Problem 11.15

Given: $\vec{r}(t) = (6.00\text{ m})\hat{i} + (5.00t\text{ m})\hat{j}$

Want: Angular momentum about the origin.

This will pretty clearly be a $\vec{L} = \vec{r}x\vec{p}$ kind of problem. To do that, we need "v." Sooo . . .

$$\vec{v} = \frac{d}{dt}\left[(6.00\text{ m})\hat{i} + (5.00\text{ m})t\hat{j}\right]$$
$$= (5.00\text{ m/s})\hat{j}$$

and

$$\vec{L} = \vec{r}x\vec{p} = \vec{r}x(m\vec{v})$$
$$= \left[(6.00\text{ m})\hat{i} + (5.00\text{ m/s})t\hat{j}\right]x\left[(2.00\text{ kg})(5.00\text{ m/s})\hat{j}\right]$$

Using the matrix approach to solve this:

$$\vec{L} = \vec{r}x\vec{p} = \vec{r}x(m\vec{v})$$
$$= \left[(6.00\text{ m})\hat{i} + (5.00\text{ m/s})t\hat{j}\right]x\left[(2.00\text{ kg})(5.00\text{ m/s})\hat{j}\right]$$

Suppressing the significant figures and units for ease of calculation, and remembering that in the matrix approach, the sign of the cross product comes out naturally (that is, you don't have to use a right-hand rule, or whatever, to determine the sign of the vector), we can write:

$$\vec{r}x\vec{p} = \left|\begin{array}{ccc|cc} \hat{i} & \hat{j} & \hat{k} & \hat{i} & \hat{j} \\ 6 & 5t & 0 & 6 & 5t \\ 0 & 10 & 0 & 0 & 10 \end{array}\right.$$
$$= (\hat{k})\left[(6)(10) - (5t)(0)\right]$$
$$= (60.0\text{ kg}\bullet\text{m}^2/\text{s})\hat{k}$$