...te feed back control $u=-Kx+lr$

determine K and l

closed loop system will have:

i) Zero-steady-state error for a unit-step input

ii) 5% overshoot and 2 seconds settling time.

A-LC

A-BK

K

c) Give the block diagram of the observer-based state feedback controller.

Percent overshoot: $\% OS = 100\exp\left(\frac{-\xi\pi}{\sqrt{1-\xi^2}}\right)$

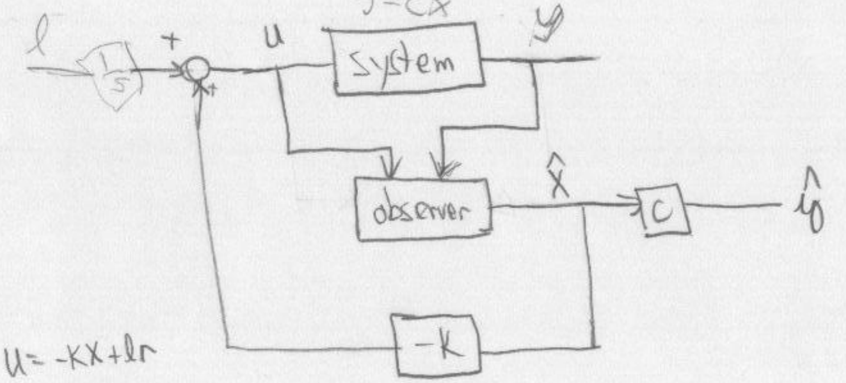
Settling time at 2%: $T_s \approx \frac{4}{\xi\omega_n}$

$$\dot{\hat{x}} = A\hat{x} + Bu + L(\hat{y} - y)$$

$$U = -K\hat{x} + lr$$

$\dot{x} = Ax + Bu$

$y = Cx$



$U = -Kx + lr$

$\dot{x} = Ax + Bu$

$\dot{x} = Ax - BKx + Blr$

$\dot{x} = x(A - BK) + Blr$

$sX(s) - X(s)[A-BK] = Blr(s)$

$X(s)[sI-(A-BK)] = Blr(s)$

$X(s) = [sI-(A-BK)]^{-1}Blr(s)$

$y = Cx$

$Y(s) = C[sI-(A-BK)]^{-1}Blr(s)$

$\lim_{y\to\infty} = \lim_{s\to 0} Y(s) = sC[sI-(A-BK)]^{-1}Bl\frac{1}{s} = 1$

$l = \left[C[(BK-A)]^{-1}B\right]^{-1}$

Eng. 0138: Advanced Control II

March 4, 2004.
8:30 AM to 10:00 AM
Closed Book exam.
Programmable calculators are not allowed.

Q-1 (8 marks)
Consider the following system

$$\dot{x} = Ax + Bu$$
$$y = Cx$$

$$A = \begin{bmatrix} 2 & 1 \\ 4 & 3 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix},\ C = [1 \ \ 0]$$

$\det(\lambda I - Q) = \varphi$

a) Write the system in controllable canonical form, observable canonical form and diagonal canonical form or Jordan canonical form.

Q-2 (8 marks)
Consider the following matrices

$$A_1 = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix},\ A_2 = \begin{bmatrix} 3 & 1 & 0 & 0 & 0 \\ 0 & 3 & 1 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 0 & 5 \end{bmatrix}$$

8.97.

0.6899

Compute $e^{A_1 t}$ and $e^{A_2 t}$.

Q-3 (14 marks)

Consider the system defined by:

$$\dot{x} = Ax + Bu$$
$$y = Cx$$

where,

$$A = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix},\quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad C = [1 \ \ 0]$$

$2 = \frac{4}{\omega_n(0.6899)}$

$\omega_n = \frac{4}{2(0.6899)}$

$\omega_n = 2.89$

a) Check the state controllability and observability of the system.

$U(s) \to \square \to X(s)$

$s^2 + 4s + 8.7012$

$sX(s) = AX(s) + BU(s)$

$X(s)[sI-A] = BU(s)$

$\frac{X(s)}{U(s)} = [sI-A]^{-1}BU(s)$

$Y = CX$

$\frac{Y(s)}{U(s)} = C[sI-A]^{-1}B$

1. $\frac{Y(s)}{U(s)} = C(sI-A)^{-1}B.$

$\rightarrow (sI-A) = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} s-2 & -1 \\ -4 & s-3 \end{bmatrix}$

$\det(sI-A) = (s-2)(s-3) - 4. = s^2 - 3s - 2s + 6 - 4$

$\det(sI-A). = s^2 - 5s + 2$

$(sI-A)^{-1} \rightarrow \text{adj} \rightarrow C_{11} = s-3 \quad C_{12} = 4$
$C_{21} = 1 \quad C_{22} = s-2.$

$\therefore \text{adj}(sI-A) \Rightarrow \begin{bmatrix} s-3 & 1 \\ 4 & s-2 \end{bmatrix}$

$\therefore \frac{Y(s)}{U(s)} = \frac{\underset{1\times2}{\begin{bmatrix} 1 & 0 \end{bmatrix}} \overset{2\times2}{\begin{bmatrix} s-3 & 1 \\ 4 & s-2 \end{bmatrix}} \underset{2\times1}{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}}{s^2-5s+2.}$

$\frac{Y(s)}{U(s)} = \frac{\begin{bmatrix} s-3 & 1 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix}}{s^2-5s+2} = \boxed{\frac{Y(s)}{U(s)} = \frac{1}{s^2-5s+2}}$

$\frac{-b \pm \sqrt{b^2-4ac}}{2} \rightarrow \frac{5}{2} \pm \frac{\sqrt{25-8}}{2}, \quad 5/2 \pm \frac{\sqrt{17}}{2}$

$\therefore$ poles are $(5/2 + \sqrt{17}/2), (5/2 - \sqrt{17}/2.)$

4.561. 0.4384

$\frac{Y(s)}{U(s)} = \frac{1}{s^2-5s+2} = \frac{C_1}{(s-(5/2+\sqrt{17}/2))} + \frac{C_2}{(s-(5/2-\sqrt{17}/2))}$

CONTROLLABLE

$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$

$y = \begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

S

OBSERVABLE

$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -2 \\ 1 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u \qquad s = 5/2 + \sqrt{17}/2, \; s = 5/2 - \sqrt{17}/2$

$y = \begin{bmatrix} 0 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}.$

DIAGONAL

Let $1 = C_1(s - 5/2 - \sqrt{17}/2) + C_2(s - 5/2 + \sqrt{17}/2)$

Let $s = 5/2 + \sqrt{17}/2$
$1 = C_2(5/2 + \sqrt{17}/2 - 5/2 + \sqrt{17}/2)$
$1 = C_2\sqrt{17}$
$\boxed{1/\sqrt{17} = C_2}$

Let $s = 5/2 - \sqrt{17}/2$
$1 = C_1(5/2 - \sqrt{17}/2 - 5/2 - \sqrt{17}/2)$
$1 = -\sqrt{17}\,C_1$
$\boxed{-1/\sqrt{17} = C_1}$

$\therefore \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 5/2+\sqrt{17}/2 & 0 \\ 0 & 5/2-\sqrt{17}/2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u \qquad y = \begin{bmatrix} -1/\sqrt{17} & 1/\sqrt{17} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

Q-2) $A_1 = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$

$(\lambda I - \xi) = \begin{bmatrix} \lambda & 0 \\ 0 & \lambda \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} = \begin{bmatrix} \lambda & -1 \\ 2 & \lambda+3 \end{bmatrix}$

det $\lambda(\lambda+3)+2 = \lambda^2 + 3\lambda + 2 = (\lambda+1)(s+2)$.

$\therefore \lambda = -1, -2$ SINCE REAL, USE P, P^{-1} METHOD

$\therefore P = \begin{bmatrix} 1 & 1 \\ -1 & -2 \end{bmatrix}$, $P^{-1} = \begin{bmatrix} 2 & 1 \\ -1 & -1 \end{bmatrix}$

and $e^{\Lambda t} = \begin{bmatrix} e^{-t} & \\ & e^{-2t} \end{bmatrix}$

$\therefore e^{At} = P e^{\Lambda t} P^{-1} = \begin{bmatrix} 1 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} e^{-t} & 0 \\ 0 & e^{-2t} \end{bmatrix} \begin{bmatrix} 2 & 1 \\ -1 & -1 \end{bmatrix}$.

$e^{At} = \begin{bmatrix} e^{-t} & e^{-2t} \\ -e^{-t} & -2e^{-2t} \end{bmatrix} \begin{bmatrix} 2 & 1 \\ -1 & -1 \end{bmatrix}$

$e^{At} = \begin{bmatrix} 2e^{-t} - e^{-2t} & e^{-t} - e^{-2t} \\ -2e^{-t} + 2e^{-2t} & -e^{-t} + 2e^{-2t} \end{bmatrix} = \begin{bmatrix} e^{-t}(2 - e^{-t}) & e^{-t}(1 - e^{-t}) \\ 2e^{-t}(e^{-t} - 1) & e^{-t}(2e^{-t} - 1) \end{bmatrix}$

→ THIS IS IS IN JORDAN FORM;

$A_2 = \begin{bmatrix} 3 & 1 & 0 & 0 & 0 \\ 0 & 3 & 1 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 0 & 5 \end{bmatrix}$.

$\therefore e^{At} = \begin{bmatrix} e^{3t} & te^{3t} & \frac{t^2 e^{3t}}{2!} & 0 & 0 \\ 0 & e^{3t} & te^{3t} & 0 & 0 \\ 0 & 0 & e^{3t} & 0 & 0 \\ 0 & 0 & 0 & e^{4t} & 0 \\ 0 & 0 & 0 & 0 & e^{5t} \end{bmatrix}$

9

Q-3)

a). $\mathcal{C} = [B \;\; AB] = \begin{bmatrix} 0 & 1 \\ 1 & 4 \end{bmatrix}$. det = -1

∴ its nonsingular

Rank ($\mathcal{C}$) = 2 ∴ its state controllable.

$Obs = \begin{bmatrix} C \\ CA \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 2 & 1 \end{bmatrix}$ ∴ det 1 - 0 = 1

∴ its nonsingular.

Rank (Obs) = 2 ∴ it is observable

b) desired k; →.

$$5\% = 100 \exp\left[\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}\right] \qquad T_s = \frac{4}{\omega_n \zeta}$$

$$\therefore \zeta = \sqrt{\frac{\ln^2(0.05)}{(\ln^2(0.05) + \pi^2)}} \qquad \omega_n = \frac{4}{2(0.6901)} = \boxed{2.898}$$

$$\boxed{\zeta = 0.6901}$$

∴ desired char eqn $s^2 + 2\zeta\omega_n s + \omega_n^2$

$$s^2 + 2(0.6901)(2.898)s + (2.898)^2$$

$$\rightarrow \boxed{s^2 + 4s + 8.398}$$

Finding k; $y(s) = C[sI - (A - Bk)]^{-1} B\, r$.

det $(sI - A + Bk)$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} [k_1 \;\; k_2]$$

$$\therefore \begin{bmatrix} s-2 & -1 \\ -3 & s-4 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ k_1 & k_2 \end{bmatrix}$$

$$\begin{bmatrix} s-2 & -1 \\ k_1-3 & s-4+k_2 \end{bmatrix}$$

$$\det(sI - A + Bk) = (s-2)(s-4+k_2) + (k_1 - 3)$$
$$= s^2 - 4s + k_2 s - 2s + 8 - 2k_2 + k_1 - 3$$
$$= s^2 + s(k_2 - 4 - 2) + 8 - 2k_2 + k_1 - 3.$$

∴ matching → $s^2 + s(k_2 - 6) + 8 - 2k_2 + k_1 - 3 = s^2 + 4s + 8.39$

$$\therefore k_2 - 6 = 4 \qquad 8 - 2(10) + k_1 - 3 = 8.39$$
$$\boxed{k_2 = 10} \qquad -12 + k_1 - 3 = 8.39$$
$$k_1 = 8.39 + 3 + 12$$
$$\boxed{k_1 = 23.39}$$

$$\boxed{\therefore K = [23.39 \quad 10]}$$

8

finding l,

$$y(s) = C[sI - A + BK]^{-1} B l r$$

$$\therefore \lim_{t\to\infty} y(t) = 1 \Rightarrow \lim_{s\to 0} s y(s) = 1$$

$$\therefore \lim_{s\to 0} C[\cancel{sI} - A + BK]^{-1} Br = C[-A+BK]^{-1} B l y_d = 1$$

$$\therefore [C[BK - A]^{-1} B] l \; 1 = 1.$$

$$l = \{C[BK - A]^{-1} B\}^{-1}$$

$$\begin{bmatrix} 0 \\ 1 \end{bmatrix} \begin{bmatrix} 23.39 & 10 \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} -2 & -1 \\ 20.39 & 6 \end{bmatrix}$$ det. [12 + ...]

$$\therefore (BK - A)^{-1} = \begin{bmatrix} 0.715 & 0.119 \\ -2.43 & -0.238 \end{bmatrix}.$$

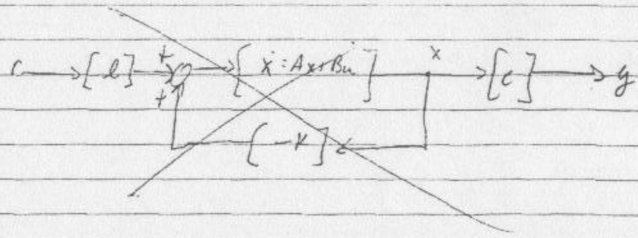
$$\therefore l = \left\{ \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} 0.715 & 0.119 \\ -2.43 & -0.238 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} \right\}^{-1}$$

$$l = \left\{ \begin{bmatrix} 0.119 \end{bmatrix} \right\}^{-1} \qquad \boxed{l = 8.40336}$$

✓

8.40336

c)



2004 #1

Q1 given $A = \begin{bmatrix} 2 & 1 \\ 4 & 3 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$

must find T.F. $U(s) \to \boxed{} \to Y(s)$ $\frac{Y(s)}{U(s)} = \frac{---}{---}$

$$\dot{X} = AX + BU$$
$$sX(s) = AX(s) + BU(s)$$
$$sX(s) - AX(s) = BU(s)$$
$$X(s)[sI - A] = BU(s)$$
$$X(s) = [sI - A]^{-1} BU(s)$$

$$Y(s) = CX(s)$$
$$\frac{Y(s)}{U(s)} = C[sI - A]^{-1} B$$

$$T.F. = C[sI - A]^{-1} B$$

$$[sI - A]^{-1}$$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} s-2 & -1 \\ -4 & s-3 \end{bmatrix}$$

$$\text{adj} = \begin{bmatrix} s-3 & 1 \\ 4 & s-2 \end{bmatrix}$$

$$\det = (s-2)(s-3) - 4$$
$$= s^2 - 5s + 6 - 4$$
$$= s^2 - 5s + 2$$

$$T.F. = C[sI - A]^{-1} B$$

$$T.F. = \frac{\begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} s-3 & 1 \\ 4 & s-2 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}}{s^2 - 5s + 2} = \frac{\begin{bmatrix} s-3 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}}{s^2 - 5s + 2} = \boxed{\frac{1}{s^2 - 5s + 2}}$$

$$s = \frac{5 \pm \sqrt{25 - 4(2)}}{2}$$
$$s = \frac{5}{2} \pm \frac{\sqrt{17}}{2}$$
$$s = 4.56 \text{ or } 0.44$$

+ve root, -ve root

Canonical $A = \begin{bmatrix} 0 & 1 \\ -2 & +5 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U$$

$$Y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

2004 #3

Q2

$$e^{At} = P \, e^{Dt} \, P^{-1}$$

$$e^{At} = \mathcal{L}^{-1}\left[(sI - A)^{-1}\right]$$ then also use P.F. $\frac{1}{s+a} = e^{-at}$

$$\boxed{A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}}$$

adj. $= \begin{bmatrix} s+3 & 1 \\ -2 & s \end{bmatrix}$ det $= s^2+3s+2$ $= (s+2)(s+1)$

must use $\frac{\text{adjoint.}}{\text{det.}}$

$$e^{At} = \mathcal{L}^{-1}\left[\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\right]^{-1} = \mathcal{L}^{-1}\begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}^{-1} = \mathcal{L}^{-1}\begin{bmatrix} \frac{s+3}{(s+2)(s+1)} & \frac{+1}{(s+2)(s+1)} \\ \frac{-2}{(s+2)(s+1)} & \frac{s}{(s+2)(s+1)} \end{bmatrix}$$

4 $\frac{s}{(s+2)(s+1)} = \frac{A}{s+2} + \frac{B}{s+1}$ $A = \left.\frac{s}{s+1}\right|_{s=-2} = \frac{-2}{-1} = 2$

$= \frac{2}{s+2} + \frac{-1}{s+1}$ $B = \left.\frac{s}{s+2}\right|_{s=-1} = \frac{-1}{1} = -1$

$= 2e^{-2t} - e^{-t}$

2 $\frac{+1}{(s+2)(s+1)} = \frac{A}{s+2} + \frac{B}{s+1}$ $A = \left.\frac{+1}{s+1}\right|_{s=-2} = \frac{+1}{-1} = -1$ $(sI - A)^{-1}$

$B = \left.\frac{+1}{s+2}\right|_{s=-1} = \frac{+1}{1} = +1$

$= -e^{-2t} + e^{-t}$

3 $\frac{-2}{(s+2)(s+1)} = \frac{A}{(s+2)} + \frac{B}{s+1}$ $A = \left.\frac{-2}{s+1}\right|_{s=-2} = \frac{-2}{-1} = +2$

$= +2e^{-2t} - 2e^{-t}$ $B = \left.\frac{-2}{s+2}\right|_{s=-1} = \frac{-2}{1} = -2$

1 $\frac{s+3}{(s+2)(s+1)} = \frac{A}{s+2} + \frac{B}{s+1}$ $A = \left.\frac{s+3}{s+1}\right|_{s=-2} = \frac{1}{-1} = -1$

$B = \left.\frac{s+3}{s+2}\right|_{s=-1} = \frac{2}{1} = 2$

$= -e^{-2t} + 2e^{-t}$

$$\therefore e^{At} = \begin{bmatrix} -e^{-2t} + 2e^{-t} & -e^{-2t} + e^{-t} \\ 2e^{-2t} - 2e^{-t} & 2e^{-2t} - e^{-t} \end{bmatrix}$$ ✓

2004 #5

Q3 given $A = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$

a) $\boxed{G = \begin{bmatrix} B & AB & A^2B \ldots \end{bmatrix}} = \begin{bmatrix} 0 & 1 \\ 1 & 4 \end{bmatrix}$

$AB = \underset{2\times2}{\begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}} \underset{2\times1}{\begin{bmatrix} 0 \\ 1 \end{bmatrix}} = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$ $\det G = -1$ ✓ $\neq 0$

$\boxed{O = \begin{bmatrix} C \\ CA \\ CA^2 \\ \vdots \end{bmatrix}}$ $CA = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 2 & 1 \end{bmatrix}$ $O = \begin{bmatrix} 1 & 0 \\ 2 & 1 \end{bmatrix}$ $\det(O) = 1$ ✓ $\neq 0$

b) P.O. = 5% $\zeta = 0.6901$ given $u = -Kx + lr$

$T_s = 2\text{ sec}$ $\omega_n = 2.898$ r = unit step

$\dot{x} = Ax + Bu$

$y = Cx$

$\underline{S^2 + 4S + 8.4 = 0}$

$\underline{\text{So find } K}$? $A - BK = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} - \begin{bmatrix} 0 \\ 1 \end{bmatrix} \begin{bmatrix} K_1 & K_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} - \begin{bmatrix} 0 & 0 \\ K_1 & K_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 3-K_1 & 4-K_2 \end{bmatrix}$

$\boxed{\det\left[SI - (A - BK) \right]}$

$\det\left(\begin{bmatrix} S & 0 \\ 0 & S \end{bmatrix} - \begin{bmatrix} 2 & 1 \\ 3-K_1 & 4-K_2 \end{bmatrix} \right) = \det \begin{bmatrix} S-2 & -1 \\ K_1-3 & S+K_2-4 \end{bmatrix} = (S-2)(S+K_2-4) + (K_1-3)$

$= S^2 + K_2S - 4S - 2S - 2K_2 + 8 + K_1 - 3$

$= \underline{S^2 + S(K_2 - 6) + K_1 - 2K_2 + 5}$

$K_2 - 6 = 4$

$\underline{K_2 = 10}$

$\boxed{\therefore K = \begin{bmatrix} 23.4 & 10 \end{bmatrix}}$ $K_1 - 2K_2 + 5 = 8.4$

$K_1 = 8.4 - 5 + 2(10)$

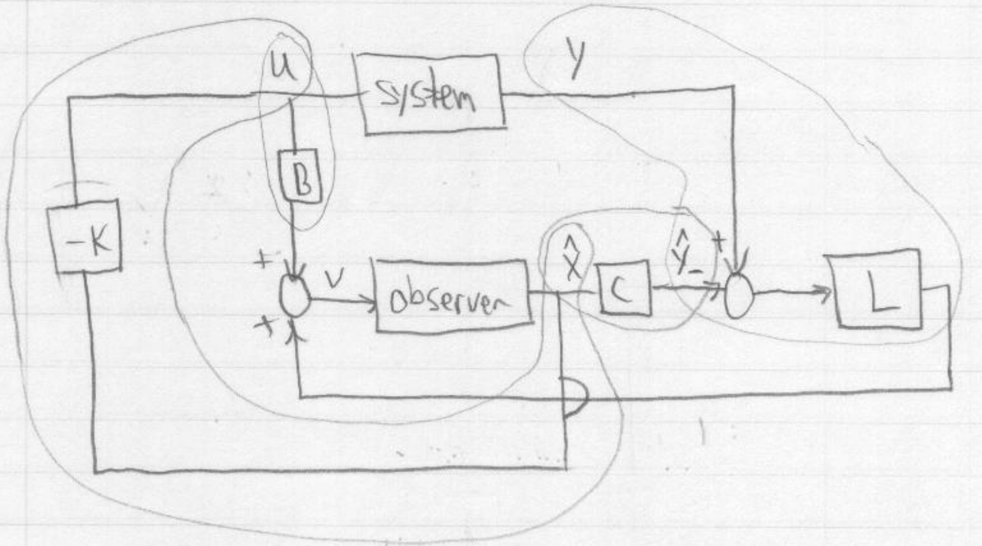
$\underline{K_1 = 23.4}$

2004 #7

c) **Observer Based State Feedback**

$\dot{\hat{x}} = A\hat{x} + Bu + \underbrace{L(y-\hat{y})}_{v}$ $\qquad u = -K\hat{x}$

$\hat{y} = C\hat{x}$



State feedback controller plus integrator

$y = Cx$