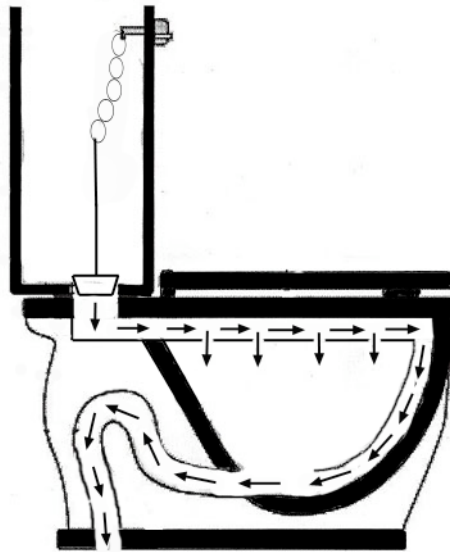


Toilet Model

A Draining Experience



In this toilet model, the upper plastic funnel represents the toilet tank, the lower funnel represents the toilet bowl, the wooden dowel/wine cork represents the handle and flapper valve that allow flushing, and the plastic tube represents the siphon that connects the bowl to the sewer line.

Materials

3 PVC 1/2 in. pipe, 6 in. long
2 PVC 1/2 in. pipe, 4 in. long
2 PVC 1/2 in. pipe, 3 in. long
1 PVC 1/2 in. pipe 10 in. long
2 PVC 1/2 in. 90 degree elbows
2 PVC 1/2 in. T
1 PVC 1/2 in. cross
PVC shears, or alternate way to cut PVC pipe
electric drill and 15/32 in. bit (1/2 in. bit may also work -- see Assembly comment below)
1 wine cork (large enough in diameter to effectively seal the outlet of one of the bottles)
1 wooden dowel or bamboo skewer, approximately 5 in. long
optional: bottom half of a larger plastic bottle (e.g., 710 mL, 1L or 2 L) for collection, so there will be no danger of overflow -- alternatively a large clear plastic cup can be used

2 ft. clear plastic tubing, 3/8 in. i.d., 1/2 in. o.d.
1 plastic cable tie
2 plastic water bottles, 500 mL
1 cap to fit one of the water bottles
hot glue gun and hot glue sticks
utility knife
scissors

Assembly

Assemble the toilet model as shown in Figure 1 on the next page. Following are some notes and comments for the assembly process. **These are NOT intended to be step-by-step instructions in logical order. It would be a good idea to read ALL the Notes and Comments BEFORE starting the assembly.**

- PVC pieces are joined WITHOUT glue. This has posed no problems in using the model, and allows disassembly for efficient storage, as well as changes in design if desired.
- Cut the 500 mL water bottles approximately in half, so that each bottle provides a funnel, and a cup. The funnels will be used for the toilet tank and bowl. The cups will be used to pour water into the toilet, and to collect it at the outlet (as noted in the Materials section, a larger container may be a good idea for collection, to avoid overflow or spillage).
- Drill a 15/32 in. or 1/2 in. hole in the bottle cap for the tubing. Use the smallest drill which will still allow the tubing to be forced through the hole. The tighter the fit, the better. If water leaks where the tubing goes through the cap, use hot glue on the outside of the cap to seal the joint between cap and tubing.

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- The cable tie is not absolutely necessary, but helps keep the tubing in place (see Figure 4).
- Figures 2a and 2b show a plug in the end of the pipe to prevent water from accidentally running into the frame of the device if the end of the hose is inside the T. The plug was made by crumpling up a small opiece of a bottle label and stuffing it in the end of the pipe, and then putting hot glue on it seal it.
- To make the cork substitute for the "flapper valve," first use a wooden pencil or a ball-point pen (or anything else that works) to poke a hole about 1/2 inch deep into the end of the cork. Put some hot glue on the hole, and insert the dowel or skewer. Put a little more hot glue around the hole to provide a good bond. See Figures 3a and 3b.

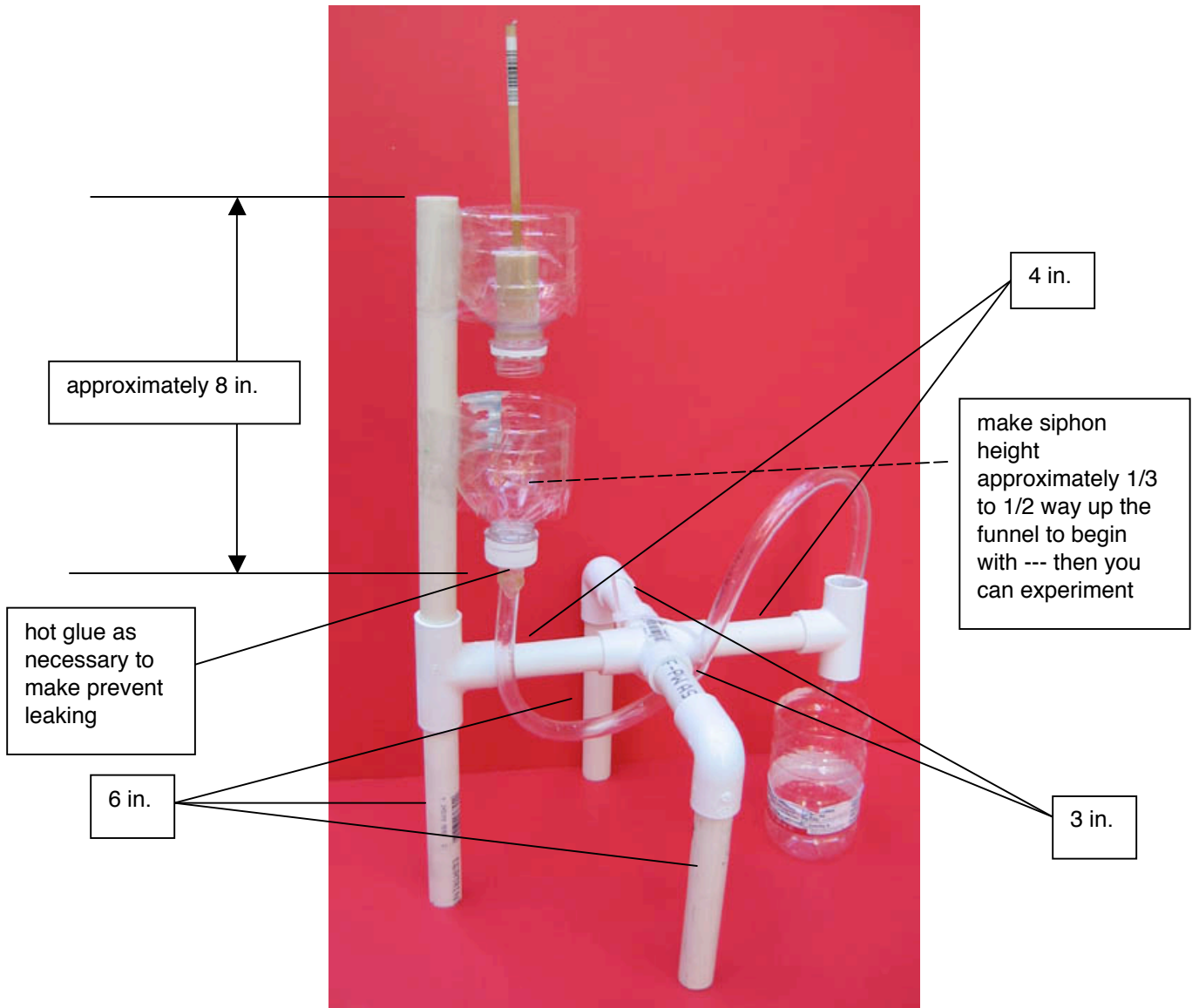


Figure 1

(more photos on next page)



Figure 2a

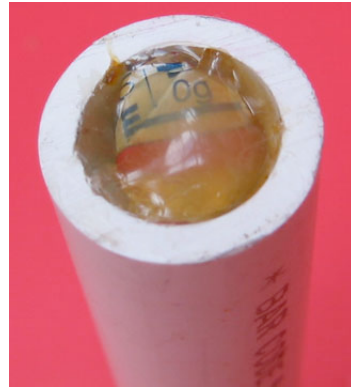


Figure 2b

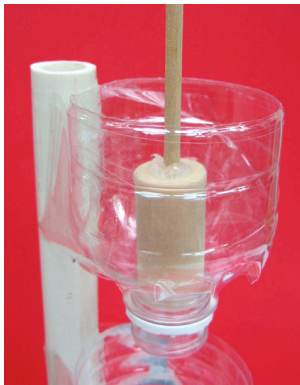


Figure 3a



Figure 3b



Figure 4

To Do and Notice

Set up the toilet model as shown. The top of the "inverted U" section of the plastic tube should be approximately the same elevation as a third to halfway up the lower funnel. See Figure 1.

Carefully pour water into the top funnel until the water level in the plastic tube is almost to the top of the "inverted U."

Insert the wine cork plug into the opening of the top funnel.

Pour water into the upper funnel. If it leaks significantly, adjust the cork plug until there is little or no leakage.

"Flush" the toilet by lifting the wooden handle of the cork plug. Observe the flushing action, including the sound at the end!

What's Going On?

When you press the handle on a toilet to flush it, the flapper valve in the tank lifts and allows water to flow from the tank to the bowl. As the bowl fills with water from the tank, the water level also rises in the siphon tube that connects the bowl to the sewer drain. When the water level gets higher than the top of the siphon, the siphoning process begins, and empties the bowl. When the bowl is empty, air enters the siphon, and flow stops.

Now let's go through the flushing process with the model, and see how it relates to an actual toilet (actual toilet parts are shown in parentheses in bold type). As you fill the lower funnel (**bowl**), water also rises in the clear plastic tube (**trap and siphon**). Putting the cork (**flapper**) in place and filling the top funnel (**tank**) gives you a reservoir of water. At this point you are ready to begin the flushing process by lifting the cork (**flapper**) and allowing the water to flow into the bottom funnel (**bowl**).

As the lower funnel (**bowl**) rapidly fills, the water level in the tube reaches the top of the "inverted U" loop (**siphon**), and begins to fall down the other side to the outlet drain. This starts the siphon action, and the flow continues until the water level in the lower funnel and "U" (**bowl and trap**) allows air into the siphon tube.

In a real toilet, the bowl and tank automatically refill, but the model does not demonstrate this.

The lower "U" shaped part of the tube is known as the trap, and its purpose is to keep gases from the sewer drain from rising into the toilet and bathroom. The water in the bottom of the "U" prevents this, and usually there is a vent from the sewer drain to the roof of a house, which allows the sewer gases to escape into the atmosphere.

Going Further

- Try different heights for the top of the siphon tube, and for the outlet of the siphon tube.
- Do some research and experiments on how siphons work. What is an antisiphon device and what are some of its practical uses?
- The flush toilet has a long history, dating back at least to Leonardo daVinci in the 1400s. The modern flush toilet is generally considered to have been invented by Thomas Crapper in the late 1800s. There are now many brands and models of toilets, with a variety of flushing mechanisms. Do some research on the history of the toilet, and on various toilet designs.

Credit

This model is a "PVC version" of models developed and used by Curt Gabrielson and Modesto Tamez.

References

- Walker, Jearl. *The Flying Circus of Physics, With Answers*. John Wiley & Sons, 1977. See items 4.105 (Siphons) and 4.107 (The Crapper), p. 106, and their corresponding explanations, pp. 263–264.
- Ehrlich, Robert. *Why Toast Lands Jelly-Side Down*. Princeton University Press, 1997. See item 6.6 (Maximum Height of a Siphon), pp. 104–106.
- Reyburn, Wallace. *Flushed With Pride: The Story of Thomas Crapper*. Prentice Hall, 1969.
- Google. You can find lots of information on the web.