Blood Pressure Monitor

LEARNING OBJECTIVES

- Supplement classroom instruction on the circulatory system and blood pressure and its measurement with hands on engineering application.
- Control devices (e.g., lights, pumps, valves, and buzzers) based on input from measured physical quantities (e.g., blood pressure).
- Apply mathematical logic processing to the control of devices.
- Repurpose existing components and devices.

RECOMMENDED GRADES/SUBJECTS

Grades 8–12/Physiology or Biology

TIME NEEDED

The project is designed to be completed in one 75 minute class period or two 45 minute class periods.

RELATED EXPERIMENTS

"Blood Pressure as a Vital Sign" – Experiment 7 from *Human Physiology with Vernier*

"Blood Pressure and Exercise" – Experiment 8 from *Human Physiology with Vernier*

"Diurnal Blood Pressure Variation" – Experiment 9 from *Human Physiology with Vernier*

"Heart Rate and Blood Pressure as Vital Signs" – Experiment 10 from *Human Physiology with Vernier*

"Heart Rate, Blood Pressure, and Exercise" – Experiment 11 from *Human Physiology with Vernier*

"Blood Pressure as a Vital Sign" – Experiment 10A from *Advanced Biology with Vernier*

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
ETS1.A. Defining and Delimiting Engineering Problems ETS1.B. Developing Possible Solutions ETS1.C. Optimizing the Design Solution	Patterns Cause and effect Scale, proportion, and quantity Systems and system models	Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information

INFORMATION FOR THE INSTRUCTOR

For students to be successful in this extension activity, they need to be somewhat familiar with two processes: the Engineering Process and running the Digital Control Unit (DCU). In addition to the information in this document, we have provided the following resources:

- Introduction to Engineering Design: This document includes a brief introduction to the engineering design process and an example of an Engineering Design Sheet. The Design Sheet is a great way to help your students organize their time and efforts. It also provides you with a way to assess student progress and learning.
- Blood Pressure Monitor – Example Design Sheet (Word® document): A completed Design Sheet that will help you integrate the use of Engineering Design Sheets in your classroom
- Blood Pressure Monitor – Example LP file: An example Logger *Pro* experiment file for this activity that will help you better understand how to program Logger *Pro* to run the DCU
- DCU Tips – Background information about using the DCU, programming it in Logger *Pro* and LabQuest 2, and general troubleshooting tips for the DCU.

In the remainder of this document you will find additional resources to help you successfully integrate this engineering extension activity into your course:

- Follow Up Questions: A few reflection questions to help your students better understand the engineering process and to help you assess their learning
- Challenge Activities: Additional activities for advanced students

- Supplemental Student Instructions: Additional instructions you can give to students if this is their first time using the DCU with Logger *Pro* or a LabQuest 2.

Follow Up Questions

Engineering extension activities usually require a different assessment than a traditional lab. We suggest that you create a rubric for grading the Engineering Design Sheet. Additionally, you can use follow up questions, such as those below, to help students reflect on the engineering process and to help you evaluate their learning:

- This project provides a long list of design requirements. Which features were the most difficult to implement and why?
- Which features were the most important to the design? Explain.
- Explain a design decision you made in which you had to choose from multiple ideas. How did you make your choice? Why?
- Justify your choices for output device. Why did you choose to indicate the subject's blood pressure using this device? What advantages does it have over an alternative?
- What do you see as the strengths and weaknesses of your blood pressure monitor? What changes would you make in the next version?

Challenge Activities

If your students need more of a challenge, provide them with one or more of the following options:

- Allow the user to adjust the maximum inflation pressure and the exhaust trigger point using the User Parameters features in Logger *Pro*.
- Make an indicator light that turns on to show that a measurement is being made. It should turn on when the pump starts and off when the cuff deflates.
- Integrate a device (buzzer or light) that comes on briefly when the blood pressure measurement is complete.
- Think about how you could modify the system using the manual pump that came with the Blood Pressure Sensor to get added capabilities. **Note to teachers**: The use of the manual pump to start data collection, combined with calculated columns, should allow the system to start once and then automatically and periodically measure the pressure. It is a bit tricky to implement, but getting this experience and being able to apply it to future projects is valuable for students.

SUPPLEMENTAL STUDENT INSTRUCTIONS

We feel that the student sheets present engaging challenges. However, depending on your emphasis for this project and the level of your students, you may wish to provide students with more detailed instructions on various aspects of the software and logic setup.

In particular, the logic that controls the pump and exhaust valve is a bit subtle and outside the general guidelines given in the DCU Tips document. The control logic is sequential rather than the Boolean logic many students are familiar with.

Equipment Setup

1. Run the commercial consumer blood pressure monitor to make sure it is working correctly.

2. Open the blood pressure monitor you were given and identify the key components: pump, pressure relief valve, electrically controlled exhaust valve, and blood pressure cuff. Salvage as much of the air tubing as possible while you remove these components.

3. Using cable ties or glue, mount the components on a board. Using aquarium tubing and Luer Lock connectors as needed, connect the Blood Pressure Sensor to the other components (see Figure 1). In the figure, double lines represent pneumatic tubing connection and solid lines represent electrical connections.

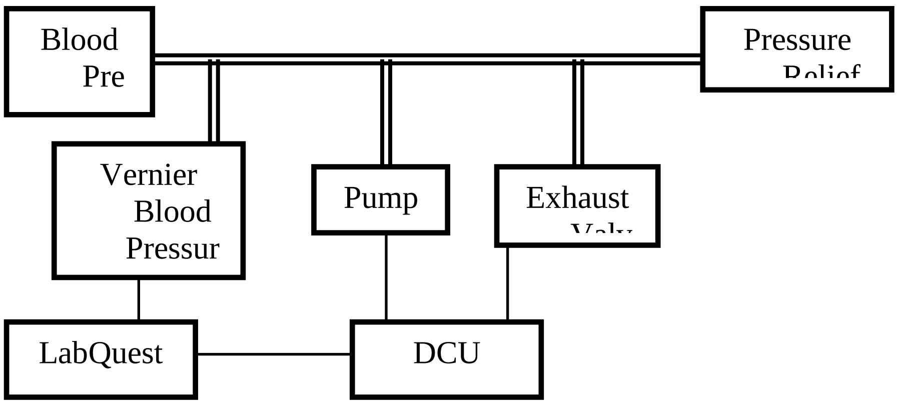

Figure 1

4. Connect the positive lead of the pump to line D1 of the DCU and the positive lead of the exhaust valve to D2. Connect the negative leads of the pump and the exhaust valve to the GND line of the DCU. If you are using an LED for the maximum inflation signal, connect the LED and its resistor to D3 and GND lines on the DCU. Connect the positive LED lead to the digital line and the negative lead to its matching resistor. Connect the other end of the resistor to the GND lead on the DCU. If you are using a buzzer, connect the positive lead of your buzzer to D3 and the negative lead to GND.

   Tip: *LEDs have polarity. If the two leads are of different length, the longer one will be the positive or anode lead. If there is a flat side on the plastic housing, the lead near the flat is the negative, or cathode, lead.*

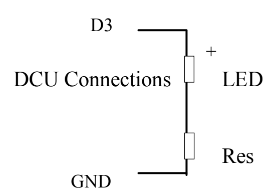

Figure 2

5. Connect a power supply to the DCU.

6. Connect the DCU to the first digital (DIG) port on the interface and the Blood Pressure Sensor to Analog Port 1.

7. Connect the interface to the computer (unless using a LabQuest 2 as a stand-alone device. If the interface has a power switch, turn it on.

Software Setup - Logger *Pro*

1. Start Logger *Pro*.

2. Choose Set Up Sensors from the Experiment menu and select your interface from the list.

3. Click the DIG/SONIC1 button, and select Digital Out.

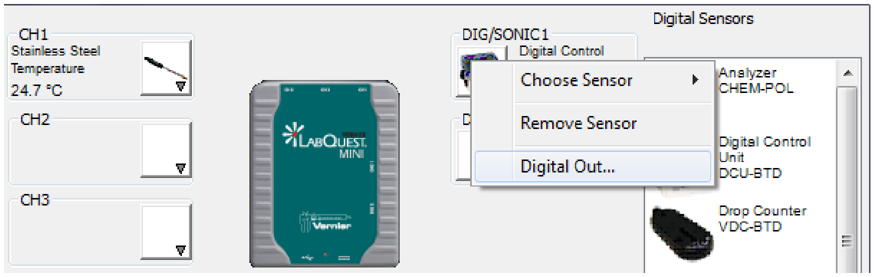

Figure 3

4. First check your hardware setup. Check the "Line 1 On" box and verify that the pump activates. Check the "Line 2 On" box and verify that the exhaust valve closes (you will probably only hear a click). Your device connected to D3 should activate when its box is checked. Fix any problems and uncheck all boxes.

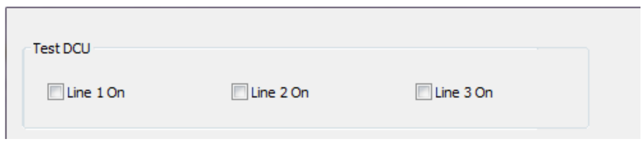

Figure 4

5. Configure the output lines as shown in Figure 5.

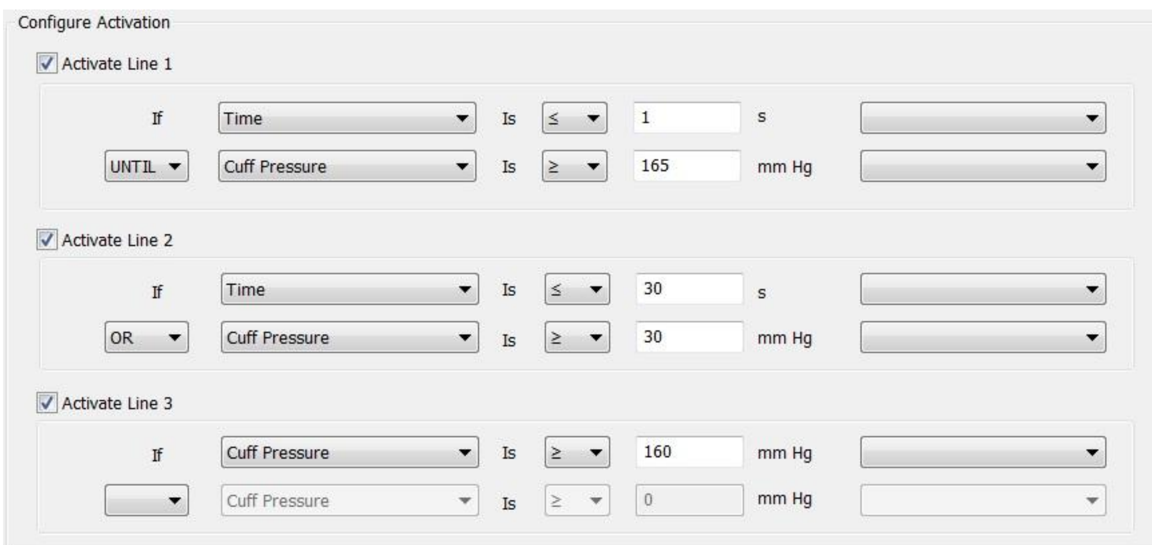

Figure 5

6. Select the option to Start activation when experiment run is started and select OK.

7. Close the Set Up Sensors window.

Software Setup - LabQuest 2

1. Start your LabQuest 2, connect the DCU to one of the DIG ports and your sensor to one of the CH ports.

2. Choose the Sensors tab from the app and select DCU Setup. Tap on the DCU from the list.

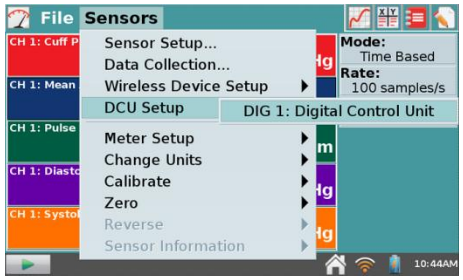

Figure 6

3. First check your hardware setup. Check the "Line 1 On" box and verify that the pump activates. Check the "Line 2 On" box and verify that the exhaust valve closes (you will probably only hear a click). Your device connected to Line 3 should activate when its box is checked. Fix any problems and uncheck all boxes.

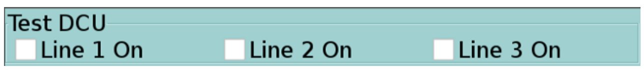

Figure 7

4. Configure the output lines as shown below. Note that Line 3 does not have a compound logic statement. Leave the second line empty.

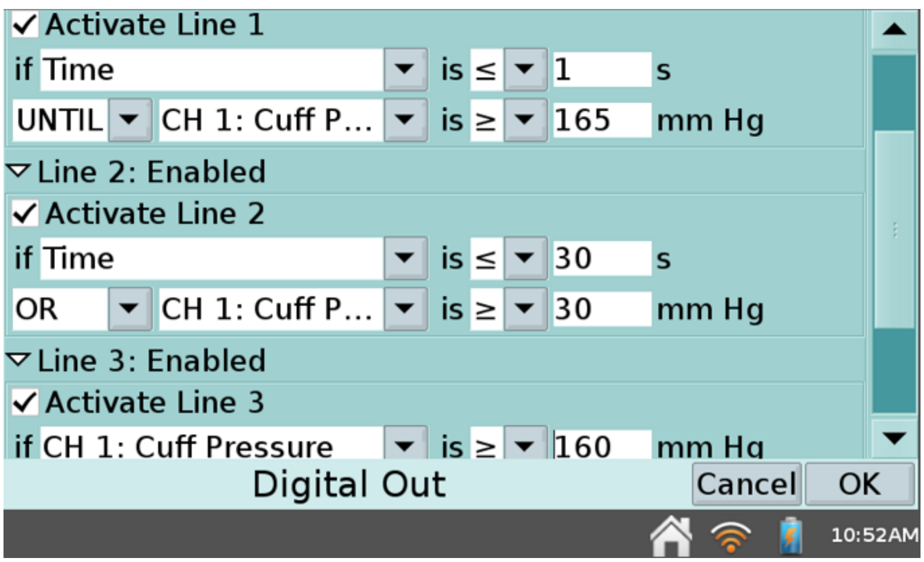

Figure 8

5. Select the option to Start activation when experiment run is started and select OK.

6. Close the Set Up Sensors window.