ME 132 — Homework # 1

Issued: September 03, 2021 — Due: September 12, 2021

1 *Structure of Control Systems*

Draw the block diagram for temperature control in a refrigerator. Use as much detail as you can think of. What disturbances are present in this problem? Clearly label the plant, sensor, reference, and controlled output.

2 *Components of Control Systems*

Consider the problem of controlling the temperature in a room. There is a thermometer that records the room temperature, a heater than can be turned on of off, and a thermostat where the user can enter the temperature they like. People go in an out of the room which has a door and several windows. There is an electronic switch that turns the heater on and off.

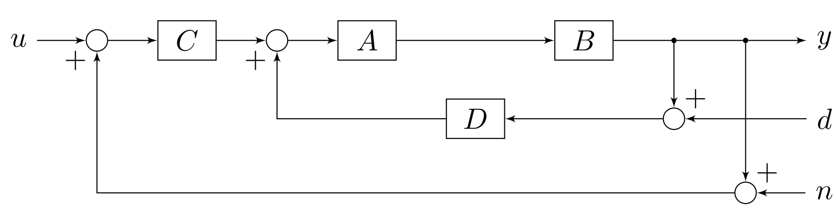
Match the following terms with their appropriate meanings.

(a) electronic switch	A. sensor
(b) thermostat setting	B. actuator
(c) opening windows	C. reference
(d) people leaving the room	D. an example of a disturbance
(e) thermometer	E. another example of a disturbance

3 *Block diagrams*

Consider the block diagram shown below. Each block is a gain with the letter in the block denoting the numerical value of the gain. Find the matrix M (which is 1×3) such that

$$y(t) = M \begin{bmatrix} u(t) \\ d(t) \\ n(t) \end{bmatrix}$$



4 SIMULINK

Plot the trajectory of a ball thrown up in the air at an angle of 65° with an initial speed of 35 `meters/sec`. The ball has mass 0.3 `Kg`. Assume that the only force acting on the ball is gravity. Provide a plot of the trajectory of the ball for 7 seconds.

5 SIMULINK *and Modeling*

Now lets throw in wind resistance. Because of wind resistance, the ball experiences a force of $0.028 * v^2$ where v is the speed of the ball. This force is in the direction opposite to the velocity vector. First derive the equations of motion for the ball. These will be coupled differential equations of the form

$$\ddot{x} = f_1(x, y), \quad \ddot{y} = f_2(x, y)$$

Then, simulate and plot the trajectory of the ball.

6 SIMULINK *and Open Loop Control*

The dynamics for a spring-mass-damper system are

$$m\ddot{y} + c\dot{y} + ky = u$$

where y is the position of the mass, $m = 1$ `Kg`, $c = 1\ \frac{\mathtt{Ns}}{\mathtt{m}}$, $k = 1\ \frac{\mathtt{N}}{\mathtt{m}}$, and u is the control signal. We wish to choose u to make $y = 1$.

Assume the mass is initially at rest at $y = 0$

(a) We use the naive controller that just sets the force to a constant, i.e. $u = 1$. What is the asymptotic position of the mass, i.e compute

$$\lim_{t \to \infty} y(t)$$

(b) Using SIMULINK, compute and plot y versus t for $0 \leq t \leq 12$. Comment on the performance of this controller.

(c) Suppose there was an error in measuring the spring constant, so the actual spring constant is $\widetilde{k} = 1.1\ \frac{\mathtt{N}}{\mathtt{m}}$. Use the open-loop controller $u = 1$. Overlay a plot of y versus t for $0 \leq t \leq 12$ on the plot from Part (a) (use the `hold on` command). Comment on the effect of modeling uncertainty on the controller performance.

7 SIMULINK *and Closed Loop Control*

Consider again the spring-mass-damper system of Problem **??**.

(a) Let $u = 10 - 9y$. Plot y versus t for $0 \leq t \leq 12$. Comment on the performance of this controller.

(b) Suppose the actual spring constant is $\widetilde{k} = 1.1\ \frac{\mathtt{N}}{\mathtt{m}}$. Use the feedback controller $u = 10 - 9y$. Overlay a plot of y versus t for $0 \leq t \leq 12$ on the plot from Part (a). Comment on the effect of modeling uncertainty on the controller performance.

(c) Compare the open-loop and closed-loop control strategies.