Problem 5.16

(Note: This is an "added thrill" problem only because I did it by accident and figured I might as well share.)

a.) To get the acceleration direction, we need the net force. To get that, we start by writing:

$$\begin{aligned} \vec{F}_1 &= \left(-2.00\hat{i} \;+\; 2.00\hat{j}\right)\text{N} \\ \vec{F}_2 &= \left(\;5.00\hat{i} \;-\; 3.00\hat{j}\right)\text{N} \\ +\;\vec{F}_3 &= \left(-45.0\hat{i} \;-\; 0\hat{j}\right)\text{N} \\ \hline \vec{F}_{net} &= \left(-42.0\hat{i} \;-\; 1.00\hat{j}\right)\text{N} \end{aligned}$$

The direction of the acceleration is the direction of the net force. Noting that that vector is in the second quadrant which means we need to add 180 degrees to whatever our calculator gives us), we can write:

$$\begin{aligned} \phi &= \tan^{-1}\left(\frac{-1.00}{-42.0}\right) + 180^\circ \\ &= 181^\circ \end{aligned}$$

So the acceleration's direction is at 181 degrees . . .

b.) Using N.S.L. to determine the mass, we can write:

$$\begin{aligned} &\left|\vec{F}_{net}\right| = m\left|\vec{a}\right| \\ \Rightarrow\;& \left[\left(F_x\right)^2 + \left(F_y\right)^2\right]^{1/2} = m\left|\vec{a}\right| \\ \Rightarrow\;& \left[\left(-42.0\text{ N}\right)^2 + \left(-1.00\text{ N}\right)^2\right]^{1/2} = m\left(3.75\text{ m/s}^2\right) \\ \Rightarrow\;& m = 11.2\text{ kg} \end{aligned}$$

c.) Assuming it starts from rest, how fast is it going after 10 seconds?

Not always, but most of the time when you are given a time it will turn out to be a kinematic problem (which means this is review). In this case:

$$\begin{aligned} \left|\vec{v}_2\right| &= \cancelto{0}{\left|\vec{v}_1\right|} + \left|\vec{a}\right|\left(\Delta t\right) \\ \Rightarrow\; \left|\vec{v}_2\right| &= \left(3.75\text{ m/s}^2\right)\left(10.0\text{ s}\right) \\ &= 37.5\text{ m/s} \end{aligned}$$

d.) The velocity components at t = 10.0 seconds?

$$\begin{aligned} \vec{v}_2 &= \cancelto{0}{\vec{v}_1} + \vec{a}\left(\Delta t\right) \\ \Rightarrow\; \vec{v}_2 &= \left(\frac{\vec{F}}{m}\right)\left(\Delta t\right) \\ \Rightarrow\; \left(v_{2,x}\hat{i} + v_{2,y}\hat{j}\right) &= \left(\frac{\left(F_x\hat{i} + F_y\hat{j}\right)}{m}\right)\left(\Delta t\right) \\ \Rightarrow\; \left(v_{2,x}\hat{i} + v_{2,y}\hat{j}\right) &= \left(\frac{\left(\left(-42.0\text{ N}\right)\hat{i} + \left(-1.00\text{ N}\right)\hat{j}\right)}{\left(11.2\text{ kg}\right)}\right)\left(10\text{ s}\right) \\ &= \left(-37.5\text{ m/s}\right)\hat{i} + \left(-.089\text{ m/s}\right)\hat{j} \end{aligned}$$

Teasing out the $\hat{i}$ and $\hat{j}$ parts, the velocity components are:

$$v_{2,x} = \left(-37.5\text{ m/s}\right) \quad \text{and} \quad v_{2,y} = \left(-.089\text{ m/s}\right)$$