ECE 595 HW 1
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MATLAB code

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%% Problem 1
METERS_PER_KM = 1000;
SECONDS_PER_HOUR = 60*60;
Cd = 0.32; % Aerodynamic drag coefficient
A = 1.71; % Area
air_density = 1.293;
g = 9.8; % gravity
m0 = 1100; % kg
m1 = 150; % kg
up = 0.013; % rolling coefficient
grade = 0.05; % Grade percentage
alpha = atan(grade); % Radians
mass_total = m0 + m1;
velocity = 100*METERS_PER_KM/SECONDS_PER_HOUR;
% Weight
W = mass_total*g;
% Gradient resistance
Fg = W*sin(alpha);
% Aerodynamic drag force
Fa = Cd*A*air_density*(velocity^2)/2;
try
    % Tire rolling resistance
    Ff = up*W*(1-(up*W/(4*Ct*St)));
catch
    % Simplified tire rolling resistance formula if parameters are missing
    % from above equation
    Ff = up*W;
end
Ft = Fa + Ff + Fg;
fprintf('Problem 1:\n');
fprintf('Aerodynamic drag force (Fa) = %.2f N\n', Fa);
fprintf('Tire rolling resistance (Ff) = %.2f N\n', Ff);
fprintf('Gradient resistance (Fg) = %.2f N\n', Fg);
fprintf('Total resistance force: Fa+Ff+Fg = %.02f KN\n', Ft/1000);
fprintf('-------------------------------------------------\n');

%% Problem 2
close all;
xMax = 5;
yMax = 3.4;
theta = 23;
fprintf('Problem 2:\n');
fprintf('Friction ellipse equation: (Fx/Fxmax)^2 + (Fy/Fymax)^2 = 1\n');
displayEllipse(xMax, yMax, theta)
xMax = 12; yMax = 6; theta = 45;
displayEllipse(xMax, yMax, theta);
fprintf('-------------------------------------------------\n');
```

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%% Problem 3
L = 4; % Meters
R = 400; % Meters
alpha_f = deg2rad(5); % Converting to radians
alpha_r = deg2rad(3); % Converting to radians

Steering_Angle_High_Speed = L/R + alpha_f - alpha_r;
Steering_Angle_Low_Speed = L/R; % Assuming minimal tire slip angles
fprintf('Problem 3:\n');
fprintf('1) Steering Angle at high speed: %.1f
degrees\n',rad2deg(Steering_Angle_High_Speed));
fprintf('2) Steering Angle at low speed: %.1f
degrees\n',rad2deg(Steering_Angle_Low_Speed));
fprintf('-------------------------------------------------\n');

%% Problem 4
L = 4;
Wf = 2500; % Pounds
Wr = 1500; % Pounds
Caf = 200; % Pounds
Car = 150; % Pounds

Kus = Wf/Caf - Wr/Car;
if Kus > 0
    Steering_Condition = 'Understeer';
elseif Kus < 0
    Steering_Condition = 'Oversteer';
else
    Steering_Condition = 'Neutral steer';
end

Vcrit = sqrt(g*L/abs(Kus));
fprintf('Problem 4:\n');
fprintf('1) Understeer coefficient: %.02f\n',Kus);
fprintf('2) The vehicle state is %s\n', Steering_Condition);
fprintf('3) The critical speed is: %.02f m/s\n', Vcrit);

%% Problem 2 Ellipse function
function [x, y] = getEllipse(a, b)
    % Plot range
    N = 100;
    theta = 0:1/N:2*pi+1/N;

    % Equation of ellipse in Parametric Form
    % https://testbook.com/learn/maths-equation-of-
ellipse/#:~:text=Equation%20of%20Ellipse%20Solved%20Examples%201%20Solution%3A%20The,
both%20the%20foci%20rest%20on%20the%20Y-axis.%20
    x = a*cos(theta);
    y = b*sin(theta);
end

%% Problem 2 Ellipse plot
function[] = displayEllipse(xMax, yMax, theta)
    figure();
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    h = zeros(1,2);
    thetaRad = deg2rad(theta);
    [x,y] = getEllipse(xMax, yMax);
    h(1) = plot(x,y);
    hold on

    % Fy, Fx line
    xPoint = xMax*cos(thetaRad);
    yPoint = yMax*sin(thetaRad);
    h(2) = plot([0 xPoint], [0 yPoint]);
    hold on

    % Create grid
    plot([-xMax xMax], [0 0],'k');
    plot([0 0], [-yMax yMax], 'k');
    hold on
    plot([0 xPoint], [yPoint yPoint],'k', 'LineStyle', '--');
    plot([xPoint xPoint], [0 yPoint],'k', 'LineStyle', '--');
    txt = 'Fy max';
    text(0,(yMax+yMax/10),txt,'HorizontalAlignment','center');
    txt = 'Fx max';
    text(xMax,0,txt,'HorizontalAlignment','left');
    txt = 'Fy \rightarrow';
    text(0,yPoint,txt,'HorizontalAlignment','right');
    txt = 'Fx \uparrow     ';
    text(xPoint,-0.25,txt,'HorizontalAlignment','center');

    % Make the x,y axis the same size
    m = max(xMax, yMax);
    axis([-m m -m m]);
    title('Friction ellipse');
    xlabel('Braking or tractive force (KN)');
    ylabel('Cornering force (KN)')
    grid;
    legend(h(1:2),'Friction ellipse', 'Fx, Fy vector');

    % Return Fx, Fy
    fprintf('Given FxMax = %.1f KN, FyMax = %.1f KN, and theta = %i degrees, Fx =
%.2f KN and Fy = %.2f KN\n',xMax, yMax, theta, xPoint, yPoint);
end
```

MATLAB output

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>> ECE595_HW1

Problem 1:

Aerodynamic drag force (Fa) = 272.97 N

Tire rolling resistance (Ff) = 159.25 N

Gradient resistance (Fg) = 611.74 N
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Total resistance force: Fa+Ff+Fg = 1.04 KN

Problem 2:

Friction ellipse equation: (Fx/Fxmax)^2 + (Fy/Fymax)^2 = 1

Given FxMax = 5.0 KN, FyMax = 3.4 KN, and theta = 23 degrees, Fx = 4.60 KN and Fy = 1.33 KN

Given FxMax = 12.0 KN, FyMax = 6.0 KN, and theta = 45 degrees, Fx = 8.49 KN and Fy = 4.24 KN

Problem 3:

1) Steering Angle at high speed: 2.6 degrees

2) Steering Angle at low speed: 0.6 degrees

Problem 4:

1) Understeer coefficient: 2.50

2) The vehicle state is Understeer

3) The critical speed is: 3.96 m/s

MATLAB plots (problem 2)