Module 13 - Vehicle Dynamics - Example

Example 1:

The weight of a vehicle exerts 8000 N Force on the front axle and 6000 N on the rear axle. wheelbase is 2.5 m.

$C_f = 1100$ N/deg

$C_r = 903$ N/deg

Determine: (i) Acherman angle for a turn radius of 200 m

(ii) understeer gradiant

(iii) characteristic/critical speed

(iv) Lateral acceleration gain at 88 $\frac{km}{h}$ (24.44 m/s)

(v) Yaw velocity gain at 88 km/h

(vi) side slip angle at the c.g. on 250 m turn at 88 km/h

(vii) static margin

(i) Acherman angle for a turn radius of 200m

$$\delta = \frac{L}{R} = \frac{2.5}{200} = 0.0125 \text{ rad} = 0.716 \text{ deg}$$

(ii) understeer gradiant

Load (N)	cornering stiffness (N/deg)	cornering coefficient (N/N/deg)
8000/2	1100	3.636
6000/2	903	3.323

$$\frac{W_f}{C_{\alpha f}} - \frac{W_r}{C_{\alpha r}} = K_u = 3.636 - 3.322$$

$$= 0.3141 \ \frac{N}{N/deg}$$

Vehicle is close to neutral steer

(iii) characteristic/critical speed

$$U_{char} = \sqrt{\frac{gL(57.3)}{K}} = \sqrt{\frac{9.81 \times 2.5 \times 57.3}{0.3141}}$$

$$= 66.9 \ m/s$$

$$\left(\delta = 2\frac{L}{R} = L/R + K\frac{U^2}{gR}\right.$$

(iv) Lateral acceleration gain at 88 $\frac{km}{h}$ (24.44 m/s)

$$G_a = \frac{a_y}{\delta} = \frac{U^2}{57.3Lg + KU^2}$$

$$= \frac{(24.44)^2}{57.3 \times 2.5 \times 9.81 + 0.3141 \times 24.44^2}$$

$$= 0.375 \ \frac{\text{deg}}{\text{sec}}$$

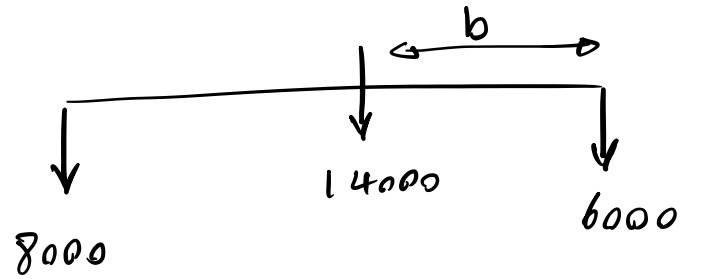
(v) Yaw velocity gain at 88 km/h

$$G_r = \frac{\dot{\psi}}{\delta} = \frac{U/L}{1 + \frac{KU^2}{57.3Lg}} = \frac{24.44}{1 + \frac{Ku^2}{57.3g}} = 8.625 \ \frac{\text{deg/s}}{\text{deg}}$$

(vi) side slip angle at the c.g. on 250 m turn at 88 km/h

$$\beta = 57.3 \frac{b}{R} - \alpha_r = 57.3 \frac{b}{R} - \frac{W_r u^2}{C_{\alpha r} g R}$$

$a = 1.07$ $b = 1.43$ (given)



$8000\,l = 14000\,b$

$b = 8000 \times \frac{2.5}{14000}$

$b = 1.43$

$$\beta = 57.3\left(\frac{1.43}{250}\right) - \frac{6000(24.44)^2}{2 \times 903 \times 9.81 \times 250}$$

$$= -0.485 \text{ deg}$$

(vii) static margin

$$S.M. = \frac{bC\alpha r - aC\alpha f}{C\alpha f + C\alpha r}$$

$$= \frac{(1.43 \times 2 \times 903) - (107 \times 2 \times 1100)}{2(903 + 1100)}$$

$= 0.057$ m behind c.g.