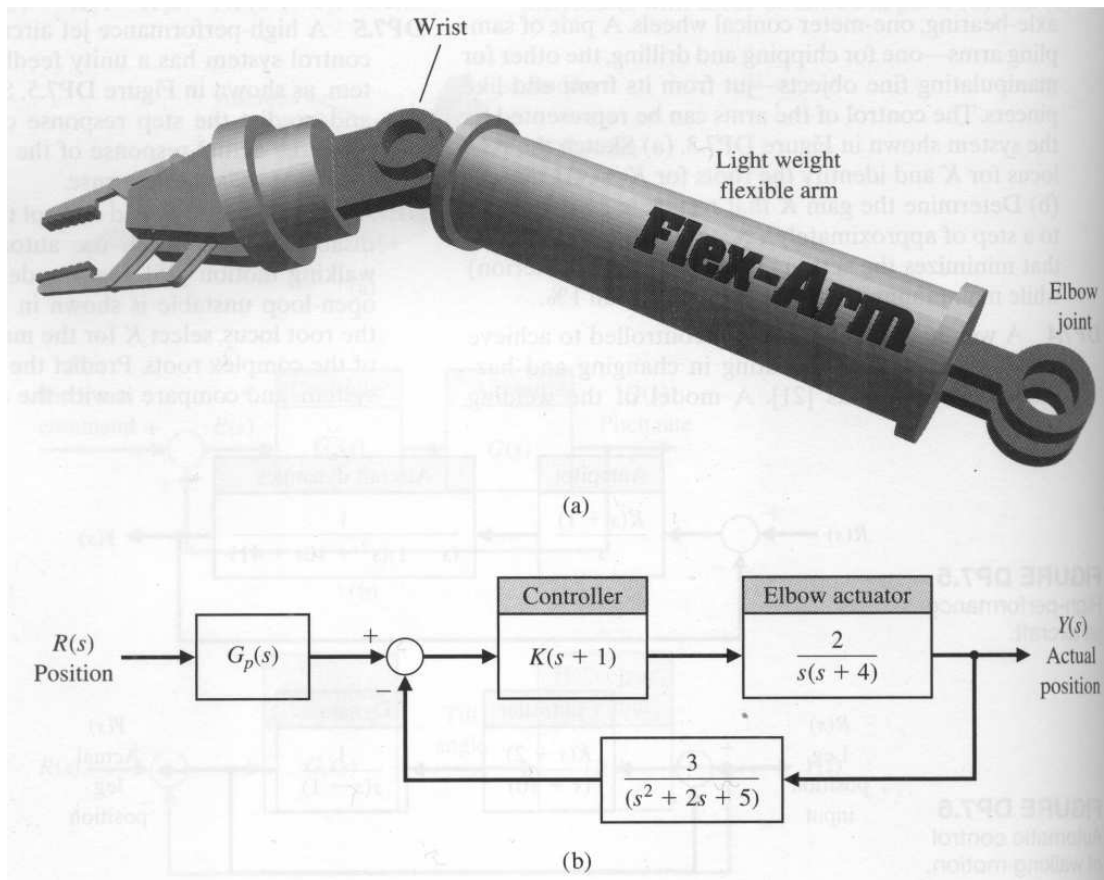


Design Problem: DP7.8



PART 1: Sketching the Root Locus

```
%DP7_8.m -chap7 Dorf
```

```
syms s g1 g2 h K
```

```
g1=K*(s+1);
```

```
g2=2/(s*(s+4));
```

```
h=3/(s^2+2*s+5);
```

```
L=1+ g1*g2*h;
```

```
display('Characteristic EQ if equated to 0')
```

```
pretty(L)
```

```
[n,d]=numden(L);
```

```
display('-K = 1/P(s) is given below from which we can extract P(s):')
```

```
pretty(solve(n,K))
```

```
% Execution produce: P(s)= num/den
```

```
num=[6 6];
```

```
den=[1 6 13 20 0];
```

```
rlocus(num,den)
```

```
% sgrid
```

```
title(' DP7.8')
```

Execution Results,

>> DP7_8

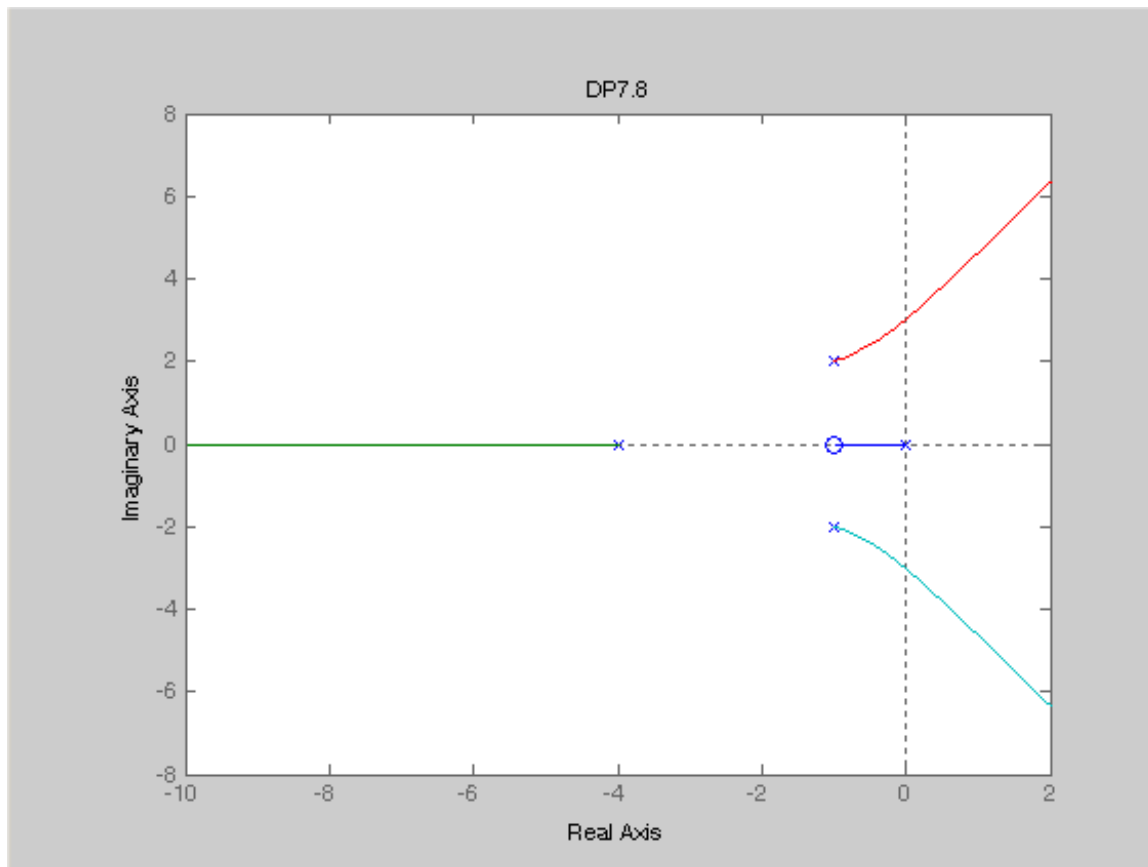
Characteristic EQ if equated to 0

$$1 + 6 \frac{K (s + 1)}{s (s + 4) (s + 2s + 5)}$$

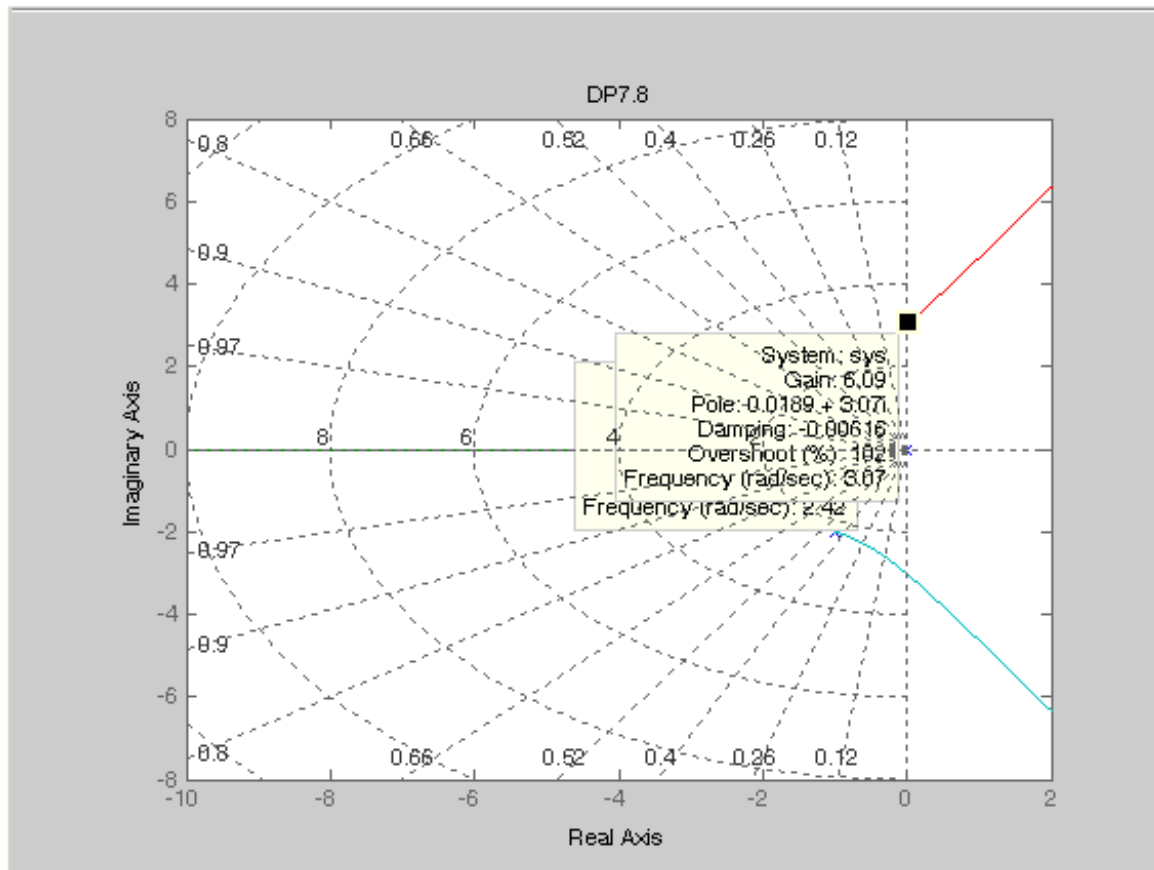
$-K = 1/P(s)$ is given below from which we can extract $P(s)$:

$$- 1/6 \frac{s (s + 6s + 13s + 20)}{s + 1}$$

>>



If % is remove in front of the command `sgrid`, we get,



Note, it appear the system is **unstable** if the gain $K > 6$.
(See PART 2 below for validity of this K value)

PART 2: Find range of positive gain K for Stable Robotic Arm Operation

- employing Routh-Hurwitz Stability Criterion from Chap 6 sec 6.2

Bishop

(NOTE: this code composed interactively and finalized)

```
% DP7_8sub.m
syms K s
Q=1+ 6*K*(s+1)/( s*(s+4)*(s^2+2*s+5));
[n,d] = numden(Q);
display('Char Polynomial')
Pol=sort(n);
pretty(Pol)
display(' ')
display(' Routh Array 1st Column:' )
display('s^4 row: 1')
display('s^3 row: 6')
display('s^2 row: (58-6K)')
display('s^1 row:')
R1=expand((58-6*K)*(20+6*K)-6^3*K)
display('s^0 row: 36*k')
display(' ')
display('s^0 row suggest K > 0 while s^2 row suggest K < ')
58/6
display('s^1 row suggest K < ')
eval(solve(R1,K))

display (' Thus for stable operation 0 < K < 5.8456 ')
```

Execution Results,

```
>> DP7_8sub
Char Polynomial
```

$$s^4 + 6s^3 + 13s^2 + 6sK + 20s + 6K$$

```
Routh Array 1st Column:
```

```
s^4 row: 1
s^3 row: 6
s^2 row: (58-6K)
s^1 row:
```

```
R1 =
```

```
1160+12*K-36*K^2
```

```
s^0 row: 36*k
```

```
s^0 row suggest  $K > 0$  while s^2 row suggest  $K <$ 
```

```
ans =
```

```
9.6667
```

```
s^1 row suggest  $K <$ 
```

```
ans =
```

```
-5.5122
```

```
5.8456
```

```
Thus for stable operation  $0 < K < 5.8456$ 
```

```
>>
```

Above is our Step 4, calculation of jw-axis Crossing points