Name: ____

Problem	Points	Score
7.40(b)	15	
7.40(c)	15	
7.40(d)	15	
8.9(a)(i)	15	
8.9(a)(ii)	10	
8.9(a)(iii)	10	
9.1(a)	10	
9.1(c)	10	
Total	100	

Notes:

(1) The exam is closed books and notes except for one double-sided sheet of notes.

(2) Please indicate clearly your answer to the problem.

(3) The details of your solutions are more important than the answers. Please explain your solutions clearly and include as many details as possible.

7.40. For the following linear time-invariant discrete-time systems with unit-pulse response $h[n]$, determine if the system is BIBO stable.

(b) $h[n] = (1/n)u(n-1)$

$$\sum_{n=0}^{\infty} |h[n]| = \sum_{n=1}^{\infty} \frac{1}{n} = \infty$$

So the system is not BIBO stable

(c) $h[n] = (1/n^2)u[n-1]$

$\sum_{n=0}^{\infty} |h[n]| = \sum_{n=1}^{\infty} \frac{1}{n^2} < \infty$ so the system is BIBO stable

(d) $h[n] = e^{-n}\sin(\pi n/6)u[n]$

$$\sum_{n=0}^{\infty} |h[n]| = \sum_{n=0}^{\infty} \left|e^{-n}\sin\left(\frac{\pi n}{6}\right)\right| \le \sum_{n=0}^{\infty} e^{-n} = \frac{1}{1-e^{-1}} < \infty$$

thus the system is BIBO stable

8.9(a). Determine if the system is critically damped, underdamped, or overdamped.

(i) $H(s) = \dfrac{32}{s^2 + 4s + 16}$

(ii) $H(s) = \dfrac{32}{s^2 + 8s + 16}$

(iii) $H(s) = \dfrac{32}{s^2 + 10s + 16}$

8.9 (a) i. poles at $-2 \pm j3.46 \Rightarrow$ underdamped

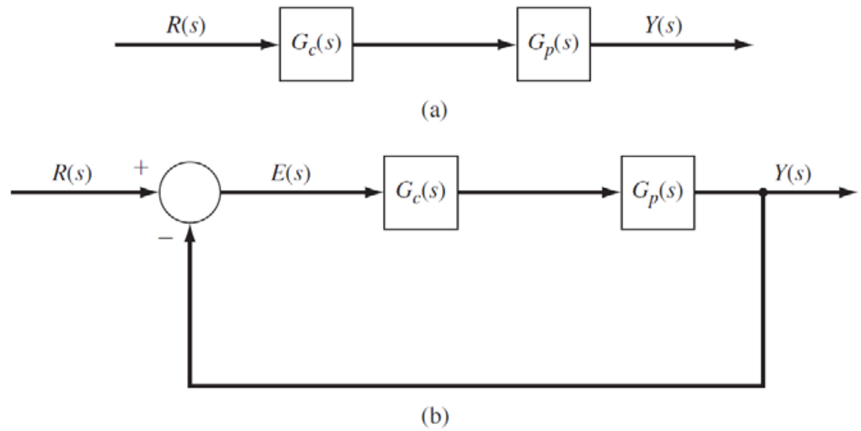
ii. poles at $-4, -4 \Rightarrow$ critically damped

iii. poles at $-8, -2 \Rightarrow$ overdamped

9.1. Consider the transfer function:

$$G_p(s) = \frac{1}{s + 0.1}$$

(a) An open-loop control is shown in Figure P9.1(a). Design the control system, $G_c(s)$, so that the combined plant and controller, $G_c(s)G_p(s)$, has a pole at $p = -2$.



(a) $G_c(s) = \frac{k(s+0.1)}{(s+2)}$ $R(s) = \frac{r_0}{s}$

$Y(s) = \frac{k}{(s+2)} R(s)$ $e_{ss} = r_0 - \lim_{s \to 0} s Y(s)$

$e_{ss} = 0 = r_0 - \frac{k r_0}{2} \Rightarrow k = 2$

$G_c(s) = \frac{2(s+0.1)}{(s+2)}$

(c) A feedback controller $G_c(s) = 2(s + 0.1)/s$ is used in place of open-loop control as shown in Figure P9.1b. Verify that the closed-loop pole of the nominal system is at p = -2.

(c) Closed loop transfer function $G_{cl}(s) = \frac{G_c G_p}{1 + G_c G_p}$

$G_{cl}(s) = \frac{\frac{2}{s}}{1 + \frac{2}{s}} = \frac{2}{(s+2)}$

$\lim_{s \to 0} s Y(s) = \lim_{s \to 0} \frac{2 r_0}{(s+2)} = r_0 \Rightarrow e_{ss} = 0$