MEA313 Automotive Theory

Major Task 2 LAB 2

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1839

Car Used: 1969 Ford Mustang Sportsroof 200 SIX

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1.0 INTRODUCTION

This laboratory aims to determine the vehicle's front and rear braking coefficients (Kbf, Kbr), which represent the distribution of braking force between the front and rear wheels. The front and rear braking coefficients indicate the amount of force applied to the front and rear wheels, respectively. Achieving the correct balance between these coefficients is crucial for effective braking, reducing skidding, and maintaining stability during braking maneuvers.

2.0 FUNCTIONS USED

1.1 Longitudinal Force Function

```
function[longitudinal] = FX(fx, fy)
    global fr mass g delta
    longitudinal = (fx - fr * mass * g) .* cosd(delta) - fy .* sind(delta);
end
```

This function computes the longitudinal force (FX) in Newtons using global variables: delta (steering angle), [fr (rolling coefficient), mass (kg), gravity (m/sec^2)] for rolling resistance. Moreover, it receives two parameters, fx and fy, from the main code.

1.2 Lateral Force Function

```
function[lateral] = FY(fx, fy)
    global fr mass g delta
    lateral = fy .* cosd(delta) + (fx - fr * mass * g) .* sind(delta);
end
```

This function determines the lateral force (FY) in Newtons using global variables: delta (steering angle), [fr (rolling coefficient), mass (kg), gravity (m/sec^2)] for rolling resistance. Additionally, it takes two parameters, fx and fy, from the main code.

1.3 Longitudinal Torque Function

```
function[Torq_X] = TX(fx)
    global taw r_Kp gamma R_nom
    Torq_X = fx * cosd(taw) * [r_Kp * cosd(gamma) + R_nom * sind(gamma)];
end
```

This function computes the longitudinal torque (TX) in N.m using global variables: taw (caster angle), r_Kp (Scrub Radius in m), gamma (KPI), R_nom (nominal radius). Additionally, it receives fx from the main code.

1.4 Lateral Torque Function

```
function[Torq_Y] = TY(fy)
    global gamma taw R_nom t
    Torq_Y = fy * cos(gamma) * [t * cosd(taw) + R_nom * sind(taw)];
end
```

This function determines the lateral torque (TY) in N.m using global variables: taw (caster angle), t (Mechanical & Pneumatical trails), gamma (KPI), R_nom (nominal radius). Moreover, it takes fy from the main code.

1.5 Torque in Z direction Function

```
function[Torq_Z] = TZ(fz)
   global gamma taw delta r_Kp R_nom
   Torq_Z = fz * sind(gamma) * cosd(taw) .* sind(delta) * cosd(gamma) * [r_Kp
+ R_nom * tand(gamma)];
end
```

This function computes the z-direction torque (TZ) in N.m using global variables: taw (caster angle), r_Kp (Scrub Radius), gamma (KPI), R_nom (nominal radius), and delta (steering angle). Additionally, it receives fz from the main code.

3.0 MAIN CODE

```
clearvars
clc

%%% 1969 Ford Mustang Sportsroof 200 Six %%%


global gamma R_nom fr mass g delta taw r_Kp t

% Car Specifications
mass = 1295; % car weight
fr = 0.015; % rolling coefficient
g = 9.81; % gravitational acceleration
% wheelbase
l1 = 1.454;
l2 = 1.289;
L = 2.743;
w_f = mass * g * l2 / L; % front weight (N)
gamma = 1.5; % KPI (degree)
R_nom = 0.26; % nominal radius (m)
delta = 0:2:20; % steering angle (degree)
taw = 1; % caster angle (degree)
r_Kp = 0.01; % scrub radius (m)
t = 0.01; % tp + tm [Pneumatic + Mechanical] (m)

mu_long = 0.8; % longitudinal coeff of adhesion
mu_lateral = 0.7; % lateral coeff of adhesion

fx = mu_long * mass * g; % longitudinal force (N)
fy = mu_lateral * mass * g; % lateral force (N)

Torque_X = TX(FX(fx,fy));
Torque_Y = TX(FY(fx,fy));
Torque_Z = TZ(w_f / 2);
```

```
Torque_Alignment = -Torque_X + Torque_Y + Torque_Z;
plot(delta, Torque_Alignment);
xlabel("Steering Angle Delta (degrees)");
ylabel("Torque Alignment (N.m)");
table(delta', Torque_X', Torque_Y', Torque_Z', Torque_Alignment',
'VariableNames',{'Steering angle (Deg)', ...
    'Torque X (Nm)', 'Torque Y (Nm)', 'Torque Z (Nm)', 'Torque Align (Nm)'})
```

3.1 Command Window

Command Window

```
ans =

  11×5 table
```

Steering angle (Deg)	Torque X (Nm)	Torque Y (Nm)	Torque Z (Nm)	Torque Align (Nm)
0	167.54	149.4	0	-18.141
2	162.22	155.15	0.045812	-7.0234
4	156.71	160.72	0.091569	4.103
6	151.01	166.09	0.13721	15.224
8	145.12	171.26	0.18269	26.327
10	139.05	176.22	0.22795	37.398
12	132.82	180.97	0.27293	48.423
14	126.42	185.49	0.31757	59.39
16	119.87	189.79	0.36183	70.283
18	113.17	193.86	0.40565	81.092
20	106.34	197.69	0.44897	91.801

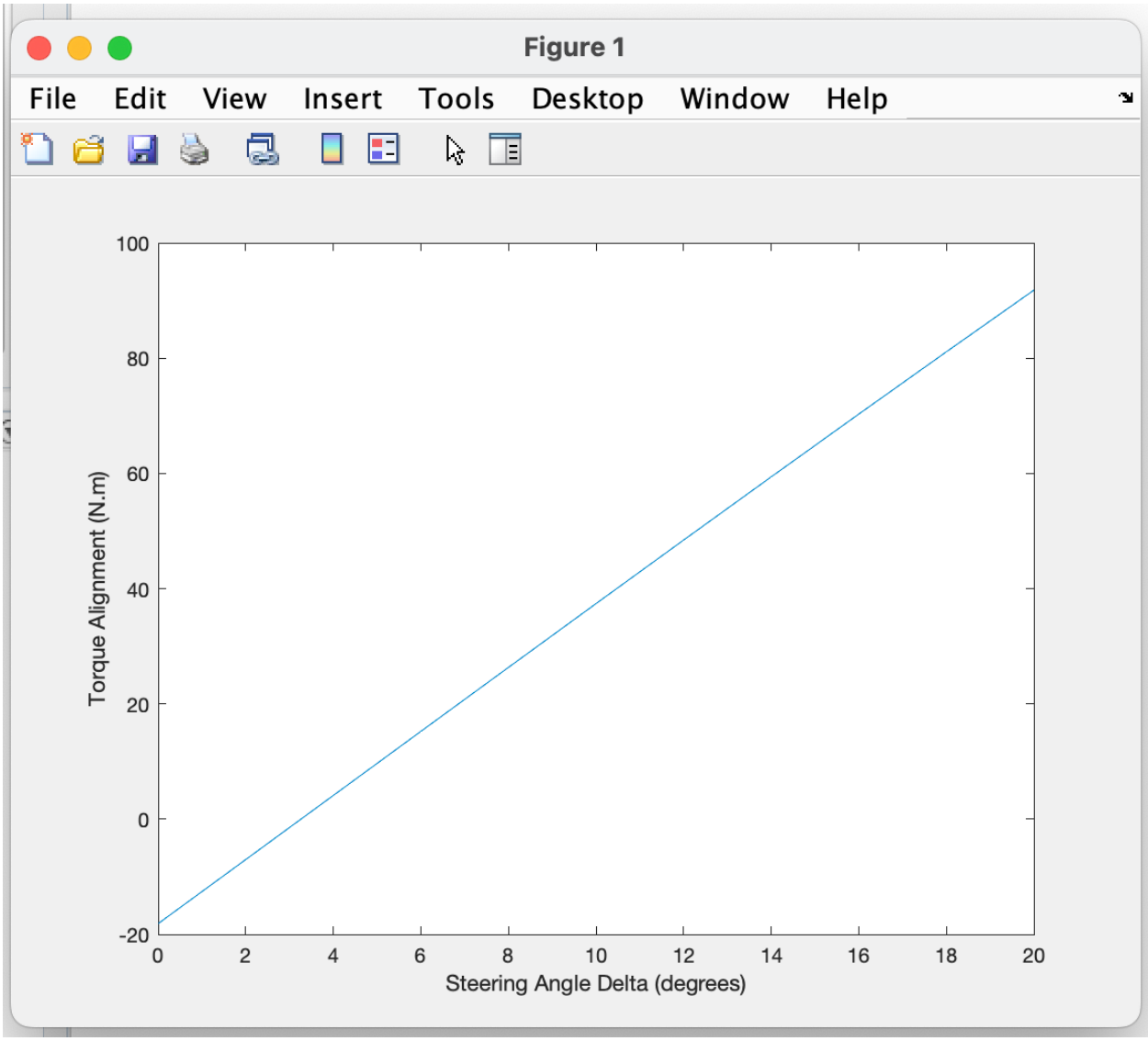
```
fx >>
```

3.2 Workspace

Workspace

Name	Value	Size	Bytes	Class
ans	*11x5 table*	11x5	2399	table
delta	*1x11 double*	1x11	88	double (global)
fr	0.0150	1x1	8	double (global)
fx	1.0163e+04	1x1	8	double
fy	8.8928e+03	1x1	8	double
g	9.8100	1x1	8	double (global)
gamma	1.5000	1x1	8	double (global)
L	2.7430	1x1	8	double
l1	1.4540	1x1	8	double
l2	1.2890	1x1	8	double
mass	1295	1x1	8	double (global)
mu_lateral	0.7000	1x1	8	double
mu_long	0.8000	1x1	8	double
r_Kp	0.0100	1x1	8	double (global)
R_nom	0.2600	1x1	8	double (global)
t	0.0100	1x1	8	double (global)
taw	1	1x1	8	double (global)
Torque_Alignment	*1x11 double*	1x11	88	double
Torque_X	*1x11 double*	1x11	88	double
Torque_Y	*1x11 double*	1x11	88	double
Torque_Z	*1x11 double*	1x11	88	double
w_f	5.9699e+03	1x1	8	double

3.3 Graph



The self-aligning torque increases with the increase in steering angle delta, which moves from 0 to 20 degrees with a step of 2 degrees, starting from -18.141 Nm up to 91.801 Nm.

REFERENCE

[1] Ford Mustang Sportsroof 200 Six (man. 3) (1969): https://www.automobile-catalog.com/make/ford_usa/mustang_1gen/mustang_1gen_base_fastback/1969.html#gsc.tab=0

Drive link for the m file:

https://drive.google.com/drive/folders/13yi48LoTaSAXTc5Gu25-GeR6E8pq76GN?usp=sharing