File Header

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Master file for simulating the quarter car model. Name: Matthew Klein Contact: mpklein@ucdavis.edu Date: 3/27/14

Clear old data, Designate global variables

```
clear; close all; clc;
global A B v_in dt g
```

Initial Parameters

-- System Constants

```
g    = 9.81;        % [m/s]
 % masses
m_s  = 1500/4;      % [kg]
m_us = m_s/7;       % [kg]
 % springs
d_s  = 2*.0254;         % equilibrium displacement of spring, [m]
d_t  = d_s/5;           % equilibrium displacement of tire, [m]
k_s  = m_s*g/d_s;       % Spring stiffness, [N/m]
k_t  = (m_s+m_us)*g/d_t;% Tire stiffness, [N/m]
 % damping
zeta = 0.5;             % Damping ratio
b_c  = 2*sqrt(k_s*m_s); % Critical damping coefficient
b_s  = zeta*b_c;        % Damping coefficient
b_t  = .1*2*sqrt(k_t*(m_s+m_us)); % ~false tire damping for numerical stability
% ---------------------------------------------------------------------------
% State transition matrix
A = [-b_s/m_s,  b_s/m_us,       k_s, 0;     % p_s
      b_s/m_s,(-b_s-b_t)/m_us, -k_s, k_t;   % p_us
     -1/m_s,    1/m_us,         0,     0;   % q_s
      0,       -1/m_us,         0,     0];  % q_t
% Input matrix
B = [0, -m_s; b_t, -m_us; 0, 0; 1, 0];      % u = [v_in(t); g]
% ---------------------------------------------------------------------------
% Sim time
dt_ratio = 20;                  % ratio of time steps to fastest eigenvalue of the
tau_fast = abs(1/max(eig(A)));  % fastest system time constant, [seconds]
dt       = tau_fast/dt_ratio;   % time step size, [seconds]
t_end    = 5;                   % end time, [seconds]
time     = (0:dt:t_end)';       % simulation time vector, [seconds]
```

```
% --------------------------------------------------------------------------
% System Input
U    = 25;                          % forward velocity, [m/s]
a_d  = .05;                         % amplitude of road displacement, [m]
d_b  = 30;                          % bump spacing, [m]
test_type = 0;
if test_type == 1
    % x_in = a*sin(b_d*x) then take the time derivative ->
    v_in = (2*pi/d_b)*U*a_d*cos((2*pi/d_b)*U*time); % velocity input, [m/s]
    test = 'sinusoidalInput';
else
    % Use for step velocity input
    v_in = zeros(length(time),1);
    v_in(round(length(v_in)/2):end) = 1;
    test = 'stepInput';
end
% --------------------------------------------------------------------------
% Initial Conditions
x_0 = [0, 0, 1/k_s*m_s*g, 1/k_t*(m_s + m_us)*g];
```

Call the ODE solver

```
[t_out, x_out] = ode45(@Lab1_eqns, time, x_0);
```

Create outputs

```
C = [1/m_s, 0,      0, 0;   % output 1: v_s
     0,     1/m_us, 0, 0;   % output 2: v_us
     0,     0,      1, 0;   % output 3: displacement of spring
     0,     0,      0, 1];  % output 4: displacement of tire
y = zeros(size(x_out));
for i = 1:length(time)
    y(i,:) = x_out(i,:)*C';
end
```

Plot data

```
FS=12;FN='Arial';FW='bold';
F1 = figure(1); hold on; lw = 1;        %
set(F1,'units','inches','OuterPosition',[4.5000    0.9479    11.5    6.5]);

sp1=subplot(1,2,1);
plot(time,[y(:,1:2),v_in],'linewidth',lw);
legend('Sprung Vel','Unsprung Vel','Velocity Input');
xlabel('Time, [s]','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
ylabel('Speed, [m/s]','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
title('Speeds','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
set(gca,'Fontsize',FS,'Fontname',FN,'Fontweight',FW,'linewidth',lw);

sp2=subplot(1,2,2);
plot(time,y(:,3:4),'linewidth',lw);
legend('Spring Disp.','Tire Disp.');
```

```
xlabel('Time, [s]','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
ylabel('Diplacment, [m]','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
title('Displacements','Fontsize',FS,'Fontname',FN,'Fontweight',FW);
set(gca,'Fontsize',FS,'Fontname',FN,'Fontweight',FW,'linewidth',lw);

nameFig1=['Lab1Demo_' test '_032714'];
export_fig([nameFig1,'.png'],'-transparent','-r300','-painters');
```

```
Warning: print2array generating a 50.9M

pixel image. This could be slow and
might also cause memory problems.
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```

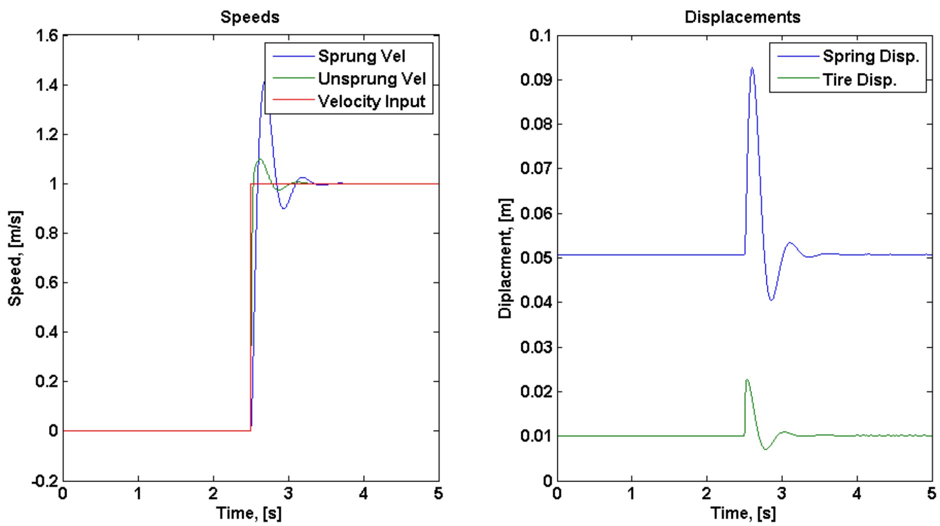

Published with MATLAB® 7.14