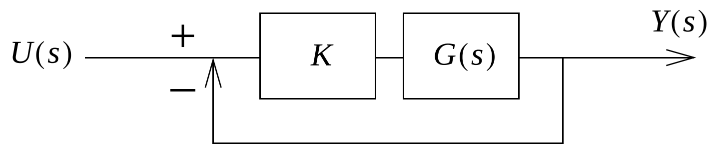
EECE 360 Homework - Root Locus

1) The following system has the closed-loop characteristic equation shown.
   - Find the value of K for which the system is stable.
   - Draw the Root Locus.



$$CE:\ s^3 + (K-4)s^2 + 10Ks + 29K = 0$$

$$Hint:\ s^3 + 20s^2 + 47s - 232 \approx (s+16.2)(s+6.1)(s-2.3)$$

$$\text{atan}(2/5) = 22° \qquad \text{atan}(2/9) = 13°$$

2) You are the new ECE360 Instructor and need to create a Root Locus quiz question. Identify the minimum components an open-loop transfer function must have in order for students to demonstrate the following abilities. Create an open-loop transfer that has all of these components but results in a question that is AS EASY AS POSSIBLE.
   - identify the parts of the real axis that contain the root-locus
   - compute assymptotes (centres and angles)
   - compute at least 1 break point
   - compute departure angles
   - compute arrival angles

   Use the following Matlab code to check your question:
   - KGH = pzk([vector of poles], [vector of zeros], 1);
   - rlocus(KGH);
   - axis equal

3) Solve the problem by hand.

4) You want to be able to ask a question about stability so you would like your root locus to indicate an unstable systems for some (but not all) values of K. Adjust your question to accomplish this. Solve the problem by hand.

5) Turn 2 of your poles into zeros and two of your zeros into poles. Solve the problem by hand.

6) Add an additional pole at (s+a). Choose "a" such that the problem is as easy as possible and solve it.

7) Change the pole to (s-a) and solve it. Is the system ever stable? Use the RH criteria to check your answer.

8) Change the pole to a double imaginary pole at (s^2+a) and add a zero at (s+a). Solve it.

9) For the following open-loop transfer functions, use a 6-sided die to determine each of the constants, a, b, c and d, and draw the root-locus. Be sure to:

- identify the parts of the real axis that contain the root-locus
- compute the assymptotes (centres and angles)
- compute the breakpoints if they exist
- compute the departure angles if they exist
- compute the arrival angles if they exist

Use the Matlab function specified above to check your answer:

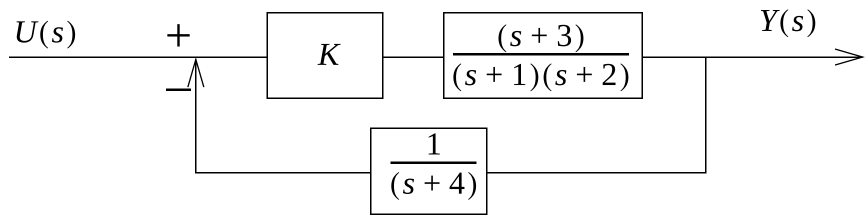
$$GH = \frac{(s+a)}{(s+b)^2(s+c)} \qquad GH = \frac{(s^2+a^2)}{(s+b)^2(s+c)}$$

$$GH = \frac{(s+a^2)}{(s^2+bs+c)(s+d)} \qquad GH = \frac{(s^2+a)}{(s^2+bs+c)(s+d)}$$

$$GH = \frac{(s+a)}{(s^2+b)^2} \qquad GH = \frac{(s^2+as+b)}{s(s+c)(s+d)} \qquad GH = \frac{s(s+a)}{(s+b)^2(s+c)}$$

10) Ask your lab partner to give you all of their questions from this assignment and solve them.

11) For the following system:



- When K=0
    - Compute the open-loop poles
    - Compute the open-loop zeros
    - Compute the closed-loop poles
    - Compute the closed-loop zeros
- When K=1
    - Compute the open-loop poles
    - Compute the open-loop zeros
    - Compute the closed-loop poles
    - Compute the closed-loop zeros
- When K=10
    - Compute the open-loop poles
    - Compute the open-loop zeros
    - Compute the closed-loop poles
    - Compute the closed-loop zeros
- When K=100
    - Compute the open-loop poles
    - Compute the open-loop zeros
    - Compute the closed-loop poles
    - Compute the closed-loop zeros

12) Do the open-loop poles change when K changes?

13) Do the open-loop zeros change when K changes?

14) Do the closed-loop poles change when K changes?

15) Do the closed-loop zeros change when K changes?

16) For the parts that change (above):
- where do they start (K=0)?
- where do they go (K=big)?

17) What is the main thing (open/closed poles/zeros) that determines the behaviour of a closed system?

18) What is the purpose of a root locus diagram? How is it used in practice?