Chapter 1 HW Solution

Review Questions.

1. Name three applications for feedback control systems.

1. Elevator
2. Robot vehicle or manipulator arm
3. Spacecraft

2. Name three reasons for using feedback control systems and at least one reason for *not* using them.
(a) Reasons *for* using feedback control systems:

1. Power amplification (input signal is amplified on its way to output)
2. Remote control (output location is remote from input location)
3. Compensation for disturbances (disturbances do not affect output)

(b) Reason(s) for *not* using feedback control system.

1. Cost
2. Complexity

4. Functionally, how do closed-loop systems differ from open-loop systems? In closed-loop systems, the output is measured and used (in some way) to affect the control input to the system.

8. Name the three major design criteria for control systems.

1. Transient response: the nature of the system's response while it is changing
2. Steady-state response: the nature of the response after it has reached steady-state
3. Stability: this really comes before anything else

9. Name the two parts of a system's response. Transient and Steady-State.

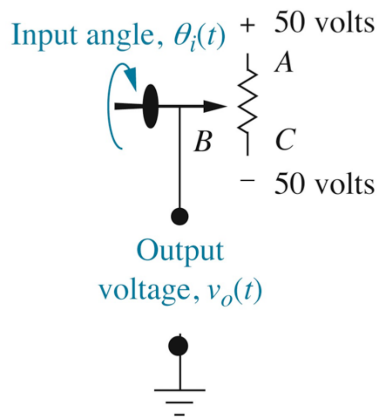
14. Adjustment of the forward path gain can cause changes in the transient response. TRUE

15. Name three approaches to the mathematical modeling of control systems.

1. Modeling using LTI (linear, time-invariant) **differential equations**
2. Modeling using the **Laplace transform** and **transfer functions**
3. Modeling using the **state-space representation**

Problems.

Problem 1. The schematic of a potentiometer is shown below.

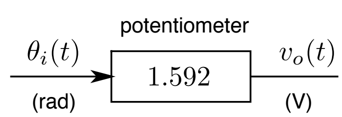


If it takes 10 turns to move the wiper arm from A to C, draw a block diagram of the potentiometer showing the input variable, the output variable, and (inside the block) the gain.

The **gain** is just the range of the output (100 V) divided by the range of the input (10 turns). To be "mathematically-oriented" I'll specify the input rotation in units of **radians** (not specified in problem statement). Thus,

$$\text{GAIN} = \frac{100 \text{ V}}{10(2\pi) \text{ rad}} = 1.592 \, \frac{\text{V}}{\text{rad}} \tag{1}$$

A block diagram of this component is:

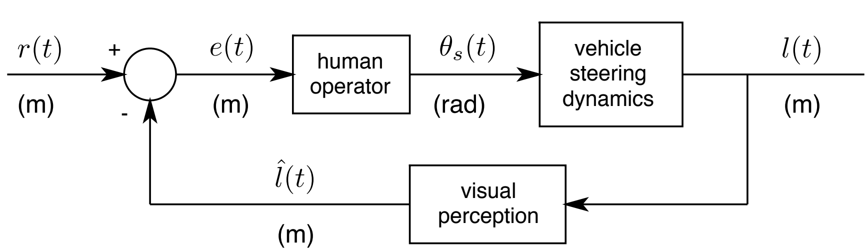


where I have shown the units of the input and output signals (and also given the component a "title").

Problem 2. Draw a functional block diagram for the task of steering an automobile (*i.e.* keeping the vehicle in the center of the lane). Use as many blocks and variables as you wish, but:

- Label each block (inside the block) with the title of that component
- Label each variable (lines connecting the blocks) with a variable name (like "u"), and the UNITS of that variable
- Don't worry about any physical analysis of anything; this is all qualitative
- *Hint:* The reference input will be "desired position in lane" and the output will be "actual position in lane"

Here is a relatively simple block diagram (description of variables on next page):



A description of the variables of the "steering block diagram" is:

$$
\begin{aligned}
r(t) &= \text{desired position of vehicle in lane (deviation from center), in m} \\
e(t) &= \text{error in lane position, in m} \\
\theta_s(t) &= \text{steering wheel angle, in rad} \\
l(t) &= \text{actual position of vehicle in lane, in m} \\
\hat{l}(t) &= \textit{perceived} \text{ position of vehicle in lane, in m}
\end{aligned}
$$

There are **MANY** possible block diagrams of this system...