Lab 1

Task 1

Determine Desired Characteristic Equation

```
clear; clc;

% Given
zeta = sqrt(2)/2;
omega_n = 2;

syms lambda

% Setting this equation equal to zero yields the desired characteristic
% equation, and finding the roots yields the desired poles

FSF_CE = lambda^2 + 2*zeta*omega_n*lambda + omega_n^2
```

FSF_CE = $\lambda^2 + 2\sqrt{2}\,\lambda + 4$

```
lambda_sol = roots([1, 2*zeta*omega_n, omega_n^2])
```

```
lambda_sol = 2×1 complex
  -1.4142 + 1.4142i
  -1.4142 - 1.4142i
```

Determine Gain Matrix (K) for Desired Poles

```
% System State Space Representation
A = [0 1; -1.62 -0.57];
B = [0; 4];
C = [1 0; 0 1];

% Use MatLab's Acker function to determine the gain matrix
K = acker(A, B, lambda_sol)
```

```
K = 1×2
    0.5950    0.5646
```

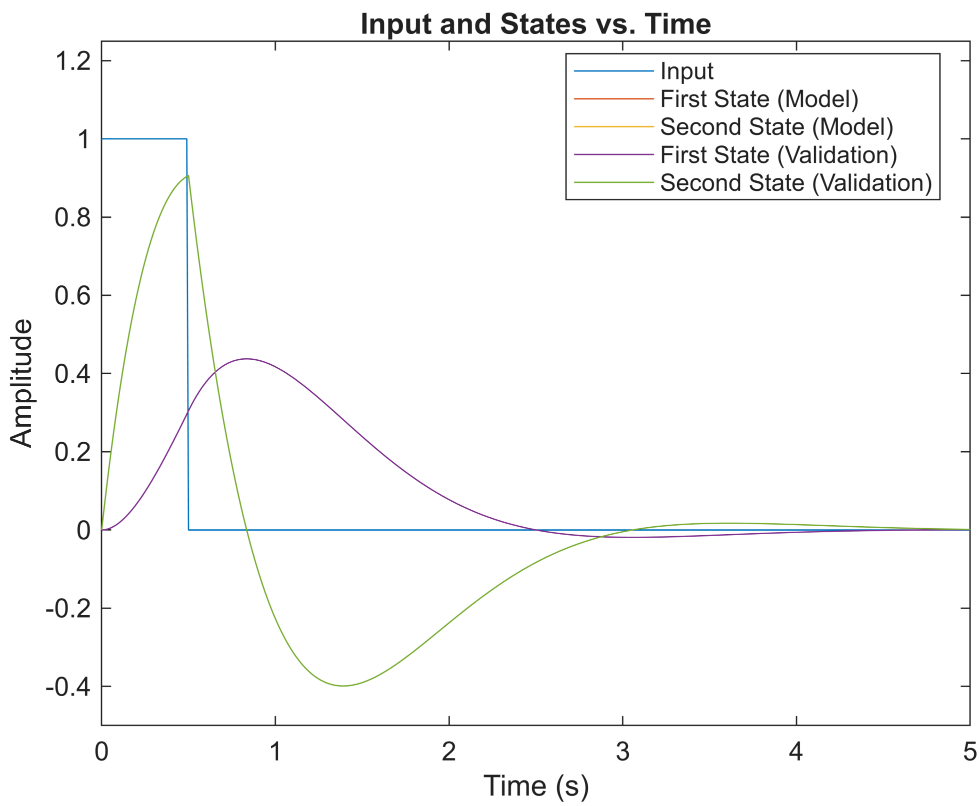
Run the Simulink Model, lsim Model, and Create Plots

```
% Runs Simulink Model
out_FSF = runModel(A, B, C, K, 0, "FSF");

% Creates ss representation of system and runs lsim
sys = ss(A - B*K, B, C, 0);
y = lsim(sys, out_FSF.input, out_FSF.tout);

figure
plot(out_FSF.tout, out_FSF.input,...
    out_FSF.tout, out_FSF.ybar(:,1),...
```

```
    out_FSF.tout, out_FSF.ybar(:,2),...
    out_FSF.tout, y(:,1),...
    out_FSF.tout, y(:,2));
xlim([0, 5])
ylim([-0.5 1.25])
title("Input and States vs. Time")
xlabel("Time (s)")
ylabel("Amplitude")
legend("Input", "First State (Model)", "Second State (Model)",...
    "First State (Validation)", "Second State (Validation)",...
    "Location", "best")
```



Task 2

Determine Desired Observer Characteristic Equations

```
syms lambda

% Setting this equation equal to zero yields the desired observer
% characteristic equation; Note that there are three equations for each of
% the three pole placement scenarios

OBS_CE_1 = expand((lambda + 2)^2)
```

OBS_CE_1 = $\lambda^2 + 4\,\lambda + 4$

```
lambda_sol_1 = [-2; -2]
```

```
lambda_sol_1 = 2×1
    -2
    -2
```

```
OBS_CE_2 = expand((lambda + 4)^2)
```

OBS_CE_2 = $\lambda^2 + 8\,\lambda + 16$

```
lambda_sol_2 = [-4; -4]
```

```
lambda_sol_2 = 2×1
    -4
    -4
```

```
OBS_CE_3 = expand((lambda + 8)^2)
```

OBS_CE_3 = $\lambda^2 + 16\,\lambda + 64$

```
lambda_sol_3 = [-8; -8]
```

```
lambda_sol_3 = 2×1
    -8
    -8
```

Determine Gain Matrix (L) for Desired Poles

```
% Redefine C for the Observer Case
C_obs = [1 0];
% Use MatLab's Acker function to determine the gain matrix
L_1 = acker(A', C_obs', lambda_sol_1)'
```

```
L_1 = 2×1
    3.4300
    0.4249
```

```
L_2 = acker(A', C_obs', lambda_sol_2)'
```

```
L_2 = 2×1
    7.4300
   10.1449
```

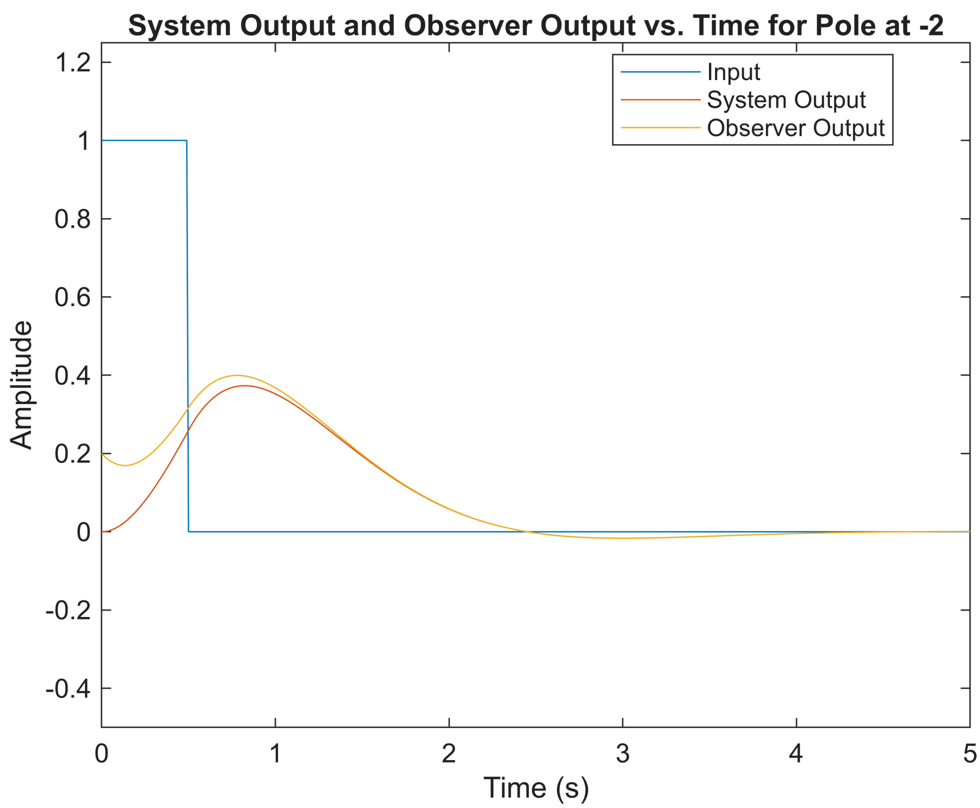
```
L_3 = acker(A', C_obs', lambda_sol_3)'
```

```
L_3 = 2×1
   15.4300
   53.5849
```

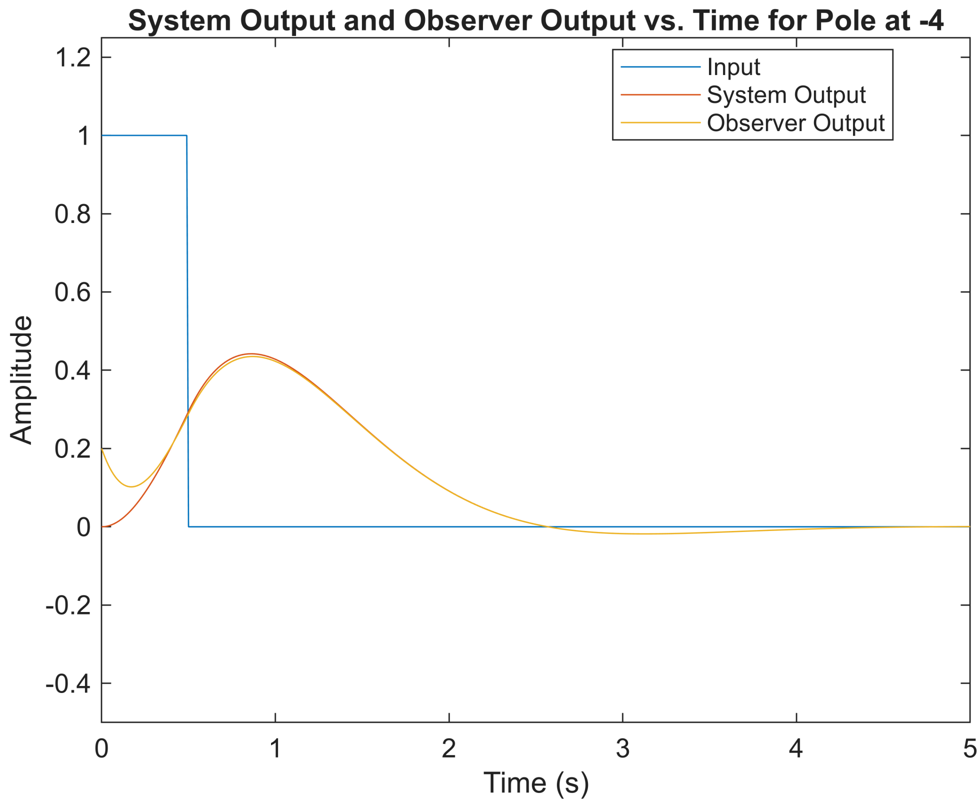
Run the Simulink Model and Create Plots

```
out_OBS_1 = runModel(A, B, C_obs, K, L_1, "OBS");
figure
```

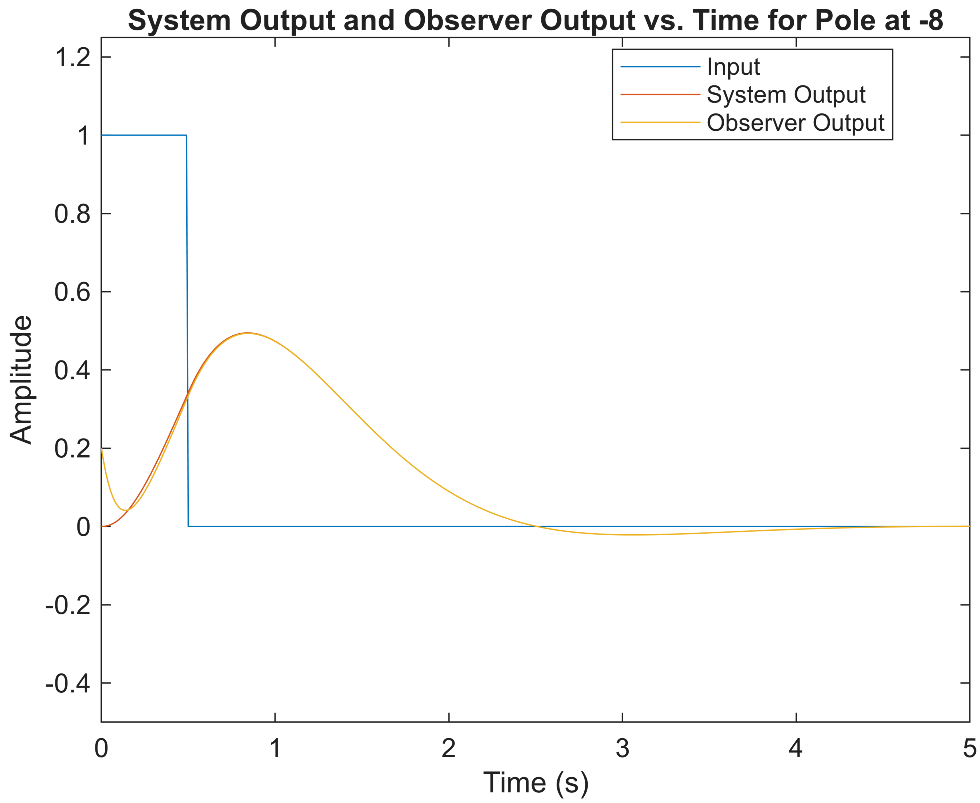
```
plot(out_OBS_1.tout, out_OBS_1.input,...
    out_OBS_1.tout, out_OBS_1.ybar,...
    out_OBS_1.tout, out_OBS_1.yhat)
xlim([0, 5])
ylim([-0.5 1.25])
title("System Output and Observer Output vs. Time for Pole at -2")
xlabel("Time (s)")
ylabel("Amplitude")
legend("Input", "System Output", "Observer Output",...
    "Location", "best")
```




```
out_OBS_2 = runModel(A, B, C_obs, K, L_2, "OBS");
figure
plot(out_OBS_2.tout, out_OBS_2.input,...
    out_OBS_2.tout, out_OBS_2.ybar,...
    out_OBS_2.tout, out_OBS_2.yhat)
xlim([0, 5])
ylim([-0.5 1.25])
title("System Output and Observer Output vs. Time for Pole at -4")
xlabel("Time (s)")
ylabel("Amplitude")
legend("Input", "System Output", "Observer Output",...
    "Location", "best")
```




```
out_OBS_3 = runModel(A, B, C_obs, K, L_3, "OBS");
figure
plot(out_OBS_3.tout, out_OBS_3.input,...
    out_OBS_3.tout, out_OBS_3.ybar,...
    out_OBS_3.tout, out_OBS_3.yhat)
xlim([0, 5])
ylim([-0.5 1.25])
title("System Output and Observer Output vs. Time for Pole at -8")
xlabel("Time (s)")
ylabel("Amplitude")
legend("Input", "System Output", "Observer Output",...
    "Location", "best")
```


System Output and Observer Output vs. Time for Pole at -8
Input
System Output
Observer Output
Amplitude
Time (s)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
1
2
3
4
5