Experiment 4.1

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Objectives

To evaluate the effect of pole and zero location upon the time response of first- and second-order systems.

Minimum Required Software Packages

MATLAB, Simulink, and the Control System Toolbox.

Prelab

Problem 1

Given the transfer function $G(s) = \frac{a}{s+a}$, evaluate settling time and rise time for the following values of *a*: 1,2,3,4. Also, plot the poles.

Answer:

```
syms s;
a=1;
G(s) = a/(s+a);get_param('Ex4_1_P1/TF1', 'Numerator');
```

```
Error using InputOutputModel/subsasgn (line 57)
Cannot assign a model of class "sym" into a model of class "tf".
```

```

sys=tf([a],[1 a])
step(sys)
pzmap(sys)
S=stepinfo(sys);
RiseTime=S.RiseTime
SettlingTime=S.SettlingTime

a=2
sys=tf([a],[1 a])
step(sys)
pzmap(sys)
S=stepinfo(sys);
RiseTime=S.RiseTime
SettlingTime=S.SettlingTime

a=3
sys=tf([a],[1 a])
step(sys)
pzmap(sys)
S=stepinfo(sys);
RiseTime=S.RiseTime
```

```
SettlingTime=S.SettlingTime

a=4
sys=tf([a],[1 a])
step(sys)
pzmap(sys)
S=stepinfo(sys);
RiseTime=S.RiseTime
SettlingTime=S.SettlingTime
```

Problem 2

Given the transfer function $G(s) = \dfrac{b}{s^2 + as + b}$.

2.a

Evaluate precent overshoot, settling time, peak time, and rise time for the following values: $a = 4$, $b = 25$. Also, plot the poles.

Answer:

```
a=4;
b=25;

sys_p2a = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys_p2a)
```

2.b

Calculate the values of *a* and *b* so that the imaginary part of the poles remains the same but the real part is increased two times over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a);
new_poles=real(poles)*2 + i*imag(poles);
new_denominator=poly(new_poles);
a = new_denominator(1,2)
b = new_denominator(1,3)
```

```
sys = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

2.c

Calculate the values of *a* and *b* so that the imaginary part of the poles remains the same but the real part is decreased by one half over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a)
new_poles=real(poles)/2 + i*imag(poles)
new_denominator=poly(new_poles)
a = new_denominator(1,2)
b = new_denominator(1,3)

sys = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

Problem 3

3.a

For the system of Prelab 2a, calculate the values of *a* and *b* so that the real part of the poles remains the same but the imaginary part is increased two times over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a)
new_poles=real(poles) + i*2*imag(poles)
new_denominator=poly(new_poles)
a = new_denominator(1,2)
b = new_denominator(1,3)

sys = tf([b],[1 a b]);
S=stepinfo(sys);
```

```
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

3.b

For the system of Prelab 2a, calculate the values of *a* and *b* so that the real part of the poles remains the same but the imaginary part is increased four times over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a);
new_poles=real(poles) + i*4*imag(poles);
new_denominator=poly(new_poles);
a = new_denominator(1,2)
b = new_denominator(1,3)

sys = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

Problem 4

4.a

For the system of Prelab 2a, calculate the values of *a* and *b* so that the damping ratio remains the same but the natural frequency is increased two times over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a);
denominator=poly(poles);

a = denominator(1,2);
b = denominator(1,3);
denominator=poly(poles);

wn = sqrt(b)
dampining = a/(2*wn)

new_wn = 2*wn
```

```
new_dampining = dampining

new_denominator=[1 2*new_wn*new_dampining new_wn*new_wn];
a = new_denominator(1,2)
b = new_denominator(1,3)

sys = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

4.b

For the system of Prelab 2a, calculate the values of *a* and *b* so that the damping ratio remains the same but the natural frequency is increased four times over that of Prelab 2a, and repeat Prelab 2a.

Answer:

```
poles=pole(sys_p2a);
denominator=poly(poles);

a = denominator(1,2);
b = denominator(1,3);
denominator=poly(poles);

wn = sqrt(b);
dampining = a/(2*wn);

new_wn = 4*wn;
new_dampining = dampining;

new_denominator=[1 2*new_wn*new_dampining new_wn*new_wn];
a = new_denominator(1,2)
b = new_denominator(1,3)

sys = tf([b],[1 a b]);
S=stepinfo(sys);
OverShoot = S.Overshoot
SettlingTime = S.SettlingTime
PeakTime = S.PeakTime
RiseTime = S.RiseTime

pzmap(sys)
```

Problem 5

Briefly describe the effects on the time response as the poles are changed in each of the Prelabs 2, 3, and 4.

Answer:

Lab

Problem 1

Using Simulink, set up the systems of Prelab 1 and plot the step response of each of the four transfer functions on a single graph by using the Simulink LTI Viewer (See Appendix E.6 online for tutorial). Also, record the values of settling time and rise time for each step response.

For your Simulink, please provide a screenshot that clearly shows the system.

```
open_system("Ex4_1_P1/Scope")

TF1 = [get_param('Ex4_1_P1/TF1', 'Numerator') get_param('Ex4_1_P1/TF1', 'Denominator')]

% stepinfo(TF1)
% stepinfo(TF2)
% stepinfo(TF3)
% stepinfo(TF4)
```

Problem 2

Using Simulink, set up the systems of Prelab 2. Using the Simulink LTI Viewer, plot the step response of each of the three transfer functions on a single graph. Also, record the values of pervent overshoot, settling time, peak time, and rise time for each step response.

For your Simulink, please provide a screenshot that clearly shows the system.

```
% Insert your code here
```

Problem 3

Using Simulink, set up the systems of Prelab 2a and Prelab 3. Using the Simulink LTI Viewer, plot the step response of each of the three transfer functions on a single graph. Also, record the values of percent overshoot, settling time, peak time, and rise time for each step response.

For your Simulink, please provide a screenshot that clearly shows the system.

```
% Insert your code here
```

Problem 4

Using Simulink, set up the systems of Prelab 2a and Prelab 4. Using the Simulink LTI Viewer, plot the step response of each of the three transfer functions on a single graph. Also, record the values of percent overshoot, settling time, peak time, and rise time for each step response.

For your Simulink, please provide a screenshot that clearly shows the system.

```
% Insert your code here
```

Postlab

Problem 1

For the first-order systems, make a table of calculated and experimental values of settling time, rise time, and pole location.

Problem 2

For the second-order systems of Prelab 2, make a table of caluclated and experimental values of percent overshoot, settling time, peak time, rise time, and pole location.

Problem 3

For the second-order systems of Prelab 2a and Prelab 3, make a table of calculated and experimental values of percent overshoot, settling time, peak time, rise time, and pole location.

Problem 4

For the second-order systems of Prelab 2a and Prelab 4, make a table of calculated and experimental values of percent overshoot, settling time, peak time, rise time, and pole location.

Problem 5

Discuss the effects of pole location upon the time response for both first- and second-order systems. Discuss any discrepancies between your calculated and experimental values.