Exercise 3: The brush tyre model

In the lectures on tyre modelling (4, 5 and 6) it is explained that the tyre can be seen as a function block with multiple inputs and outputs, as shown in the figure below.

In lecture 5 the brush tyre model has been discussed and in this case effect of the inclination angle γ is neglected. In this exercise you are asked to program the brush model yourself and to make plots of the resulting tyre characteristics. The model parameters are given below.

Parameter	Description	Value
r_f	free tyre radius	0.3 m
c_z	tyre vertical stiffness	250000 N/m
c_p	tread element stiffness	$9 \cdot 10^6$ N/m^2
μ	friction coefficient	1.2

a) Make a plot of half of the contact length a as a function of the vertical force F_z using the empirical equation given on VD lecture notes page 126 (suggested range: 0 to 10 kN).

The next thing to be done is to program the brush model as a MATLAB function, typically the calling syntax would be:

```
[Fx,Fy,Mz] = brush(kappa,alpha,Fz)
```

So you create a file “brush.m”, which will contain the following lines:

```
function [Fx,Fy,Mz] = brush(kappa,alpha,Fz)
... (your algorithm)
Fx = ... (provide the right equations here)
Fy = ... (provide the right equations here)
Mz = ... (provide the right equations here)
return
```

This function can then be called from the MATLAB command line. The function should be able to handle combined slip conditions.

b) Program the function and include the listing of brush.m in the report. How to handle the case of complete wheel lock? (κ exactly equal to -1)

c) Make plots of the pure slip characteristics at a vertical load of 4000 N:

- Longitudinal force F_x versus longitudinal slip κ
- Lateral force F_y versus sideslip angle α
- Aligning moment M_z versus sideslip angle α

You can use the graphs of the lecture notes 135 and 139 as a reference.

d) Make plots of the combined slip characteristics at a vertical load of 4000 N. For the side slip angle α use a value of 0, 5, and 20 degrees, vary the longitudinal slip κ from -1 to 1.

- Longitudinal force F_x versus longitudinal slip κ
- Lateral force F_y versus longitudinal slip κ
- Aligning moment M_z versus longitudinal slip κ