ECE 3510 homework # 10

1. Draw a control system loop like the bottom one shown on p.2 of my <u>Control System Characteristics & Performance</u> notes. This is a more complex version of Fig 4.7 (Bodson, p.67), including gain, a feedback sensor ($F(s)$) and a disturbance input ($D(s)$).

2. With $F(s)$ (or $N_F(s)$ and $D_F(s)$) added into the following equations, find: a) The full $Y(s) =$
   Note: you may consider k as part of $C(s)$.

   b) $E(s)$ with disturbance as zero: Eq. 4.14 Eq. 4.19

   c) $E(s)$ with input ($R(s)$) as zero: Eq. 4.22 Eq. 4.23

3. List 5 measures of a control system's quality (see p. 64) and list one or two things that can be done to achieve each.

4. The transfer functions of C(s) and P(s) are given below. In each case determine if the steady-state error will go to zero and whether disturbances will be completely rejected. Be sure to check for closed-loop stability when needed.

   a) $C(s) = \dfrac{s+4}{s^2+3\cdot s+2}$ $P(s) = \dfrac{s+1}{s^2+3\cdot s}$ b) $C(s) = \dfrac{s+1}{s^2+3\cdot s}$ $P(s) = \dfrac{s+4}{s^2+3\cdot s+2}$

   c) $C(s) = \dfrac{s\cdot(s+6)}{s^2+3\cdot s+2}$ $P(s) = \dfrac{s+8}{s^2+12\cdot s}$ d) $C(s) = \dfrac{s+9}{s^2+3\cdot s+2}$ $P(s) = \dfrac{s}{s+16}$

   e) $C(s) = \dfrac{s+1}{s^2+5\cdot s+6}$ $P(s) = \dfrac{s+1}{s^2+8\cdot s+15}$ f) $C(s) = \dfrac{s+1}{s^3+7\cdot s^2+12\cdot s}$ $P(s) = \dfrac{s+1}{s+3}$

5. Problem 4.2 (p.108) in the text. Use your calculator or Matlab to find the actual roots, or use the Routh-Hurwitz method.

6. EXTRA CREDIT

   Characteristic equations of feedback sytems are shown below. In each case, use the Routh-Hurwitz method to determine the value range of K that will produce a stable system. You must show your work.

   a) $0 = s^4+20\cdot s^3+10\cdot s^2+s+K$ b) $0 = s^4+2\cdot K\cdot s^3+5\cdot s^2+K\cdot s+K$

<u>Answers</u>

1.& 3. See notes and read sections 4.1 - 4.2 in text (Bodson).

2. a) $Y(s) = \dfrac{P\cdot C\cdot R+P\cdot D}{1+P\cdot C\cdot F} = \dfrac{P\cdot k\cdot C\cdot R+P\cdot D}{1+P\cdot k\cdot C\cdot F}$

   k as part of $C(s)$ k separate from $C(s)$

   b) Eq. 4.10 $\dfrac{1}{1+F(0)\cdot P(0)\cdot C(0)} = \dfrac{D_F(0)\cdot D_P(0)\cdot D_C(0)}{D_F(0)\cdot D_P(0)\cdot D_C(0)+N_F(0)\cdot N_P(0)\cdot N_C(0)}$

   c) Eq. 4.15 $\dfrac{-N_F(0)\cdot N_P(0)\cdot D_C(0)}{D_F(0)\cdot D_P(0)\cdot D_C(0)+N_F(0)\cdot N_P(0)\cdot N_C(0)}$

4. a) Yes No b) Yes Yes

   c) No No d) No Yes

   e) No No f) Yes Yes

5. a) Yes b) No c) No

6. EXTRA CREDIT a) $0 < K < 0.4975$ b) $0 < K < 2.25$