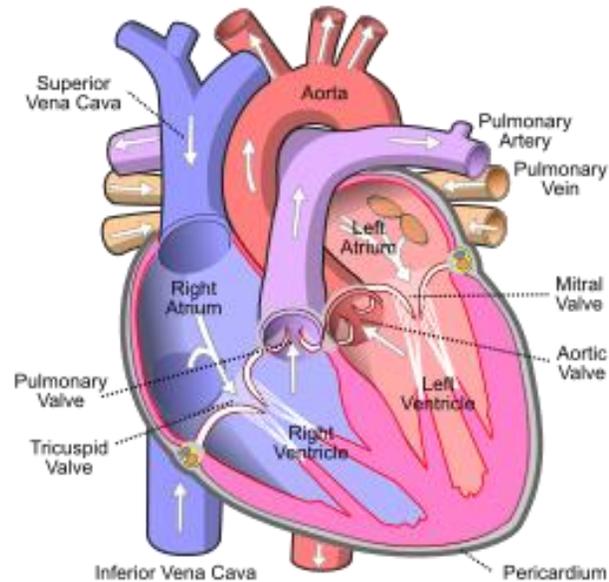## Four-Chambered Heart – "The Plumber"

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 or 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 Nspire CX family 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
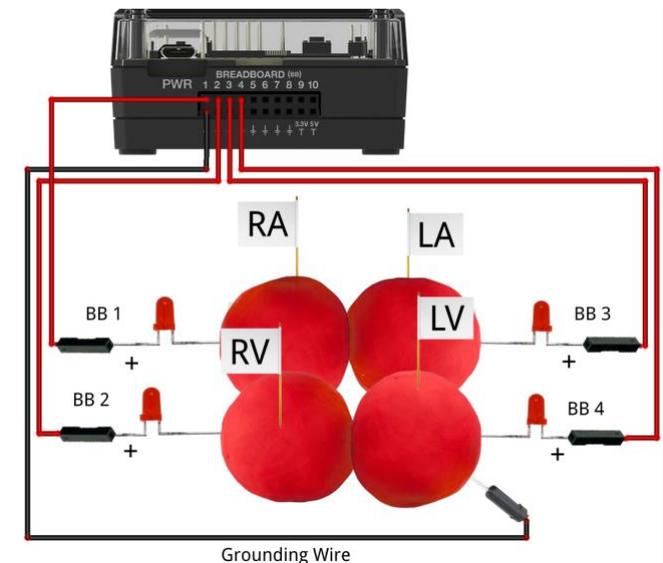- Grove Temperature sensor

Project Challenges

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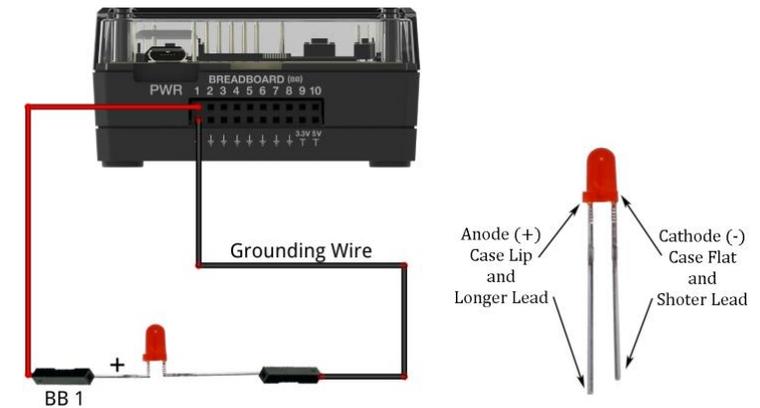
Challenge 2:

- 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.
- 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?

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.

Temperature to IN1

RA   LA

LV

RV

BB 1   BB 3

BB 2   BB 4

Grounding Wire
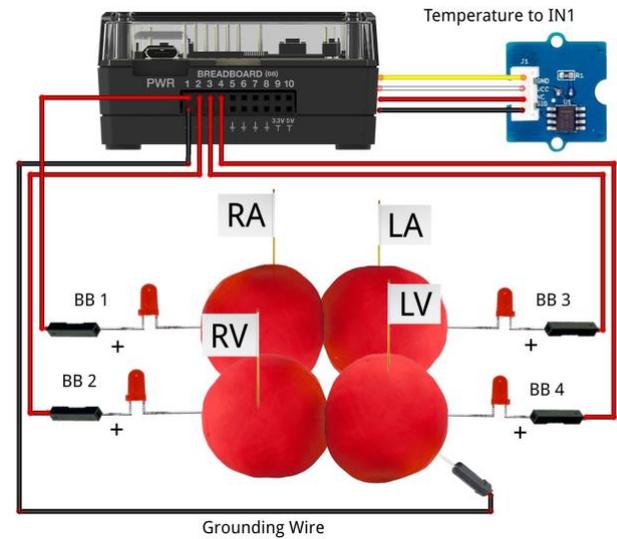
Example Programming Commands for the project

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:
- On the Home screen press 4:Current to return to your document file.
- On the Home screen Press 1:New to create a new document file.
- You create and edit programs in a Program Editor app. You run programs from within a Calculator app.
- Use the [menu] key to see the options for your current app.
- ctrl-b is the shortcut from the Check Syntax and Store menu to store changes to your program.
- ctrl-r is the shortcut from the Check Syntax and Store menu to store changes to your program and paste the name to a Calculator app
- Press [enter] to run a program named on a Calculator app entry line.
- The Calculator app "remembers" the last command entered. Press Enter after a program has run to run the program again.
- Find your program names in a Calculator app by pressing the [var] (variables) key.
- Move from page to page by using ctrl-left arrow and ctrl-right arrow or by using the touchpad pointer to click on the desired page tab.
- ctrl-doc (+page) will add a blank page to your document.
- ctrl-z will undo your last action.
- To stop ("break") a program press and hold the ON key until you receive a dialogue box.
- ctrl-s is the shortcut for saving your entire document file. Do this periodically to save your work.