Vehicle Dynamics in Ride and Handling Stability

Homework #1

Question #1

a. Describe mechanics of *rolling resistance* of a pneumatic tire with an appropriate sketch.
b. Discuss two factors that have the most influence on rolling resistance of a tire.
c. Laboratory tests on a tire (nominal diameter = 70 cm) under a 4000N load show that at a speed of 7 m/s, the normal pressure acts 1 cm ahead of vertical central axis when there is 6% slip. Similarly at 20 m/s, the normal pressure acts 1.8 cm ahead and when there is 10% slip.

   Determine α_1 and α_2 for the rolling resistance model, expressed as:

$$f_1 = \alpha_1 + \alpha_2 V^2 \quad \text{for } V \text{ in km/h}$$

Question #2

A 20 KN vehicle with 4 identical tires is known to support 12 KN on its front axle. For the vehicle, compute and plot the power required to overcome the rolling resistance in the speed range 0 to 100 km/h. (Use rolling resistance model in Question #1).

Question #3

A truck tire (Uniroyal Fleet Master) with vertical load 25kN has longitudinal stiffness of 195 kN/unit slip in traction and 240 kN/unit skid in braking. Using simplified approximate approach; obtain plots for the following on dry concrete (μ_p=0.74; μ_s=0.55)and wet concrete (μ_p=0.51; μ_s=0.38)pavement.

a) Plot tractive effort vs. slip considering slip up to 30%

b) Plot braking effort vs. skid considering skid up to 30%

Question #4

The above tire is subjected to simultaneous cornering and braking. Given that the cornering stiffness of the tire is 180kN/rad and it experiences a skid of 5%, estimate the available cornering force corresponding to a side slip angle of 3°.

Question #5

Using the 'Magic Tire formula', determine the cornering force properties of a car tire for a normal load of 6 kN in the 0 to 8 degrees side-slip range, assuming negligible camber and absence of tire skid. Repeat the problem for normal load of 4 kN. Use following relationships:

$$D = a_1 F_z^2 + a_2 F_z;\ a_1 = -22.1,\ a_2 = 1011\ \left(F_z \text{ in } kN\right)$$

C=1.30

$BCD = a_3 \sin\left[a_4 \tan^{-1}\left(a_5 F_z\right)\right]$; $a_3 = 1078$, $a_4 = 1.82$, $a_5 = 0.208$

$E = a_7 F_z + a_8$; $a_7 = -0.354$, $a_8 = 0.707$

S_h= -0.126 for F_z = 6 kN and -0.049 for F_z= 4 kN

S_v= -77.34 – 20.33 F_z

Briefly discuss the influence of normal load on the cornering force developed by the tire.