5.3 For the characteristic equation

$$1 + \frac{K}{s(s+1)(s+5)} = 0,$$

(a) Draw the real-axis segments of the corresponding root locus.

(b) Sketch the asymptotes of the locus for $K \to \infty$.

(c) Sketch the locus?

(d) Verify your sketch with a MATLAB plot.

5.4 *Real poles and zeros.* Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choices for $L(s)$. Be sure to give the asymptotes, and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using MATLAB. Turn in your hand sketches and the MATLAB results on the same scales.

(a) $L(s) = \dfrac{(s+2)}{s(s+1)(s+5)(s+10)}$

(b) $L(s) = \dfrac{1}{s(s+1)(s+5)(s+10)}$

(c) $L(s) = \dfrac{(s+2)(s+6)}{s(s+1)(s+5)(s+10)}$

(d) $L(s) = \dfrac{(s+2)(s+4)}{s(s+1)(s+5)(s+10)}$

5.5 *Complex poles and zeros.* Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choices for $L(s)$. Be sure to give the asymptotes and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using MATLAB. Turn in your hand sketches and the MATLAB results on the same scales.

(a) $L(s) = \dfrac{1}{s^2 + 3s + 10}$

(b) $L(s) = \dfrac{1}{s(s^2 + 3s + 10)}$

(c) $L(s) = \dfrac{(s^2 + 2s + 8)}{s(s^2 + 2s + 10)}$

(d) $L(s) = \dfrac{(s^2 + 2s + 12)}{s(s^2 + 2s + 10)}$

(e) $L(s) = \dfrac{(s^2 + 1)}{s(s^2 + 4)}$

(f) $L(s) = \dfrac{(s^2 + 4)}{s(s^2 + 1)}$

5.6 *Multiple poles at the origin.* Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choices for $L(s)$. Be sure to give the asymptotes and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using MATLAB. Turn in your hand sketches and the MATLAB results on the same scales.

(a) $L(s) = \dfrac{1}{s^2(s+8)}$

(b) $L(s) = \dfrac{1}{s^3(s+8)}$

(c) $L(s) = \dfrac{1}{s^4(s+8)}$

(d) $L(s) = \dfrac{(s+3)}{s^2(s+8)}$

(e) $L(s) = \dfrac{(s+3)}{s^3(s+4)}$

(f) $L(s) = \dfrac{(s+1)^2}{s^3(s+4)}$

(g) $L(s) = \dfrac{(s+1)^2}{s^3(s+10)^2}$

5.7 *Mixed real and complex poles.* Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choices for $L(s)$. Be sure to give the asymptotes and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using MATLAB. Turn in your hand sketches and the MATLAB results on the same scales.

(a) $L(s) = \dfrac{(s+2)}{s(s+10)(s^2+2s+2)}$

(b) $L(s) = \dfrac{(s+2)}{s^2(s+10)(s^2+6s+25)}$

(c) $L(s) = \dfrac{(s+2)^2}{s^2(s+10)(s^2+6s+25)}$

(d) $L(s) = \dfrac{(s+2)(s^2+4s+68)}{s^2(s+10)(s^2+4s+85)}$

(e) $L(s) = \dfrac{[(s+1)^2+1]}{s^2(s+2)(s+3)}$

5.8 *RHP and zeros.* Sketch the root locus with respect to K for the equation $1 + KL(s) = 0$ and the listed choices for $L(s)$. Be sure to give the asymptotes and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using MATLAB. Turn in your hand sketches and the MATLAB results on the same scales.

(a) $L(s) = \dfrac{s+2}{s+10}\dfrac{1}{s^2-1}$; the model for a case of magnetic levitation with lead compensation.

(b) $L(s) = \dfrac{s+2}{s(s+10)}\dfrac{1}{(s^2-1)}$; the magnetic levitation system with integral control and lead compensation.

(c) $L(s) = \dfrac{s-1}{s^2}$

(d) $L(s) = \dfrac{s^2+2s+1}{s(s+20)^2(s^2-2s+2)}$. What is the largest value that can be obtained for the damping ratio of the stable complex roots on this locus?

(e) $L(s) = \dfrac{(s+2)}{s(s-1)(s+6)^2}$

(f) $L(s) = \dfrac{1}{(s-1)[(s+2)^2+3]}$

5.9 Put the characteristic equation of the system shown in Fig. 5.52 in root-locus form with respect to the parameter α, and identify the corresponding $L(s)$, $a(s)$, and $b(s)$. Sketch