ECEN 4413 Controls II
Fall 1997
Midterm Exam #2

Name: ______________________________

Student ID: ______________________________

E-Mail Address: ______________________________
Problem 1:
Find the equivalent \( G \) configuration of a plant transfer function given as

\[
G_p(s) = \frac{2}{s^3 + 19s^2 + 95s + 77}
\]

with state feedback control (i.e., \( K = 2, k^T = [1 \ 2 \ 1] \)).

Show the resulting block diagram.
**Problem 2:**
Apply the state feedback with controller gain \( K = 2 \) to an open-loop DC motor with transfer function, \( G_p(s) = \frac{s^2 + 2s + 1}{s^3 + 2s^2 + 3s + s} \). Find the feedback coefficients (vector \( k \)) so that the eigenvalues of the closed-loop system matrix are -2, -3 and -5.
Problem 3:
For the state feedback control system described by
\[
\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)
\]
\[
y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(t),
\]
\[
u(t) = 10(r(t) - \begin{bmatrix} 2 & 3 \end{bmatrix} x(t))
\]
find a) \( \Phi_k(s) \), b) \( G_p(s) \), c) \( G_{eq}(s) \), and d) \( Y(s) / R(s) \) by matrix method.
Problem 4:
The resolvent matrix, $\Phi(s)$ for a given plant is

$$
\Phi(s) = \begin{bmatrix}
\frac{1}{s} & \frac{1}{s(s+3)} & \frac{10}{s(s+3)(s+10)} \\
0 & \frac{1}{s+3} & \frac{10}{(s+3)(s+10)} \\
0 & 0 & \frac{1}{s+10}
\end{bmatrix},
$$

and $b = \begin{bmatrix} 0 & 0 & 5 \end{bmatrix}^T$, $c^T = \begin{bmatrix} 1 & 2 & 1 \end{bmatrix}$. Find only $x_2(t)$ for $u(t) = e^{-3t}u_p(t)$ (i.e., $u_p(t)$ is the step function) and $x(0) = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}^T$. 