

# How fast does a tank empty?

## Worksheet: How fast does a tank empty?

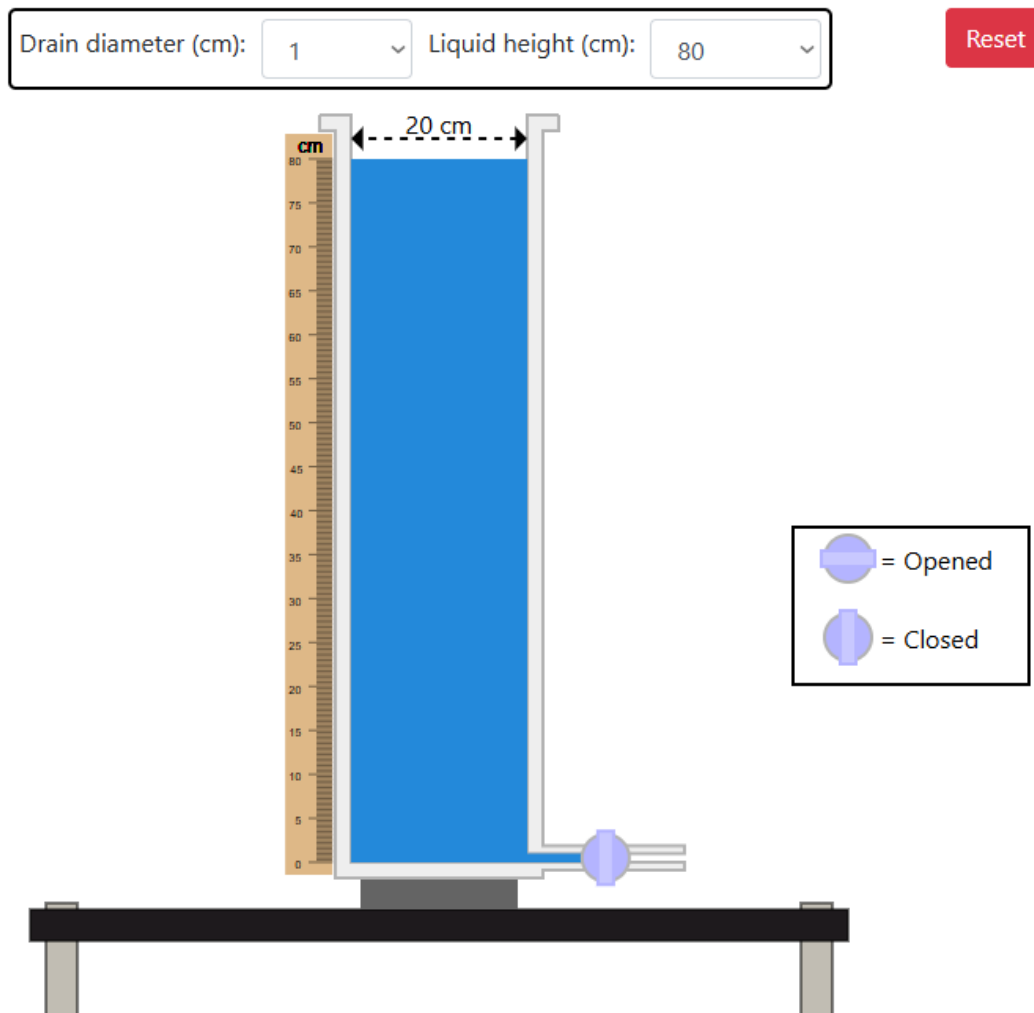
Name(s): \_\_\_\_\_

This experiment measures the volumetric flow rate of a liquid leaving a tank as a function of the liquid height and the drainpipe diameter. The results are compared to predictions from Bernoulli's equation.

### Student Learning Objectives

1. Use the continuity equation and mechanical energy balance to predict velocity in a tank.
2. Use differential equations to predict height vs time in a tank.
3. Demonstrate how tank height and drain diameter impact the change in height versus time.

### Experimental equipment



### Before running the experiment:

1. Imagine you open the valve, and the water starts to flow out. Where (top of the tank, middle of the tank, bottom of the tank, drain) would the velocity be maximum? Why?

## How fast does a tank empty?

2. Imagine you open the valve, and the water starts to flow out. When (just after turning the valve, middle of the drain time, end of the drain time) would the velocity be maximum? Why?
3. If the tank starts with half the height of water, do you expect it to drain in less than half the time, half the time, or more than half the time? Why?
4. If drain diameter is reduced, would you expect the water to drain slower, at the same rate, or faster? Why?

### Running the experiment:

1. Measure height versus time for the 4 conditions of starting height  $h$  and drain diameter  $d$  listed in Table 1 and record the data in Table 1.

**Table 1**

h = 80 cm, d = 1.0 cm		h = 40 cm, d = 1.0 cm		h = 80 cm, d = 0.5 cm		h = 40 cm, d = 0.5 cm	
time (s)	height (cm)	time (s)	height (cm)	time (s)	height (cm)	time (s)	height (cm)

## How fast does a tank empty?

Plot all the values on a single plot of height versus time. What do you notice?

### After the experiment:

1. Use continuity and Bernoulli's equation to predict the velocity of the liquid in the tank for a tank height  $h$ , tank diameter  $D$  (20 cm), and drain diameter  $d$ .
2. Assuming velocity in the tank is equal to  $-dh/dt$ , solve the differential equation for  $h(t)$ , assuming the initial height is " $H$ ".

## How fast does a tank empty?

3. Plot the predicted trends on top of the experimental collected data. What did you conclude?