We need to find ${}^{E_0}R_d$: matrix from $E_0 \rightarrow$ desired.

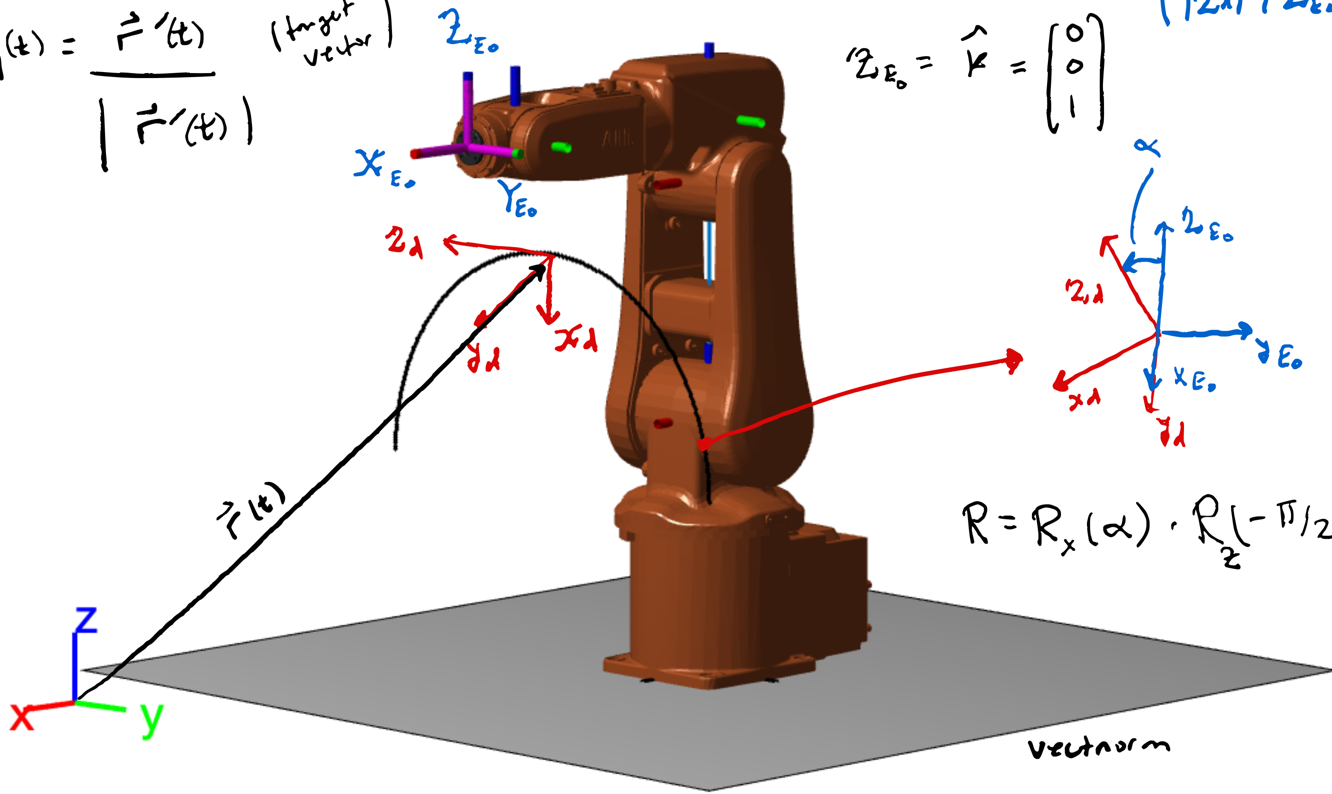
$$\vec{r}(t) = f_x(t)\,\hat{i} + f_y(t)\,\hat{j} + f_z(t)\,\hat{k}$$ (parametric curve)

$$z_d \cdot z_{E_0} = |z_d|\,|z_{E_0}| \cos\alpha$$

$$\alpha = \cos^{-1}\left(\frac{z_d \cdot z_{E_0}}{|z_d|\,|z_{E_0}|}\right)$$

$$z_d(t) = \frac{\vec{r}\,'(t)}{|\vec{r}\,'(t)|}$$ (target vector)

$$z_{E_0} = \hat{k} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$



$$R = R_x(\alpha) \cdot R_z(-\pi/2)$$

vectnorm

$\dot{x} = J(q)\,\underbrace{\dot{q}}$ {generalized coordinates which typically are just the same as joint variables}

generalized coordinate: small set of variables that describes the system

$$q = \begin{matrix} r \\ \theta \end{matrix} \Rightarrow \begin{bmatrix} \dot{r} \\ \dot{\theta} \end{bmatrix}$$

$$x = \begin{bmatrix} x \\ y \\ \omega_3 \end{bmatrix} \Rightarrow \quad x = \begin{bmatrix} x \\ y \\ \cancel{z} \\ \cancel{\omega_x} \\ \cancel{\omega_y} \\ \omega_z \end{bmatrix} \begin{matrix} \\ \\ 0 \\ 0 \\ 0 \\ \\ \end{matrix}$$