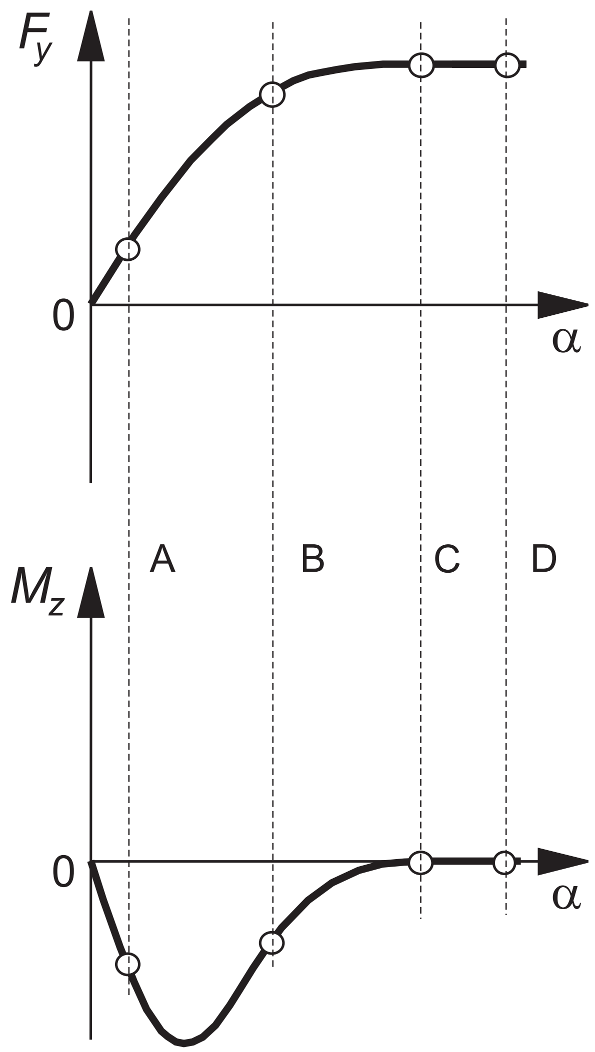
Answers Exam Vehicle Dynamics (4L150)

22-11-2005, 9:00-12:00 am

A. Multiple-choice questions

1)	B
2)	C
3)	C
4)	A
5)	D
6)	B
7)	B
8)	B
9)	C
10)	B
11)	B
12)	B
13)	C
14)	D
15)	C
16)	B
17)	C
18)	A

B. Brush model



C. Steady-state cornering

a) $m\left(\dot{v}+ur\right)=F_{y1}+F_{y2}$

$I\dot{r}=aF_{y1}-bF_{y2}$

and:

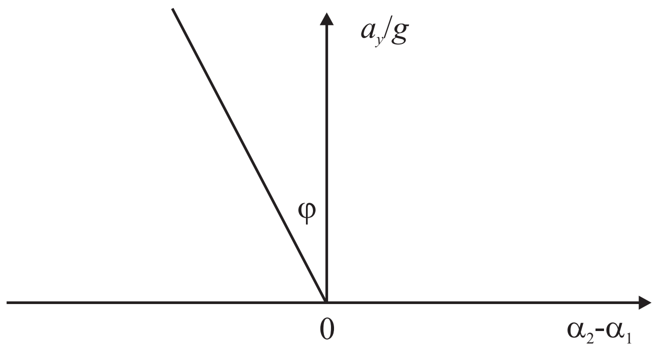
$\alpha_1=\delta-\frac{1}{u}(v+ar)\ ;\ \alpha_2=-\frac{1}{u}(v-br)$

$F_{y1}=C_1\alpha_1\ ;\ F_{y2}=C_2\alpha_2$

b) $\eta=0.02$

=> Vehicle is understeered

c) $\tan\varphi=\eta$



d) V = 20 m/s; R = 100 m

$$\delta=\frac{l}{R}+\eta\frac{a_y}{g}=\frac{l}{R}+\eta\frac{V^2}{Rg}=\frac{2.5}{100}+0.02\frac{400}{1000}=0.033\text{ rad}$$

$\delta_s=i_s\delta=10*0.033=0.33\text{ rad}=18.9^\circ$

e) $mg=F_{z1}+F_{z2}\Rightarrow m=1400\ kg$

$aF_{z1}=bF_{z2}\Rightarrow a/b=F_{z2}/F_{z1}$

$mV^2/R=F_{y1}+F_{y2}$

$aF_{y1}=bF_{y2}\Rightarrow F_{y2}=a/b*F_{y1}$

$$mV^2/R=F_{y1}\left(1+a/b\right)\Rightarrow F_{y1}=\frac{mV^2}{R(1+F_{z2}/F_{z1})}=3200\text{ N}$$

$$F_{y2}=\frac{a}{b}F_{y1}=\frac{F_{z2}}{F_{z1}}F_{y1}=\frac{6000}{8000}*3200=2400\text{ N}$$

f) $\alpha_1=\frac{F_{y1}}{C_1}=\frac{3200}{100000}=0.032\text{ rad}=1.83^\circ$

$\alpha_2=\frac{F_{y2}}{C_2}=\frac{2400}{100000}=0.024\text{ rad}=1.38^\circ$

g) $r=\frac{V}{R}=\frac{20}{100}=0.2\text{ rad/s}$

$\frac{r}{\delta}=\frac{0.2}{0.033}=6.06\text{ s}^{-1}$ or: $\frac{r}{\delta_s}=\frac{0.2}{0.33}=0.606\text{ s}^{-1}$

D. Straight line braking

a) $\Sigma F_x = ma_x \Leftrightarrow ma_x = F_{x1} + F_{x2}$

$\Sigma F_z = 0 \Leftrightarrow F_{z1} + F_{z2} - mg = 0 \quad \Rightarrow \quad F_{z2} = mg - F_{z1}$

$\Sigma M = 0 \Leftrightarrow a_1 F_{z1} - a_2 F_{z2} + ma_x h = 0$

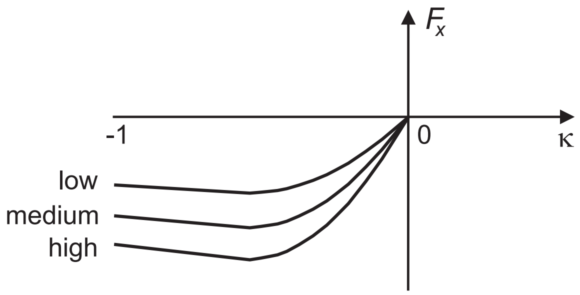
$$a_1 F_{z1} - a_2\left(mg - F_{z1}\right) + ma_x h = 0$$

$$F_{z1} = \frac{a_2}{a_1 + a_2} mg - \frac{ma_x h}{a_1 + a_2} = \frac{a_2 mg - ma_x h}{l}$$

$$a_1\left(mg - F_{z2}\right) - a_2 F_{z2} + ma_x h = 0$$

$$F_{z2} = \frac{a_1}{a_1 + a_2} mg + \frac{ma_x h}{a_1 + a_2} = \frac{a_1 mg + ma_x h}{l}$$

b)



c) $ma_x = F_{x1} + F_{x2} = -\mu_{x,peak}\left(F_{z1} + F_{z2}\right)$

$ma_x = -\mu_{x,peak} mg \quad \Rightarrow \quad a_x = -\mu_{x,peak} g$

d) $$p = \frac{M_{b1}}{M_{b1} + M_{b2}} = \frac{F_{x1} R}{RF_{x1} + RF_{x2}} = \frac{-\mu_{x,peak} F_{z1}}{-\mu_{x,peak}\left(F_{z1} + F_{z2}\right)} = \frac{a_2 mg - ma_x h}{lmg}$$

$$p = \frac{a_2 g - a_x h}{lg} = \frac{a_2 g + \mu_{x,peak} gh}{lg} = \frac{a_2 + \mu_{x,peak} h}{l}$$

e) On low $\mu_{x,peak}$, p to high => too much brake moment on the front axle => front wheels will lock up first => not possible to obtain maximum deceleration. $\mu_x < \mu_{x,peak}$ (over the peak); rear wheels have too little brake torque $\mu_x < \mu_{x,peak}$ (below the peak). Also: before front wheel lock ($\mu_x < \mu_{x,peak}$), rear wheels have too little brake torque.