**SEOUL NATIONAL UNIVERSITY**
**DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING**

**CONTROL SYSTEM THEORY** **Fall 2010**

**HW#1** **Assigned: March 10 (We)**
**Due: March 17 (We)**

Consider 2 DOF bicycle Model as follows:

$$\dot{x} = \begin{bmatrix} \dot{\beta} \\ \ddot{\psi} \end{bmatrix} = \begin{bmatrix} -\frac{2(C_f + C_r)}{m \cdot v_x} & -1 - \frac{2(l_f \cdot C_f - l_r \cdot C_r)}{m \cdot v_x^{\,2}} \\ -\frac{2(l_f \cdot C_f - l_r \cdot C_r)}{I_z} & -\frac{2(l_f^{\,2} \cdot C_f + l_r^{\,2} \cdot C_r)}{I_z \cdot v_x} \end{bmatrix} \cdot \begin{bmatrix} \beta \\ \dot{\psi} \end{bmatrix} + \begin{bmatrix} \frac{2 \cdot C_f}{m v_x} \\ \frac{2 \cdot l_f \cdot C_f}{I_z} \end{bmatrix} \cdot \delta_f$$

$$= Ax + B\delta_f$$

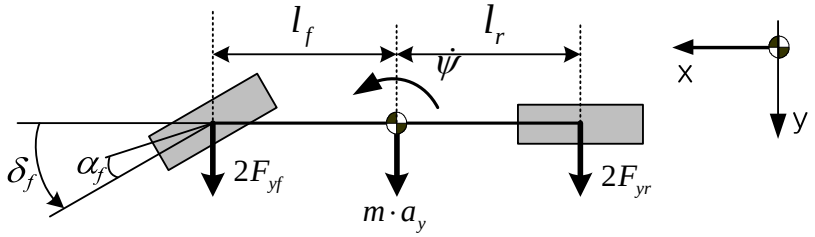


Fig.1 2-DOF Bicycle Model

1. Vehicle parameters of 2 DOF bicycle model are listed in Table.1. Simulate the vehicle behaviors using the steering wheel angle maneuver ($\delta_{SW}$ = Steering Ratio $\cdot \delta_f$) as shown in Fig.2.

   (1) Plot body slip angle and yaw rate. ( Vx = 30, 50 and 70 kph)

   (2) Plot vehicle trajectory. ( Vx = 30, 50 and 70 kph)

   (3) Discussion – Why the Vehicle Behavior (body slip and yaw rate) is different in the situation of same steering wheel angle with different vehicle velocity?

Table.1 Vehicle Parameters

| Symbol | Value | Symbol | Value | Symbol | Value |
|---|---|---|---|---|---|
| $m$ | 1723.8 kg | $L$ | 2.7 m | $C_f$ | 67248 N/rad |
| $I_z$ | 4175 kgm$^2$ | $l_f$ | 1.24 m | $C_r$ | 53248 N/rad |
| Steering Ratio | 15 | $l_r$ | $L - l_f$ | | |

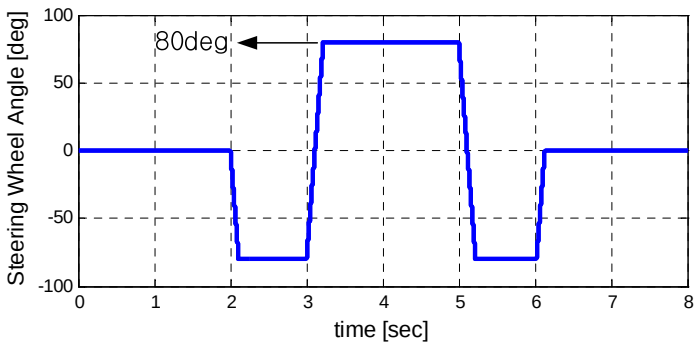


Fig.2 Steering Wheel Angle Maneuver ($\delta_{SW}$)

2. Consider the 2-DOF Bicycle Model in Preblem.1. Vehicle parameters of 2 DOF bicycle model are listed in Table.2. Simulate the vehicle behaviors using the steering wheel angle maneuver as shown in Fig.3.

(1) Determine $l_f$ and $l_r$ for Neutral Steer Vehicle at Vx = 50 kph.

(2) Determine $l_f$ and $l_r$ for $K_{us} = 2\,\text{deg}$ at Vx = 50 kph

(3) Determine $l_f$ and $l_r$ for $K_{us} = -1\,\text{deg}$ at Vx = 50 kph

(4) Plot vehicle behaviors and vehicle trajectory of the above simulations using the below steering Behaviors

Table.2 Vehicle Parameters

| Symbol | Value | Symbol | Value |
|---|---|---|---|
| $m$ | 1723.8 kg | $C_f$ | 67248 N/rad |
| $I_z$ | 4175 $\text{kgm}^2$ | $C_r$ | 53248 N/rad |
| Steering Ratio | 15 | $L = l_f + l_r$ | 2.7 m |

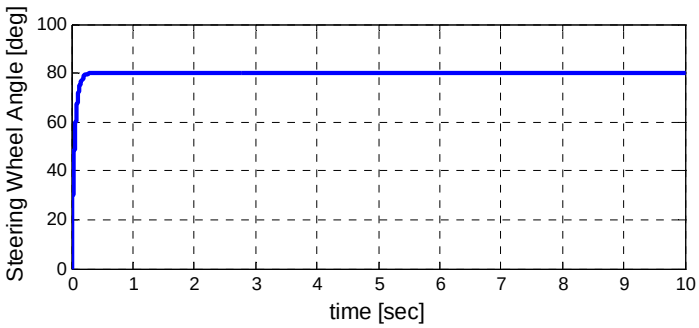


Fig.3 Steering Wheel Angle Maneuver ($\delta_{SW}$)