ME 1020 Engineering Programming with MATLAB

Problem 4.25:

25. We want to analyze the mass-spring system discussed in Problem 20 for the case in which the weight W is dropped onto the platform attached to the center spring. If the weight is dropped from a height h above the platform, we can find the maximum spring compression x by equating the weight's gravitational potential energy $W(h + x)$ with the potential energy stored in the springs. Thus

$$W(h + x) = \frac{1}{2}k_1x^2 \qquad \text{if } x < d$$

which can be solved for x as

$$x = \frac{W \pm \sqrt{W^2 + 2k_1Wh}}{k_1} \qquad \text{if } x < d$$

and

$$W(h + x) = \frac{1}{2}k_1x^2 + \frac{1}{2}(2k_2)(x - d)^2 \qquad \text{if } x \geq d$$

which gives the following quadratic equation to solve for x:

$$(k_1 + 2k_2)x^2 - (4k_2d + 2W)x + 2k_2d^2 - 2\,Wh = 0 \qquad \text{if } x \geq d$$

a. Create a function file that computes the maximum compression x due to the falling weight. The function's input parameters are k_1, k_2, d, W, and h. Test your function for the following two cases, using the values $k_1 = 10^4$ N/m; $k_2 = 1.5 \times 10^4$ N/m; and $d = 0.1$ m.

$$W = 100 \text{ N} \qquad h = 0.5 \text{ m}$$

$$W = 2000 \text{ N} \qquad h = 0.5 \text{ m}$$

b. Use your function file to generate a plot of x versus h for $0 \leq h \leq 2$ m. Use $W = 100$ N and the preceding values for k_1, k_2, and d.

W = 50 N:

problem4_25.m × spring_deflection25.m* ×

```
% Problem 4.25
clear
clc
disp('Problem 4.25: Scott Thomas')
disp(' ')
W = 50; %N
h = 0.5; %m
%N = 1000; % Number of evaluated points
%W = linspace(0,3000,N); %N
k_1 = 10^4; %N/m
k_2 = 1.5*10^4; %N/m
d = 0.1; %m

a = k_1 + 2*k_2;
b = -(4*k_2*d + 2*W);
c = 2*k_2*d^2 - 2*W*h;

p = [a b c];
q = roots(p);

x1 = (W + sqrt(W^2 + 2*k_1*W*h))/k_1
x2 = (W - sqrt(W^2 + 2*k_1*W*h))/k_1
x3 = q(1)
x4 = q(2)

% Determine if the second set of springs is hit
if x1 >= d
    disp('x1 >= d')
    x1 = x3
    x2 = x4
else
    disp('x1 < d')
end

% Find the larger of the two deflections
x = 0;
if x1 >= x;
    x = x1;
end
if x2 >= x;
    x = x2;
end
disp('Maximum Deflection (m): ')
x

```

```
Problem 4.25: Scott Thomas


x1 =

    0.0759


x2 =

   -0.0659


x3 =

   0.0763 + 0.0209i


x4 =

   0.0763 - 0.0209i

x1 < d
Maximum Deflection (m):

x =

    0.0759
```

W = 2000 N:

```
Problem 4.25: Scott Thomas


x1 =

    0.6899


x2 =

   -0.2899


x3 =

    0.3661


x4 =

   -0.1161

x1 >= d

x1 =

    0.3661


x2 =

   -0.1161

Maximum Deflection (m):

x =

    0.3661
```

problem4_25.m* spring_deflection25.m

```
% Problem 4.25
clear
clc
disp('Problem 4.25: Scott Thomas')
disp(' ')
W = 100 %N
%h = 0.5; %m
N = 100; % Number of evaluated points
h = linspace(0,2,N); %m
k_1 = 10^4 %N/m
k_2 = 1.5*10^4 %N/m
d = 0.1 %m

for k = 1:N
x(k) = spring_deflection25(W, k_1, k_2, d, h(k) );
end

plot(h,x),xlabel('Drop Height (m)'), ylabel('Spring Deflection (m)'), grid on
title('W = 100 N, k_1 = 10^4 N/m, k_2 = 1.5*10^4 N/m, d = 0.1 m',...
  'FontWeight','bold')

```

problem4_25.m* | spring_deflection25.m

```
% Problem 4.25: Function File
function [x] = spring_deflection25(W,k_1,k_2,d,h)

a = k_1 + 2*k_2;
b = -(4*k_2*d + 2*W);
c = 2*k_2*d^2 - 2*W*h;
p = [a b c];
q = roots(p);

x1 = (W + sqrt(W^2 + 2*k_1*W*h))/k_1;
x2 = (W - sqrt(W^2 + 2*k_1*W*h))/k_1;
x3 = q(1);
x4 = q(2);

% Determine if the second set of springs is hit
if x1 >= d
   % disp('x1 >= d')
    x1 = x3;
    x2 = x4;
end

% Find the larger of the two deflections
x = 0;
if x1 >= x;
    x = x1;
end
if x2 >= x;
    x = x2;
end

```