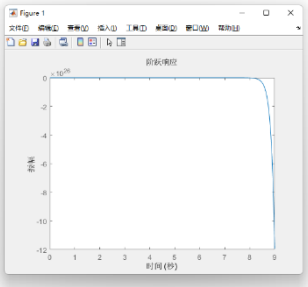
Preparation:

In Matlab, use the step command to plot the step response of the system.

```
L = 0.2; % effective length of pendulum
g = 9.81; % const
w = sqrt(g/L); % oscillation freqency
Pdm = tf([0,0,-w^2],[1,0,-w^2]); % transfer function model of Pendulum
step(Pdm); % step input
disp(Pdm);
%rlocus(Pdm); % root locus of Pendulum Model
```

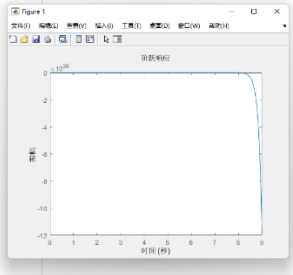


Labwork:

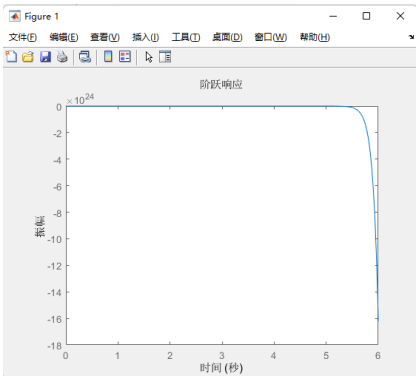
Question 5: variable pendulum under negative feedback:

K=0

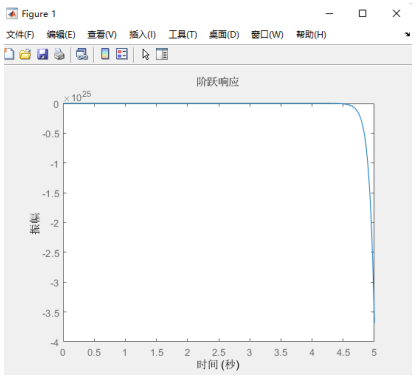
```
g = 9.81;       % gravity constant in m/s^2
L = 0.20;       % length of the pendulum in meters
omega = sqrt(g / L);

num = -omega^2; % numerator of the transfer function
den = [1, 0, -omega^2]; % denominator of the transfer function

P_s = tf(num, den); % create the transfer function


k = 0;
sysclp1 = feedback(P_s,k);
step(sysclp1);

sysclp2 = feedback(P_s,k,+1);
%step(sysclp2);

%rlocus(P_s); % For negative feedback
%rlocus(-P_s); % For positive feedback

% Plot the step response
%disp(sysclp1);
%disp(sysclp2);
%disp(P_s);

%step(P_s);

%title("Root Locus Analysis");
%xlabel("Im (seconds^-1 )");
%ylabel("Re (seconds^-1 )");
```



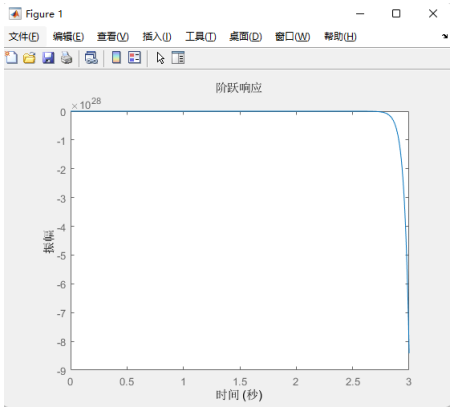
k=1



k=2

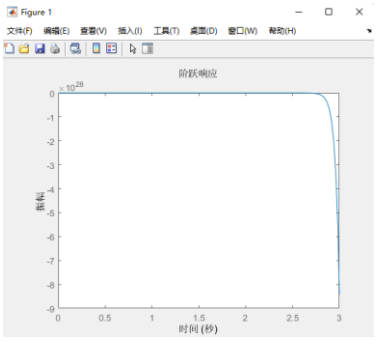


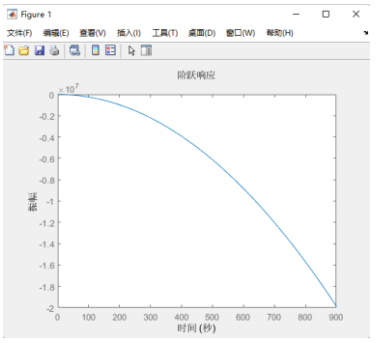
K=10

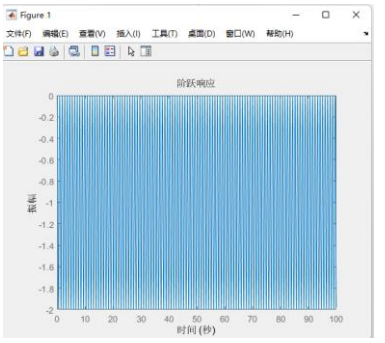


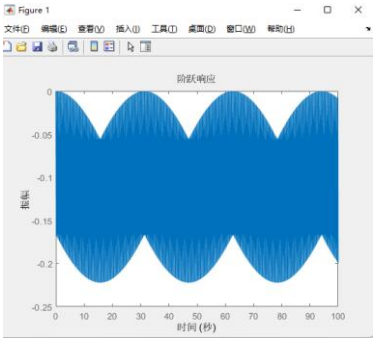
Question 6: Investigate positive feedback

K=0 k=1 k=2 k=10







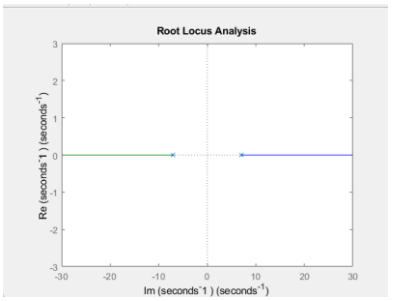


For a more readable diagram, add run time setting:

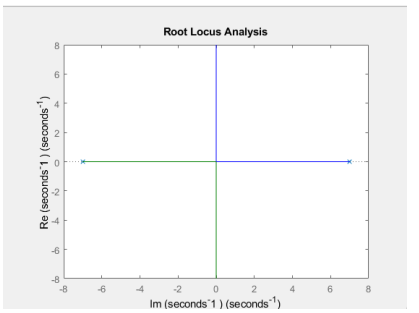
```
sysclp2 = feedback(P_s,k,+1);
t = 0 : 0.1 : 100;
step(sysclp2, t);
```

Question 7: Plot the root locus

positive feedback

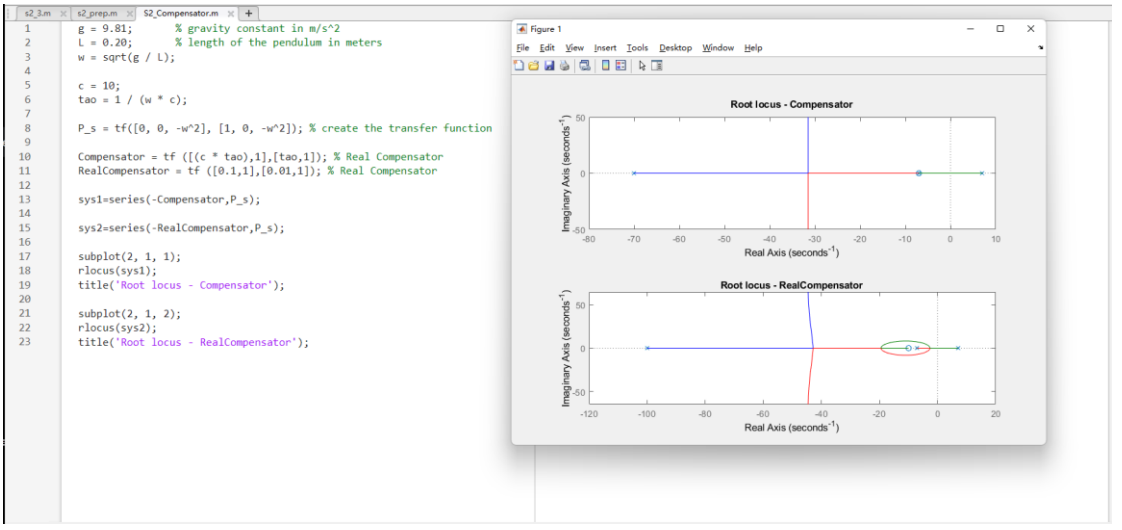


negative feedback



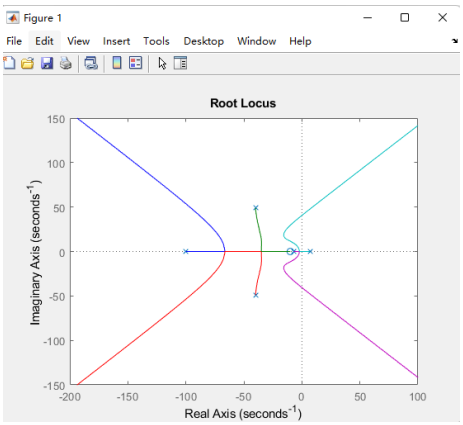
Question 8: Comment on stablilty

Question 10-11: Compensator

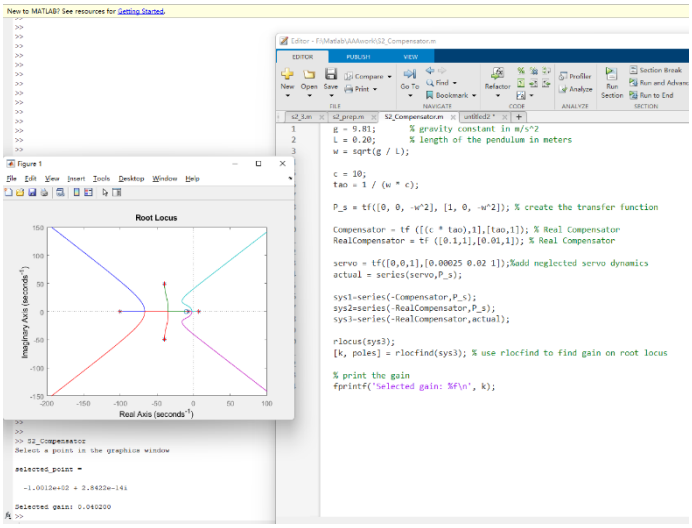


Question 13: neglected servo dynamics

Root locus:

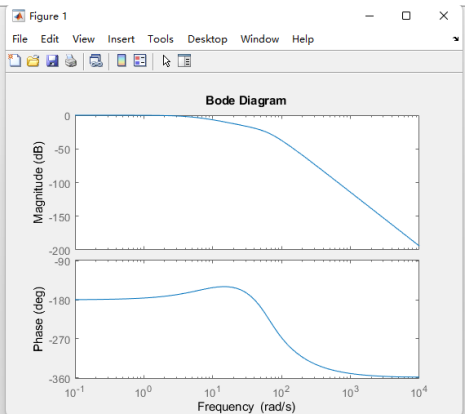


Rlocfind:



Question 14: Robustness

```
1   g = 9.81;       % gravity constant in m/s^2
2   L = 0.20;       % length of the pendulum in meters
3   w = sqrt(g / L);
4
5   c = 10;
6   tao = 1 / (w * c);
7
8   P_s = tf([0, 0, -w^2], [1, 0, -w^2]); % create the transfer function
9
10  RealCompensator = tf ([0.1,1],[0.01,1]); % Real Compensator
11
12  servo = tf([0,0,1],[0.00025 0.02 1]);%add neglected servo dynamics
13  actual = series(servo,P_s);
14
15  sys1=series(-RealCompensator,actual);
16  rlocus(sys1);
17
18  k = rlocfind (sys1); %demonstrate the value of K on Root Locus Diagram
19  sysclp = feedback (sys1,k); %Construct the Close Loop
20  bode(sysclp); % Bode(Gain&Phase Analysis)
21  %nyquistplot(sysclp); %Plot Nyquist Diagram
```



Nyquistplot: