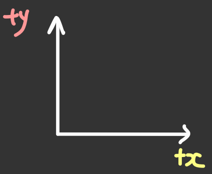
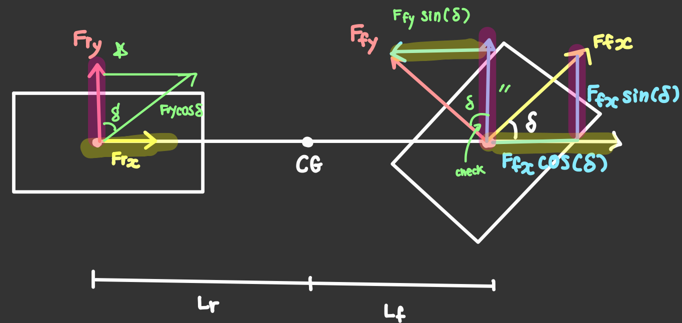




Explanation

$\sin(\delta) = \frac{1}{F_{fx}}$

$1 = F_{fx} \sin(\delta)$

Sum of forces:

$\sum F_x = F_{rx} + F_{fx} \cdot \cos(\delta) - F_{fy} \cdot \sin(\delta)$

$\sum F_y = F_{ry} + F_{fy} \cdot \cos(\delta) + F_{fx} \cdot \sin(\delta)$

$\sum \mathcal{T} = \underset{\text{moment of inertia}}{I} \cdot \underset{\text{angular acceleration}}{\alpha} = F \cdot d = L_r(F_{ry}) - L_f(F_{fx}\sin\delta + F_{fy}\sin\delta)$

Acceleration equations

$a_x = \ddot{x} + \dot{\psi}\dot{y}$

$a_y = \ddot{y} - \dot{\psi}\dot{x}$

$\alpha = \ddot{\psi}$ <yaw acc>

$$\ddot{x} = \frac{(F_{rx} + F_{fx}\cos(\delta) - F_{fy}\sin(\delta))}{m} + \dot{y}\dot{\varphi}$$

$$\ddot{y} = \frac{(F_{ry} + F_{fx}\sin(\delta) + F_{fy}\sin(\delta))}{m} - \dot{x}\dot{\varphi}$$

$$\ddot{\varphi} = \frac{(L_r(F_{ry}) - L_f(F_{fx}\sin\delta + F_{fy}\sin\delta))}{I}$$

Simulink structure

<3 Functions>

1. Calculating the $\ddot{x}, \ddot{y}, \ddot{\psi}$

Inputs: Steering angle (δ), F_{fx}, F_{fy}, F_{rx}, F_{ry}

Outputs: ddpsi, ddpx, ddpy

2. Deriving the slip angle using the steering angle

Inputs: Steering angle (δ), dpsi, dx, dy

Outputs: F_{ry}, F_{fy}

3. Changing to World coordinate system

Inputs: dpsi, dy, dx

Outputs: velocities & body slip angle

$\underbrace{K_P \quad K_I \quad K_D}_{\text{given constants}}$

PID controllers (Proportional · Integral · Derivative)

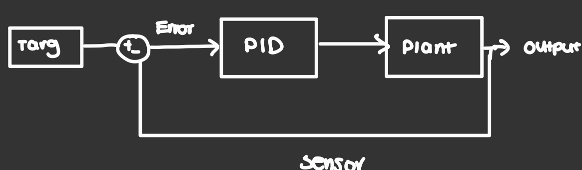
$F_y = K_{ya} \cdot \alpha$

$F_x = K_{xk} \cdot x$

If current value = 700m,

Target value = 1000m

→ Error = 300



Simulink structure

<3 Functions>

1. Calculating the $\ddot{x}, \ddot{y}, \ddot{\psi}$

Inputs: Steering angle (δ), Ffx, Ffy, Frx, Fry

Outputs: ddpsi, ddpx, ddpy

2. Deriving the slip angle using the steering angle

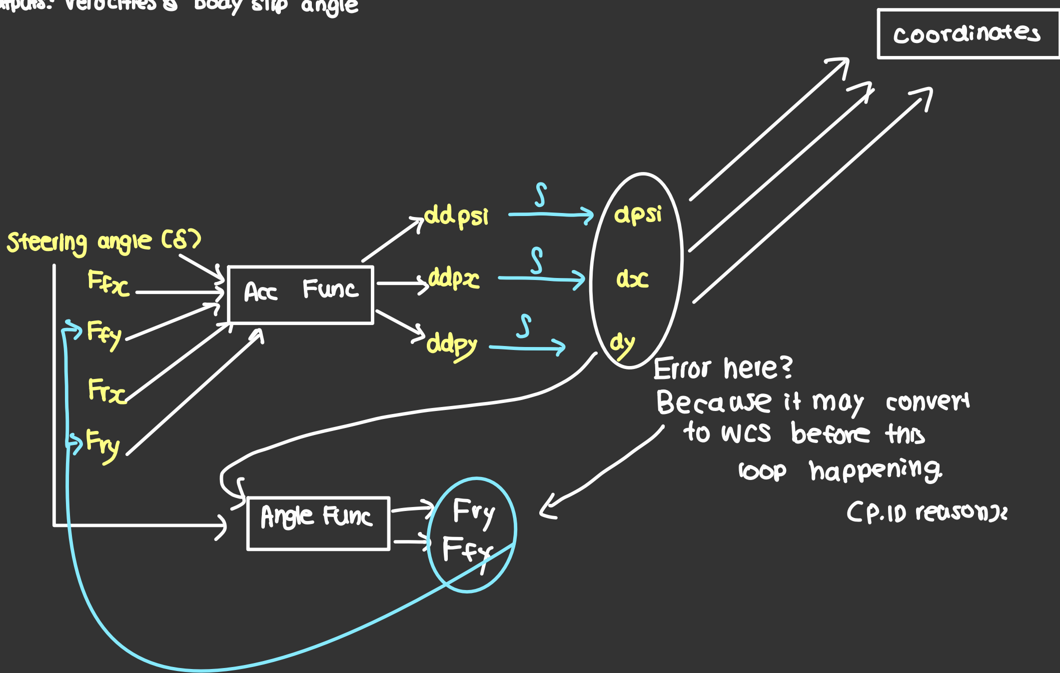
Inputs: steering angle (δ), dpsi, dx, dy

Outputs: Fry, Ffy

3. Changing to World coordinate system

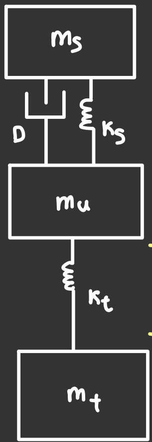
Inputs: dpsi, dy, dx

Outputs: velocities & body slip angle



→ 1/4 of car

→ Focusing on vertical motion

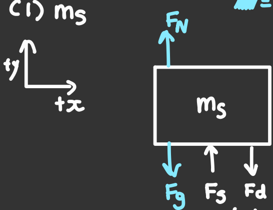


Δz = final − initial
↳ vertical position

Using Newton's second law to derive acceleration:

(1) m_s

= cancel



can be vice versa

spring equation ($k\Delta x$)

damper constant

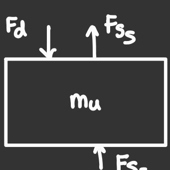
$\Rightarrow ma = \pm F_s \mp F_d$

$ma = \pm k_s \Delta z \mp d\dot{z}$

$ma = \dfrac{k_s(z_u - z_s) - d(z_u - z_s)}{m}$

※ 이거 설명 필요

2)

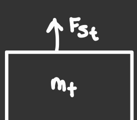


$\Rightarrow m_u a = \pm F_{s_s} \pm F_{s_T} \mp F_d$

$= \pm k_s \Delta z \pm k_t \Delta z \mp d\dot{z}$

$= \dfrac{k_s(z_s - z_u) + k_t(z_u - z_t) - d(z_s - z_u)}{m}$

3)



$\Rightarrow m_t a = \pm F_{st}$

$= \pm k_t \Delta z$

$= \dfrac{k_t(z_t - z_u)}{m}$