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Symming s, t, setting input as impulse to find transfer function

```
clear all
close all
clc
syms s t
```

Finding minimum spring constant to hold a human being

```
m_human = 28.8+22+26.35+6.76;
g = 9.8; % m/s^2 gravitational constant
weight_human = m_human*g;
x = .02; % setting the displacement to a couple of centimeters for a firm
 chair
spring_constant = weight_human/x;
```

Physical properties of the human/chair combo

```
b = 90;
k = 3500;
m1 = 30; % chair weight kg
k1 = spring_constant; % spring constant of chair
b1 = 5; % damping constant of chair
m2 = 8.164; % lower torso kg
k2 = k; % spring constant of bones
b2 = b; % damping constant of soft tissue
m3 = 11.953; % middle torso kg
k3 = k; % spring constant of bones
b3 = b; % damping constant of soft tissue
m4 = 11.654; % upper torso kg
k4 = k; % spring constant of bones
b4 = b; % damping constant of soft tissue
m5 = 5.018; % head weight kg
```

Circuit Conversion Into S Domain

```
ZC1 = 1/(s*m1);
ZL1 = s/k1;
ZR1 = 1/b1;
ZC2 = 1/(s*m2);
ZL2 = s/k2;
ZR2 = 1/b2;
ZC3 = 1/(s*m3);
ZL3 = s/k3;
ZR3 = 1/b3;
ZC4 = 1/(s*m4);
ZL4 = s/k4;
ZR4 = 1/b4;
ZC5 = 1/(s*m5);
ZRL1 = (1/ZR1 + 1/ZL1)^-1;
ZRL2 = (1/ZR2 + 1/ZL2)^-1;
ZRL3 = (1/ZR3 + 1/ZL3)^-1;
ZRL4 = (1/ZR4 + 1/ZL4)^-1;
```

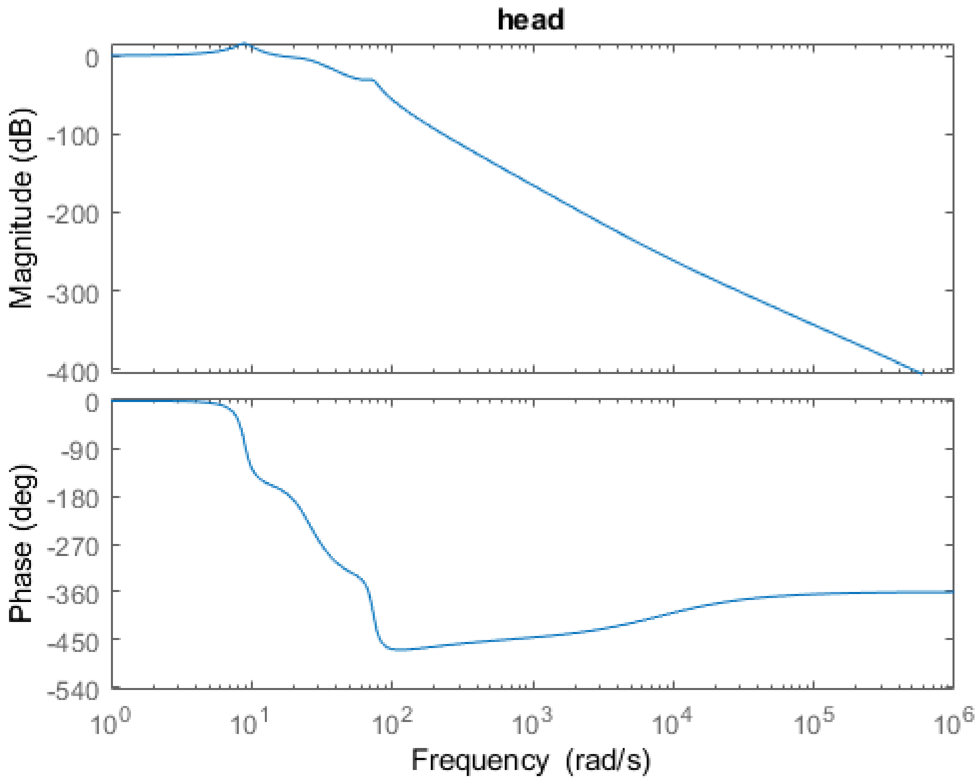
Nodal

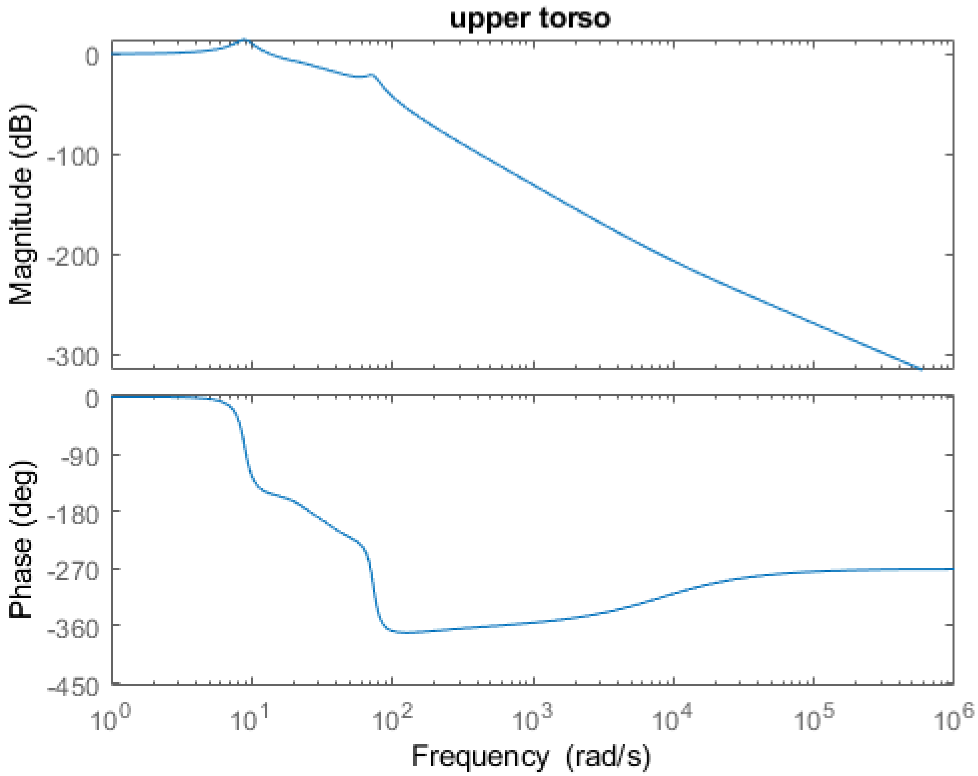
```
% Simulating Variables
syms I1 I2 I3 I4 I5 I6 I7 I8 I9

% Nodal Equations
eq1 = I1 == I2 + I3;
eq2 = I2 == I4 + I5;
eq3 = I4 == I6 + I7;
eq4 = I6 == I8 + I9;

% Defining our impulse
vx = dirac(t);
Vx = laplace(vx);
syms V1 V2 V3 VY

% Defining Current's
eq5 = I1 == (Vx-V1)/ZRL1;
eq6 = I2 == (V1-V2)/ZRL2;
eq7 = I3 == V1/ZC2;
eq8 = I4 == (V2-V3)/ZRL3;
eq9 = I5 == V2/ZC3;
eq10 = I6 == (V3-VY)/ZRL4;
eq11 = I7 == V3/ZC4;
eq12 = I8 == 0;
eq13 = I9 == VY/ZC5;

% Getting solution Matrixes
eqns = [eq1 eq2 eq3 eq4 eq5 eq6 eq7 eq8 eq9 eq10 eq11 eq12 eq13];
vars = [I1 I2 I3 I4 I5 I6 I7 I8 I9 V1 V2 V3 VY];

% Solving the system of equations
```

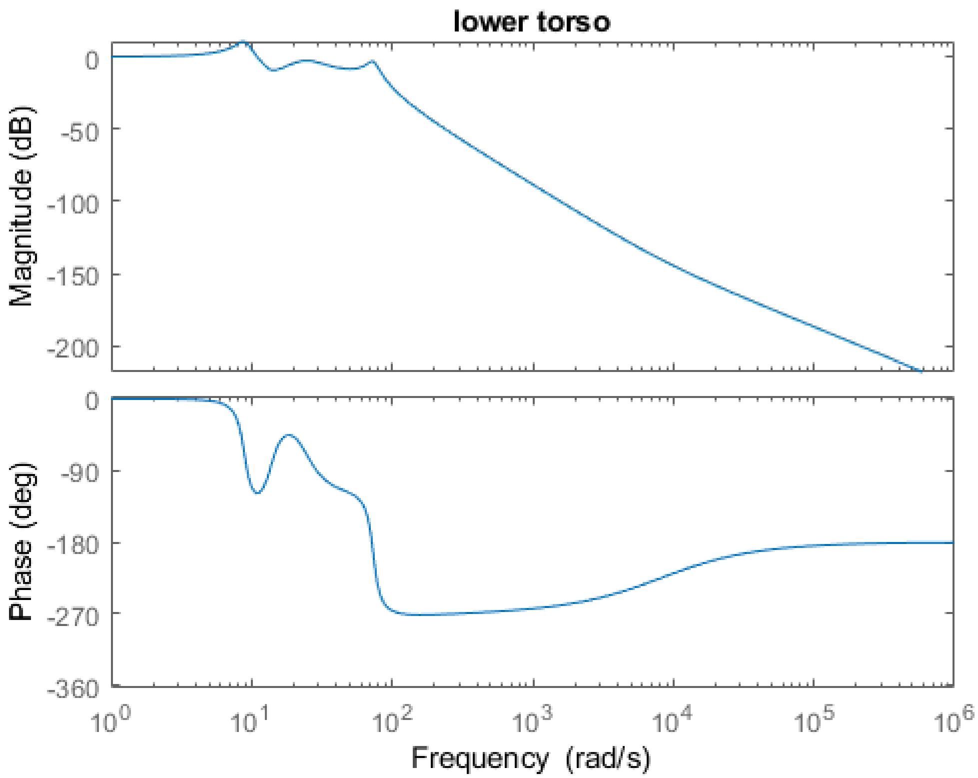
```
sol = solve(eqns,vars);

% Setting Transfer Functions For head and parts of the torso
Hs_head = partfrac(sol.VY);
save head.mat Hs_head -mat
Hs_hightorso = partfrac(sol.V3);
Hs_lowtorso = partfrac(sol.V2);
```

Getting the resonant frequency of our system

```
% Plotting the frequencies in order to determine where we are amplifying
% frequencies to make sure we aren't distrubing any organs
getfreqresp(Hs_head,'head')
getfreqresp(Hs_hightorso,'upper torso')
getfreqresp(Hs_lowtorso,'lower torso')
```

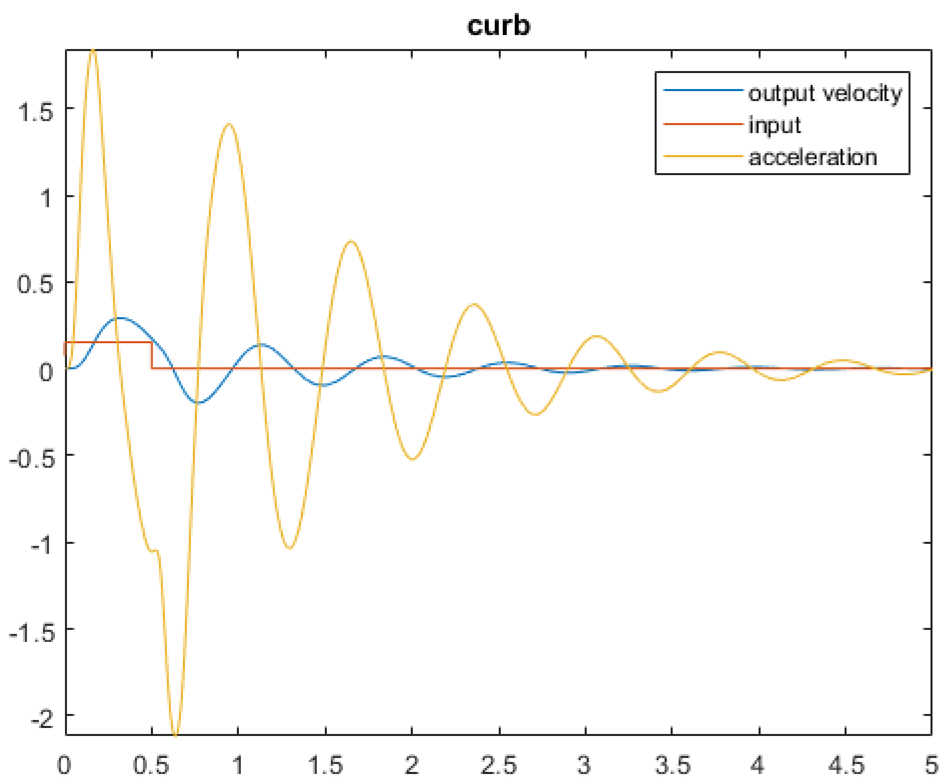



upper torso
Magnitude (dB)
0
-100
-200
-300
Phase (deg)
0
-90
-180
-270
-360
-450
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Frequency (rad/s)


lower torso
Magnitude (dB)
0
-50
-100
-150
-200
Phase (deg)
0
-90
-180
-270
-360
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Frequency (rad/s)

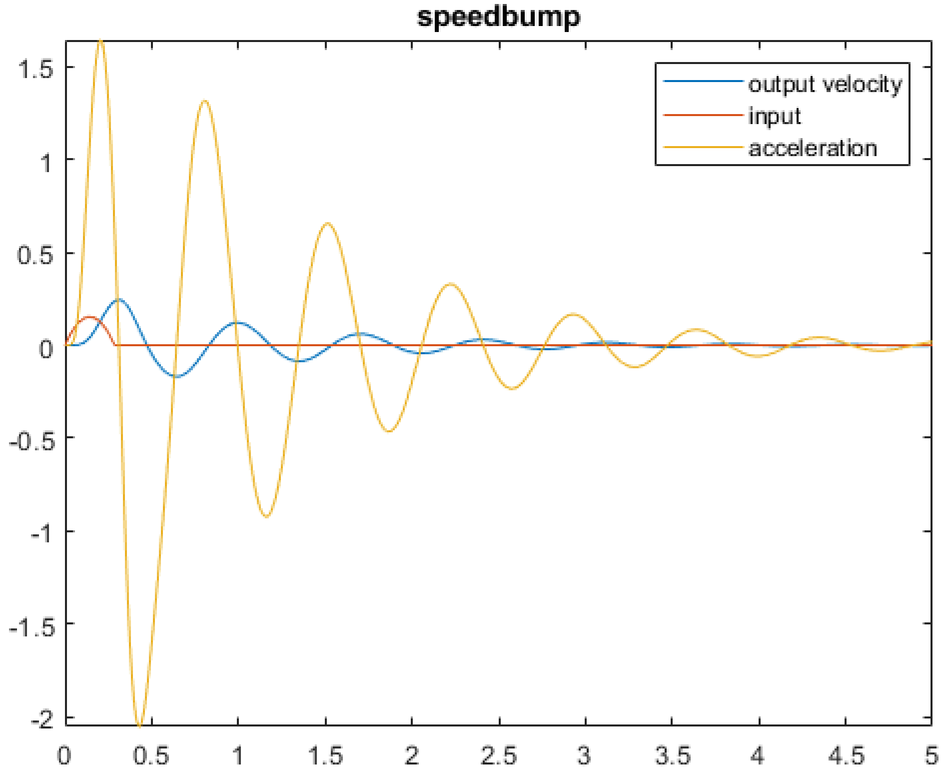
Response to various road blocks

```
% Plotting the convolution of the head with a curb(6 inches) in .5 seconds
curbmax = findmaxaccel(Hs_head,.1524*(heaviside(t)-heaviside(t-.5)),'curb')

% Plotting the convolution of the head with a speed bumb(6 inches tall, 24
% inches wide) in .2857 seconds use exponentials on modeling speedbumps
bumpmax = findmaxaccel(Hs_head,.1524*((1-(7*(t)-1)^2)*heaviside(t))-
(.1524*((1-(7*(t)-1)^2)*heaviside(t-.2857))),'speedbump')

% Going over a 1cm amplitude wavy curve
curvemax = findmaxaccel(Hs_head,.0254*cos(t),'curvy pavement')

% Going up a 6 inch curb
upacurbmax = findmaxaccel(Hs_head,.1524*heaviside(t),'up a curb')

% Going down a 6 inch curb
downacurbmax = findmaxaccel(Hs_head,-.1524*heaviside(t),'down a curb')

% Going down a 6 inch pothole
potholemax = findmaxaccel(Hs_head,-1*(.1524*((1-(7*(t)-1)^2)*heaviside(t))-
(.1524*((1-(7*(t)-1)^2)*heaviside(t-.2857)))),'pothole')
```

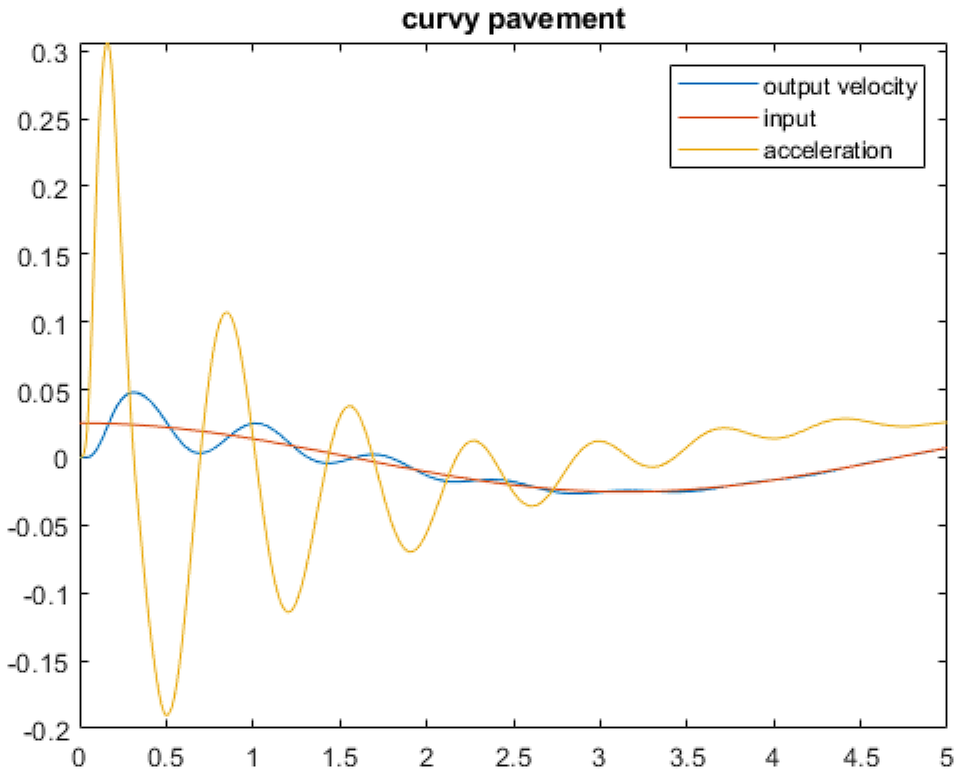


curbmax =

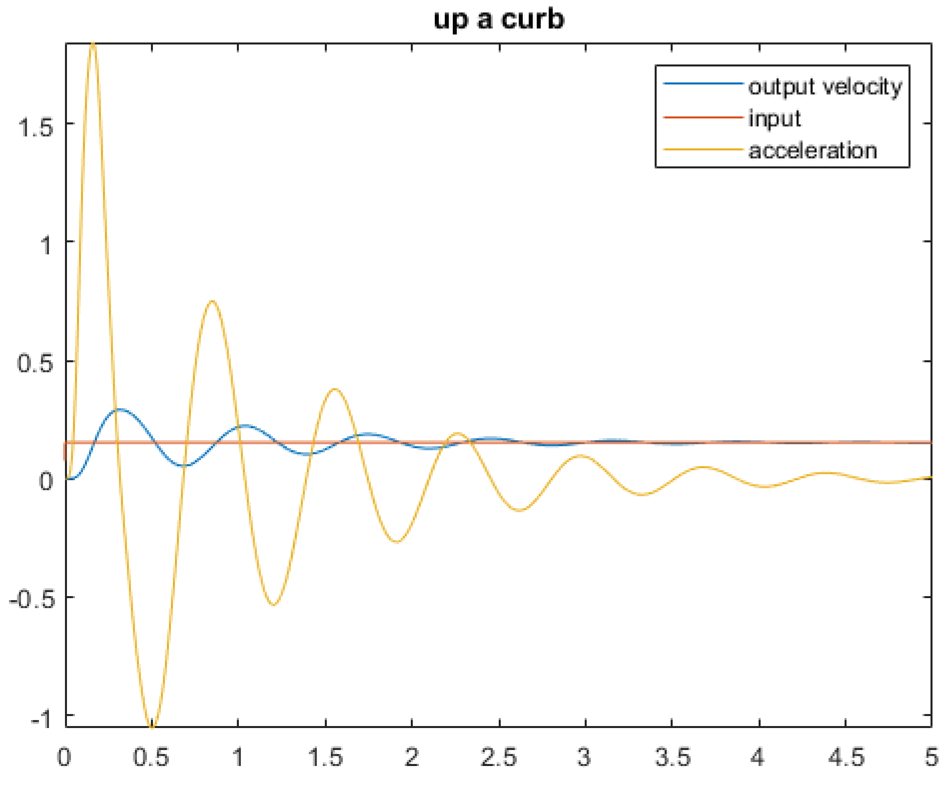
```
    2.1162
```



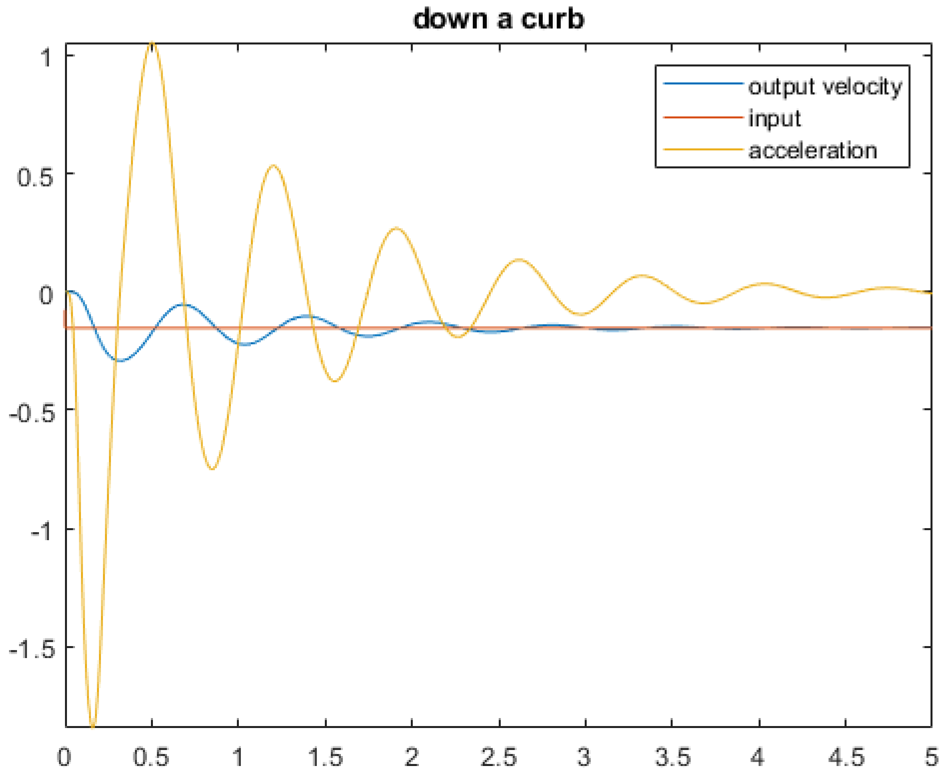

```
bumpmax =

    2.0497
```



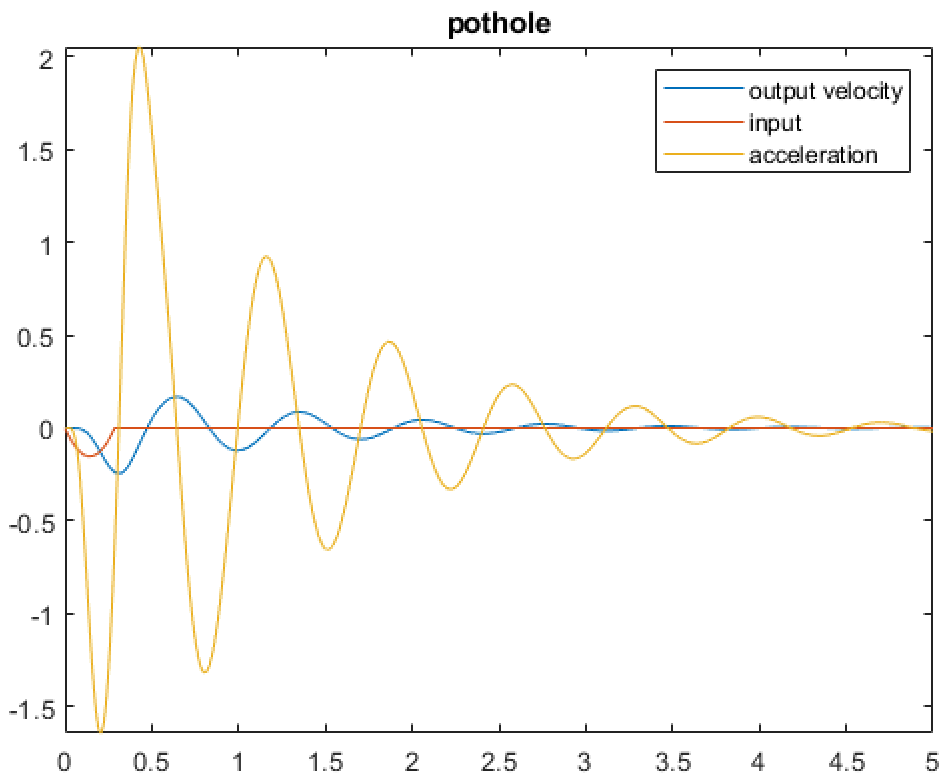

```
curvemax =

    0.3042
```




```
upacurbmax =

    1.8301
```




```
downacurbmax =

    1.8301
```




```
potholemax =

    2.0497
```

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