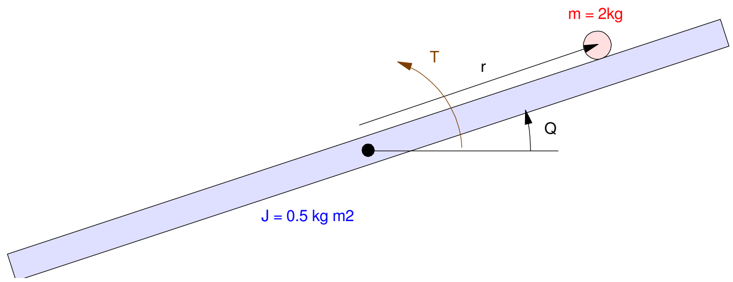
ECE 463/663 - Test #2: Name ________________

Due midnight Sunday, March 26th.   Individual Effort Only (no working in groups)



The linearized dynamics for a ball and beam system are:

$$s\begin{bmatrix} r \\ \theta \\ \dot{r} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & -7 & 0 & 0 \\ -7.84 & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} r \\ \theta \\ \dot{r} \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0.4 \end{bmatrix}(T+d)$$

C Level (max 80 points)

Design a feedback control law for the ball and beam system assuming

- All states are measured (no observer is needed)
- A constant & sinusoidal set point (R(t) = 1 + 0.3 sin(0.4t)), and
- A constant disturbance (d(t) = 1)

Validate your feedback control law on the linear system

Validate your feedback control law on the nonlinear system

- With the ball having a mass of 2.0kg (nominal case)
- With the ball having a mass of 1.9kg (constant disturbance)

B Level (max 90 points)

1) Design a feedback control law for the ball and beam system assuming

- Only position and angle are measured, (observer is required)
- A constant & sinusoidal set point (R(t) = 1 + 0.3 sin(0.4t)), and
- No disturbance (d(t) = 0)

2) Validate your feedback control law on the linear system

3) Validate your feedback control law on the nonlinear system

- With the ball having a mass of 2.0kg (nominal case)
- With U defined by the actual states

```
    U = -Kz*Z - Kx*X;
```

(The observer in this case should track - but it's not used for the feedback control law)

4) Validate your feedback control law on the nonlinear system

- With the ball having a mass of 2.0kg (nominal case)
- With U defined by the actual states after 15 seconds

```
 if(t < 15)
    U = -Kz*Z - Kx*X;
 else
    U = -Kz*Z - Kx*Xe;
 end
```

Note: it may or may not work when using the estiamted states if you don't use the angle measurement (no points off if it doesn't work - we'll cover using multiple outputs later.)

A Level (max 100 points)

1) Design a feedback control law for the ball and beam system assuming

- Only position and angle are measured, (observer is requried)
- A constant & sinusoidal set point (R(t) = 1 + 0.3 sin(0.4t)), and
- A constant disturbance (d(t) = 1)

2) Validate your feedback control law on the linear system

3) Validate your feedback control law on the nonlinear system

- With the ball having a mass of 2.0kg (nominal case) and m = 1.9kg
- With U defined by the actual states

```
    U = -Kz*Z - Kx*X;
```

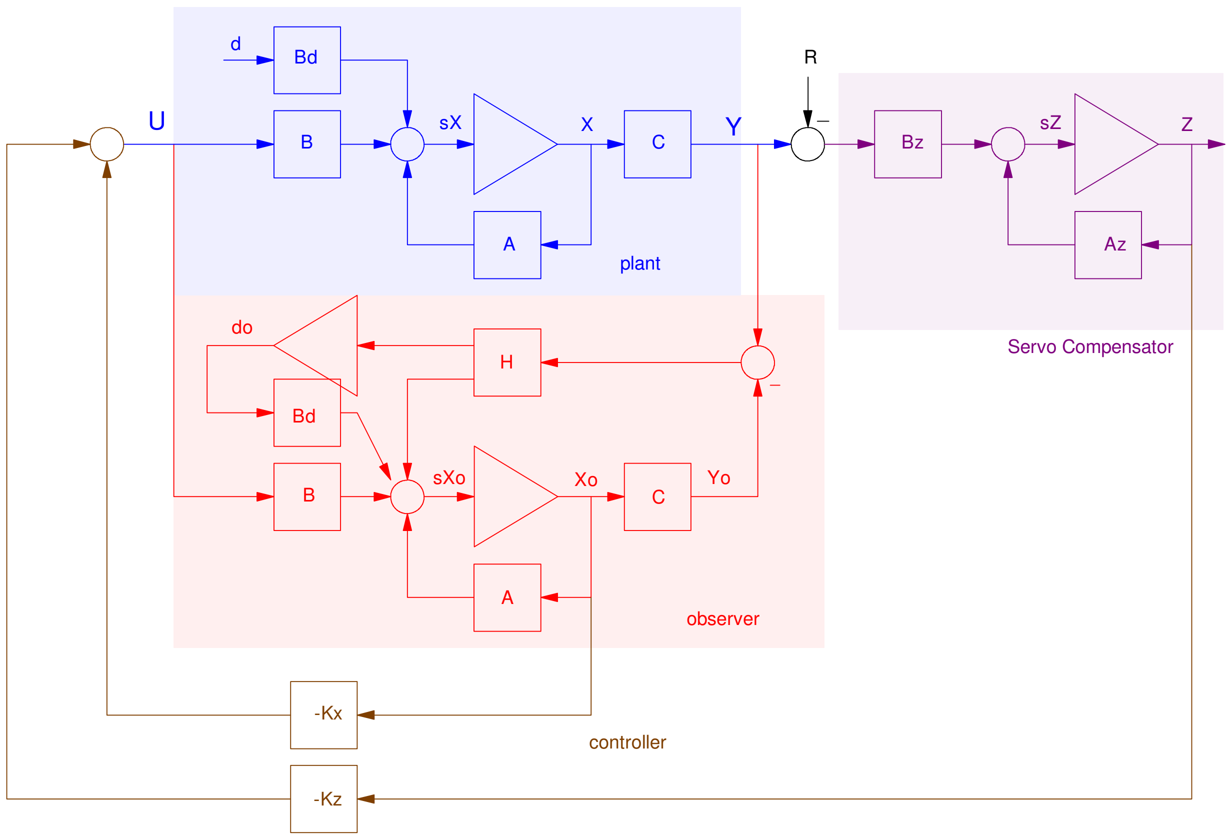
(The observer in this case should track - but it's not used for the feedback control law)

4) Validate your feedback control law on the nonlinear system

- With the ball having a mass of 2.0kg (nominal case) and m = 1.9kg
- With U defined by the actual states after 15 seconds

```
 if(t < 15)
    U = -Kz*Z - Kx*X;
 else
    U = -Kz*Z - Kx*Xe;
 end
```

Note: it may or may not work when using the estiamted states if you don't use the angle measurement (no points off if it doesn't work - we'll cover using multiple outputs later.)



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