



Modeling a Mechanism for Controlling Water Level

In this activity we will simulate a system for controlling the water level in a cylinder.

Instructions for Students:

Step 1. Study the diagram APPARATUS FOR CONTROLLING WATER LEVEL as your teacher explains it briefly.

Step 2. Learn what your job is as part of the model control mechanism. One person will perform each of the following tasks:

- **Input Flow Controller:** Operate the water tap.
- **Output Flow Regulator:** Raise or lower the bucket.
- **Set Point Adjuster:** Decide what the desired water level in the cylinder should be and tell only the **Error Detector** and the **Recorder** what this set point is. (For example, the set point might be 400 mL.)
- **Error Detector:** Measure the difference between the set point and the water level, walk quickly to where the **Feedback Signaler** is standing, and tell the **Feedback Signaler** whether the level is too high or too low. Also tell the Recorder what the reading is.
- **Feedback Signaler:** Stand at least 15 feet from the apparatus; when the **Error Detector** tells you whether the level is too high or too low, walk quickly to where the **Output Flow Regulator** is standing and tell him/her to increase or decrease the flow.
- **Recorder:** Write down the set point at the beginning of the test; when the test starts, use a watch and tell the **Error Detector** to take a reading every 30 seconds; and record the water level at 30 second intervals.

Put on the badge that shows what role you will play.

Rules for the Simulation:

- a) Only the **Error Detector** and the **Recorder** are permitted to observe the cylinder; all others should keep their backs toward the apparatus.
- b) The **Feedback Signaler** must stand several feet away from the others (far enough away so that the others cannot hear what he/she is being told).

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- c) The **Set Point Adjuster** should tell only the **Error Detector** and the **Recorder** what the set point should be (for example, the set point may be 400 mL).

Procedures for the Simulation:

- a) The **Recorder** sets up a data table on chart paper, the chalk board, or a transparency.
- b) The **Set Point Adjuster** decides what the set point will be and tells the **Error Detector** and the **Recorder**.
- c) The **Input Flow Controller** states that the water is flowing at the desired rate and the siphon is functioning.
- d) The **Recorder** tells the group to begin the test by telling the **Error Detector** to take the initial reading. Every 30 seconds the **Recorder** tells the **Error Detector** to take a reading.
- e) The **Error Detector** estimates the difference between the set point and the water level. Then he/she walks over to where the **Feedback Signaler** is standing and tells what the difference is. For example, if the set point is 400 mL and the water level is 320 mL, he/she says, "The level is low by 80 mL." The **Error Detector** also quietly gives this information to the **Recorder**.
- f) The **Feedback Signaler** then walks over to the **Output Flow Regulator** (the person in charge of the bucket) and tells him/her to increase or decrease the flow. For example, if the level is low by 80 mL, the message will be, "Decrease the flow." Then the **Feedback Signaler** returns to his/her post at some distance from the others.
- g) When the **Output Flow Regulator** learns whether to increase or decrease the flow, he/she lowers the bucket (to increase flow) or raises it (to decrease the flow). There are three different levels for the bucket: on the floor, on a chair, and on the table. If the bucket is already on the floor and the **Feedback Signaler** says, "Increase the flow," leave the bucket where it is because the bucket can't be placed any lower. If the bucket gets over half full, pinch the siphon to stop flow and ask the **Set Point Adjuster** to empty the bucket in the sink.
- h) While all this is going on, the **Recorder** records the water level every 30 seconds. Continue operation of the system for about 8 minutes. The **Recorder** should decide when the test is over and so inform the **Set Point Adjuster**.
- i) The **Input Flow Controller** shuts off the water flow by closing the faucet. The **Output Flow Regulator** puts the bucket on the table.

Step 3. Construct a siphon: First watch your teacher as he/she demonstrates the following steps.

- a) Fill the graduated cylinder with water until it is almost full.
- b) Place the bucket on a chair.
- c) Pick up the longer rubber tube. One end of this tube will be weighted with a stopper and glass tube.
- d) Fill this longer rubber tube with water.
- e) Pinch one end and place a thumb over the tube at the other end to keep the water from flowing out. Carefully place the weighted end of the tube under water in the cylinder.

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- f) Place the other end of the rubber tube in the bucket, curling the extra tubing around in the bottom of the bucket.
- g) Release the tube at both ends.

This makes the tube into a siphon that will allow water to flow out of the cylinder. Now work with the members of your group to make the siphon your group will use. If you have difficulty making water flow in the siphon, ask your teacher for help.

Step 4. Set up the apparatus as shown in the diagram. While you are doing this, prevent the water from draining out of the cylinder by pinching the siphon.

Step 5. Adjust the water flow rate until it is between 250 and 350 mL/min. To do this, the **Input Flow Controller** should open the water tap a little to allow water to flow into the cylinder. Other group members may observe how much the water rises in the cylinder in 15 seconds. When the flow rate is adjusted, you are ready to begin the first test. Be sure to pinch off the siphon while measuring the input water rate.

Step 6. Conduct a test of the feedback control system, using the rules and procedures listed in Step 2.



Apparatus for Controlling Water Level

