```
clear
close all
clc
%{ The following program will simulate the local behavior of the vertical
% and horiztonal aircraft position around the equilibrium point.
%
% - Convert Linearized Jacobian Matrices to state-space form & transfer
%   functions.
% - Compute the poles and zeros & plot bode for each transfer function.
% - Plot the impulse, step, and high/low frequency sinusoidal
%   responses for each transfer function.
%}

% Model parameters
J = 0.0475; %kg m^2
m = 4; %kg
r = 0.25; %m
g = 9.81; % m/s^2
c = 0.05; %Ns/m

% Linearized Jacobian Matrices evaluated at the equilibrium point
A = [0 0 0 1 0 0;
    0 0 0 0 1 0;
    0 0 0 0 0 1;
    0 0 -g -c/m 0 0;
    0 0 0 0 -c/m 0;
    0 0 0 0 0 0];

B = [0 0;
    0 0;
    0 0;
    1/m 0;
    0 1/m;
    r/J 0];

C = [1 0 0 0 0 0;
    0 1 0 0 0 0];

D = [0 0;
    0 0];

% Convert Jacobian Matrices to State-Space Form
stateSpace = ss(A,B,C,D);
% Visualize the State-Space Form
disp('State-Space Form:')
display(stateSpace)
```

```
State-Space Form:

stateSpace =

  A =
            x1       x2       x3       x4       x5       x6
```

```
   x1         0         0         0         1         0         0
   x2         0         0         0         0         1         0
   x3         0         0         0         0         0         1
   x4         0         0     -9.81   -0.0125         0         0
   x5         0         0         0         0   -0.0125         0
   x6         0         0         0         0         0         0

  B =
          u1     u2
   x1      0      0
   x2      0      0
   x3      0      0
   x4   0.25      0
   x5      0   0.25
   x6  5.263      0

  C =
       x1  x2  x3  x4  x5  x6
   y1   1   0   0   0   0   0
   y2   0   1   0   0   0   0

  D =
       u1  u2
   y1   0   0
   y2   0   0

Continuous-time state-space model.
```

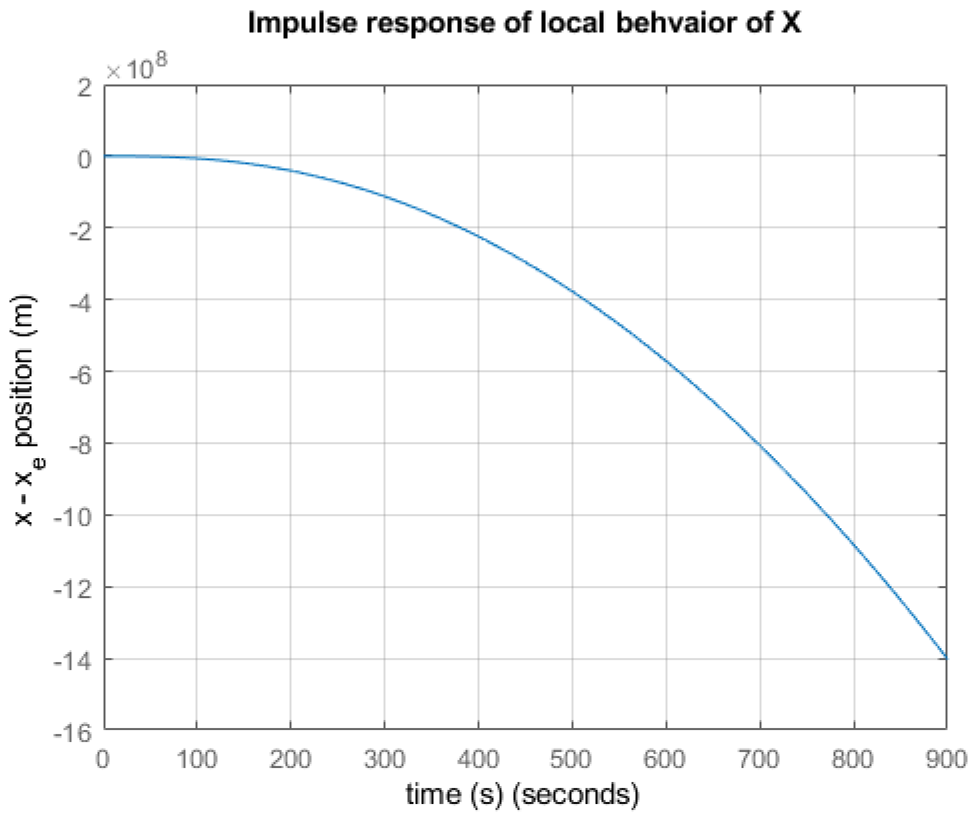
Local X Simulation Response Convert State-Space Form to local X Transfer Function

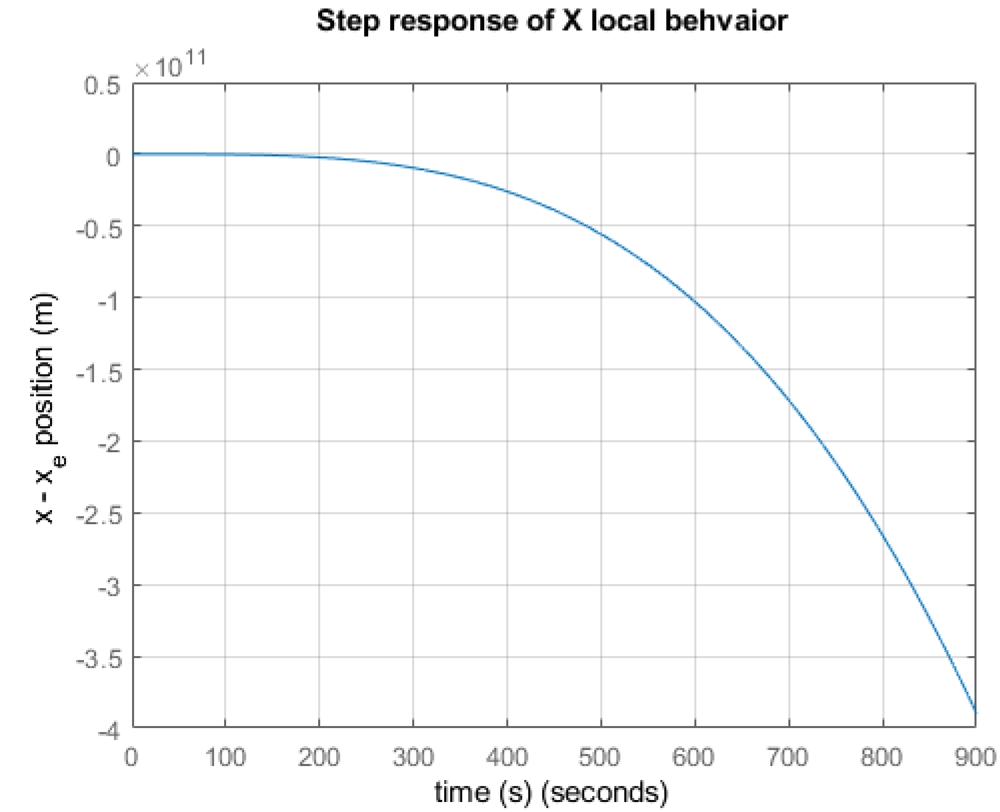
```
[X_num, X_den] = ss2tf(A,B,C,D,1);
X_tf = tf(X_num(1,:),X_den);

% Visualize the local X transfer function
disp('local X Transfer Function:')
display(X_tf)

% Visualize local X Transfer Function Poles
disp('X Transfer Function Poles:')
display(pole(X_tf));

% Visualize local X Transfer Function Zeros
disp('local X Transfer Function Zeros:')
display(zero(X_tf));

% Impulse response of local X
figure(1)
impulse(X_tf)
xlabel('time (s)')
ylabel('x - x_e position (m)')
title('Impulse response of local behvaior of X')
grid on

% Step response of local X
```

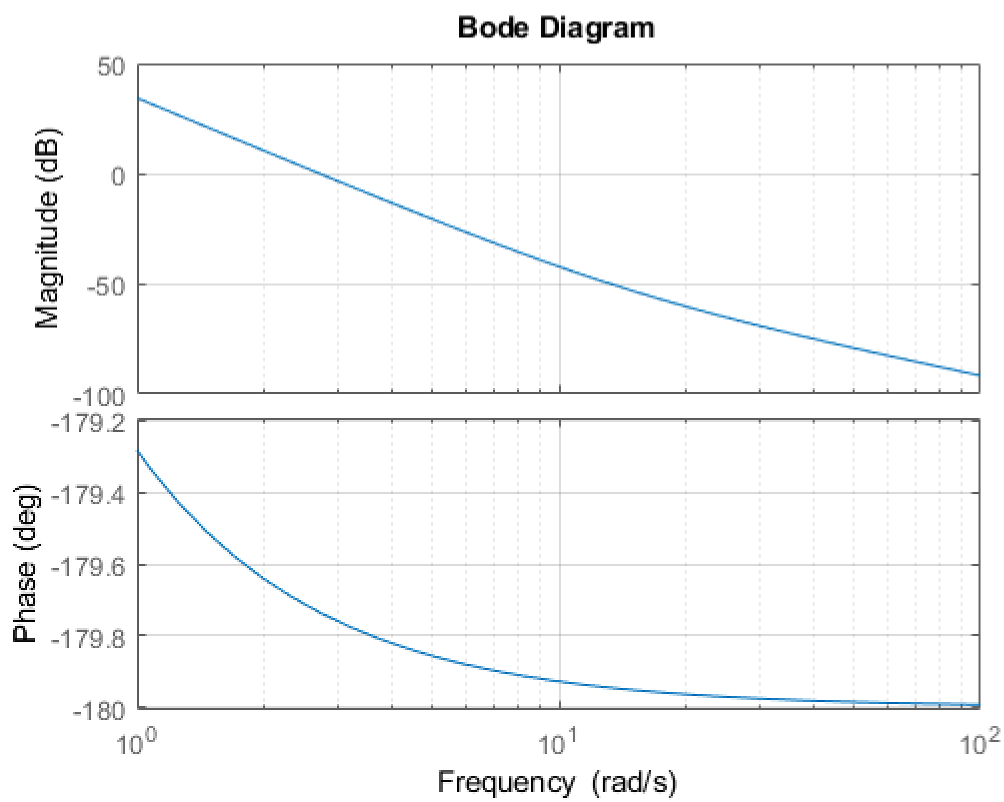
```
figure(2)
step(X_tf)
xlabel('time (s)')
ylabel('x - x_e position (m)')
title('Step response of X local behvaior')
grid on

% Bode Plot of local X
figure(3)
bode(X_tf)
grid on

% Sinuoidal input for local X
t_x = linspace(0, 1000, 100);  % Time Vector for local X

% Low frequency at 0.01
omega_lw_x = 0.01;
u_X_low = sin(omega_lw_x*t_x); % Forcing Function for local X
XLowfreq = lsim(X_tf, u_X_low, t_x);

% High frequency at 1000
omega_hi_x = 1000;
u_X_hi = sin(omega_hi_x*t_x); % Forcing Function for local X
XHifreq = lsim(X_tf, u_X_hi , t_x);

% Plot Low Frequency Sinusoidal response for local X
figure(4)
plot(t_x,XLowfreq)
xlabel('time (s)')
ylabel('x - x_e position (m)')
title('Low Frequency Sinusoidal response of X local behvaior')
grid on

% Plot High Frequency Sinusoidal response for local X
figure(5)
plot(t_x,XHifreq)
xlabel('time (s)')
ylabel('x - x_e position (m)')
title('High Frequency Sinusoidal X local behvaior')
grid on
```

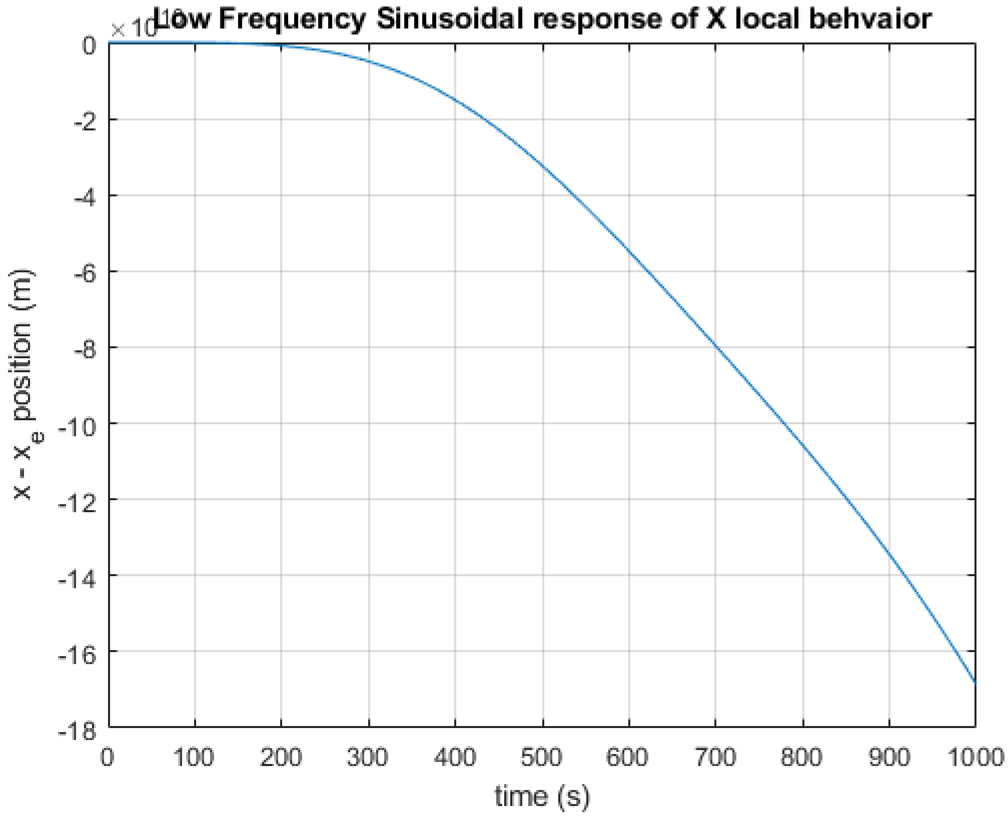
```
local X Transfer Function:

X_tf =

  0.25 s^4 + 0.003125 s^3 - 51.63 s^2 - 0.6454 s
  ----------------------------------------------
         s^6 + 0.025 s^5 + 0.0001563 s^4

Continuous-time transfer function.
X Transfer Function Poles:
   0.0000 + 0.0000i
   0.0000 + 0.0000i
   0.0000 + 0.0000i
```

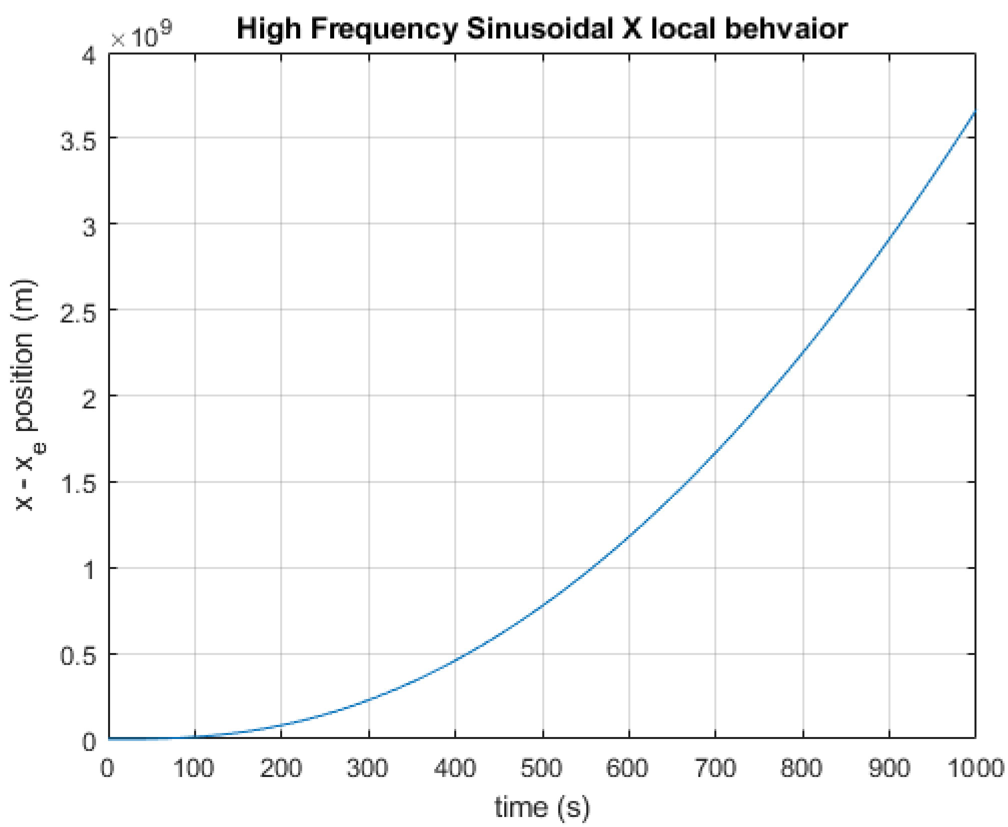
```
   0.0000 + 0.0000i
  -0.0125 + 0.0000i
  -0.0125 - 0.0000i

local X Transfer Function Zeros:
         0
   14.3710
  -14.3710
   -0.0125
```




Step response of X local behvaior
×10^11
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
x - x_e position (m)
0
100
200
300
400
500
600
700
800
900
time (s) (seconds)


Bode Diagram
50
0
-50
-100
Magnitude (dB)
-179.2
-179.4
-179.6
-179.8
-180
Phase (deg)
10^0
10^1
10^2
Frequency (rad/s)


Low Frequency Sinusoidal response of X local behvaior
×10^10
x - x_e position (m)
time (s)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
100
200
300
400
500
600
700
800
900
1000

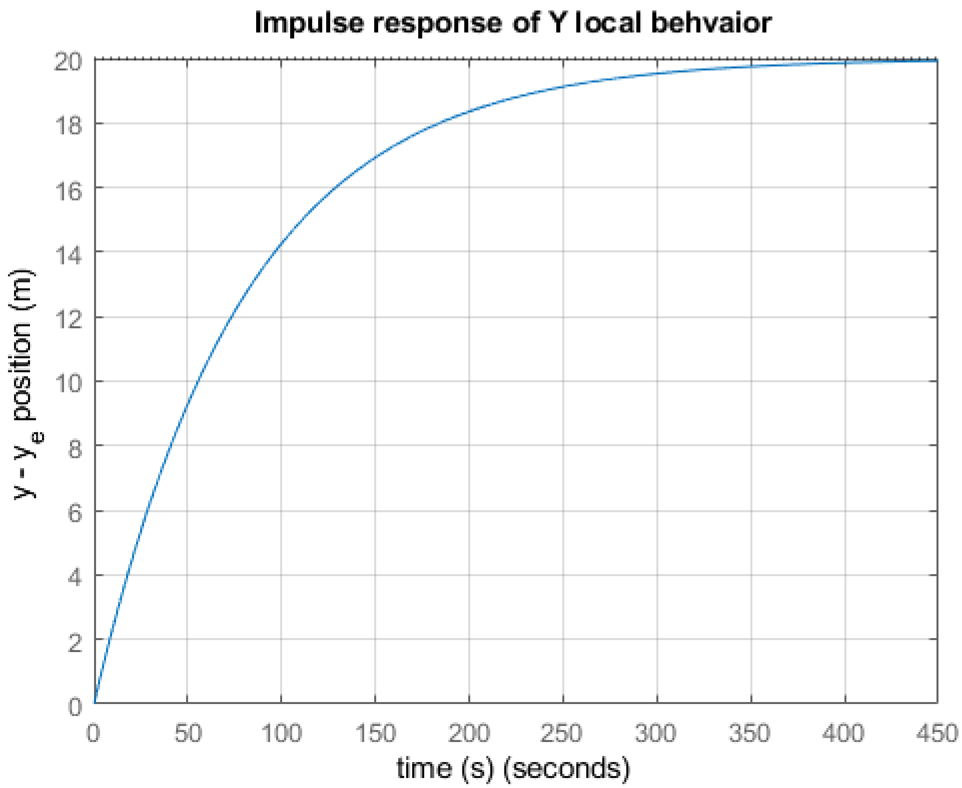

High Frequency Sinusoidal X local behvaior
×10^9
x - x_e position (m)
time (s)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
800
900
1000

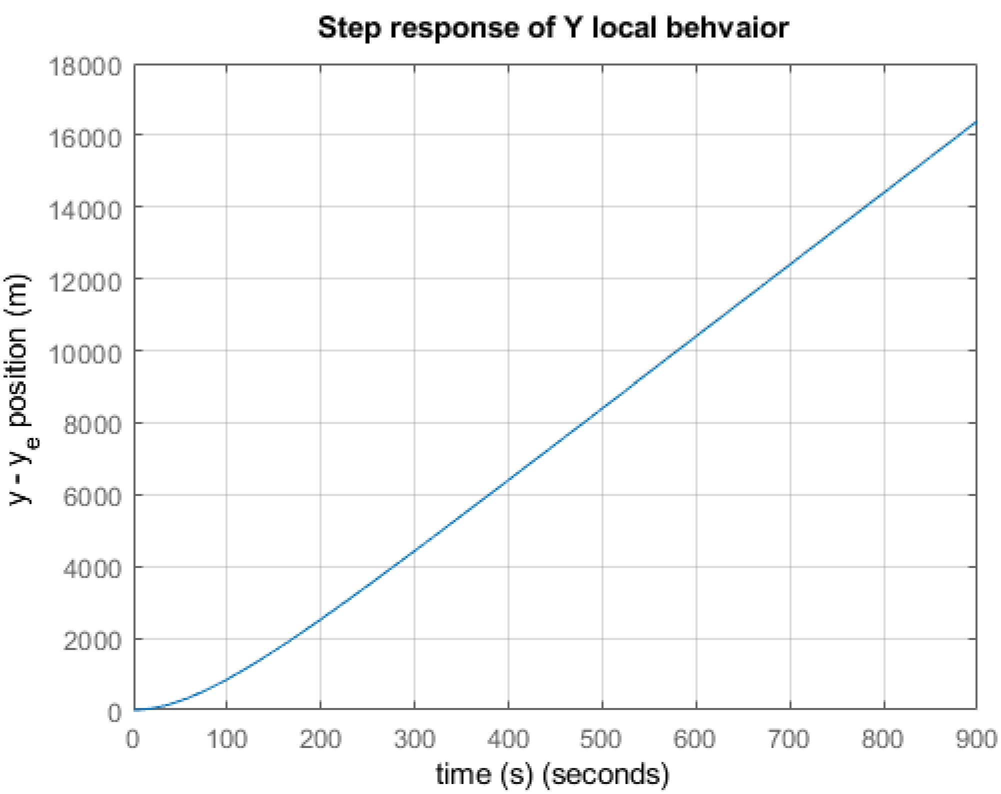
Local Y Simulation Response Convert State-Space Form to Y Transfer Function

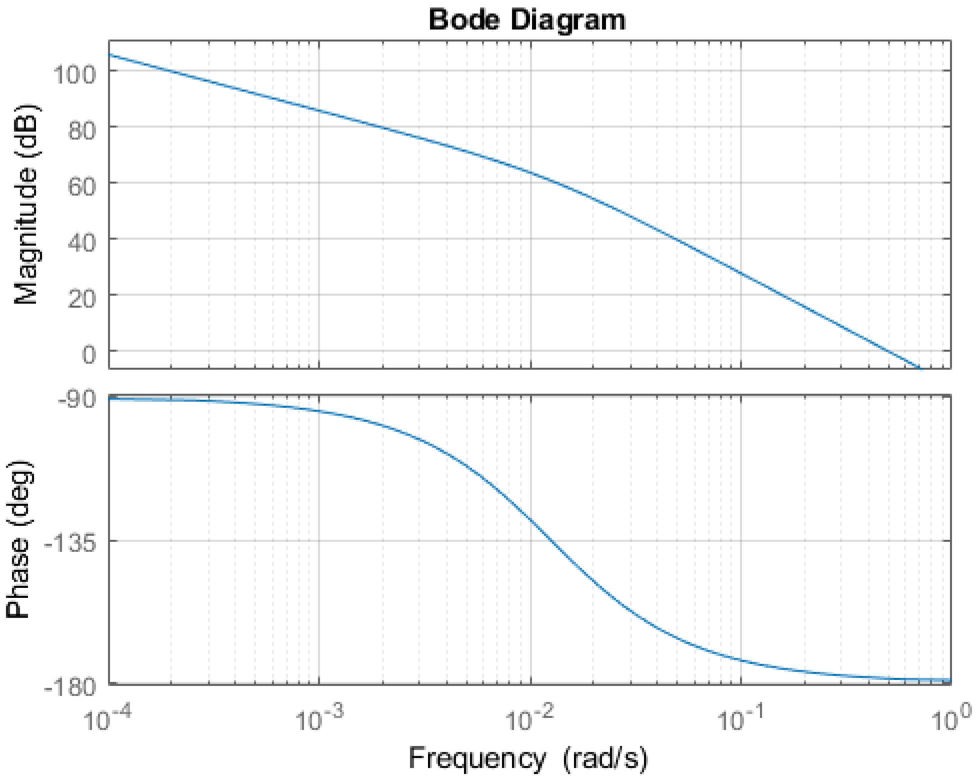
```
[Y_num, Y_den] = ss2tf(A,B,C,D,2);
disp('Y Transfer Function:')
Y_tf = tf(Y_num(2,:),Y_den);

% Visualize the Y transfer function
disp('Y Transfer Function:')
display(Y_tf)

% Visualize Y Transfer Function Poles
disp('Y Transfer Function Poles:')
display(pole(Y_tf));

% Visualize Y Transfer Function Zeros
disp('Y Transfer Function Zeros:')
display(zero(Y_tf));

% Impulse response of local Y
figure(6)
impulse(Y_tf)
xlabel('time (s)')
ylabel('y - y_e position (m)')
title('Impulse response of Y local behvaior')
grid on

% Step response of local Y
figure(7)
step(Y_tf)
xlabel('time (s)')
ylabel('y - y_e position (m)')
title('Step response of Y local behvaior')
grid on

% Bode Plot of local Y
figure(8)
bode(Y_tf)
grid on

% Sinuoidal input for local Y
t_y = linspace(0, 1000, 1000);  % Time Vector for local Y

% Low frequency at 0.01
omega_lw_y = 0.01;
u_Y_low = sin(omega_lw_y*t_y); % Forcing Function for local Y
YLowfreq = lsim(Y_tf, u_Y_low, t_y);

% High frequency at 1000
omega_hi_y = 1000;
u_Y_hi = sin(omega_hi_y*t_y); % Forcing Function for local Y
YHifreq = lsim(Y_tf, u_Y_hi , t_y);

% Plot Low Frequency Sinusoidal response for local Y
figure(9)
```

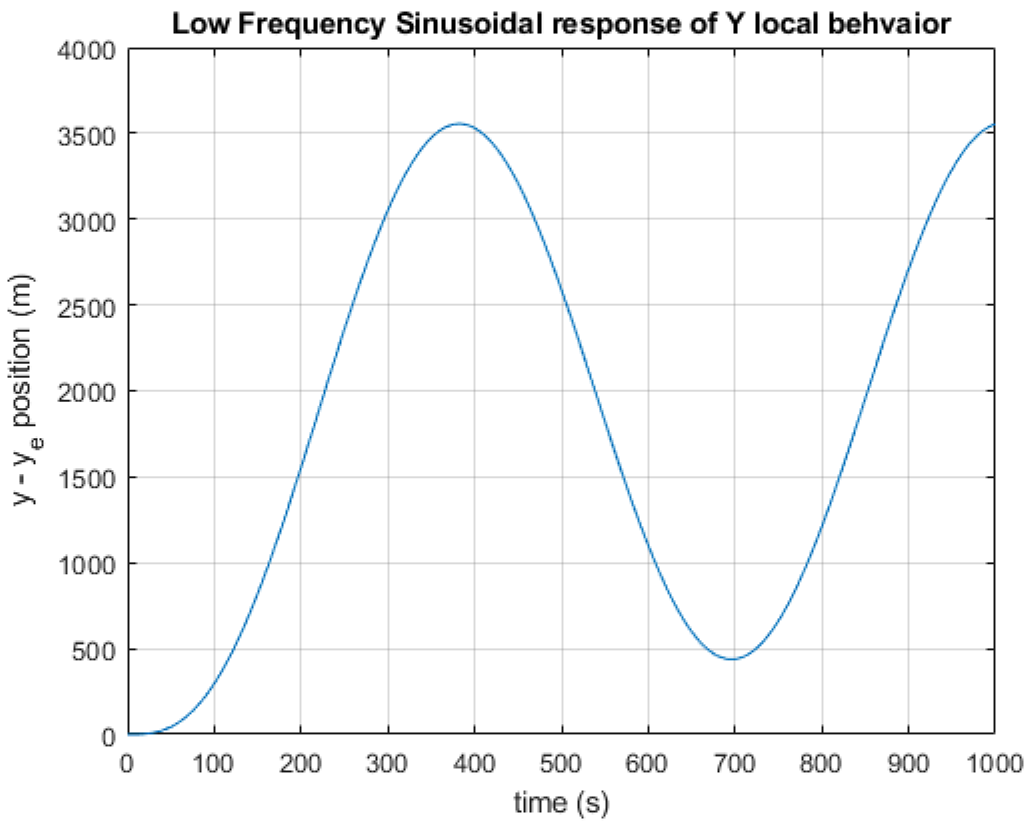
```
plot(t_y,YLowfreq)
xlabel('time (s)')
ylabel('y - y_e position (m)')
title('Low Frequency Sinusoidal response of Y local behvaior')
grid on

% Plot High Frequency Sinusoidal response for local Y
figure(10)
plot(t_y,YHifreq)
xlabel('time (s)')
ylabel('y - y_e position (m)')
title('High Frequency Sinusoidal of Y local behvaior')
grid on
```

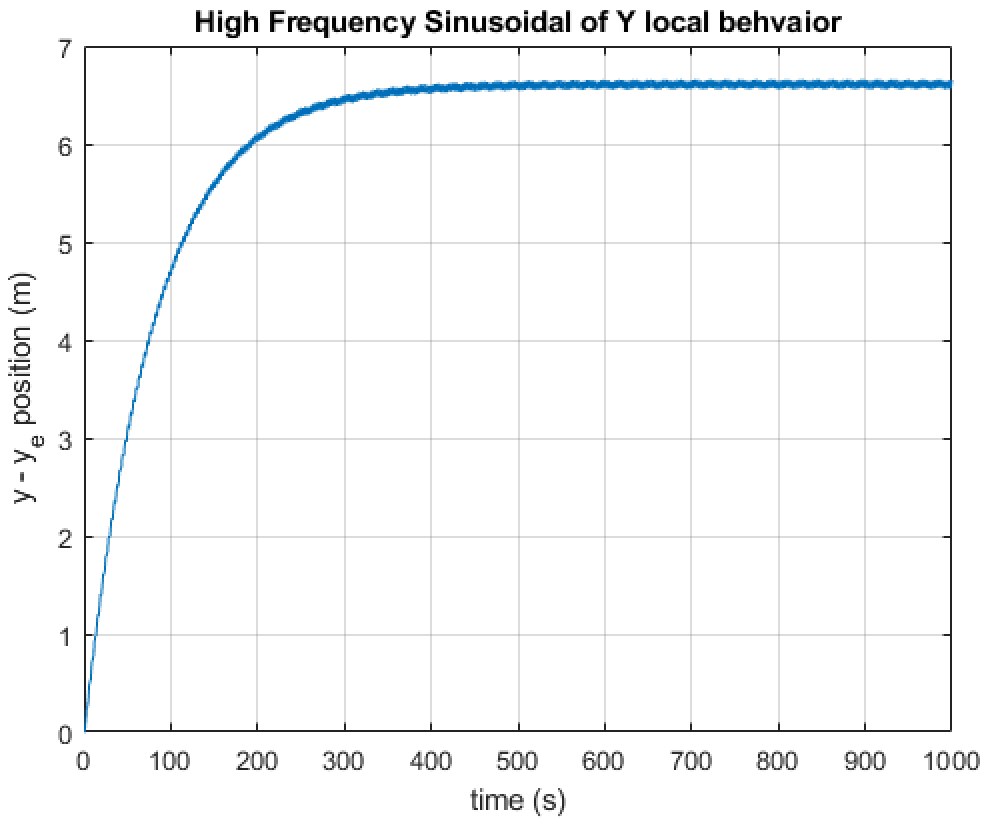
```
Y Transfer Function:
Y Transfer Function:

Y_tf =

      0.25 s^4 + 0.003125 s^3
  -------------------------------
  s^6 + 0.025 s^5 + 0.0001563 s^4

Continuous-time transfer function.
Y Transfer Function Poles:
   0.0000 + 0.0000i
   0.0000 + 0.0000i
   0.0000 + 0.0000i
   0.0000 + 0.0000i
  -0.0125 + 0.0000i
  -0.0125 - 0.0000i

Y Transfer Function Zeros:
         0
         0
         0
   -0.0125
```


Impulse response of Y local behvaior
y - $y_e$ position (m)
time (s) (seconds)
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300
350
400
450


Step response of Y local behvaior
y - $y_e$ position (m)
time (s) (seconds)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
100
200
300
400
500
600
700
800
900


Bode Diagram
Magnitude (dB)
100
80
60
40
20
0
Phase (deg)
-90
-135
-180
$10^{-4}$
$10^{-3}$
$10^{-2}$
$10^{-1}$
$10^{0}$
Frequency (rad/s)


Low Frequency Sinusoidal response of Y local behvaior
$y - y_e$ position (m)
4000
3500
3000
2500
2000
1500
1000
500
0
0
100
200
300
400
500
600
700
800
900
1000
time (s)

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