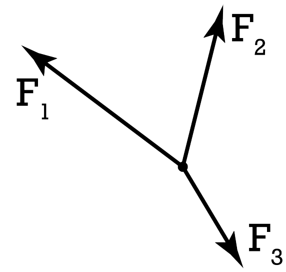
Flipping Physics Lecture Notes:

Using Unit Vectors to find Acceleration, Mass, and Velocity of 3 Forces
http://www.flippingphysics.com/unit-vector-3-forces.html

An object has the following forces acting on it: $\vec{F}_1 = \left[-4.00\hat{i} + 3.00\hat{j}\right]N; \vec{F}_2 = \left[1.00\hat{i} + 4.00\hat{j}\right]N; \vec{F}_3 = \left[1.50\hat{i} - 2.50\hat{j}\right]N$

The object experiences an acceleration of magnitude of 2.34 m/s^2 and an initial velocity of $\vec{v}_0 = \left[2.50\hat{i}\right]\frac{m}{s}$

a) What is the direction of the acceleration of the object?
b) What is the mass of the object?
c) What is the velocity object after 15.0 seconds?



We can begin by determining the net force acting on the object:

$$\sum \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \left[-4.00\hat{i} + 3.00\hat{j}\right] + \left[1.00\hat{i} + 4.00\hat{j}\right] + \left[1.50\hat{i} - 2.50\hat{j}\right]$$

$$\Rightarrow \sum \vec{F} = \left[-4 + 1 + 1.5\right]\hat{i} + \left[3 + 4 - 2.5\right]\hat{j} = \left[-1.5\hat{i} + 4.5\hat{j}\right]N$$

We can even determine the magnitude and direction of that net force:

$$a^2 + b^2 = c^2 \Rightarrow \left\|\sum F\right\| = \sqrt{\left(\sum F_x\right)^2 + \left(\sum F_y\right)^2} = \sqrt{\left(-1.5\right)^2 + \left(4.5\right)^2} = 4.74342N$$

$$\tan\theta = \frac{O}{A} = \frac{\sum F_y}{\sum F_x} \Rightarrow \theta = \tan^{-1}\left(\frac{\sum F_y}{\sum F_x}\right) = \tan^{-1}\left(\frac{4.5}{-1.5}\right) = -71.5651 \approx 71.6^\circ \text{ above -x axis}$$

But, have we found the answer to any of the questions yet? No.
Let's look at Newton's Second Law: $\sum \vec{F} = m\vec{a}$

Because force and acceleration are both vectors, Newton's Second Law tells us that the direction of the net force acting on the object is the same as the direction of the acceleration of the object. Therefore, the direction of the acceleration of the object is: 71.6° above -x axis.

We can also use Newton's Second Law to find the mass of the object:

$$\sum \vec{F} = m\vec{a} \Rightarrow m = \frac{\sum F}{a} = \frac{4.74342}{2.34} = 2.027101 \approx 2.03kg$$

We know the acceleration of the object is constant, therefore, we can use the uniformly accelerated motion (UAM) equations, for example: $\vec{v}_f = \vec{v}_0 + \vec{a}t$. However, currently the velocity initial is in unit vector form and the acceleration is in magnitude and direction form. We need the acceleration in unit vector form:

$$\sum \vec{F} = m\vec{a} \Rightarrow \vec{a} = \frac{\sum \vec{F}}{m} = \frac{\left[-1.5\hat{i} + 4.5\hat{j}\right]}{2.027101} = \left[-0.739973\hat{i} + 2.21992\hat{j}\right]\frac{m}{s^2}$$

Notice that, while the net force and acceleration of the object are in the same direction, the velocity and acceleration of the object are *not* in the same direction. The two would be in the same direction if the initial velocity of the object were zero.

And now, we can use the UAM equation to determine the velocity of the object at 15.0 seconds:

$$\vec{v}_f = \vec{v}_0 + \vec{a}t \Rightarrow \vec{v}\left(15\right) = \left[2.5\hat{i}\right] + \left[-0.739973\hat{i} + 2.21992\hat{j}\right]\left(15\right) = \left[2.5\hat{i}\right] + \left[-11.0996\hat{i} + 33.2988\hat{j}\right]$$

$$\Rightarrow \vec{v}\left(15\right) = -8.59959\hat{i} + 33.2988\hat{j} \approx \left[-8.60\hat{i} + 33.3\hat{j}\right]\frac{m}{s}$$

We do not need to determine the magnitude and direction of this velocity. If the problem asked for the "speed" of the object, we could use the Pythagorean Theorem to determine the magnitude of the velocity of the object at 15 seconds, however, the question only asks for the velocity of the object. A unity vector final velocity answers that question.