SIPHON

OBJECTIVE:

You will understand and demonstrate how a siphon uses gravity to raise water.

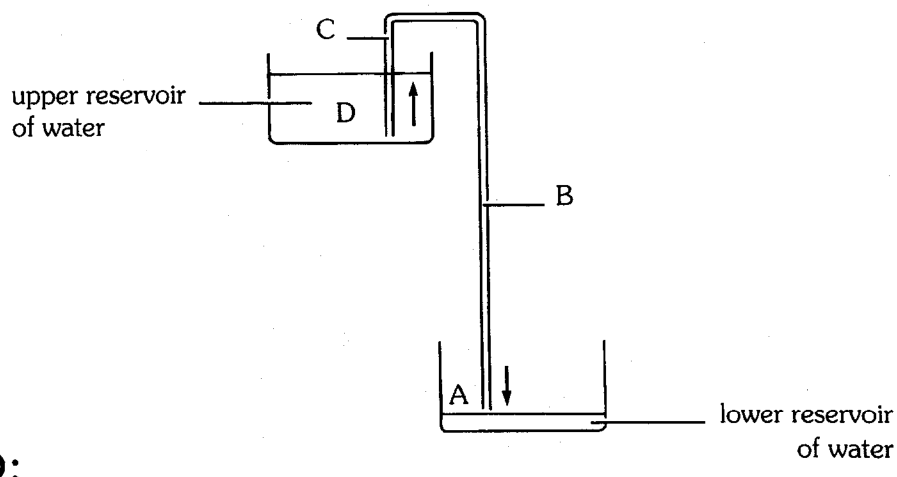
INTRODUCTION:

A siphon is a device for achieving what appears to be impossible: making water flow uphill over short distances. A siphon is usually a tube connecting a higher water reservoir with a lower one, over an intervening ridge (see figure 1). The flow of water between the bottom and top reservoirs depends on the influence of gravity. The mass of water in column B is greater than that in column C, pulling water from A to D. The water columns within the tubing do not break because of the cohesiveness of water—water molecules are strongly attracted to one another.

As early as the sixth century BC, Greek engineers in Asia Minor and elsewhere were running pipework over several miles to carry water supplies using the siphon effect. The aqueduct of Pergamon, built around 180 BC, carried water from a mountain top at 1,174 meters, across two valleys at 172 meters and 195 meters and over the intervening ridge at 233 meters, before reaching Pergamon citadel at 332 meters.

Today, perhaps the best example of the use of a siphon is in the toilet cistern. Depressing the toilet handle raises water into the siphon tube between cistern and toilet bowl. Water then travels from cistern to bowl by the siphon effect.

Figure 1



TIME NEEDED:

1 hour

MATERIALS:

Note: You will need a partner for this experiment.

- 2 pieces of 1.2m-long plastic aquarium tubing, one with internal diameter of 6 mm and one of 12 mm
- shallow bowl with at least 4-liter capacity
- meterstick
- plastic bucket with at least 4-liter capacity
- books to make stack up to 60 cm
- 1-liter graduated cylinder
- permanent waterproof marker
- stopwatch
- graph paper
- calculator

Note: You will need a table or workbench 27–31 in. high, and a sink and faucet.

Safety Precautions

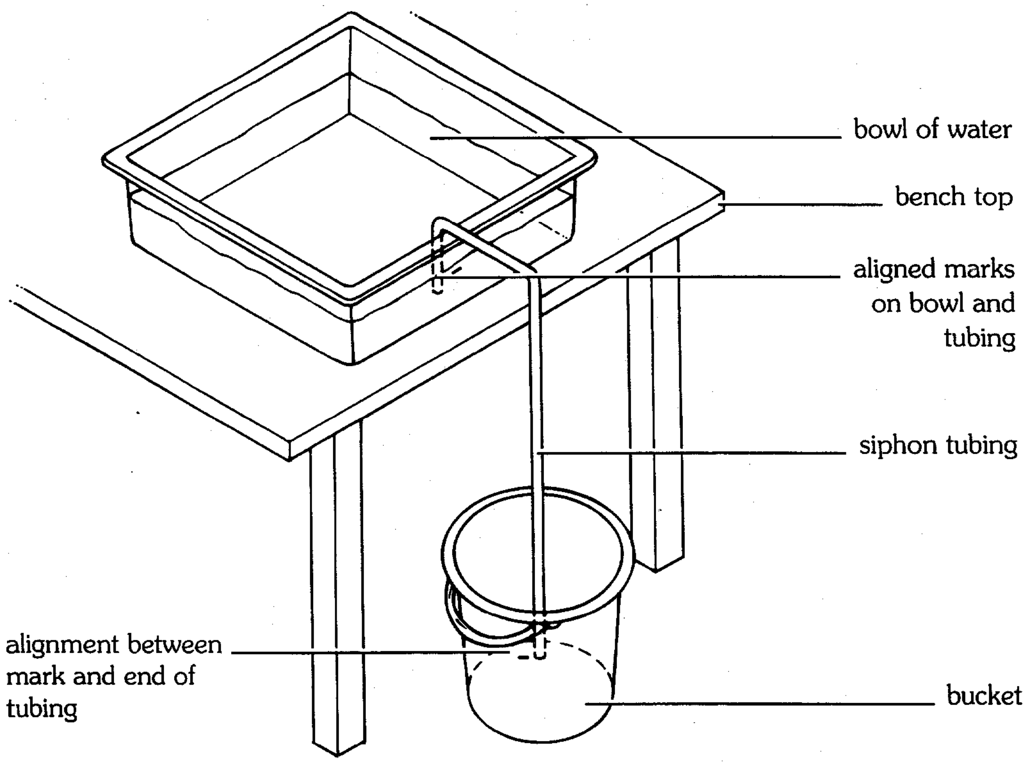
Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Make sure you carry out the investigation away from any electrical power sources and wiring.

PROCEDURE:

Part 1—Siphoning rate and height

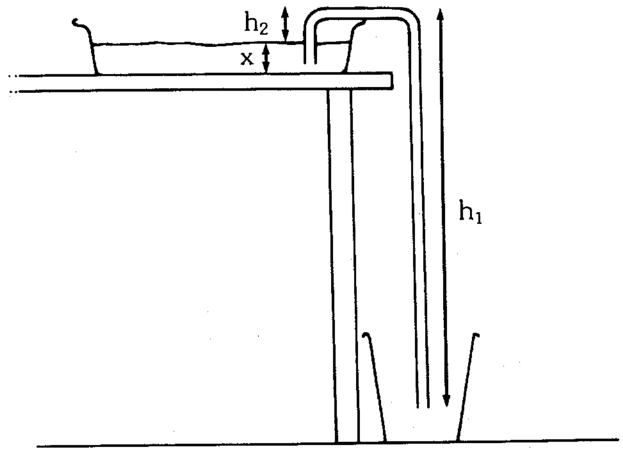
1. Fill the bowl about two-thirds full with water and place it on the bench or table. Mark the level of the water on the inside of the bowl with the marker.
2. Place an empty bucket below the bench. Mark a level two-thirds up the inside of this.
3. Take the 12mm-diameter tubing and mark a line 5 cm from one end of the tube.
4. Load the siphon tube by immersing the tube in a sink of water. Make sure the tubing is full of water and does not contain any air bubbles. With the tubing still under water, place a thumb tightly over either end and lift the tube out of the sink. Position the tube between the bowl and the bucket with the tubing resting over the rim of the bowl (see figure 2). Align the mark on the tubing with the mark inside the bowl. Also align the other end of the tube with the line in the bucket .

Figure 2



5. Have your partner hold the stopwatch. At a prearranged signal, you uncover the ends of the tube while your partner starts the stopwatch. If the siphon is correctly set up, and contains no air bubbles, water should flow from D to A.
6. Allow the water to flow for exactly 15 seconds, and then cover the ends of the tubing with your thumbs. Return the tubing to the sink.
7. Use the graduated cylinder to measure the volume of water you have collected in the bucket. Record the result in line 1 of the Data Table in the column marked V_1. (Important: Make sure all the water you have collected is returned to the bowl on the bench or table.)
8. Measure h_1, the vertical distance between the highest part of the tube and the bottom end of the tubing. Also measure the heights h_2 and x (see figure 3). Enter the values for h_2 and x at the top of the Data Table, and enter the value for h_1 in line 1 of column h_1 of Part 1 of the Data Table.
9. Repeat steps 4–8 but with the bucket placed on a stack of books about 15 cm off the floor. Repeat, but increase the stack height to 30 cm, then 45 cm, and finally 60 cm. The values for h_2 and x should be constant in all cases. The value for h_1 in each case is most easily calculated by subtracting the new height of the bucket from the original value for h_1. Enter the new values for h_1 in the appropriate lines of column h_1 in Part 1 of the Data Table.

Figure 3



Part 2—Siphoning rate and diameter of tubing

10. Repeat steps 4–8, with the bucket on the floor, but using the 6mm-diameter tubing and collecting water over 30 seconds rather than 15 seconds. Repeat four more times as in step 9, with the bucket at heights of 15 cm, 30 cm, 45 cm, and 60 cm, and using the 6mm-diameter tubing collecting water over 30 seconds. Enter all your results in Part 2 of the Data Table.

DATA TABLE

h_2 (cm) =
x (cm) =

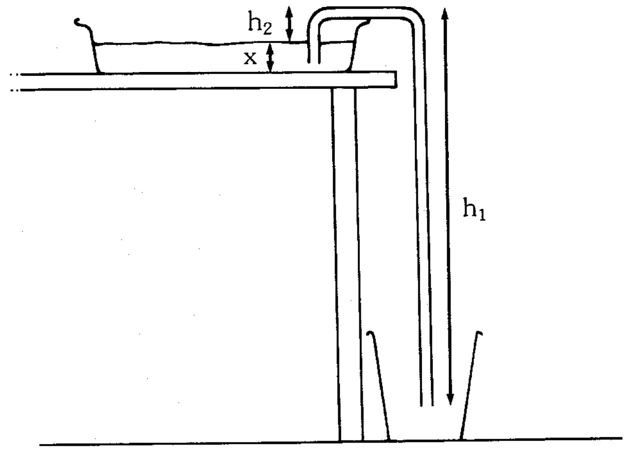
Part 1 Using 12mm-diameter tubing

Height of bucket off floor (cm)	h_1 (cm)	V_1, volume of water (liters) collected in 15 seconds	Flow rate (liters/minute) $= V_1 \times 4$
0			
15			
30			
45			
60			

Part 2 Using 6mm-diameter tubing

Height of bucket off floor (cm)	h1 (cm)	V_2, volume of water (liters) collected in 30 seconds	Flow rate (liters/minute) $= V_2 \times 2$
0			
15			
30			
45			
60			

Figure 3



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0			
15			
30			
45			
60			

ANALYSIS:

1. Calculate the flow rate for each of your tests and enter your results in Part 1 and Part 2 of the Data Table.
2. Plot a graph of h_1 (along the x axis) against flow rate (along the y axis) for your results for the 6mm-diameter tubing. On the same piece of paper, plot your results for the 12mm-diameter tubing.
3. What is the relationship between h_1 and flow rate? How do you account for this?
4. Does the diameter of the tubing affect the flow rate?
5. a) Is the velocity of the water flowing from the upper to the lower container the same for both diameters of tube? To check this, use data from your graphs with h_1 at 60 cm. To calculate the water's velocity, use the following equation:

$$\text{velocity (cm/minute)} = \frac{\text{flow rate (cm}^3\text{/minute)}}{\text{cross-sectional area } (\pi r^2)\ (\text{cm}^2)}$$

(Note: 1000 cm^3 = 1 liter)
(Note: r = radius (cm))

b) Try to account for any difference in the velocity of water flowing in the 6mm-diameter and the 12mm-diameter tubing.

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific investigation. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly when you are constructing or demonstrating a model invention. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each project you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while carrying out these projects. Be sure to check the individual projects in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk or bench
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES