EE547 - HW2

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Initialization

```
close all
clear
syms xd x x1d x2d x1 x2 u y s
x_ini = [0.05; 0.05];
dt = 0.01;
t = 0:dt:10-dt;
fs = 2000;  %
```

Problem 1

Part 1.a

Derive the state-space representation of this system

```
x = [x1; x2];
xd = [x1d; x2d];
A = [0, 1; 3, -2];
B = [0; -1];
C = [0, 1];
D = 0;
xd = A*x + B*u;
y = C*x + D*u;
fprintf('x dot is \n')
pretty(xd)
fprintf('y is \n')
pretty(y)
```

```
x dot is
/        x2        \
|                  |
```

```
\ 3 x1 - u - 2 x2 /

y is
x2
```

Part b

Show the details of inversion of matrix A.

```
A_det = det(A);
A_ = zeros(2);
if A_det == 0
    error('A is not invertible')
else
    % swap element (1,1) with element (2,2)
    A_(1, 1) = A(2, 2);
    A_(2, 2) = A(1, 1);
    % flip sign of elements (1, 2) and (2, 1)
    A_(1, 2) = -A(1, 2);
    A_(2, 1) = -A(2, 1);
    % multiply reciprocal of determinant of A by the new A_
    A_inv = 1/A_det*A_;
    % check result
    if ~isequal(A_inv, inv(A))
        error('Matrices are not equal!')
    end
end
```

Part c

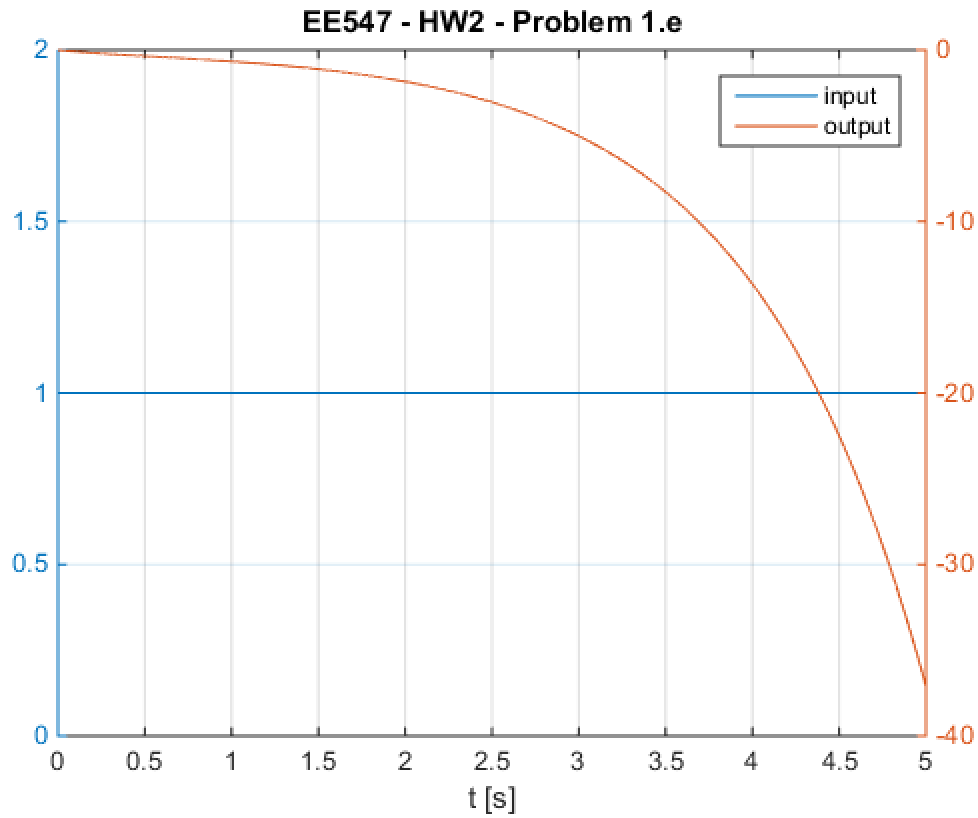
Show the details of deriving the transfer function of this system

```
G = C*inv((s*eye(2) - A))*B + D;
[num, den] = numden(G);
num = sym2poly(num);
den = sym2poly(den);
%
```

Part d, e

Create a Simulink model of this system by using the Simulink blocks shown in Figure 1. Please simulate the model created in 1(c) and plot the output signal y when input is a unit step function starting at t = 0, i.e., u(t) = 1, t ? 0. Explain what you discover from the output plot.

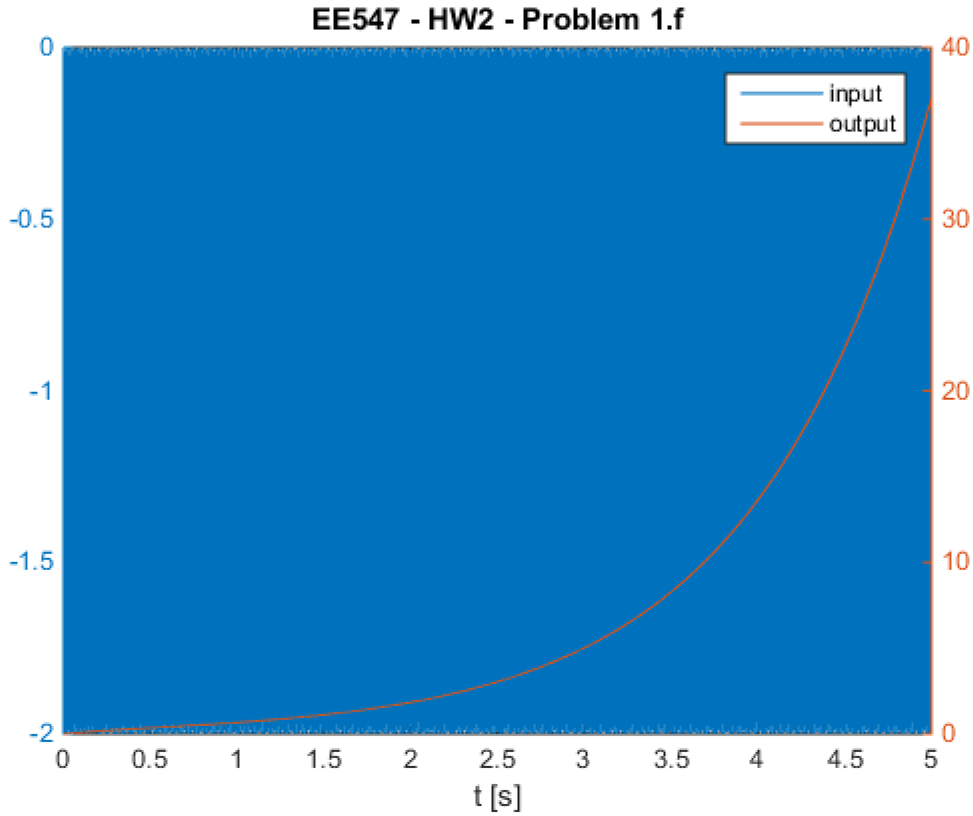
```
input_selector = 1; % select step input
t = sim('hw2S.slx', 5);
figure
plotyy(t, u, t, y)
xlabel('t [s]')
legend({'input', 'output'})
title('EE547 - HW2 - Problem 1.e')
```



Part f

Please simulate the model created in 1(c) and plot the output signal y when input is a biased sine function: u(t) = -1 + sin(1000*t).

```
input_selector = 2; % select sine input
t = sim('hw2S.slx', 5);
figure
plotyy(t, u, t, y)
xlabel('t [s]')
legend({'input', 'output'})
title('EE547 - HW2 - Problem 1.f')
```



Problem 2

Part 2.a

Please derive the transfer functions of these two systems.

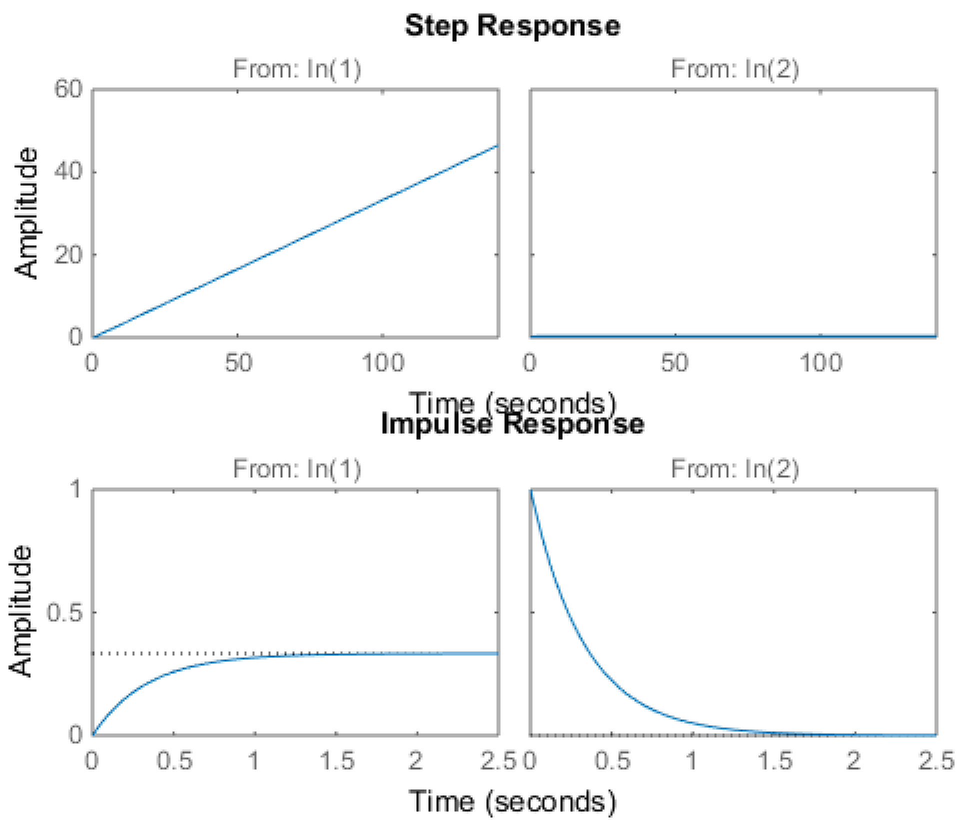
```
A1 = [0, 1; 0, -3];
B1 = [0; 1];
C1 = [1, 0; 0, 1];
D1 = [0; 0];
[num1, den1] = ss2tf(A1, B1, C1, D1);

A2 = [-7.5, 2.5; -13.5, 4.5];
B2 = [2; 4];
C2 = [-2, 1; 1.5, -0.5];
D2 = [0; 0];
[num2, den2] = ss2tf(A2, B2, C2, D2);
% The system transfer functions are equivalent within double precision error
```

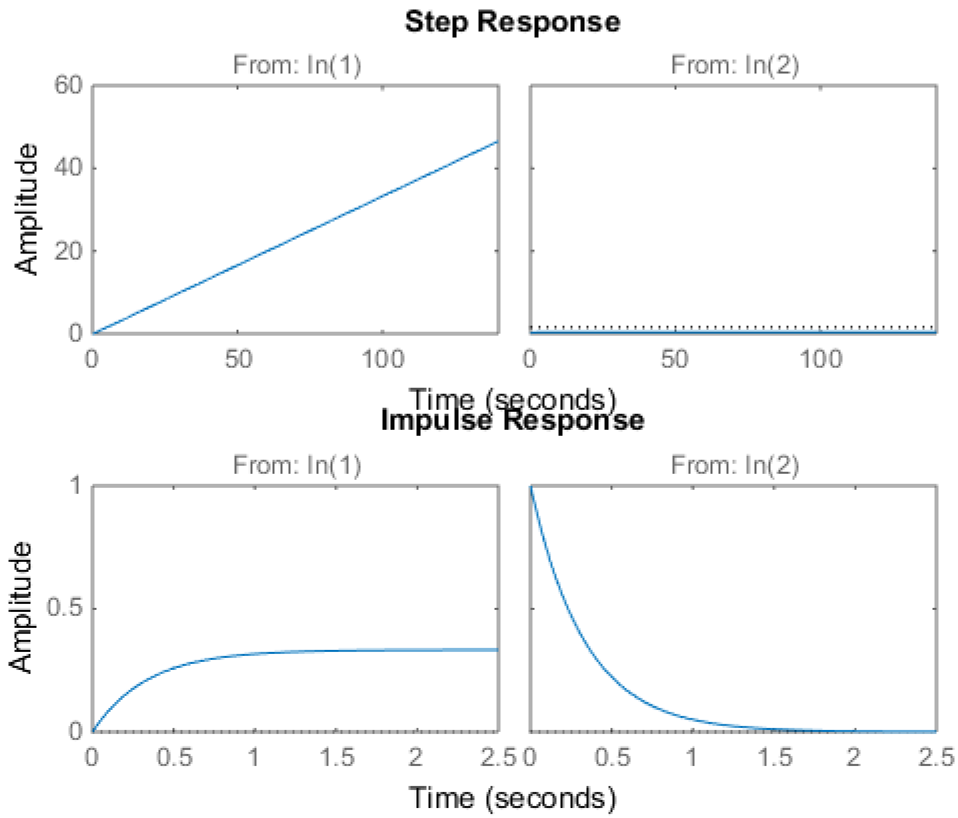
Part 2.b

Please plot the outputs of these two systems with respect to step input and impulse input.

```
sys1 = tf({num1(1, :), num1(2, :)}, den1);
```

```
sys2 = tf({num2(1, :), num2(2, :)}, den2);
figure
subplot(211), step(sys1)
subplot(212), impulse(sys1)
figure
subplot(211), step(sys2)
subplot(212), impulse(sys2)
```





Part 2.c

Based on the previous two steps, can you conclude these dynamic systems are zero-state equivalent? Yes they are zero-state equivalent. Their transfer functions are approximately equivalent

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