32. Both $\vec{r}$ and $\vec{v}$ lie in the xy plane. The position vector $\vec{r}$ has an x component that is a function of time (being the integral of the x component of velocity, which is itself time-dependent) and a y component that is constant ($y = -2.0$ m). In the cross product $\vec{r} \times \vec{v}$, all that matters is the y component of $\vec{r}$ since $v_x \neq 0$ but $v_y = 0$:

$$\vec{r} \times \vec{v} = -y v_x \,\hat{\text{k}} \; .$$

(a) The angular momentum is $\vec{\ell} = m\,(\vec{r} \times \vec{v})$ where the mass is $m = 2.0$ kg in this case. With SI units understood and using the above cross-product expression, we have

$$\vec{\ell} = (2.0)\left(-(-2.0)\left(-6.0t^2\right)\right)\hat{\text{k}} = -24t^2\,\hat{\text{k}}$$

in kg·m^2/s. This implies the particle is moving clockwise (as observed by someone on the $+z$ axis) for $t > 0$.

(b) The torque is caused by the (net) force $\vec{F} = m\vec{a}$ where

$$\vec{a} = \frac{d\vec{v}}{dt} = -12t\,\hat{\text{i}} \text{ m/s}^2 \; .$$

The remark above that only the y component of $\vec{r}$ still applies, since $a_y = 0$. We use $\vec{\tau} = \vec{r} \times \vec{F} = m\,(\vec{r} \times \vec{a})$ and obtain

$$\vec{\tau} = (2.0)\,(-(-2.0)(-12t))\,\hat{\text{k}} = -48t\,\hat{\text{k}}$$

in N·m. The torque on the particle (as observed by someone on the $+z$ axis) is clockwise, causing the particle motion (which was clockwise to begin with) to increase.

(c) We replace $\vec{r}$ with $\vec{r}\,'$ (measured relative to the new reference point) and note (again) that only its y component matters in these calculations. Thus, with $y' = -2.0 - (-3.0) = 1.0$ m, we find

$$\vec{\ell}\,' = (2.0)\left(-(1.0)\left(-6.0t^2\right)\right)\hat{\text{k}} = 12t^2\,\hat{\text{k}}$$

in kg·m^2/s. The fact that this is positive implies that the particle is moving counterclockwise relative to the new reference point.

(d) Using $\vec{\tau}\,' = \vec{r}\,' \times \vec{F} = m\,(\vec{r}\,' \times \vec{a})$, we obtain

$$\vec{\tau} = (2.0)\,(-(1.0)\,(-12t))\,\hat{\text{k}} = 24t\,\hat{\text{k}}$$

in N·m. The torque on the particle (as observed by someone on the $+z$ axis) is counterclockwise, relative to the new reference point.