EEL 3657 Test # 2 - In Class - Apr 4

1. For a second order underdamped system whose characteristic equation is given by $Js^2 + Bs + K = 0$, how does one decrease the damping ratio without affecting the settling time. (30)

$t_s = \frac{2J}{B} = \frac{1}{J\omega_n}$, $\omega_n = \sqrt{\frac{K}{J}}$ (10)

$\zeta = \frac{B}{2J\omega_n} = \frac{B}{2\sqrt{KJ}}$ (10)

Increase K to decrease ζ while not affecting t_s. (10)

2. For a type 2 system, is the steady-state error to a *ramp* input (a) zero, or (b) constant other than zero, or (c) infinite? Explain. (10)

$e_{ss} = \frac{1}{K_V}$, $K_V = \lim_{s \to 0} sG(s) = \infty$ for Type 2

$\Rightarrow e_{ss} = 0$ (10)

3. Consider $s^4 + Ks^3 + s^2 + s + 1 = 0$ to be the characteristic equation for a system. Is the system stable? If so, find the range of K for stability. If not, explain why. (20)

s^4	1	1	1
s^3	K	1	0
s^2	$1-\frac{1}{K}$	1	
s	$1-K/(1-\frac{1}{K})$	0	
1	1		

(10)

$1 - \frac{1}{K} > 0 \Rightarrow K > 1$ (1)

$K > 0$

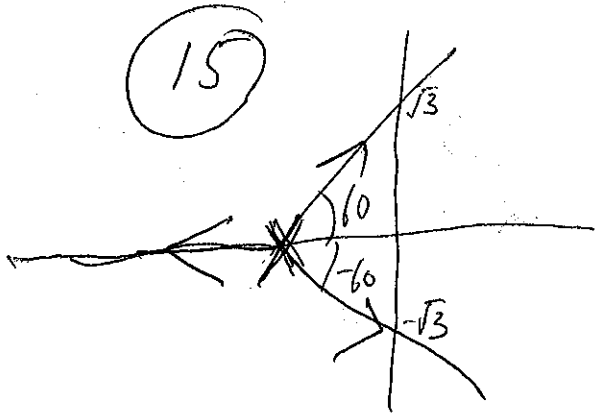
$1 - \frac{1}{K} - K > 0$

$\Rightarrow K^2 - K + 1 < 0$

$\Rightarrow K^2 < K - 1$ (2)

(10) No value of K satisfies both (1) and (2), so unstable system.

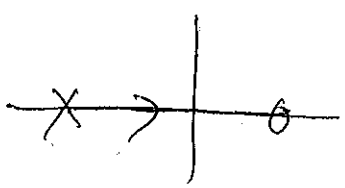
4. Draw the exact root locus (with K as a parameter) for a unity feedback system whose feed-forward transfer function is given by $G(s) = \dfrac{K}{(s+1)^3}$. Compute what you feel is necessary to obtain the general shape of the root locus. (30)



3 asymptotes
Centroid = -1
∠ asymptotes = -60, +60, -180
Breakaway point = -1

15

5. When can a system with stable open-loop transfer function given by $G(s) = \dfrac{K(s+z_1)}{(s+p_1)}$ go unstable under negative feedback when gain K is increased. (10)



When $z_1 < 0$, i.e. RHP zero or non-minimum phase system

10