ADCS Homework 6

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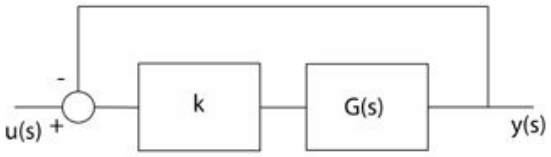
Given a system in a feedback loop,



$$G(s) = \frac{s^2 + 3s + 1}{s^4 + 2s^3 + 3s^2 + 1s + 1}$$

Problem 1

Formulate $G(s)$ in Matlab

```
G = tf([1 3 1], [1 2 3 1 1])
```

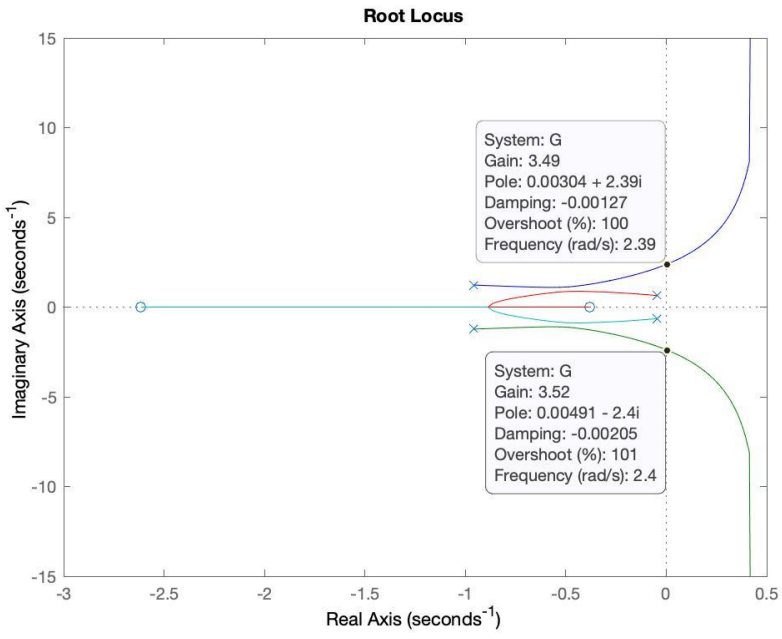
```
G =

        s^2 + 3 s + 1
  -------------------------
  s^4 + 2 s^3 + 3 s^2 + s + 1

Continuous-time transfer function.
```

Problem 2

Draw the Root Locus Plot.



Problem 3

At what gain values does the system go unstable?

Now, from this image we can see that the gain is unstable around $\pm 2.4j$. To find a more exact value, we will use rlocfind(G)

```
rlocfind(G,[0 + 1i*2.4])
```

```
ans = 3.5199
```

```
rlocfind(G, [0 - 1i*2.4])
```

```
ans = 3.5199
```

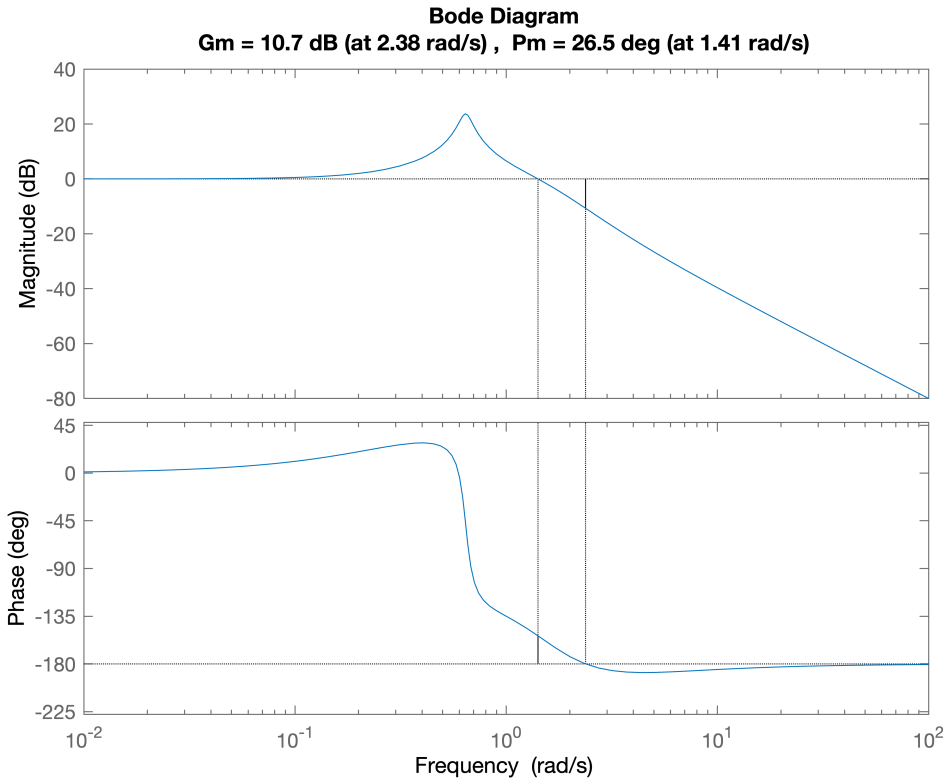
Therefore, the gain that leads to instability is

$$\text{gain} = 3.5199$$

Problem 4

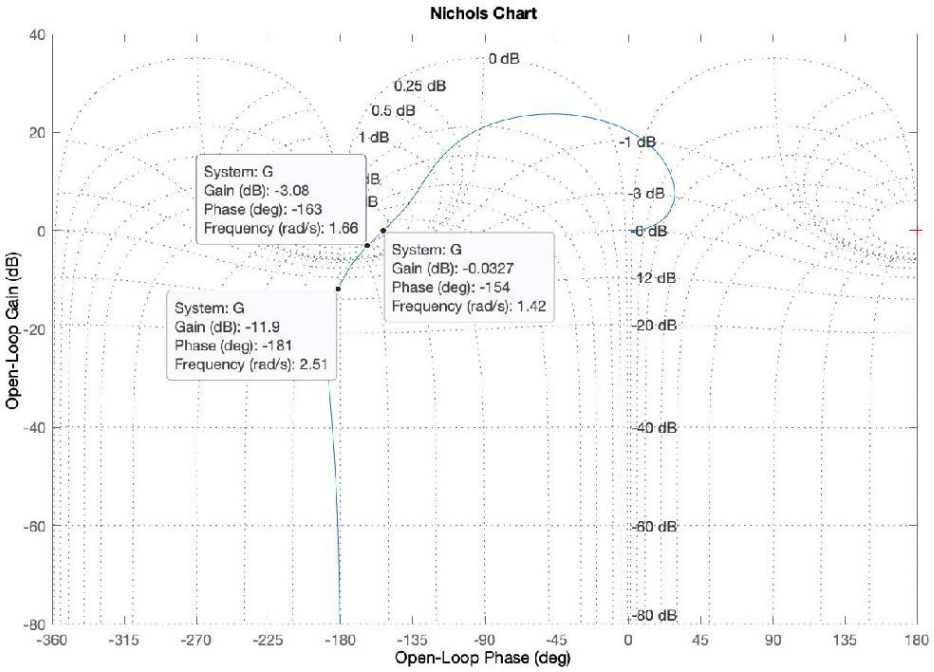
What are the gain and phase margins for the system?

```
margin(G)
```



Problem 5

Draw the Nichols plot for the system $G(s)$. Annotate the phase and gain margins.



Problem 6

For $K = 2$, what is the CLTF, $\frac{Y(s)}{U(s)}$?

From the block layout, the CLTF will be

$$\frac{Y(s)}{U(s)} = \frac{K(s)G(s)}{1 + K(s)G(s)}$$

Using $K = 2$, $G(s) = \frac{s^2 + 3s + 1}{s^4 + 2s^3 + 3s^2 + s + 1}$, we have

$$\frac{Y(s)}{U(s)} = \frac{2s^2 + 6s + 2}{s^4 + 2s^3 + 5s^2 + 7s + 2}$$

Problem 7

Plot the output of the step function, for $K = 2$.

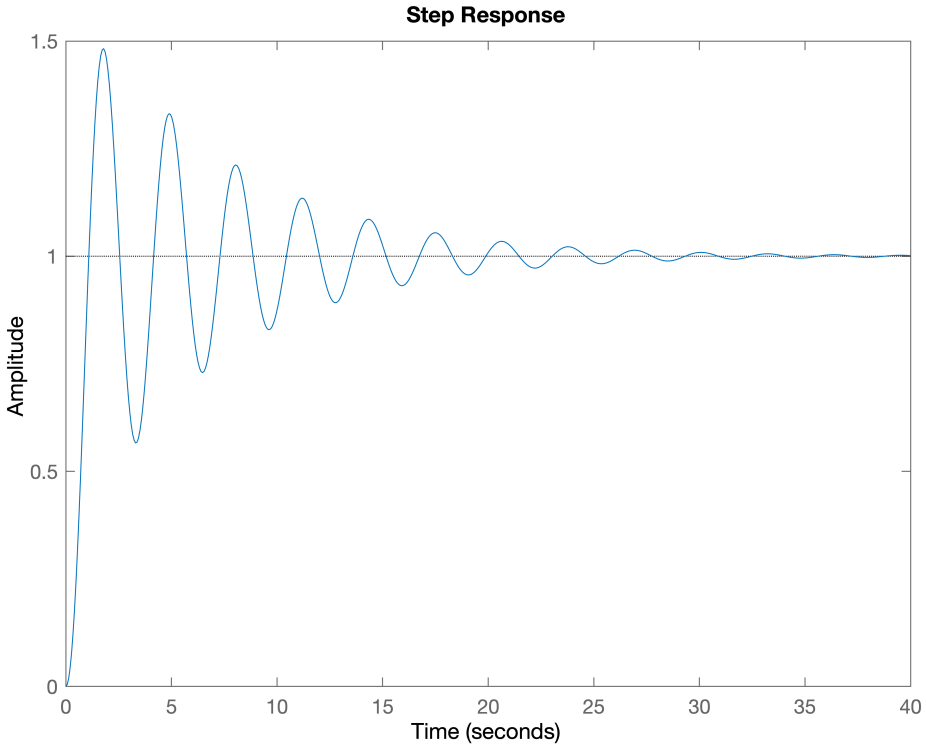
```
cltf = tf([2 6 2], [1 2 5 7 2])
```

```
cltf =

        2 s^2 + 6 s + 2
  ----------------------------
  s^4 + 2 s^3 + 5 s^2 + 7 s + 2

Continuous-time transfer function.
```

```
step(cltf)
```


Step Response
1.5
1
0.5
0
Amplitude
0
5
10
15
20
25
30
35
40
Time (seconds)