System Simulation

- Homework 2: SR-71 Supersonic Inlet
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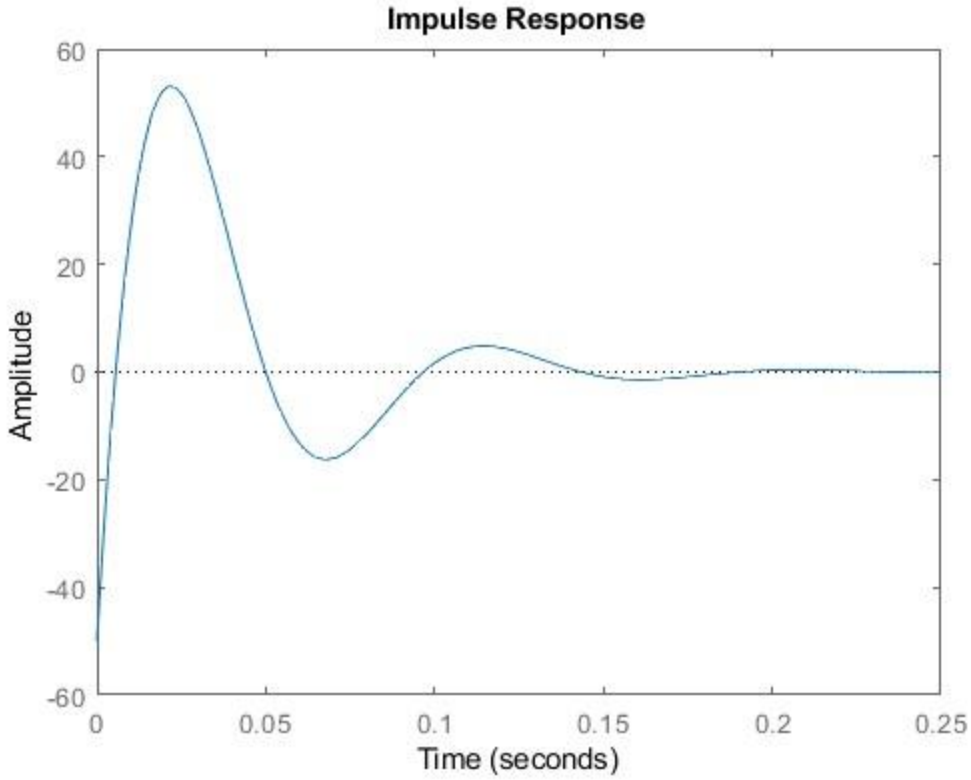
Initial Conditions

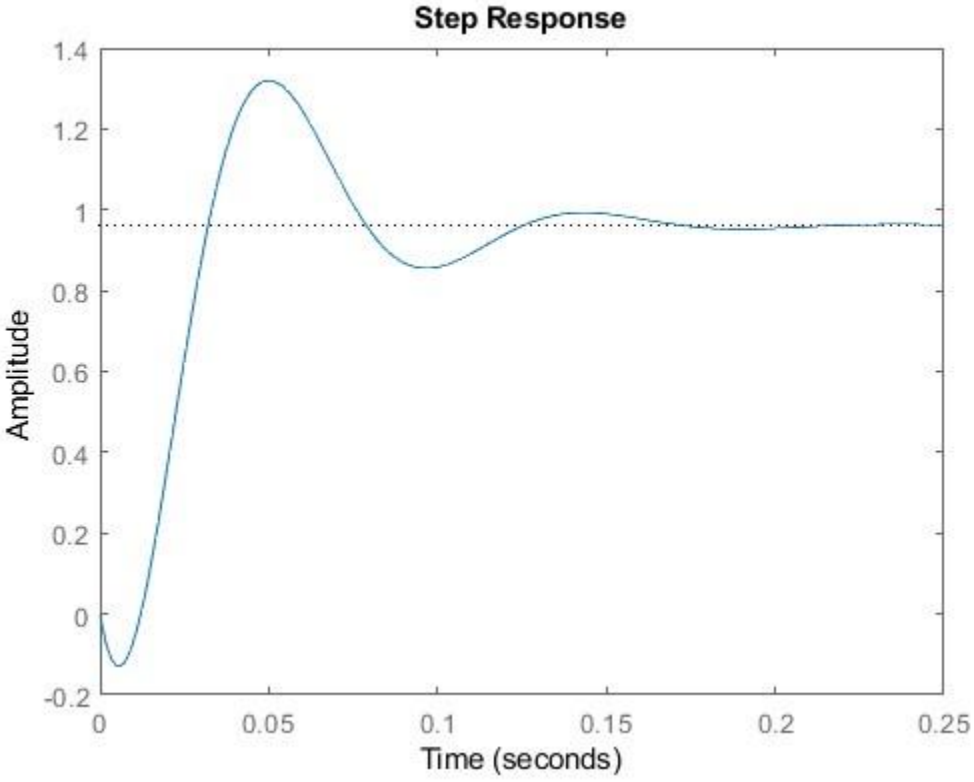
```
clc; clear;
T = 0.003;

%Setting up variables for Hc(S) approximation
A = 50;
B = 33.3333;
C = 13333.3;
D = 185.333;
E = 12133.3;
F = 693333;

%Initializing our s and z so we can use them in our transfer function
s = tf('s'); z = tf('z',T);

%Setting up Transfer Function
Hc_s = (A*(-s^2 + B*s + C))/ (s^3 + D*s^2 + E*s + F);

%Setting up Madwed Substitutions madwedOne =
(T*(z+1))/(2*(z-1)); madwedTwo =
((T^2)*(z^2+4*z+1))/(6*(z-1)^2); madwedThree =
((T^3)*(z^3+11*z^2+11*z+1))/(24*(z-1)^3);

%Madwed Approximation
Hm = (A*(-madwedOne + B*madwedTwo + C*madwedThree))/(1 + D*madwedOne +
 E*madwedTwo + F*madwedThree)

%Numerator Coefficients
G = -5951;
H = 6.109e04;
I = -2.757e05;
J = 7.08e05;
K = -1.099e06;
L = 9.413e05;
M = -1.219e05;
N = -7.472e05;
O = 1.005e06;
P = -6.872e05;
Q = 2.782e05;
R = -6.358e04;
```

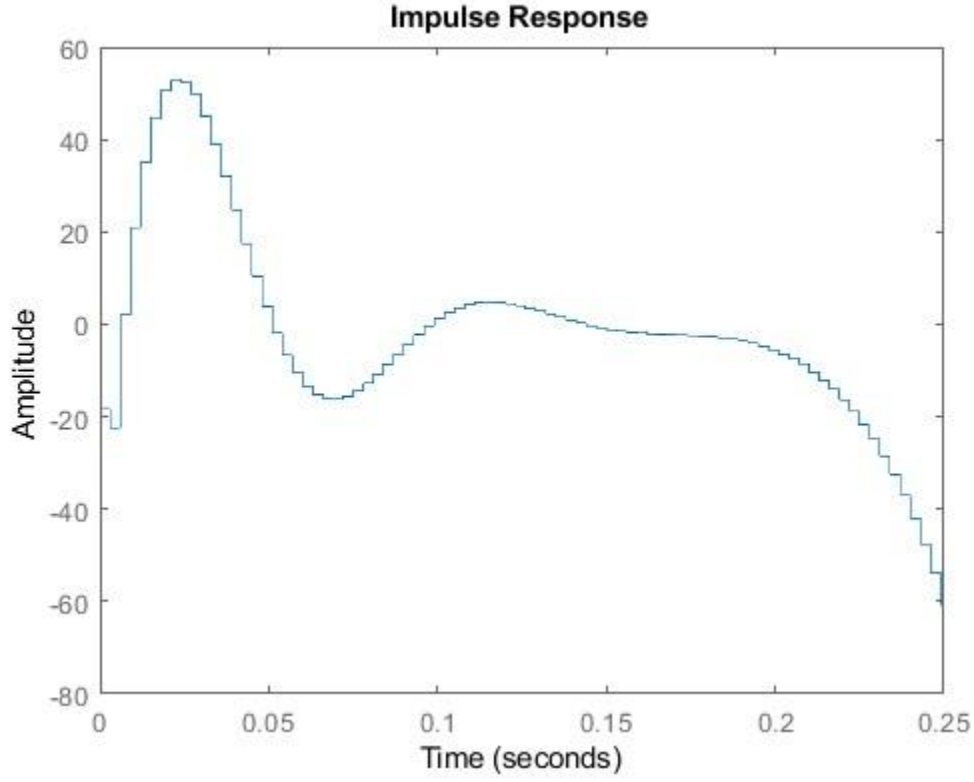
```
S = 6366;
%Denominator Coefficients
GG = 1;
HH = -1.235e06;
II = 6.495e06;
JJ = -2069e07;
KK = 4.45e07;
LL = -6.8e07;
MM = 7.57e07;
NN = -6.179e07;
OO = 3.694e07;
PP = -1.565e07;
QQ = 4.472e06;
RR = -7.739e05;
SS = 6.133e04;

%Coefficient Arrays
NC = [ G H I J K L M N O P Q R S];
DC = [ GG HH II JJ KK LL MM NN OO PP QQ RR SS];

%Difference Equation
sys = idpoly(DC, NC, 'NoiseVariance', 1)
```

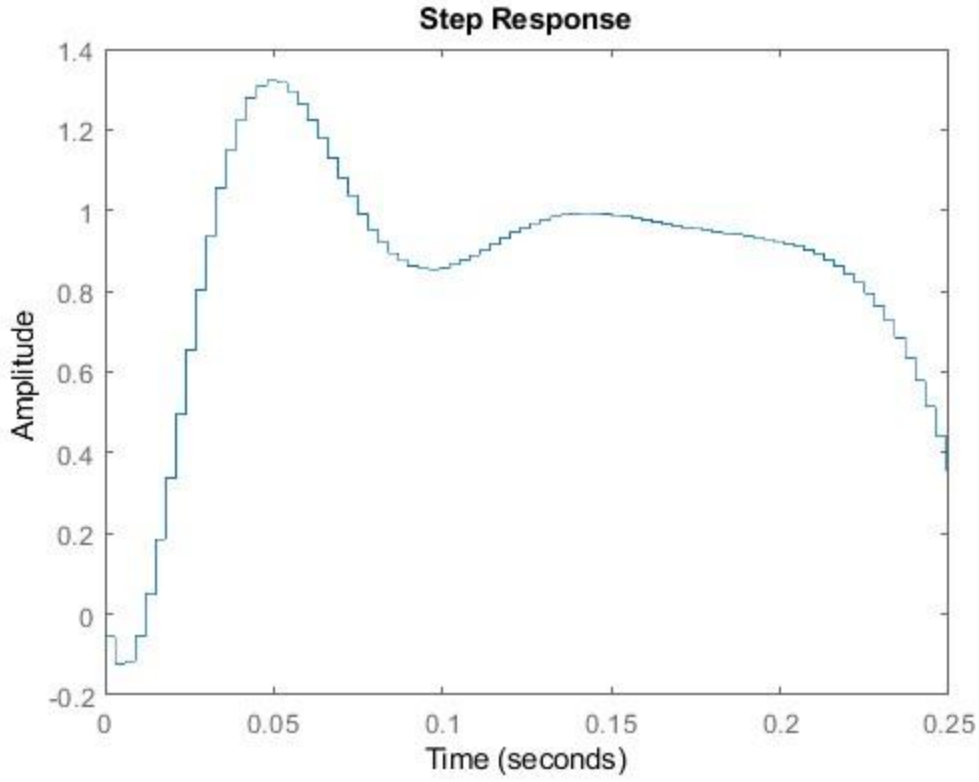
```
Hm =

             -5951 z^12 + 6.109e04 z^11 - 2.757e05 z^10 + 7.08e05 z^9 -
                                                                1.099e06  z^8

            + 9.413e05 z^7 - 1.219e05 z^6 - 7.472e05 z^5 + 1.005e06 z^4



- 6.872e05 z^3 + 2.782e05 z^2 - 6.358e04 z +
 6366

  ---------------------------------------------------------------------------


   1.076e05 z^12 - 1.235e06 z^11 + 6.495e06 z^10 - 2.069e07 z^9 +
 4.45e07 z^8


- 6.8e07 z^7 + 7.575e07 z^6 - 6.197e07 z^5 + 3.694e07 z^4
```

```
- 1.565e07 z^3 + 4.472e06 z^2 - 7.739e05 z +
 6.133e04



Sample time: 0.003 seconds Discrete-
time transfer function.


sys = Discrete-time ARX model: A(z)y(t) = B(z)u(t)
+ e(t)


       A(z) = 1 - 1.235e06 z^-1 + 6.495e06 z^-2 - 2.069e10 z^-3 +
4.45e07  z^-4           - 6.8e07 z^-5 + 7.57e07 z^-6 - 6.179e07 z^-7 +
3.694e07 z^-8
                    - 1.565e07 z^-9 + 4.472e06 z^-10 - 773900 z^-11 +
                                                        61330  z^-12


       B(z) = -5951 + 61090 z^-1 - 275700 z^-2 + 708000 z^-3 -
1.099e06  z^-4             + 941300 z^-5 - 121900 z^-6 - 747200 z^-
7 + 1.005e06 z^-8
                         - 687200 z^-9 + 278200 z^-10 - 63580 z^-11 +
                                                          6366  z^-12

Sample time: unspecified
  Parameterization:
   Polynomial orders:   na=12   nb=13   nk=0
   Number of free coefficients: 25    Use "polydata",
"getpvec", "getcov" for parameters and their  uncertainties.

Status:
Created by direct construction or transformation. Not estimated.

%Plots of Impulse and Step Responses

%Impulse Response of Original Function
figure(1) impulse(Hc_s, 0.25) %Step
Response of Original Function
figure(2) step(Hc_s, 0.25)

%Impulse Reponse of Madwed Approximation
figure(3) impulse(Hm, 0.25)
%Step Reponse of Madwed Approximation
figure(4) step(Hm, 0.25) %I was not able to plot

my difference equation..
```


Impulse Response
Amplitude
Time (seconds)
60
40
20
0
-20
-40
-60
0
0.05
0.1
0.15
0.2
0.25


Step Response
Amplitude
Time (seconds)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.05
0.1
0.15
0.2
0.25


Impulse Response
Amplitude
Time (seconds)
60
40
20
0
-20
-40
-60
-80
0
0.05
0.1
0.15
0.2
0.25



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Handwritten Analysis Below

$$H_c(s) = \frac{50(s^2 + 33s + 1333)}{s^3 + 185s^2 + 12133s + 693333}$$

$$H_m = \frac{50\left(\frac{s^2}{s^3} + \frac{33s}{s^{3/2}} + \frac{1333}{s^3}\right)}{\frac{s^3}{s^3} + \frac{185s^2}{s^3} + \frac{12133s}{s^{3/2}} + \frac{693333}{s^3}}$$

$$H_m = \frac{50\left(\frac{1}{s} + \frac{33}{s^2} + \frac{1333}{s^3}\right)}{1 + \frac{185}{s} + \frac{12133}{s^2} + \frac{693333}{63}}$$

$$H_m = \frac{50\left(\frac{T(z+1)}{2(z-1)} + 33\left(\frac{T^2(z^2+4z+1)}{6(z-1)^2}\right) + 1333\left(\frac{T^3(z^3+11z^2+11z+1)}{24(z-1)^3}\right)\right)}{1 + 185\left(\frac{T(z+1)}{2(z-1)}\right) + 12133\left(\frac{T^2(z^2+4z+1)}{6(z-1)^2}\right) + 693333\left(\frac{T^3(z^3+11z^2+11z+1)}{24(z-1)^3}\right)}$$

$$H_m = \left(\text{"}\quad\text{"}\right)\frac{(z-1)^3}{(z-1)^3}$$

$$H_m = \frac{25T(z+1) + 277.778T^2(z^2+4z+1) + 2777.71T^3(z^3+11z^2+11z+1)}{(z-1)^3 + 185T(z+1)(z-1)^2 + 2022.22T^2(z-1)(z^2+4z+1) + \left(\frac{23111T^3(z^3+11z^2+11z+1)}{8}\right)}$$

$$H_m = \frac{.96152\left(t^3(z^3+11z^2+11z+1) + .100003t^2(z^2+4z+1) - .009t(z+1)\right)}{t^3(z^3+11z^2+11z+1) + .700003t^2(z-1)(z^2+4z+1) + .06415(t(z+1) + .005396(z-1))(z-1)^2}$$

* Letting Matlab do the work *
↳ Matlab might not have worked.