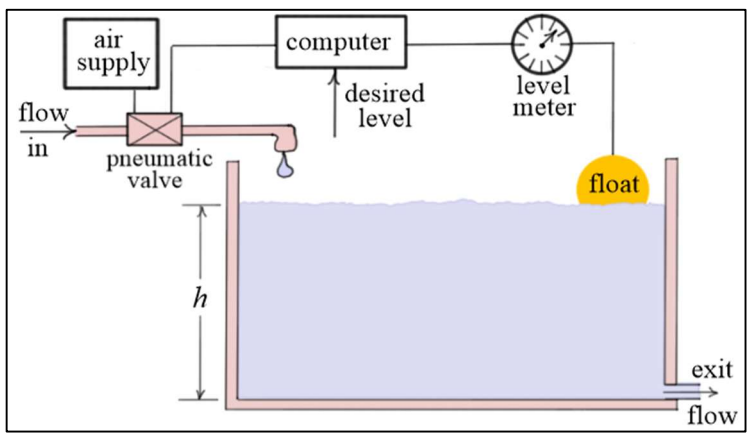
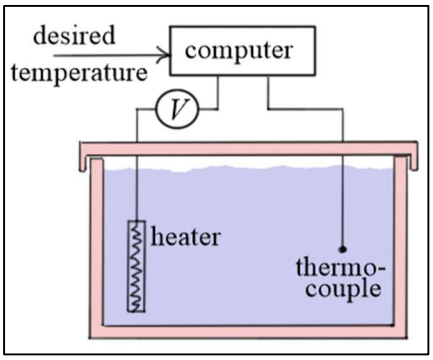
Introductory Control Systems
Exercises #1 – Conceptual Block Diagrams

1. It is your job to manually control the temperature of a small unheated room with windows during a cold winter day. You have access to an electric heater and a thermometer to do the job. The heater must be manually turned on and off to regulate the temperature. Draw a block diagram of this closed loop process. Identify the ***system input***, ***system output***, ***temperature error***, ***controller***, ***process*** (or plant), ***actuator***, ***disturbance***, and ***sensor*** on the diagram.
2. You are attempting to maintain a ***constant speed*** while driving on the highway (without using cruise control). Draw a block diagram of this closed-loop system. Identify the ***system input***, ***system output***, ***speed error***, ***controller***, ***process*** (or plant), ***actuator***, ***disturbance***, and ***sensor*** on the diagram.
3. Controlling the ***distance*** between your car and the car in front of you as you drive is a ***closed loop process***. Draw a block diagram to describe this process. Identify the ***system input***, ***system output***, ***distance error***, ***controller***, ***process*** (or plant), ***actuator***, and ***sensor*** on the diagram.
4. ***Steering*** your car as you drive is a ***closed loop process***. Draw a block diagram to describe this process. Identify the ***system input***, ***system output***, ***direction error***, ***controller***, ***process*** (or plant), ***actuator***, ***disturbance***, and ***sensor*** on the diagram.
5. The holding tank contains water that is to be maintained at some desired level h_d. Draw block diagrams for the open and closed loop systems described below. In each diagram, identify the ***system input***, ***system output***, ***level error***, ***controller***, ***process*** (or plant), ***actuator***, and ***sensor***.



   a) ***Open loop system***: A desired water level is entered into the computer. The computer then commands a fixed setting for the pneumatic valve, changing the flow rate of water into the tank. The water level h is measured and the values are plotted on the computer screen.
   b) ***Closed loop system***: The setup is as described in (a), except the computer calculates the difference between the desired and measured water levels and adjusts the valve setting accordingly to increase the input flow rate if the level is too low and decrease it if the level is too high.

6. An insulated tank holds water that is to be maintained at some specified (desired) temperature T_d. Draw block diagrams for the open and closed loop systems described below. In each diagram, identify the ***system input***, ***system output***, ***temperature error***, ***controller***, ***process*** (or plant), ***actuator***, and ***sensor***.



a) ***Open loop system***: The computer sends a signal to the voltage source that drives the heater to heat the tank. The thermocouple generates a voltage the computer uses to measure the temperature of the water. The measured temperature is plotted on the computer screen.

b) ***Closed loop system***: The setup is as described in (a) except the temperature measured by the thermocouple is used by the computer to calculate the difference between the desired and measured temperatures and adjusts the voltage command to the heater accordingly.