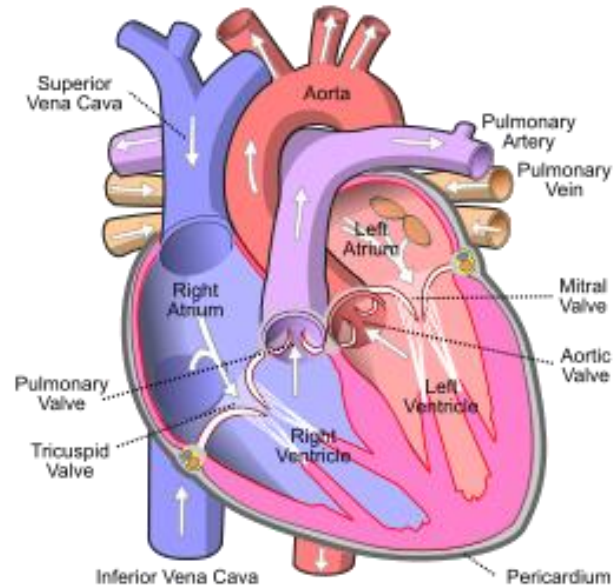


## Four-Chambered Heart – “The Plumber”

In this project you will explore the circulatory subsystem within the heart by building a model of the human four-chambered heart. In addition to the biology concepts, you have an opportunity to build electrical circuits and use coding to write a program that blinks four LEDs in the order of the filling of each chamber. During the project you will explore:

- the anatomy of the heart chambers.
- blood flow through the circulatory system.
- the calculation of pulse rate in beats per minute.
- writing a program to control the model.
- LED electrical circuits.
- material conductivity.



### Your Challenge:

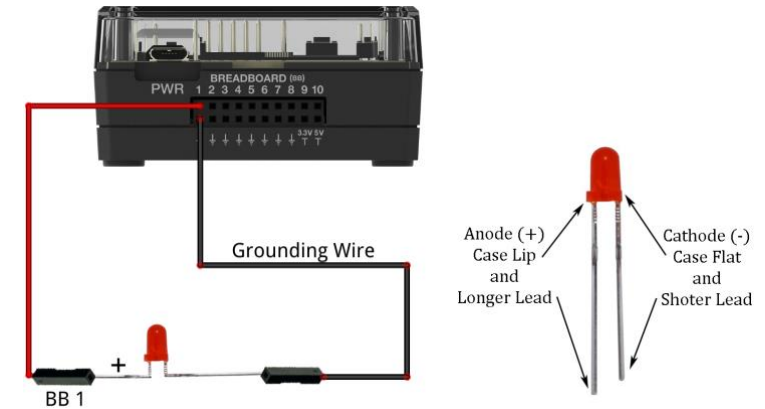
Build and code a model of the circulatory system of a four-chambered heart that responds to increased physical activity.

### Activity Materials:

- TI-84 Plus CE calculator
- TI-Innovator Hub
- 4 x M/F Jumper Wires
- 1 x M/M Jumper Wires
- 4 x LED's
- 4 x Toothpicks with labels
- 3oz. A conductive compound such as Play-Doh. Modeling clay or plasticine will not work
- Print of the Model Heart Build Sheet
- Grove Temperature sensor

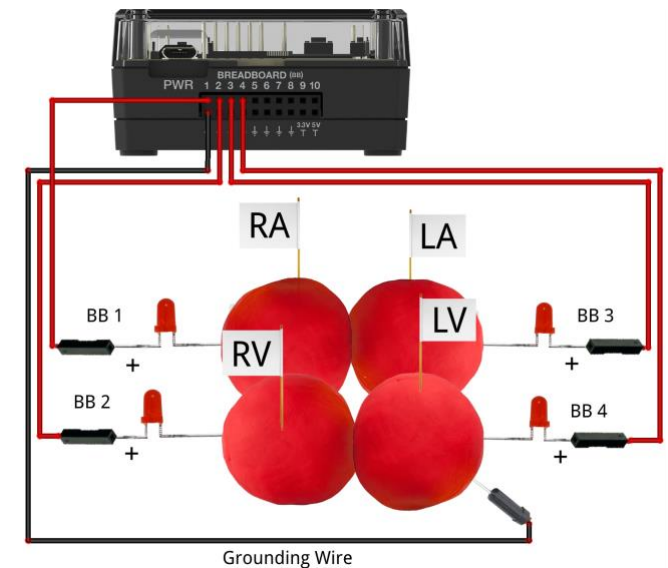
## Project Challenges

**Challenge 1:** Connect an LED to BB1 and blink at a rate of 2 Hz (flashes per second) for 10 seconds.



### Challenge 2:

- Use four pieces of Play-Doh to model the four heart chambers.
- Place build sheet on the desk and place Play-Doh pieces on sheet.
- Label each piece of Play-Doh with the appropriate chamber name.
- Add three additional LEDs to the Hub connected to BB 2 thru BB 4.
- Insert the negative lead of each LED into each piece of Play-Doh.
- Add a single grounding wire from any of the pieces back into any ground on the BB connector of the Hub.
- Write a program to blink the four LEDs in sequence 1,2,3,4. Be sure to model the blinking order to match the blood flow order. The right atrium fills first while the left ventricle fills last. For example, the program should run for at least 30 seconds.
- Add a beep to your program to sound like an EKG machine after each cycle of the heart. For example, the program should run for at least 30 seconds.
- What would you change in the program to speed up or slow down the flashing? Calculate the “heart rate” for this program.
- What happens when you separate the chambers? Can you explain your observation?



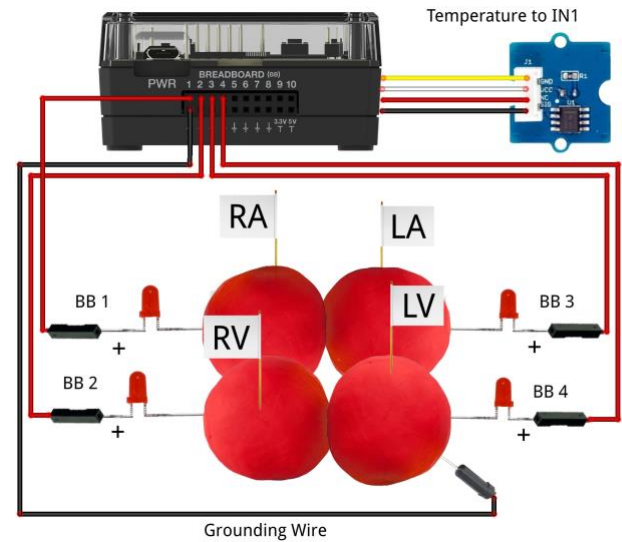
# Four-Chambered Heart – “The Plumber”

## TI-84 PLUS CE

## TI-INNOVATOR™ STEM PROJECT STUDENT ACTIVITY

**Challenge 3:** The autonomic nervous system controls the human heart rate. When frightened, we do not need to think to make our heart beat faster. When our body becomes overheated, our heart rate elevates to try to cool us.

Use the Grove temperature sensor to modify the heart rate of the model. Change the program from Challenge 2 such that when body temperature goes up, heart rate goes up.



### Example Programming Commands for the project

Example Code	Behavior
Send("CONNECT LED 1 TO BB1")	Associates an LED plugged into BB 1 on the Hub with a software object named LED 1.
Send("CONNECT TEMPERATURE 1 TO IN 1")	Associates a Grove temperature module plugged into port IN 1 on the Hub with a software object named TEMPERATURE 1.
Send("SET LED 1 TO ON")	Switches the LED associated with the corresponding "CONNECT LED 1 ..." command to ON. The state may also be OFF.
Send("READ TEMPERATURE 1")	Reads the grove temperature module associated with the corresponding "CONNECT TEMPERATURE 1 ..." command in centigrade degrees. A Get command must immediately follow the READ command.
Get(T)	Gets the value returned from the Hub from the previous READ command and stores the value into the variable named "T".
Send("SET SOUND 440 TIME 3")	Sets the speaker on the Hub to make a 440 Hz tone for 3 seconds.
Send("SET LED eval(C) OFF")	Evaluates the variable named C and substitutes the value into the command string.

#### Calculator Notes:

- Press the [prgm] key to see a menu option for creating a new program.
- Press the [prgm] key to see a menu option for selecting programs to edit.
- While in the Program Editor, press [prgm] key to see menu items for programs.
- While in the Program Editor, press [alpha] [f5] to see editing options.
- While in Program Editor, use 2<sup>nd</sup> Left Arrow and 2<sup>nd</sup> Right Arrow to jump your cursor to the beginning and end of the line.
- Press [2<sup>nd</sup>] [quit] to leave the Program Editor and return to the home screen.
- While on the home screen, Press the [prgm] key and select the execution menu option for selecting a program names to paste to the home screen.
- While on the home screen, Press [enter] to run a program named on the home screen.
- The Home Screen “remembers” the last command entered. Press Enter after a program has run to run the program again.
- To stop (“break”) a running program press and hold the ON key until you receive a dialogue box.