1. Draw a basic control system loop such as that shown in Fig 4.7 (Bodson), show all the items listed on p. 59 plus a feedback sensor labeled $F(s)$ and a disturbance input.

2. Add $F(s)$ or $n_f(s)$ and $d_f(s)$ into the following equations: full $Y(s) =$

- With disturbance as zero: Eq. 4.5 Eq. 4.7 Eq. 4.10
- With input ($R(s)$) as zero: Eq. 4.13 Eq. 4.15

3. List 5 measures of a control system's quality (see p. 59-60) 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) $C(s) = \frac{s+4}{s^2+3s+2}$ $P(s) = \frac{s+1}{s^2+3s}$
- b) $C(s) = \frac{s+1}{s^2+3s}$ $P(s) = \frac{s+4}{s^2+3s+2}$
- c) $C(s) = \frac{s(s+6)}{s^2+3s+2}$ $P(s) = \frac{s+8}{s^2+12s}$
- d) $C(s) = \frac{s+9}{s^2+3s+2}$ $P(s) = \frac{s}{s+16}$
- e) $C(s) = \frac{s+1}{s^2+5s+6}$ $P(s) = \frac{s+1}{s^2+8s+15}$
- f) $C(s) = \frac{s+1}{s^3+7s^2+12s}$ $P(s) = \frac{s+1}{s^3+3}$

5. Problem 4.2 (p.98) in the text. Use the Routh-Hurwitz method.

6. 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.

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

**Answers**

1., 2., 3. Read sections 4.1 - 4.2 in text (Bodson). $Y(s) = \frac{P\cdot C\cdot R + P\cdot D}{1 + P\cdot C\cdot F}$

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. a) $0 < K < 0.4975$
b) $0 < K < 2.25$

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