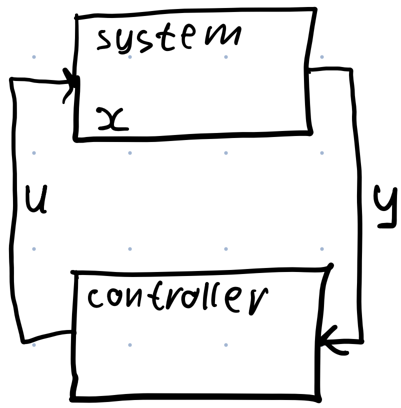
$$\dot{x} = f(x, u)$$

x – век. сост.

$x \in \mathbb{X} \subseteq \mathbb{R}^n$

u – век. упр.

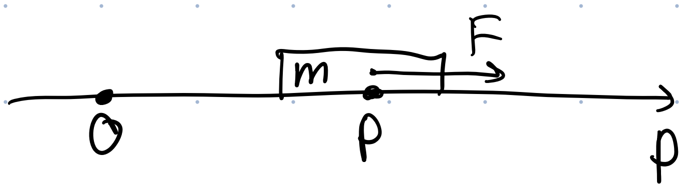
$u \in \mathbb{U} \subseteq \mathbb{R}^m$



$$\begin{cases} \dot{x} = f(x,u) = Ax + Bu \\ y = g(x) \\ \hat{x} = h(y) \\ u = u(\hat{x}) \end{cases}$$

$$\dot{x} = \begin{pmatrix} \dot{p} \\ \ddot{p} \end{pmatrix} = f(x,u) =$$

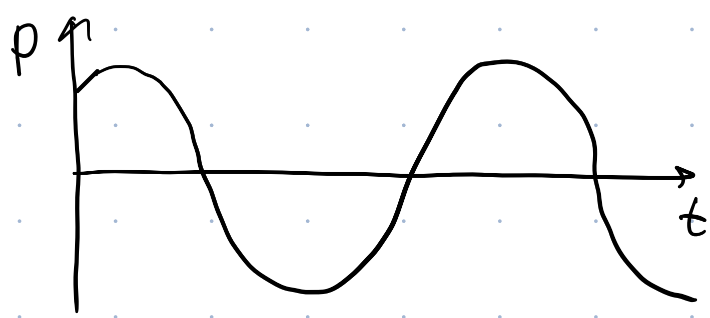
$$= \underbrace{\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}}_{A} \begin{pmatrix} p \\ \dot{p} \end{pmatrix} + \underbrace{\begin{pmatrix} 0 \\ \frac{1}{m} \end{pmatrix}}_{B} (F)$$



$$x = \begin{pmatrix} p \\ \dot{p} \end{pmatrix} \qquad u = (F)$$

$$F = m\ddot{p} \Rightarrow \ddot{p} = \frac{F}{m}$$

$$x_1 = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$



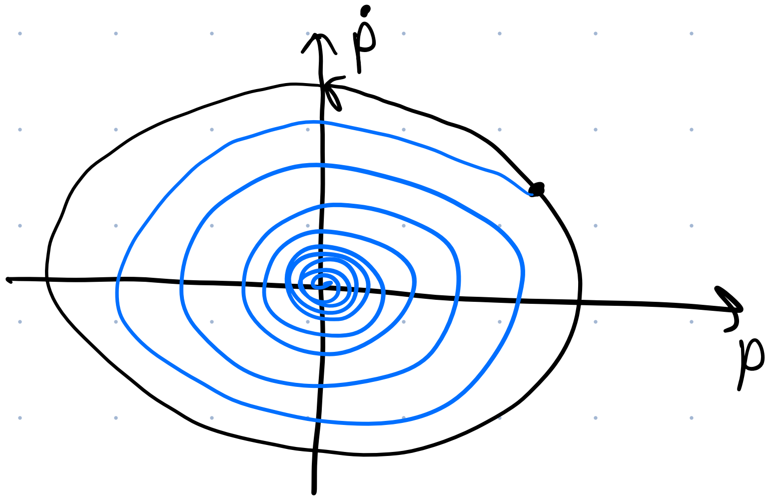
$$F = -\underset{>0}{K_p}(p - p_1) = -K_p p$$

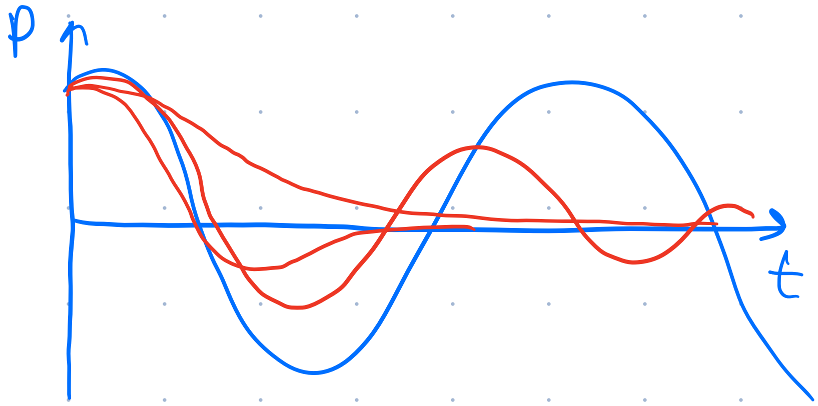
$$F = m\ddot{p}$$

$$m\ddot{p} = -K_p p \qquad \ddot{p} = -\frac{K_p}{m} p$$

$$F = -\underset{>0}{K_p}\, p - \underset{>0}{K_d}\, \dot{p}$$

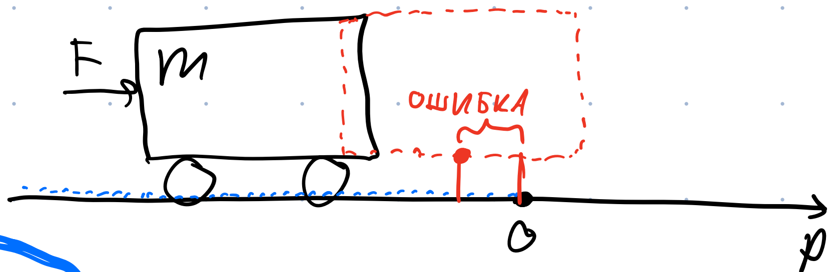
PD

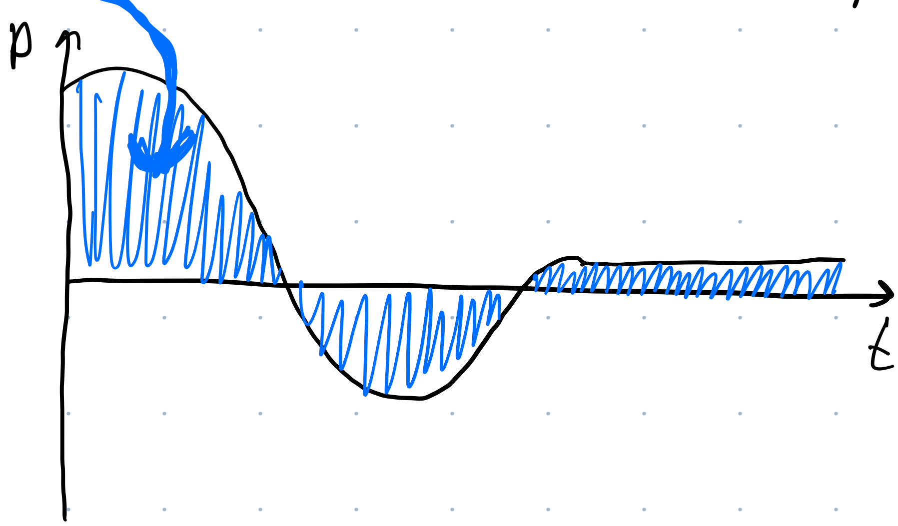




PID

$$F = -K_p p - K_d \dot{p} - K_I \int_0^T p(t)\,dt$$





$$\dot{x} = Ax + Bu$$

$$x_{k+1} = \hat{A} x_k + \hat{B} u_k \qquad \Delta t$$

$$J = \int_0^\infty x^T Q x + u^T R u \, dt$$