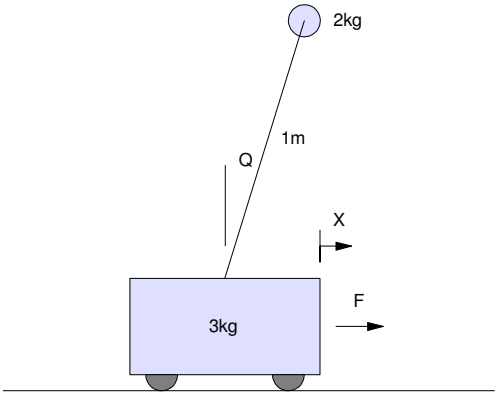
ECE 463/663 - Test #2: Name _____

Due midnight Monday, March 30th. Individual Effort Only (no working in groups)

No Aid Given, Received, or Observed: (sign if possible) _____



The dynamics for an inverted pendulum system (homework #4) is:

$$\begin{bmatrix} 5 & 2\cos\theta \\ 2\cos\theta & 2 \end{bmatrix}\begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix} = \begin{bmatrix} 2\sin(\theta)\dot{\theta}^2 \\ 2g\sin\theta \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} F + \begin{bmatrix} 1 \\ 1 \end{bmatrix} d$$

The linearized dynamics with a disturbance (d) are

$$s\begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & -6.533 & 0 & 0 \\ 0 & 16.333 & 0 & 0 \end{bmatrix}\begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0.333 \\ -0.333 \end{bmatrix} F + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0.5 \end{bmatrix} d$$

Feedback Controller Design

1) Design a servo compensator to
   - Track a sinusoidal set point

     $R = \sin(0.5t)$
   - Reject a constant disturbance

     $d = 1$

Give the resulting state-space matricies {A, B, C, D} for the closed-loop system.

2) Verify your control law on the linearized system

3) Verify your control law on the nonlinear simulation (assume all states are measured).

Observer Design

Assume you can measure both position and angle.

4) Design a full-order observer to estimate the states and the disturbance, d. Feed back the state estimates rather than the actual states.

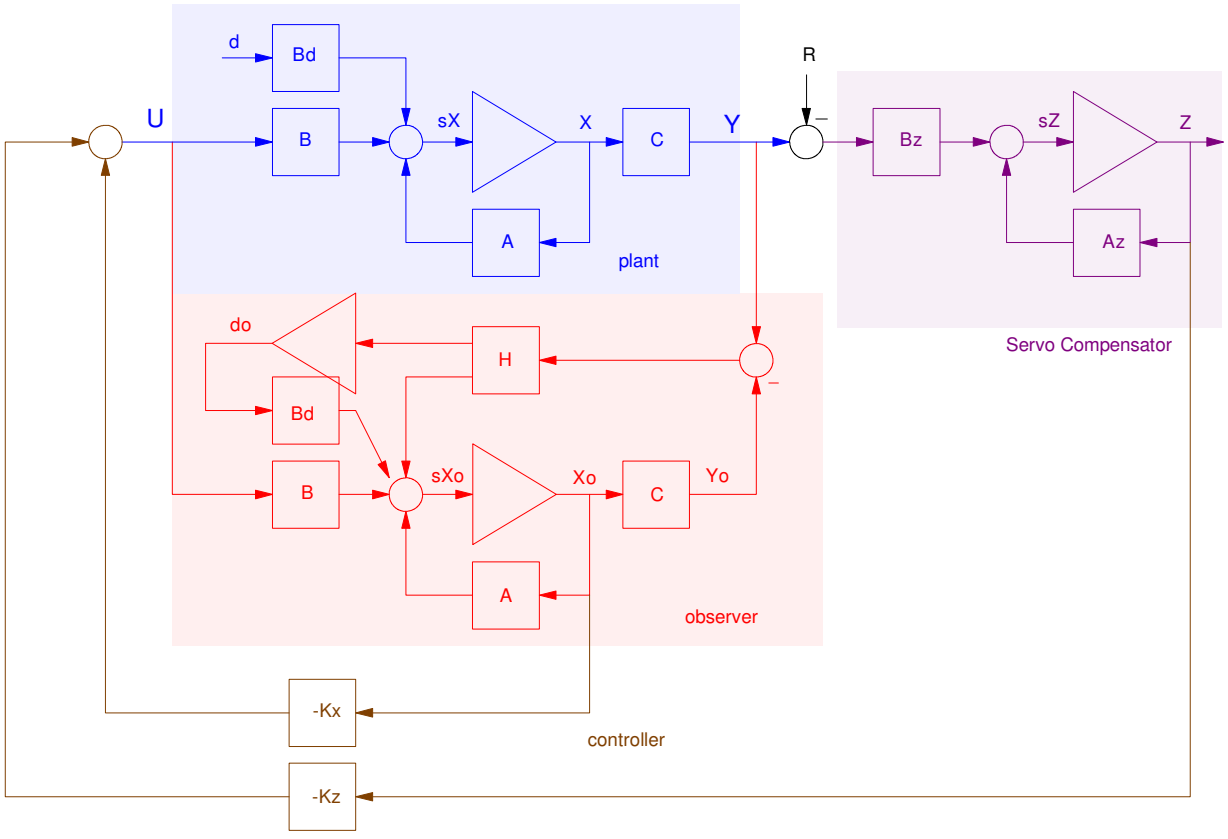
Give the state-space matricies for the resulting plant, servo compensator, observer, and full-state feedback {A, B, C, D}

5) Simulate the response of the linear system (full-order observer with the servo compensator) for

- A sinusoidal set point (R(t) = sin(t), d=0), and
- A step change in the disturbance (d=1, R=0)
- Xo(0) = X(0)

6) Simulate the response of the nonlinear system (full-order observer with the servo compensator) for

- A sinusoidal set point (R(t) = sin(t), d=0), and
- A step change in the disturbance (d=1, R=0)
- Xo(0) = X(0)



Block diagram for the Plant, Servo Compensator, Disturbance, Observer, and Full-State Feedback