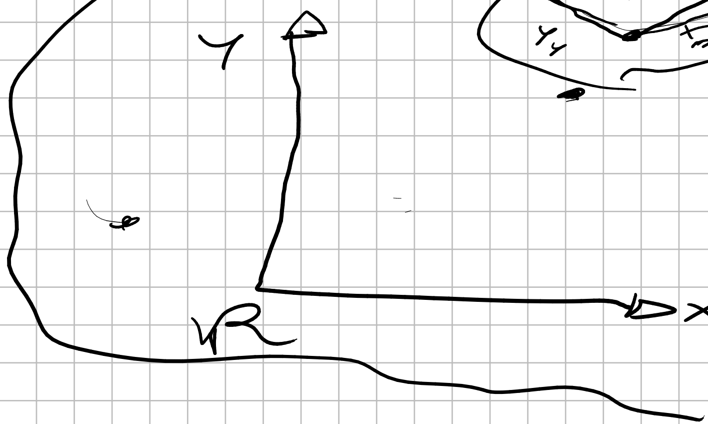
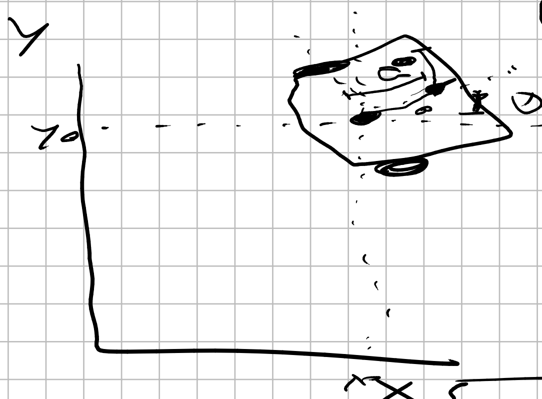


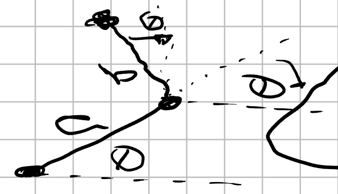
$$\begin{bmatrix} x \\ y \end{bmatrix} = R_z \begin{bmatrix} x_m \\ y_m \end{bmatrix}$$

$a =$

$a \neq c$



$$h_x = x_0 + a\cos(\theta)$$
$$h_y = y_0 + a\sin(\theta)$$



$$h_x = x_0 + a\cos(\theta) - b\sin(\theta)$$
$$h_y = y_0 + a\sin(\theta) + b\cos(\theta)$$

$$\dot{h}_x = u\cos(\theta) - a\sin(\theta)\omega \qquad a = c$$
$$\dot{h}_y = u\sin(\theta) + a\cos(\theta)\omega$$

$$\underbrace{\begin{bmatrix} \dot{h}_x \\ \dot{h}_y \end{bmatrix}}_{R^2} = \underbrace{\begin{bmatrix} \cos(\theta), & -a\sin(\theta) \\ \sin(\theta), & a\cos(\theta) \end{bmatrix}}_{J} \underbrace{\begin{bmatrix} u \\ \omega \end{bmatrix}}_{R^2}$$

$m > n$ R^1

R^2 $\qquad$ R^2 $\qquad$ R^2 u

R^3 u u_m ω $\qquad$ R^3

$x(t), \dot{x}(t)$

$\theta(t), \dot{\theta}(t)$ $\quad R^4$

$n(k+1) = n(k) + T_0 \dot{n} \quad J.v$

$\dot{n} = J.v$

$n_d = \begin{bmatrix} x_d(t) \\ y_d(t) \end{bmatrix} \qquad \dot{n}_d = \begin{bmatrix} \dot{x}_d(t) \\ \dot{y}_d(t) \end{bmatrix}$

$\tilde{n} = n_d - n \longrightarrow \dot{\tilde{n}} = \dot{n}_d - \dot{n}$

$\tilde{n} = \begin{bmatrix} x_d(t) \\ y_d(t) \end{bmatrix} - \begin{bmatrix} x(t) \\ y(t) \end{bmatrix} \qquad \boxed{\dot{\tilde{n}} = \dot{n}_d - J v}$

$\tilde{n} = \begin{bmatrix} x_d(t) - x(t) \\ y_d(t) - y(t) \end{bmatrix}$

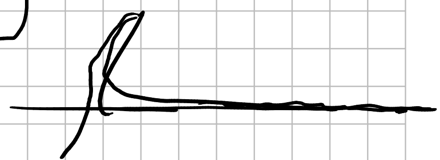
$x > 0$

$x < 0$

$V(x) \geq 0 \qquad x \neq 0$

$\frac{1}{2} x^2 \qquad \frac{1}{2}(1)^2 = \boxed{\frac{1}{2}}$

$\frac{1}{2}(-1)^2 = \frac{1}{2}(1) = \boxed{\frac{1}{2}}$



$V(x) = 0$

$V(\tilde{n}) = \frac{1}{2} \tilde{n}^T \tilde{n}$

$V(\tilde{n}) = \frac{1}{2} [\tilde{x}, \tilde{y}] \begin{bmatrix} \tilde{x} \\ \tilde{y} \end{bmatrix}$

$V(\tilde{n}) = \frac{1}{2}(\overset{x_d - x}{\tilde{x}^2} + \overset{y_d - y}{\tilde{y}^2})$

$$V(\tilde{n}) = \frac{1}{2}(\tilde{x}^2 + \tilde{y}^2)$$

$V > 0 \quad x \neq 0$

$V \geq 0 \quad \tilde{x} \neq 0$

$\tilde{y} \neq 0$

$$V(\tilde{n}) = \frac{1}{2}(\tilde{n}^T \tilde{n})$$

$$\dot{V}(\tilde{n}) = \frac{1}{\cancel{2}}(\cancel{2}\tilde{x}\dot{\tilde{x}} + 2\tilde{y}\dot{\tilde{y}})$$

$$\dot{V}(\tilde{n}) = \tilde{x}\dot{\tilde{x}} + \tilde{y}\dot{\tilde{y}}$$

$$\dot{V}(\tilde{n}) = \tilde{n}^T \dot{\tilde{n}} \rightarrow \begin{bmatrix} \tilde{x} & \tilde{y} \end{bmatrix} \begin{bmatrix} \dot{\tilde{x}} \\ \dot{\tilde{y}} \end{bmatrix}$$

$$\dot{n} = J \cdot v$$

$$\tilde{n} = n_d - n$$

$$\dot{\tilde{n}} = \dot{n}_d - \dot{n}$$

$$\dot{\tilde{n}} = \dot{n}_d - Jv$$

$$\dot{V}(\tilde{n}) = \tilde{n}^T \cdot \dot{\tilde{n}}$$

$$\dot{V}(\tilde{n}) = \tilde{n}^T(\dot{n}_d - Jv)$$

$$v = \begin{bmatrix} u \\ \omega \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}_{2\times 2} \begin{bmatrix} 0 \\ 0 \end{bmatrix}_{2\times 1} \quad I$$

$$v = J^{-1}(\dot{n}_d + \tilde{n})$$

$$\dot{V}(\tilde{n}) = \tilde{n}^T(\dot{n}_d - \cancel{J(J^{-1}}(\dot{n}_d + \tilde{n}))$$

$$V(\tilde{n}) = \tilde{n}^T(\cancel{\dot{n}_d} - \cancel{\dot{n}_d} - \tilde{n}) = \tilde{n}^T(-\tilde{n})$$

$$\dot{V}(\tilde{n}) = -\tilde{n}^T \tilde{n}$$

$$\dot{V}(\tilde{n}) = -\begin{bmatrix} \tilde{x} & \tilde{y} \end{bmatrix} \begin{bmatrix} \tilde{x} \\ \tilde{y} \end{bmatrix}$$

$$\dot{V}(\tilde{n}) = -(\tilde{x}^2 + \tilde{y}^2)$$