INSTRUCTOR INFORMATION

Outdoor Lighting

LEARNING OBJECTIVES

- Supplement classroom instruction on the properties of light with a hands-on engineering application.
- Control a light (e.g., LED or lamp) based on input from measured physical quantities (e.g., light level or motion).

RECOMMENDED GRADES/SUBJECTS

Grades 9–12/Physics

TIME NEEDED

The project is designed to be completed in one 45 minute period.

RELATED EXPERIMENTS

"Light, Brightness, and Distance" – Experiment 29 from *Physics with Vernier*

"How Bright is the Light" – Experiment 25 from *Physical Science with Vernier*

"Reflectivity of Light" – Experiment 7 from *Middle School Science 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.
- Outdoor Lighting – Example Design Sheet (Word® document): A completed Design Sheet that will help you integrate the use of Engineering Design Sheets in your classroom
- Outdoor Lighting – 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 LabQuest 2 app

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, use follow up questions, such as those below, to help students reflect on the engineering process and to help you evaluate their learning:

- Explain your choice for the trigger. How did you choose the sensor that would activate the outdoor lighting? Why?
- How did you decide on the trigger conditions that would turn on the outdoor lighting? What circumstances might make you change those conditions?
- What do you see as the strengths or weaknesses of your outdoor lighting system? 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 trigger condition that turns on the outdoor lighting using the User Parameters features in Logger *Pro*.
- Use a second sensor to expand the conditions that must be met to trigger the outdoor lighting. For example, only turn on the outdoor lighting when it is dark AND motion is detected.

- Use a Watts Up Pro (Vernier order code: WU-PRO) or other electronic energy consumption meter to measure the electrical energy used by your outdoor light system. How might use this energy data to fine-tune your system?

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 them with more detailed instructions on various aspects of the software and logic setup as included below.
Note: The instructions provided here present just one possible solution to this engineering activity.

Preliminary Data Analysis

Using a Light Sensor, determine an appropriate lux level for a partially darkened room that can be used as a threshold value for this extension.

Equipment Setup

1. Connect a lamp or a white LED to the D1 and GND lines on the DCU.

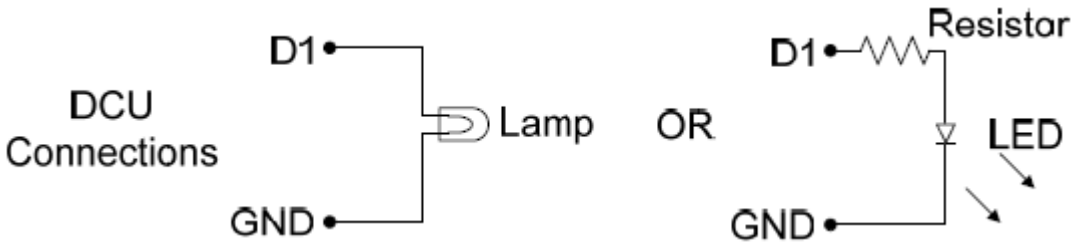

Figure 1

Tip: *Lamps do not have polarity, but LEDs do. If you are using a white LED, you must connect the positive lead (long wire) to D1 and the negative lead (short wire) to GND. You will also need to wire a resistor of about 100 ohms in series with the LED to limit the current through the device.*

Tip: *You can turn on an ordinary lamp using a DC-actuated AC power switch, like the PowerSwitch Tail II (available from many online retailers such as Amazon). Such a switch is actuated (turned on) by applying a DC voltage, like the signal put out by the DCU across two terminals.*

2. Connect a power supply to the DCU.

3. Connect the DCU to the first DIG port on the interface and connect the Light Sensor to any analog channel on the interface.

4. Set the Light Sensor to the 0-600 lux range.

5. Connect the interface to the computer. 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.

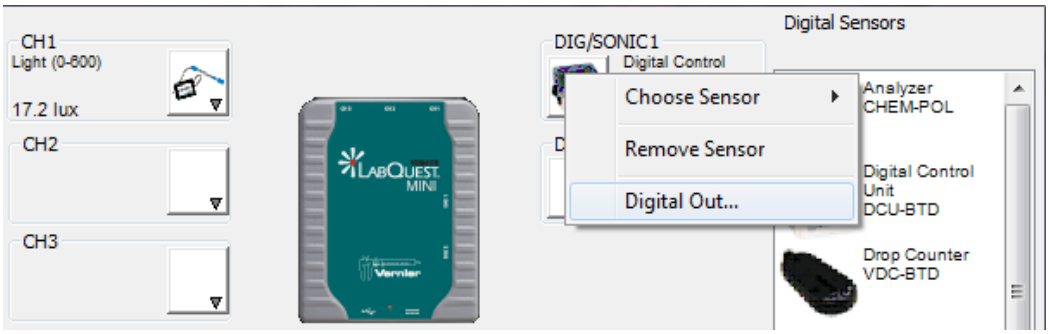

Figure 2

4. Check the box next to Activate Line 1. Select the Less Than symbol from the drop-down list and enter a threshold light value into the box.

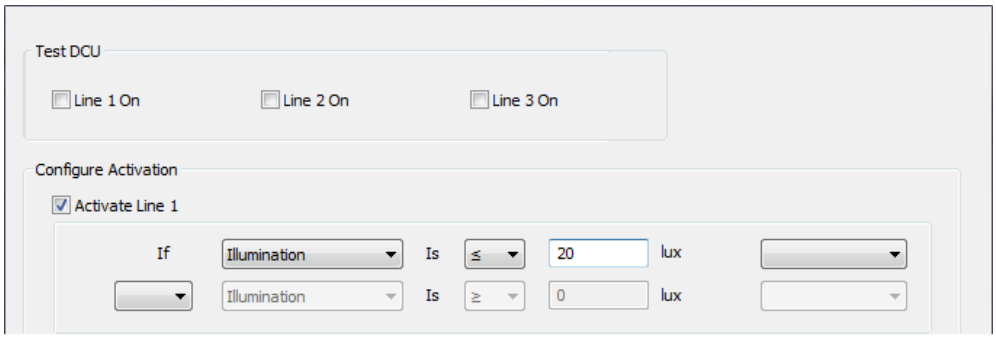

Figure 3

5. Click the radio button next to Start activation when dialog is closed.

   Tip: *When you click OK, the DCU immediately assumes control of the LED/lamp. The other option is to select Start activation when experiment run is started. With this option, the DCU will wait to control the LED/lamp until after you click the Collect button.*

6. Click OK and close the Set Up Sensors window.
7. Test your system by moving your hand over the Light Sensor; the LED/lamp should turn on. When you uncover the Light Sensor, the LED/lamp should turn off.

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 and select the DCU from the list.

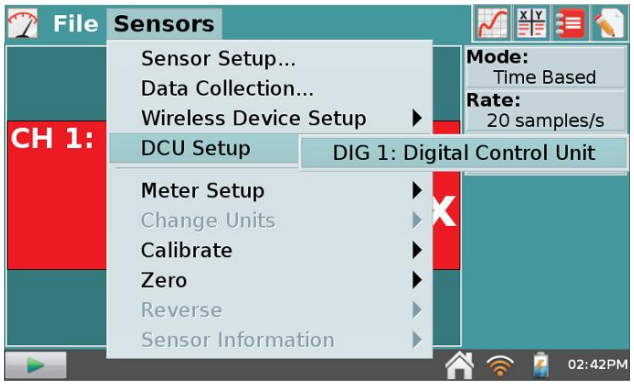

Figure 5

3. First test your hardware setup. The green LED on your DCU should light up when the DCU is connected. If you check the box next to Line 1 On, the corresponding red LED on the DCU should light up. Check the other lines as necessary. Fix any problems and uncheck all boxes.

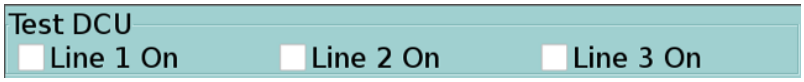

Figure 6

4. Configure the output lines as shown in Figure 7.

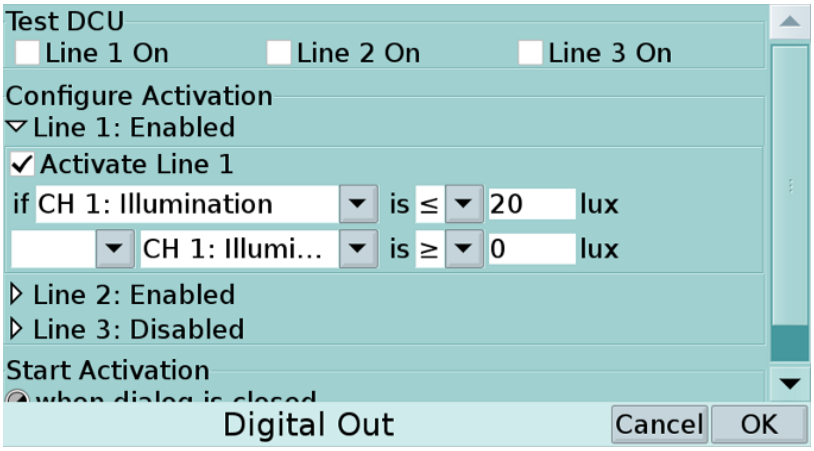

Figure 7

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

Troubleshooting

- You can test to see if your LED/lamp is working correctly or not by returning to the DCU setup window in the LabQuest 2 app or Logger *Pro*. If you check the box next to Line 1 On, the LED/lamp should immediately turn on.
- Make sure the DCU is connected to a power supply.
- Check for loose or improperly-wired connections between the LED/lamp and the DCU.
- For additional information on the DCU, refer to the *User Manual* (available at www.verniercom/dcu-btd).