is given by

$$\tan\theta = \frac{F_y}{F_x}.$$