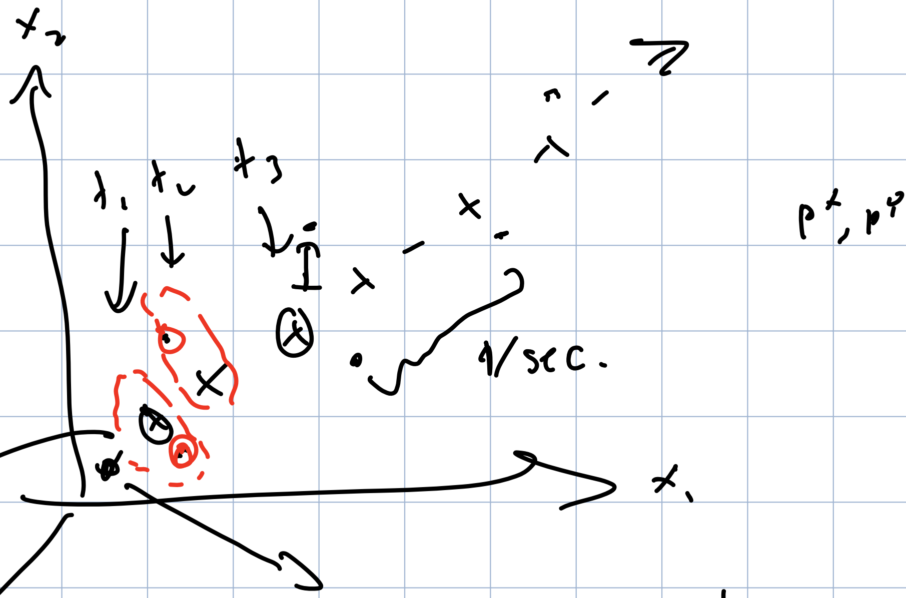


$$p^x(t) = p^x(0) + v^x \cdot t$$
$$p^y(t) = p^y(0) + v^y \cdot t$$

$(p^x(0), p^y(0))$

$(p^x(t_1), p^y(t_1))$

$$y_n(t) = \sqrt{(p^x(t) - s_n^x)^2 + (p^y(t) - s_n^y)^2} + r_n$$
$$= \sqrt{(p^x(0) + v^x \cdot t - s_n^x)^2 + (p^y(0) + v^y \cdot t - s_n^y)^2} + r_n$$

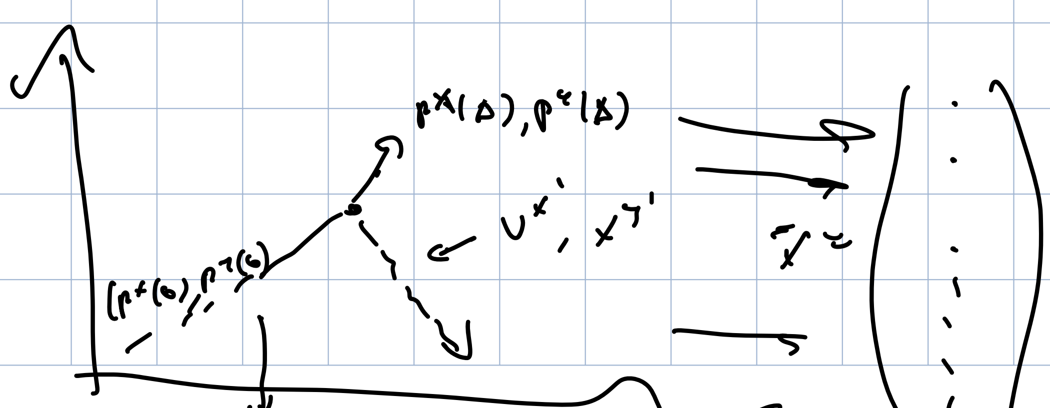
$y_n(t_1)$

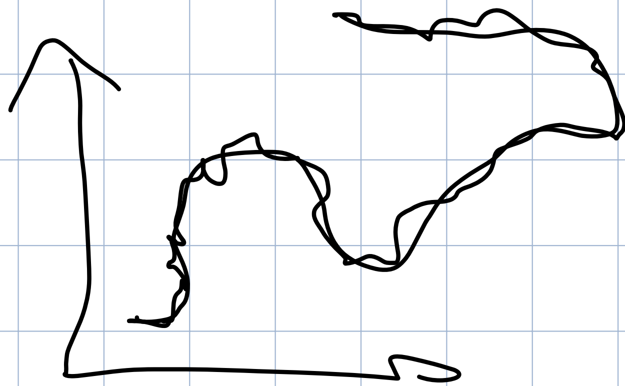
$y_n(t_2)$

$\vdots$

$$g(\vec{x}; t)$$

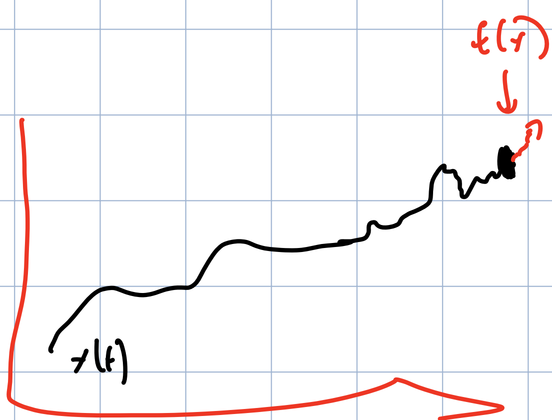
$$\vec{x} = \begin{pmatrix} p^x(0) \\ p^y(0) \\ v^x \\ v^y \end{pmatrix}$$

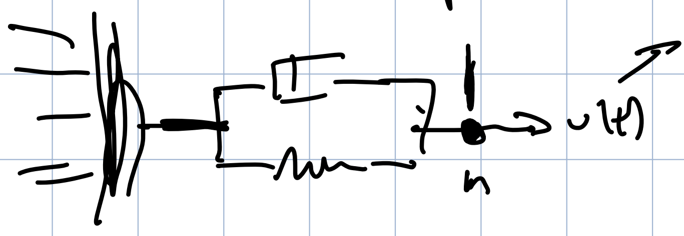




$$\frac{dx}{dt} = f(x) + w$$

$$dx = f(x)\,dt$$





$$F_u = u(t)$$

$$F_s = -k \cdot p(t)$$

$$F_d = -\eta \frac{dp}{dt}(t)$$

$$m \cdot a(t) = F$$

$$= F_s + F_d + F_u$$

$$= -k \cdot p(t) - \eta \frac{dp(t)}{dt} + u(t)$$

$$a = \frac{d^2 p}{dt}$$

$$m \cdot \frac{d^2 p}{dt^2} = -k\, p(t) - \eta \frac{dp(t)}{dt} + u(t)$$

$$\begin{cases} \dfrac{dp}{dt} = \dfrac{dp}{dt} \\[2ex] \dfrac{d^2 p}{dt^2} = -\dfrac{k}{m} p - \dfrac{\eta}{m} \dfrac{dp}{dt} + u(t)/m \end{cases}$$

$$\vec{x} = \begin{pmatrix} p \\ \frac{dp}{dt} \end{pmatrix} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \quad \frac{d\vec{x}}{dt} = \begin{pmatrix} dp/dt \\ d^2p/dt^2 \end{pmatrix}$$

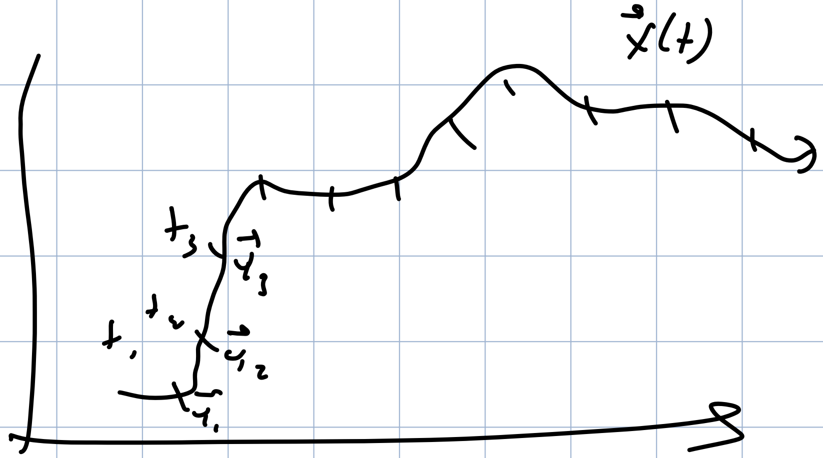
$$\frac{d\vec{x}}{dt} = \begin{pmatrix} dp/dt \\ -\frac{k}{m} p - \frac{\eta}{m} \frac{dp}{dt} + \frac{u}{m} \end{pmatrix}$$

$$= \begin{pmatrix} x_2 \\ -\frac{k}{m} x_1 - \frac{\eta}{m} x_2 \end{pmatrix} + \begin{pmatrix} 0 \cdot u \\ \frac{1}{m} \cdot u \end{pmatrix}$$

$$\vec{x} = \begin{pmatrix} p \\ \frac{dp}{dt} \end{pmatrix} = \underbrace{\begin{pmatrix} 0 & 1 \\ -\frac{k}{m} & -\frac{\mu}{m} \end{pmatrix}}_{A} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \underbrace{\begin{pmatrix} 0 \\ \frac{1}{m} \end{pmatrix}}_{B_u} u$$

$$y_n = \underbrace{(1 \quad 0)}_{G\,?} \vec{x}_n + r$$

$$\underline{\frac{d\vec{x}}{dt} = A\vec{x} + B_u\vec{u}}$$



$$\vec{y}_n = G\vec{x}_n + \vec{r}_n$$

$$\vec{a} = \frac{d^2\vec{p}}{dt^2} = \begin{pmatrix} \frac{d^2p^x}{dt} \\ \frac{d^2p^y}{dt} \end{pmatrix}$$

$m=1$

$$\rightarrow m\vec{a} = \vec{F}$$

$$\vec{F} = \begin{pmatrix} F_p^x \\ F_p^y \end{pmatrix}$$

$$\begin{cases} \frac{d^2p^x}{dt^2} = F_p^x \\ \frac{d^2p^y}{dt^2} = F_p^y \\ \frac{dp^x}{dt} = \frac{dp^x}{dt} \\ \frac{dp^y}{dt} = \frac{dp^y}{dt} \end{cases}$$

$$\vec{x} = \begin{pmatrix} p^x \\ p^y \\ \frac{dp^x}{dt} \\ \frac{dp^y}{dt} \end{pmatrix}$$

$$\frac{d\vec{x}}{dt} = \begin{pmatrix} x_3 \\ x_4 \\ 0 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ F_1^x \\ F_1^y \end{pmatrix}$$

$$= \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} F_1^x \\ F_1^y \end{pmatrix}$$

$$\underline{= A\vec{x} + B_0\vec{u}}$$

$$\underbrace{\begin{pmatrix} y_{1,n} \\ y_{2,n} \end{pmatrix}}_{\vec{y}_n} \begin{matrix} = x_{1,n} + r_{1,n} \\ = x_{2,n} + r_{2,n} \end{matrix}$$

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix}$$

$$\vec{y} = G\vec{x} + \vec{r}$$

$$G = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix}$$

$$\frac{d^2p}{dt^2} = -kp - \gamma\frac{dp}{dt} + w(t)$$