Final HW, due in the ESE441 bin or electronically to CIB on Thursday, December 18, 2008 at 4:00 PM.

1(a).(20pts) To each of the following four systems, if we apply feedback with constant gain *k*, for what values of *k* will the closed-loop system be stable?

$$g(s) = (s \pm 2)/(s^2 + 2s + 1)$$

$$g(s) = (s \pm 2)/(s^2 + 10s + 1)$$

1(b). (12pts) Using MatLab, construct the Nyquist plots for each of these four systems.

1(c). (8pts) Using your answers to parts (a) and (b), verify the Nyquist stability criterion.

2. Consider the system with transfer $g(s) = 1/(s+1)$, input u and output y.

(a) Writing $u = R$ and the error e as $e = R - y$. derive the transfer function $g_e(s)$ from R to e (5pts).

(b) We want to find a controller $k(s)$ so that when $R = \sin(t)$, the steady state error $e_{ss}(t)$ is zero. Design such a controller having the form

$$k(s) = K(s+z)/(s^2+1)$$

by choosing the gain K and $z > 0$ appropriately. Why is your closed-loop system stable, and why is $e_{ss}(t)$ zero? (25 pts)

2 (c). In general, what choices of *z* and *K* will work, and why? (10 pts)

3. Consider the transfer function

$$g(s) = 1/(s^4 + 23s^3 + 45s^2 + 56s + 78)$$

Using MatLab:

3(a). What is *u*, the number of unstable poles? (5 pts)

3(b). Find the root-locus plot of g. (5 pts)

3(c). Find the Nyquist plot of g. (5 pts)

3(d). Do your answers to parts (b) and (c) confirm the Nyquist stability criterion? (5 pts)

4. Consider the transfer function

$$g_1(s) = (s-6)/(s^3+4s^2+9s+10)$$

The following five questions are worth 5 pts. each.

4(a). Using MATLAB find the root-locus plot.

4(b). For what critical value k_c of the gain k, does the closed-loop system become unstable?

4(c). Using MATLAB find the Nyquist plot.

4(d) Using the Nyquist stability criterion, determine for which values of k the closed-loop systems will be stable or unstable.

4(e). Compare your answers in 4(d) to your answer in 4(b).

Problem 5. (25 pts) Problem 6.4, p. 198 of the text.