Week 2

Functions and Control System Toolbox

The factorial operation is defined below,

$$n! = 1 \cdot 2 \cdot 3 \cdots n$$

Some properties are listed below,

- $0! = 1$
- $1! = 1$
- $n! = n \cdot (n-1)!$

1. Write the code for factorial using `for`.
2. Write the code for factorial using a vector.
3. Write a function for factorial.
4. Write a recursive function, which calls itself, for factorial.

5. Define the transfer function $G(s) = \frac{1}{s+1}$ and plot its step response.
6. Acquire the unit feedback closed loop transfer function and plot its step response.
7. Store both step responses in individual vectors and plot them together on a figure.
8. Plot the step responses using `subplot`. Calculate the settling times and show them on each plot.

9. A first order transfer function is defined below,

$$G(s) = \frac{1}{s+p}$$

where $p = 1, 2, 3, 4, 5$. Using `subplot` plot the open loop and closed loop step responses for all p values.

A1

```
n=4;

f=1;
for x=n:-1:1
    f=f*x;
end
```

A2

```
x=1:n;
f=1;
for i=x
   f=f*i;
end
```

A3

```
function y=myfactorial(n)
    if n<=1 && n>=0
        y=1;
    elseif n<0
        y=nan;
    else
       f=1;
       for x=1:1:n
           f=f*x;
           y=f;
       end
    end
end
```

A4

```
function y=recfactorial(n)
    if n>=0 && n<=1
        y=1;
    else
        y=n*recfactorial(n-1);
    end
end
```

A5

```
figure(1);clf;hold on;grid on;
Gs=tf(1,[1 1]);
step(Gs);
```

A6

```
figure(2);clf;hold on;grid on;
step(feedback(Gs,1))
```

A7

```
t=0:0.01:5;
[y,t]=step(Gs,t);
[yc,t]=step(feedback(Gs,1),t);
figure(3);clf;hold on;grid on;
plot(t,y,'k','LineWidth',2,'DisplayName','Open loop');
plot(t,yc,'b','LineWidth',2,'DisplayName','Closed loop');
xlabel('time (sec)');
ylabel('gain');
title('Step response comparison')
legend('show');
```

A8

```
info1=stepinfo(Gs);
ts1=info1.SettlingTime;
info2=stepinfo(feedback(Gs,1));
ts2=info2.SettlingTime;

figure(4);clf;
subplot(2,1,1);cla;hold on;grid on;
plot(t,y,'k','LineWidth',2,'DisplayName','Open loop');
xlabel('time (sec)');
ylabel('gain');
title(['open loop' '  ts=' num2str(ts1)])
subplot(2,1,2);cla;hold on;grid on;
plot(t,yc,'k','LineWidth',2,'DisplayName','Closed loop');
xlabel('time (sec)');
ylabel('gain');
title(['closed loop' '  ts=' num2str(ts2)])
```

A9

```
t=0:0.01:5;
figure(1);clf;
subplot(2,1,1);cla;hold on;grid on;
xlabel('time (sec)');ylabel('gain');title('open loop');
subplot(2,1,2);cla;hold on;grid on;
xlabel('time (sec)');ylabel('gain');title('closed loop');

for p=1:5
    Gs=tf(1,[1 p]);
    [y,t]=step(Gs,t);
    [yc,t]=step(feedback(Gs,1),t);

    subplot(2,1,1);
    plot(t,y,'LineWidth',2,'DisplayName',['p= ',num2str(p)]);
    legend('show');

    subplot(2,1,2);
    plot(t,yc,'LineWidth',2,'DisplayName',['p= ',num2str(p)]);
    legend('show');
end
```