UTA PhD Diagnosis Exam (Spring 2013)

Linear Systems / Controls

**Instructions:**
- Verify that your exam contains 7 pages (including the cover sheet).
- Please be sure to use blank paper to write your answers. If more space is needed, please ask the instructor for extra paper. DO NOT WRITE ON THE BACK OF A SHEET!
- The point values listed on this exam serve only as a guideline. The Dept reserves the right to make modifications to the weighting of the problems.
- Calculator is okay.

I Choose to work on Problems _____ and _______ (Choose only 2 from the 3 problems).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Points</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Total Score (Choose 2 Problems)</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
1. Stability and Minimality

A CD reader system can be written in state-space form as

\[
\begin{bmatrix}
1 & 1 \\
6 & 0
\end{bmatrix} x + \begin{bmatrix}
1 \\
-3
\end{bmatrix} u, \quad y = \begin{bmatrix}
1 & 0
\end{bmatrix} x.
\]

a. Is the system Asymptotically stable?

b. Is the system bounded-input/bounded-output (BIBO) stable?

c. Find minimal realization (a, b, c, d)
2. **Full state controller and observer**

An LTI system with input $u(t)$ and output $y(t)$ is described by the following I/O differential equation:

$$\frac{d^2 y}{dt^2} + 2 \frac{dy}{dt} + 2y = \frac{du}{dt} + 3u.$$

a. Design a full state feedback control law to place the poles of the system at location $p_{1,2} = -2$.

b. Design a full state observer with closed loop poles at location $p_{1,2} = -20$.

c. Draw a block diagram for a combined full-state controller and estimator for this system.
3. **Realization and Canonical Forms**

A transfer function is given as

\[ H(s) = \frac{s + 3}{s^3 + 7s^2 + 14s + 8} \]

**Reachable canonical form**

a. Write SV equations for reachable canonical form

b. Draw RCF block diagram

**Observable canonical form**

c. Write SV equations for observable canonical form
d. Draw OCF block diagram

**Parallel Canonical Form (Jordan Form)**

e. Write SV equations for Parallel canonical form

f. Draw Parallel Form block diagram