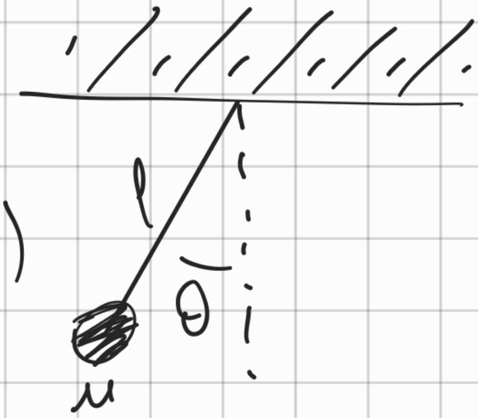
# ADRC: (Pendulum)

$l = 0.05$ | $m = \rho \cdot V$

$= 1000 \cdot (0.1 \cdot 0.01^2)$

$= 1e^{-5}$

* Also added unknown damp!




$$J\ddot{\theta} = \tau + \underbrace{f(t)}_{\text{disturbance}} \longrightarrow \ddot{\theta} = \frac{1}{ml^2}\left[u + f(t)\right]$$

$$\begin{cases} z_1 = \theta \\ z_2 = \dot{\theta} \\ z_3 = f(t) \end{cases} \longrightarrow \begin{cases} \dot{z}_1 = z_2 + k_1(y - z_1) \\ \dot{z}_2 = \frac{1}{ml^2} \cdot u + z_3 + k_2(y - z_1) \\ \dot{z}_3 = k_3(y - z_1) \end{cases}$$

## State Space:

$$\dot{z} = \begin{bmatrix} -k_1 & 1 & 0 \\ -k_2 & 0 & 1 \\ -k_3 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{ml^2} \\ 0 \end{bmatrix} u + \begin{bmatrix} k_1 \\ k_2 \\ k_3 \end{bmatrix} \cdot y$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix}$$

Note: the paper defines $e = z - y$ thats why my symbol is diffrenet

$\dot{r} = 0$

Continus $\longrightarrow$

$$\boxed{u = \frac{1}{ml^2} \cdot \left[k_p(r - z_1) + k_d(\dot{r} - z_2) - z_3\right]}$$

Discrete $\longrightarrow$

$$\dot{z}_1 = z_1 + z_2 \cdot \Delta t + k_1(y - z_1)$$
$$\dot{z}_2 = z_2 + \Delta t \cdot (z_3 + 1/ml^2 \cdot u) + k_2(y - z_1)$$
$$\dot{z}_3 = z_3 + k_3 \cdot (y - z_1)$$

# Regular PID:

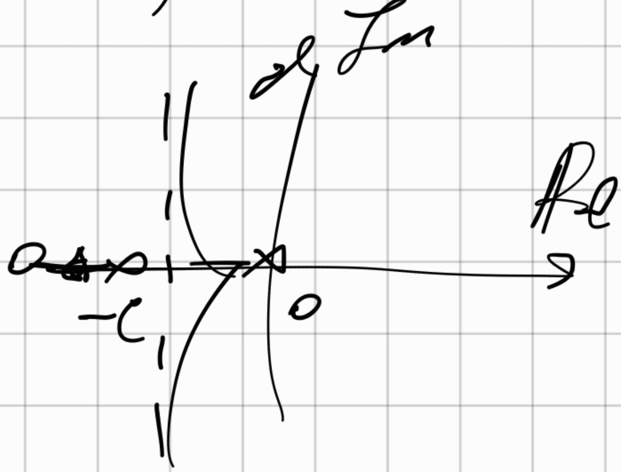
negligeable

$$ml^2\ddot{\theta} = \tau - c\,\dot{\theta} - \cancel{mg\cos(\theta)}$$

$$\ddot{\theta} = \tau - c\dot{\theta} \rightarrow s^2\theta = \tau - c\,s\,\theta$$

$$s(s+c)\,\theta = \tau$$

$$\boxed{\frac{\theta}{\tau} = \frac{1}{s(s+c)}}$$




# Rlocus:

$$C_{PID} = K_p\left(\frac{s+a}{s}\right)$$

C.G needs to be between $(-c, 0)$

$$C.G = \frac{-c-a}{2} = \frac{-\frac{1}{2}-a}{2} = -\frac{1}{4} - \frac{a}{2}$$

$$-\frac{3}{8} = -\frac{2}{8} - \frac{4a}{8} \rightarrow \boxed{a = \frac{1}{4}}$$

$$\boxed{C_{PID} = 0.568\cdot\left(\frac{s+0.25}{s}\right)}$$