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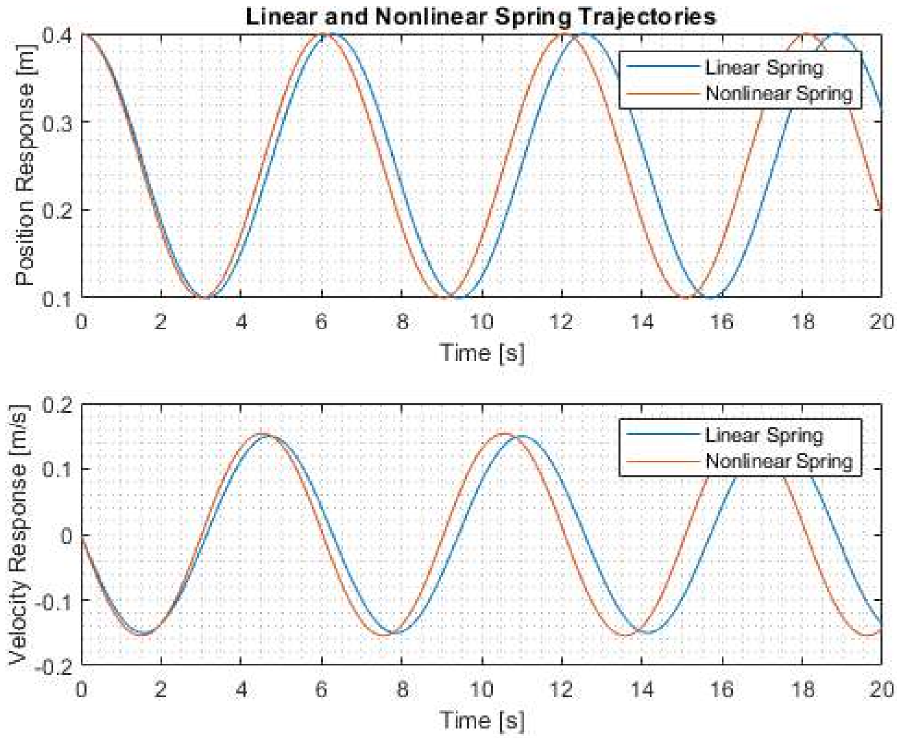
MAE 562 HW1 Gabriel Colangelo 50223306

```
clear
close all
clc
```

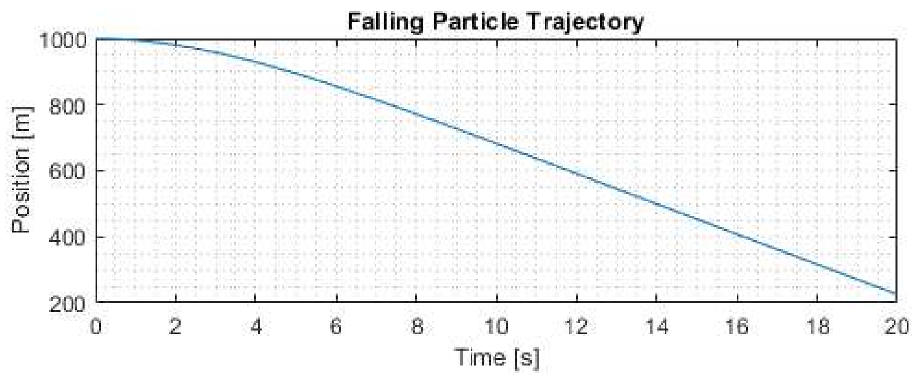
Problem 2.13

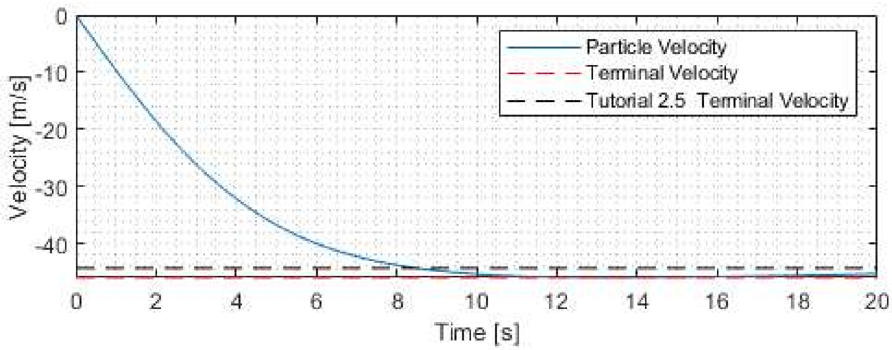
```
m       = 1                                                     ; % mass [kg]
x0      = 0.25                                                  ; % unstretched spring length [m]
k       = 1                                                     ; % Spring stiffness [N/m]
c       = 5                                                     ; % Spring constant [N/m^3]

IC      = [.4 0]'                                               ; % Initial conditions of 0.4 [m] and 0 [m/s]
time    = (0:.01:20)'                                           ; % Time vector for 0-20 [s]
options = odeset('AbsTol',1e-8,'RelTol',1e-8)                   ; % ODE45 solver options

[T1,Z1] = ode45(@(t,z) LinearSpring(t,z,m,x0,k),time,IC,options)      ; % Linear Spring Simulation
[T2,Z2] = ode45(@(t,z) NonlinearSpring(t,z,m,x0,k,c),time,IC,options)   ; % NonLinear Spring Simulation

figure
ax1 = subplot(2,1,1);
plot(T1,Z1(:,1),T2,Z2(:,1))
xlabel('Time [s]')
ylabel('Position Response [m]')
grid minor
title('Linear and Nonlinear Spring Trajectories')
legend('Linear Spring','Nonlinear Spring')

ax2 = subplot(2,1,2);
plot(T1,Z1(:,2),T2,Z2(:,2))
xlabel('Time [s]')
ylabel('Velocity Response [m/s]')
grid minor
legend('Linear Spring','Nonlinear Spring')
linkaxes([ax1 ax2],'x')
```



Problem 2.18

```
M       = 5.9742e24                                                    ; % Mass of Earth [kg]
Re      = 6378100                                                      ; % Radius of Earth [m]
G       = 6.673e-11                                                    ; % Gravitational Constant [m^3/kg-s^2]
h       = 7000                                                         ; % Scale height of atmoshere [m]
m       = 10                                                           ; % Particle mass [kg]
IC      = [1000 0]'                                                    ; % Initial condition of 1000 m and 0 m/s

[T3,Z3] = ode45(@(t,z) FallingParticle(t,z,M,G,Re,m,h),time,IC,options)     ; % Linear Spring Simulation

figure
ax1 = subplot(2,1,1);
plot(T3,Z3(:,1))
xlabel('Time [s]')
ylabel('Position [m]')
grid minor
title('Falling Particle Trajectory')

ax2 = subplot(2,1,2);
plot(T3,Z3(:,2))
line([0 20],[min(Z3(:,2)) min(Z3(:,2))],'Color','red','LineStyle','--')
line([0  20],[-44.2945  -44.2945],'Color','black','LineStyle','--')
xlabel('Time [s]')
legend('Particle Velocity','Terminal Velocity','Tutorial 2.5  Terminal Velocity')
ylabel('Velocity [m/s]')
grid minor

linkaxes([ax1 ax2],'x')
```





Function Definitions

```
function zdot = LinearSpring(t,z,m,x0,k)
z1          = z(1,1); % z1 = x
z2          = z(2,1); % z2 = xdot

% Equations of motion is first order form
zdot(1,1)   = z2;
zdot(2,1)   = -k/m*(z1 - x0);

end

function zdot = NonlinearSpring(t,z,m,x0,k,c)
z1          = z(1,1); % z1 = x
z2          = z(2,1); % z2 = xdot

% Equations of motion is first order form
zdot(1,1)   = z2;
zdot(2,1)   = (-k/m*(z1 - x0)) -(c/m*(z1 - x0)^3);

end

function zdot = FallingParticle(t,z,M,G,Re,m,h)
z1          = z(1,1); % z1 = y
z2          = z(2,1); % z2 = ydot

% Equations of motion is first order form
zdot(1,1)   = z2;
zdot(2,1)   = (-G*M/(Re + z1)^2) + (z2^2*(.05/m)*exp(-z1/h));
end
```

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