What if: \[ CE = s^2 + cs + 1 = 0 \]

Root locus does change?

\[ \text{Evdns Eq (Recall)} \]

\[ 1 + DHG = 0 \Rightarrow 1 + KL(s) = 0 \]
\[ 1 + \frac{Kb(s)}{a(s)} = 0 \]

In this case:
\[ 1 + KL(s) = 0 \quad \Rightarrow \quad K = C \]

\[ 0 = s^2 + 1 + cs = 0 \]
\[ 1 + \frac{cs}{s^2 + 1} = 0 \]
\[ L(s) = \frac{s}{s^2 + 1} \quad \Rightarrow \quad b(s) = s \quad m = 1 \quad z_1 = 0 \]
\[ a(s) = s^2 + 1 \quad n = 2 \quad p_{1,2} = \frac{-C \pm \sqrt{c^2 - 4}}{2} \]

(Adapted from Satish Narra)
What is the root locus for the system w/ CE as above?

\[ C = 0 \quad \Rightarrow \quad s^2 + c s + 1 = 0 \quad s = \pm j \]
\[ C = 2 \quad \Rightarrow \quad s^2 + 2s + 1 = 0 \quad s = -1 \]
\[ C = \infty \quad \Rightarrow \quad i) \quad s = \infty \]

(ii) \( L(s) = -\int_{0}^{\infty} e^{-st} \, dt = b(s) / a(s) \)

\[ = 0 \quad b(s) = 0 \quad s = 0 \]
Ex: Find the E(x) for the cases below.
(iii) What is the root locus for the system with the CE

\[ 1 + KG(s) = 1 + \frac{K}{s[(s + 4)^2 + 16]} \]

Use the same approach as for the two examples above. But, it is not as simple to sketch in this case! For such complex system, Evans came up with guidelines to sketch the root locus, using a 7-step procedure, as shown in the text. [Note: Matlab can sketch the root locus for any G(s) easily using the rlocus command.]
RECALL

A complex number may be defined as

\[ A = \sigma + j\omega, \]

where \( \sigma \) is the real part and \( \omega \) is the imaginary part, denoted, respectively, as

\[ \sigma = \text{Re}(A), \quad \omega = \text{Im}(A). \]

\[ A = |A| \cdot \angle \arg A = r \cdot \angle \theta = re^{j\theta}, \quad 0 \leq \theta \leq 2\pi, \]

\[ r = |A| = \sqrt{\sigma^2 + \omega^2}, \]

\[ \tan \theta = \frac{\omega}{\sigma} \]

\[ \theta = \arg(A) = \tan^{-1} \left( \frac{\omega}{\sigma} \right) \]

Figure WA.1
The complex number \( A \) represented in
(a) Cartesian and
(b) polar coordinates

Figure WA.2
Arithmetic of complex numbers: (a) addition; (b) multiplication; (c) division
Consider the transfer function

\[ G(s) = \frac{\prod_{i=1}^{m} (s + z_i)}{\prod_{i=1}^{n} (s + p_i)}. \]

\[ |G(j\omega)| = \frac{r_1}{r_2r_3r_4}. \]

\[ s_0 = j\omega_0 \]

\[ m = 1 \]
\[ n = 3 \]

\[ \angle G(s_0) = \sum_{i=1}^{m} \angle (s_0 + z_i) - \sum_{i=1}^{n} \angle (s_0 + p_i) \]