Matlab Code

```
% Hunter Phillips
% Homework 6
% MAE 488
% 03/10/19

clc
clear
format compact

%% Header
d_bullets = repmat('*', 50, 1); % concise way to make a lot of chars
fprintf('%c',d_bullets)
fprintf('\nMAE 488, Homework #6, Spring 2019, Hunter Phillips\n')
fprintf('%c',d_bullets)
fprintf('\n\n')

clear

%% Problem 8M

su_bullets = repmat('*', 25, 1); % setting up cmd line output
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 8M\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

% X(s)/F(s)
sys1=tf(4,[1,0]);
sys2=feedback(tf(1,[1,0]),8);
sys3=series(sys1,sys2);
sys4=feedback(sys3,6);
X_s_F_s = sys4

% X(s)/G(s)
sys4=sys2;
sys5=series(24,tf(1,[1,0]));
sys6=-feedback(sys4,sys5);
X_s_G_s = sys6


%% Problem 9M

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 9M\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

% C(s)/R(s)
sys1=tf([4,10],[3,1]);
sys2=tf(1,[7,1]);
sys3=series(sys1,sys2);
sys4=feedback(sys3,1);
C_s_R_s = sys4

% C(s)/D(s)
sys5=-feedback(sys2,sys1);
X_s_G_s = sys5

%% Problem 23M (b)

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 23M (b)\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

A = [-5, 3; 1, -4];
B = [4, 0;0, 5];
C = [1, 0];
D = [0, 0];
```

```
sys = ss(A,B,C,D);

fprintf('X_1(s)/U_1(s) is from input 1 to output\n')
fprintf('X_1(s)/U_2(s) is from input 2 to output\n')

transfer_fun = tf(sys)

%% Problem 25M (b)

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 25M (b)\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

sys1 = tf([1, 2], [1, 4, 3]);
sys2 = ss(sys1)

fprintf('The model is:\n')
fprintf('z_1'' = %.0f*z_1 %.1f*z_2 + %.0f*f\n',sys2.A(1), sys2.A(3), sys2.B(1))
fprintf('z_2'' = %.0f*z_1\n', sys2.A(2))
fprintf('  y  = %.1f*z_1 + %.1f*z_2\n', sys2.C(1), sys2.C(2))

%% Problem 35M

f1 = figure(1);
su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 35M\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

[t,v] = ode45('problem35',[0, 7], 0);
plot(t,v)
xlabel('t (sec)')
ylabel('v (ft/sec)')
title({'MAE 488, Homework 6, Problem 6.35M'},'interpreter','latex')
ylim([0 275])

fprintf('Results Plotted in Figure 1\n')
print(f1,'..\results\problem_5_35M.png','-dpng','-r1200');

%% Problem 41S

f2 = figure(2);

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 41S\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

sim('problem_41s')

plot(simout.time, simout.data,'r')
title({'MAE 488, Homework 6, Problem 6.41S'},'interpreter','latex')
xlabel('t')
ylabel('y(t)')

fprintf('Results Plotted in Figure 2\n')
print(f2,'..\results\problem_5_41S.png','-dpng','-r1200');

%% Problem 45S

f3 = figure(3);

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 45S\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

A_45s = [-5, 3; 0 -4]
B_45s = [2;0]
```

```
C_45s = [1, 3; 0, 1]
D_45s = [2;0]

sim('problem_45s')

plot(simout.time, simout.data)
title({'MAE 488, Homework 6, Problem 6.45S'},'interpreter','latex')
xlabel('t')
legend('y_1(t)','y_2(t)','location','southeast','fontsize',16)
ylim([-2 3])

fprintf('\nResults Plotted in Figure 3\n')
print(f3,'..\results\problem_5_45S.png','-dpng','-r1200');



%% Problem 46S

f4 = figure(4);

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 46S\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

A_45s = [-5, 3; 0 -4]
B_45s = [0;0]
C_45s = [1, 3; 0, 1]
D_45s = [0;0]

sim('problem_46s')

plot(simout.time, simout.data)
title({'MAE 488, Homework 6, Problem 6.46S'},'interpreter','latex')
xlabel('t')
legend('y_1(t)','y_2(t)','location','northeast','fontsize',16)
ylim([-1 15])
grid

fprintf('\nResults Plotted in Figure 4\n')
print(f4,'..\results\problem_5_46S.png','-dpng','-r1200');

%% Problem 28M

format long
f5 = figure(5);

su_bullets = repmat('*', 25, 1);
fprintf('\n\n')
fprintf('%c',su_bullets)
fprintf('\nProblem 28M\n')
fprintf('%c',su_bullets)
fprintf('\n\n')

% part a
m1 = 36;
m2 = 240;
k1 = 1.6e+5;
k2 = 1.6e+4;
c1 = 98;

A = [0, 1, 0, 0; -k1/m1, -c1/m1, k1/m1, c1/m1; ...
     0, 0, 0, 1; k1/m2, c1/m2, -(k1+k2)/m2, -c1/m2];
B = [0; 0; 0; k2/m2];
C = [1, 0, 0, 0; 0, 0, 1, 0];
D = [0; 0];

fprintf('Part A\n-------\n')
sys = ss(A,B,C,D)

% part b
fprintf('\nPart B\n-------\n\n')
fprintf('Results Plotted in Figure 5\n\n')
impulse(sys)
title({'MAE 488, Homework 6, Problem 5.28M'},'interpreter','latex')
```

```
% part c
fprintf('\nPart C\n-------\n\n')
print(f5,'..\results\problem_5_28M.png','-dpng','-r1200');

% characteristic polynomial
po = poly(A);
fprintf('Characteristic Polynomial:\n')
fprintf('%.2fs^4 + %.2fs^3 + %.2fs^2 + %.2fs^1 + %.2f = 0\n\n'...
        ,po(1), po(2), po(3), po(4), po(5))

% roots
roots = eig(A)

% part d
fprintf('\n\nPart D\n-------\n\n')
tfsys = tf(sys);
X1_s_Y_s = tfsys(1)
X2_s_Y_s = tfsys(2)
```

Matlab Output

```
**************************************************
MAE 488, Homework #6, Spring 2019, Hunter Phillips
**************************************************

*************************
Problem 8M
*************************

X_s_F_s =

       4
  --------------
  s^2 + 8 s + 24

Continuous-time transfer function.

X_s_G_s =

       -s
  --------------
  s^2 + 8 s + 24

Continuous-time transfer function.
```

****

Problem 9M

****

C_s_R_s =

```
      4 s + 10
  -----------------
  21 s^2 + 14 s + 11
```

Continuous-time transfer function.

X_s_G_s =

```
      -3 s - 1
  -----------------
  21 s^2 + 14 s + 11
```

Continuous-time transfer function.

****

Problem 23M (b)

****

X_1(s)/U_1(s) is from input 1 to output

X_1(s)/U_2(s) is from input 2 to output

```
transfer_fun =

  From input 1 to output:
     4 s + 16
  --------------
  s^2 + 9 s + 17

  From input 2 to output:
        15
  --------------
  s^2 + 9 s + 17

Continuous-time transfer function.
```

****

Problem 25M (b)

****

```
sys2 =

  A =
         x1    x2
   x1    -4  -1.5
   x2     2     0

  B =
       u1
   x1   2
   x2   0

  C =
        x1   x2
   y1  0.5  0.5

  D =
       u1
   y1   0

Continuous-time state-space model.
```

The model is:

z_1' = -4*z_1 -1.5*z_2 + 2*f

z_2' = 2*z_1

y = 0.5*z_1 + 0.5*z_2

****

Problem 35M

****

Results Plotted in Figure 1

****

Problem 41S

****

Results Plotted in Figure 2

****

Problem 45S

****

```
A_45s =
    -5     3
     0    -4
B_45s =
     2
     0
C_45s =
     1     3
     0     1
D_45s =
     2
     0
```

Results Plotted in Figure 3

****

Problem 46S

****

A_45s =

-5 3

0 -4

B_45s =

0

0

C_45s =

1 3

0 1

D_45s =

0

0

Results Plotted in Figure 4

****

Problem 28M

****

Part A

----

sys =

A =

	x1	x2	x3	x4
x1	0	1	0	0
x2	-4444	-2.722	4444	2.722
x3	0	0	0	1
x4	666.7	0.4083	-733.3	-0.4083

B =

	u1
x1	0
x2	0
x3	0
x4	66.67

C =

	x1	x2	x3	x4
y1	1	0	0	0
y2	0	0	1	0

D =

```
     u1
 y1   0
 y2   0
```

Continuous-time state-space model.

Part B

Results Plotted in Figure 5

Part C

Characteristic Polynomial:

1.00s^4 + 3.13s^3 + 5177.78s^2 + 181.48s^1 + 296296.30 = 0

roots =

-1.565246984696029 +71.536397419391108i

-1.565246984696029 -71.536397419391108i

-0.000030793081745 + 7.607327461964152i

-0.000030793081745 - 7.607327461964152i

Part D

X1_s_Y_s =

```
            181.5 s + 2.963e05
  ----------------------------------------------
  s^4 + 3.131 s^3 + 5178 s^2 + 181.5 s + 2.963e05
```

Continuous-time transfer function.

X2_s_Y_s =

```
        66.67 s^2 + 181.5 s + 2.963e05
  ----------------------------------------------
  s^4 + 3.131 s^3 + 5178 s^2 + 181.5 s + 2.963e05
```

Continuous-time transfer function.

Matlab Figures

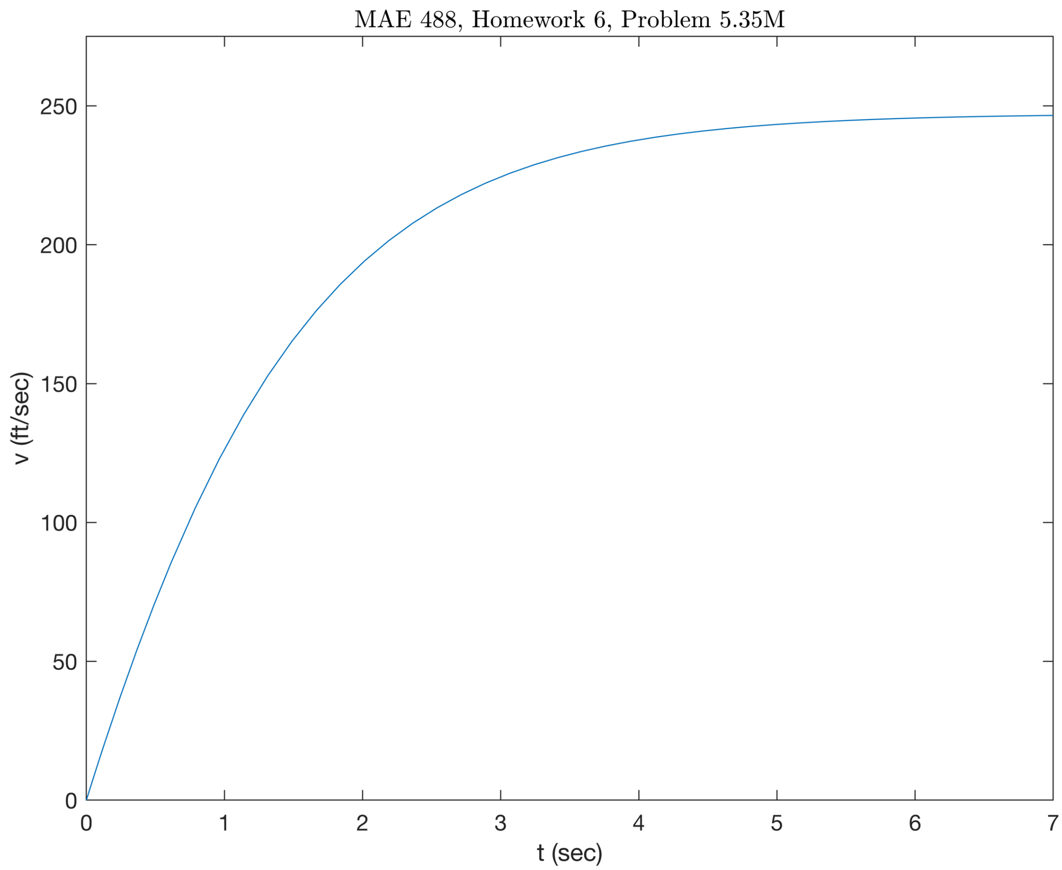


Figure 1: Problem 5.35M

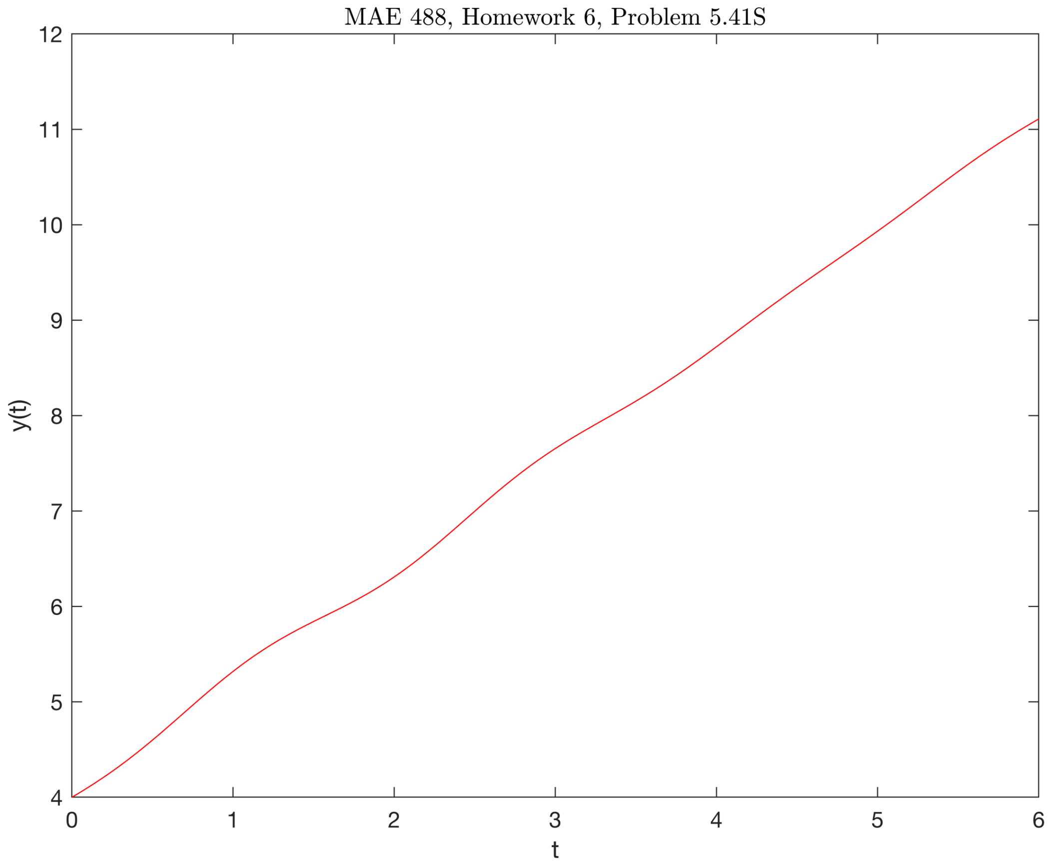


Figure 2: Problem 5.41S

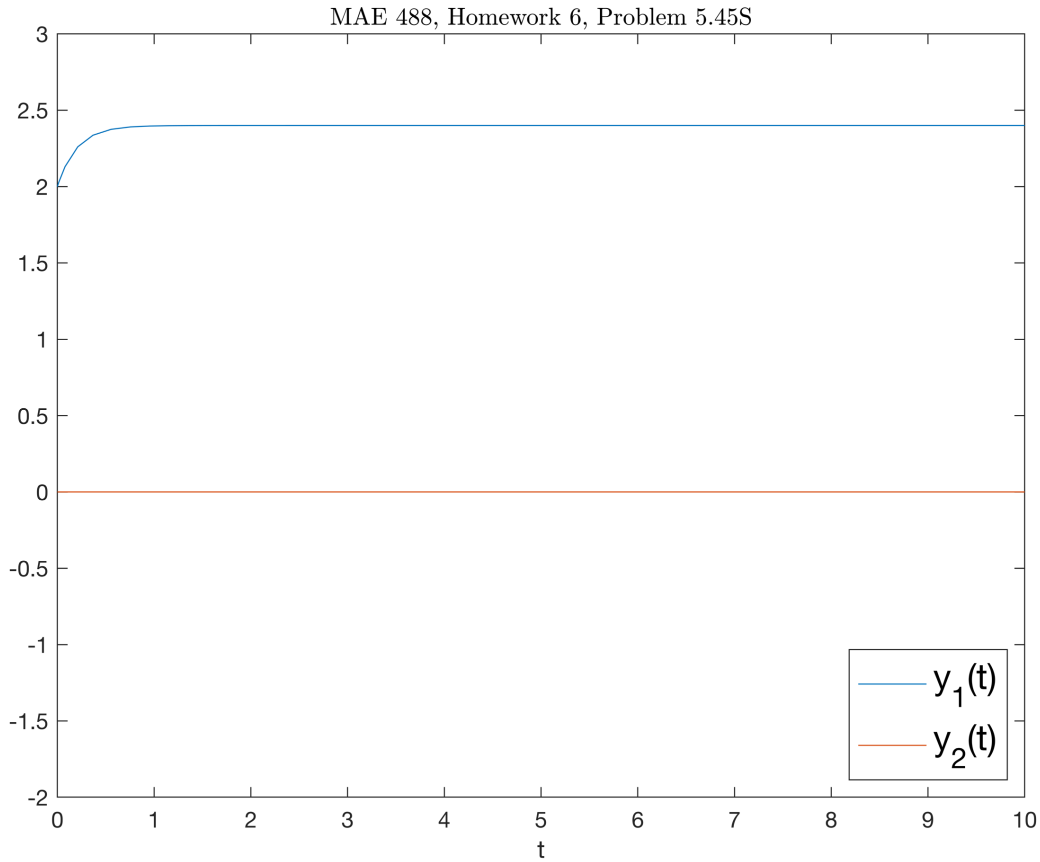


Figure 3: Problem 5.45S

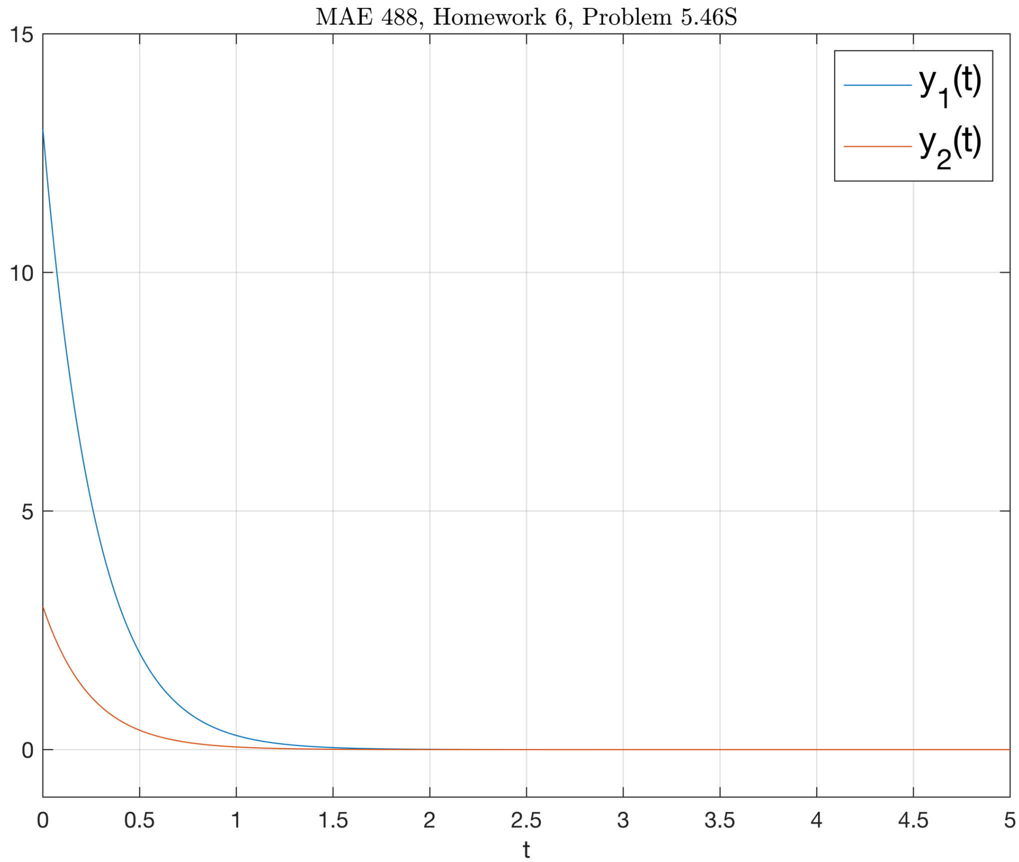


Figure 4: Problem 5.46S

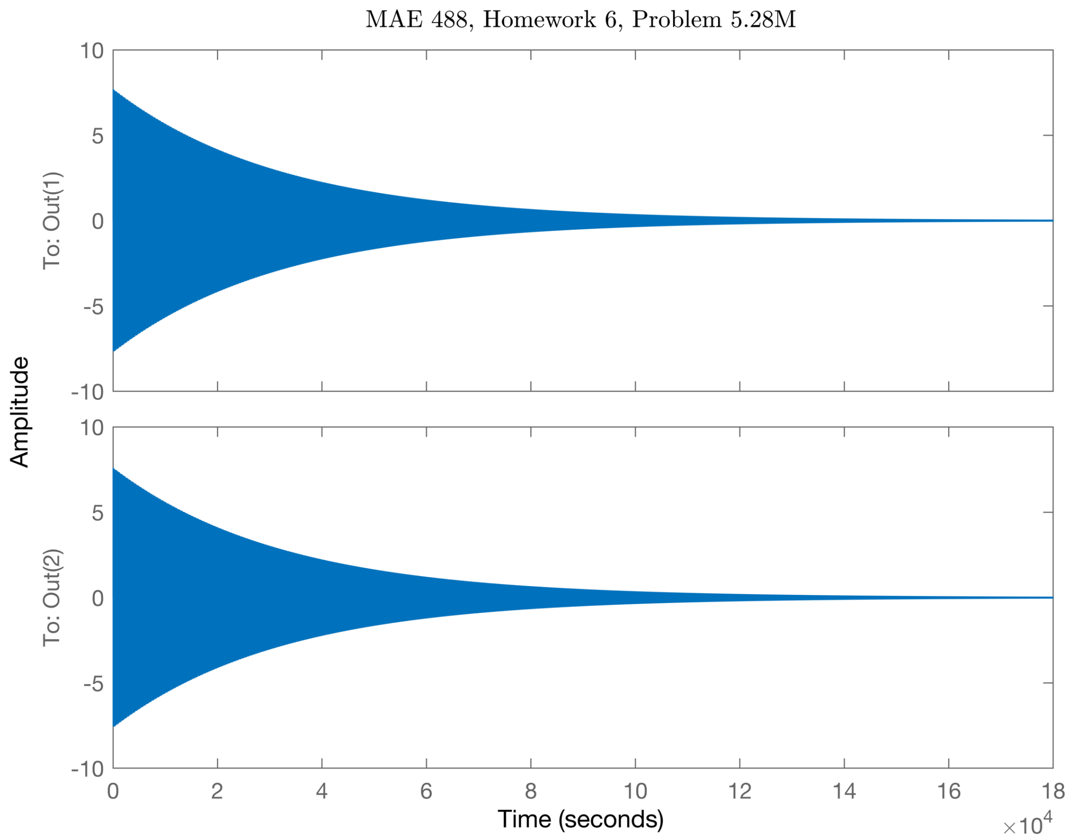
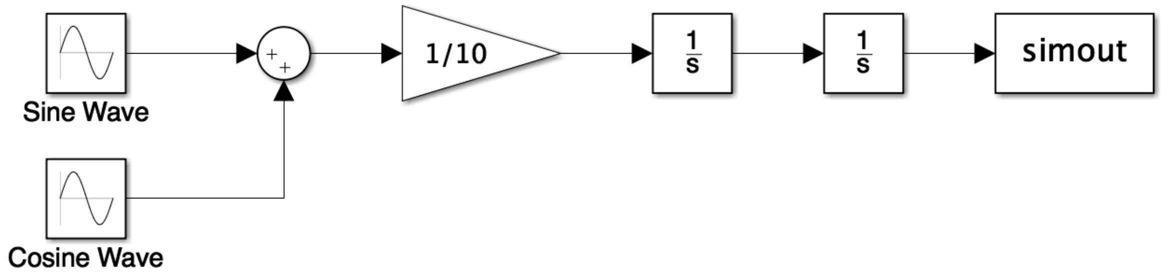
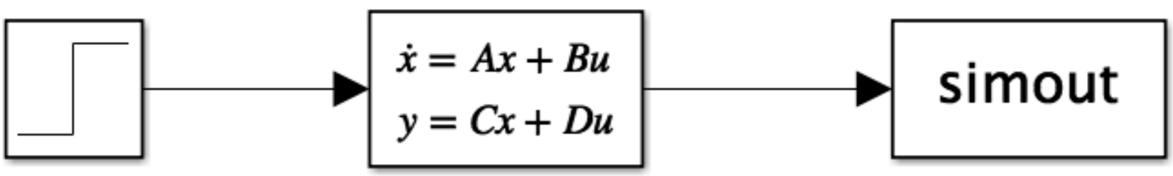


Figure 5: Problem 5.28M

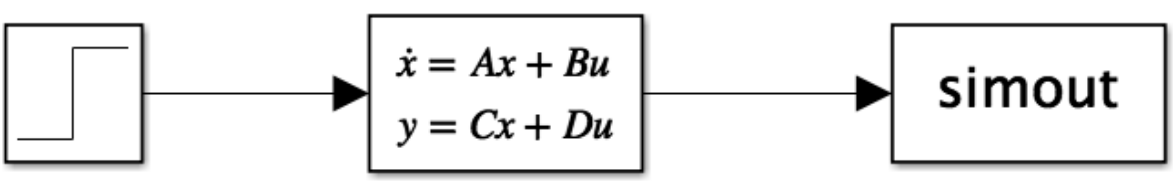
Simulink Models



Problem 41.S



Problem 45.S



Problem 46.S