1. Problem 4.5 (p.96) in the text. Note correction for part c
   a) Sketch (by hand) the root-locus plot for the following open-loop transfer function: \( G(s) = \frac{s(s+1)}{(s+2)^2(s+3)} \)
      Apply only the main rules (Section 4.4.2 in text or the first page of my notes)
   b) Repeat part a) for: \( G(s) = \frac{(s+3)}{s(s+9)^3} \)
   c) Repeat part a) for: \( G(s) = \frac{(s+a)}{(s+b)(s^2-2s+2)} \)  \( a > 0 \quad b > 0 \quad k > 0 \)
      Also give condition(s) that a and b must satisfy for the closed-loop system to be stable for sufficiently high gain (k) (note that you do not need to apply the Routh-Hurwitz criterion, nor provide the range of k for which the system is closed-loop stable).

2. Problem 4.11 (p.97) in the text. (Hint: do part c before b)
   a) Sketch the root-locus for the open-loop poles shown at right.
      There is one zero at \( s = 0 \) and two poles at \( s = 1 \).
   c) Give the locations of the break-away points on the real axis.
   b) Give the range of gain \( k \) (\( k > 0 \)) for which the system is closed-loop stable, and give the locations of the \( j\omega \) axis crossings.

3. Problem 4.12 (p.97) in the text.
   Sketch the root-locus for the open-loop poles shown at right, using only the main rules. There is a zero at \( s = 0 \), two poles at \( s = -1 \) and two poles at \( s = -1 \pm j \).

4. Problem 4.13 (p.98) in the text.
   Sketch the root-locus for the following problem. Do not calculate the range of gain for stability, the \( j\omega \) axis crossings, or the break-away points from the real axis. However, give the angles of departure from the complex poles. There is a zero at \( s = 0 \) and a zero at \( s = -2 \). There are poles at \( s = \pm j \) and \( s = \pm 2j \).

**Answers**

1.a)  
1.b)  
1.c)  
2.  
3.  
4.  

Stability at high gain:
\( a > 0 \quad b > 2 + a \)