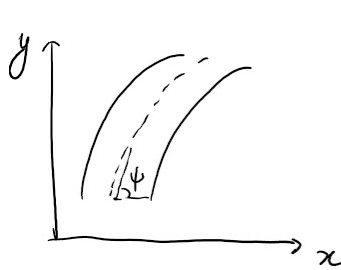


## Vehicle Dynamics and Test Track Information

### 1. Simplified Vehicle Dynamics Model



$$\begin{aligned}\dot{x} &= v \cos \psi \\ \dot{y} &= v \sin \psi \\ \dot{\psi} &= \frac{v}{L} \delta \\ \dot{v} &= a\end{aligned}$$

$$\delta \in [-25^\circ, 25^\circ]$$

$$a \in [-1, 1]$$

$$L = 3$$

### 2. Sampling Rate, MPC Horizon and Update Time

$$\Delta t = 0.01 \text{ s.}$$

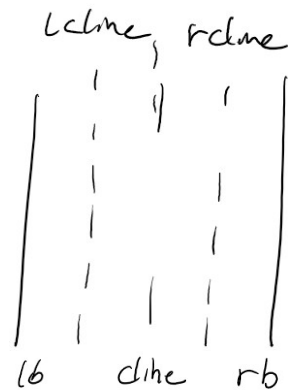
$$t_u = 0.1 \text{ s.}$$

$$t_c > 2 \text{ s}$$

### 3. Test Cases

There are 5 lane marks and 1 angle associated with each TestTrack except for Double Lane Change (DLC).

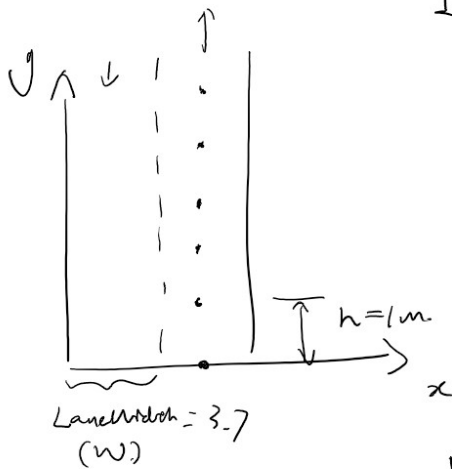
5 lane marks: lb, lcline, cline, rcline, rb each having x, y coordinates.



The information has been saved in TestTrack#.csv file, the first line of the file describes the information.

#### 3.1. Straight Line (TestTrack1.csv)

①

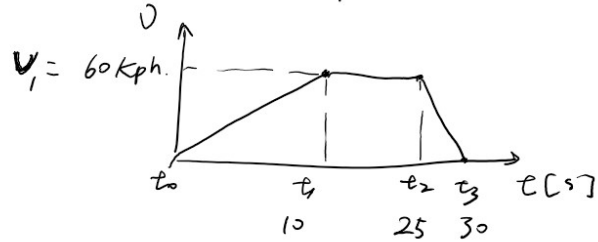


Initial Conditions:

$$\begin{pmatrix} x \\ y \\ \varphi \\ v \end{pmatrix}_0 = \begin{pmatrix} \frac{3}{2}w \\ 0 \\ \frac{\pi}{2} \\ 0 \end{pmatrix}$$

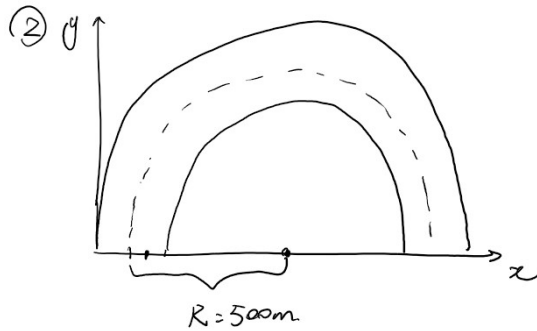
Objective:

① follow speed profile.



② centerline distance.

### 3.2. Half Circle (TestTrack2.csv)



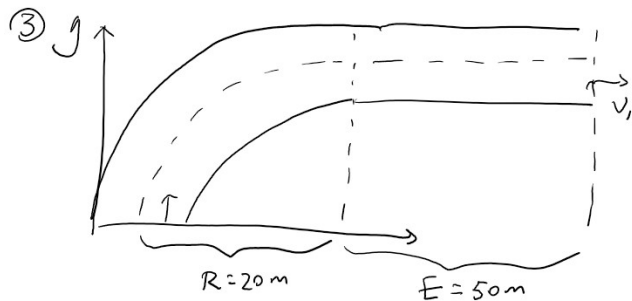
Initial conditions:

$$\begin{pmatrix} x \\ y \\ \varphi \\ v \end{pmatrix}_0 = \begin{pmatrix} \frac{3}{2}w \\ 0 \\ \frac{\pi}{2} \\ 90kph \end{pmatrix}$$

Objective:

① Constant  $v$ .

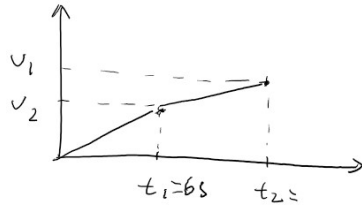
### 3.3. Right Turn (TestTrack3.csv)



$$\begin{pmatrix} x \\ y \\ \varphi \\ v \end{pmatrix}_0 = \begin{pmatrix} \frac{3}{2}w \\ 0 \\ \frac{\pi}{2} \\ 0 \end{pmatrix}$$

Obj: ①  $v_1 = 40kph$ .  
②  $\varphi_1 = 0$

③ follow center line



$$\frac{1}{2} a t_1^2 = \frac{2\pi(20 - \frac{w}{2})}{4} \Rightarrow a$$

$$v_2 = a t_1 = \frac{2\pi(20 - \frac{w}{2})}{6^2}$$

$$E = \frac{1}{2} (v_1 + v_2) \cdot (t_2 - t_1)$$

$$t_2 = t_1 + \frac{2E}{v_1 + v_2}$$

Make  $t_1=6s$ ,  $a$  can be explicitly calculated, so does  $v_2$ .  
Then  $t_2$  can be calculated.

### 3.4. Double Lane Change (To be updated)

### 3.5. Circuit of Americas Track Modified (TestTrack5.csv)