



TeachEngineering

What's In Our Stars? Student Procedures



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Brought to you by





1. Computer Prep

Installing and preparing the computer application



2. Equipment Prep

Setting up the lab equipment and samples



3. Data Collection [★]

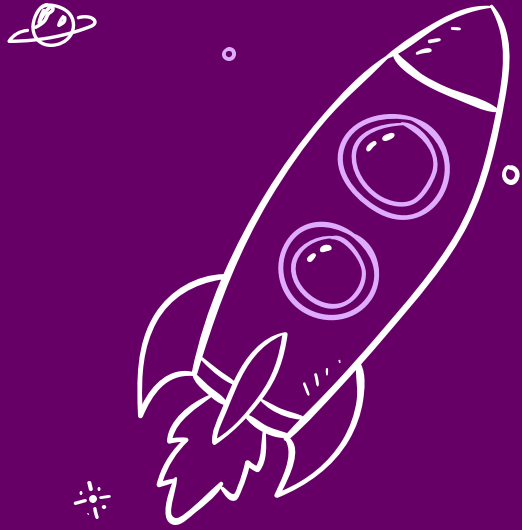
Running the experiment and collecting data



4. Post-Lab

Interpreting and analyzing the data collected





1. Computer

Prep

Follow these steps to install the needed programs on your device.

ARDUINO IDE – DOWNLOAD/INSTALL

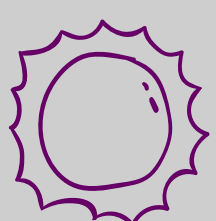


1. Go to <https://www.arduino.cc/en/software> and select the software that is appropriate for your student device.

2. Follow the installation prompts.

3. If asked for an admin username and password, raise your hand and your teacher will come to you.

The screenshot shows the Arduino IDE 2.1.1 download page. The navigation bar at the top includes links for HARDWARE, SOFTWARE (highlighted), CLOUD, DOCUMENTATION, COMMUNITY, BLOG, and ABOUT. The main heading is "Downloads". The central content area features the Arduino logo and the text "Arduino IDE 2.1.1". Below this, a paragraph describes the new major release as faster and more powerful, highlighting features like a modern editor, responsive interface, autocompletion, code navigation, and a live debugger. It also provides a link to the "Arduino IDE 2.0 documentation" for more details and mentions that nightly builds with the latest bugfixes are available. A "SOURCE CODE" section notes that the IDE is open source and hosted on GitHub. On the right side, a teal sidebar titled "DOWNLOAD OPTIONS" lists the following options: Windows Win 10 and newer, 64 bits; Windows MSI installer; Windows ZIP file; Linux AppImage 64 bits (X86-64); Linux ZIP file 64 bits (X86-64); macOS Intel, 10.14: "Mojave" or newer, 64 bits; and macOS Apple Silicon, 11: "Big Sur" or newer, 64 bits. A "Release Notes" link is also present at the bottom of the sidebar.

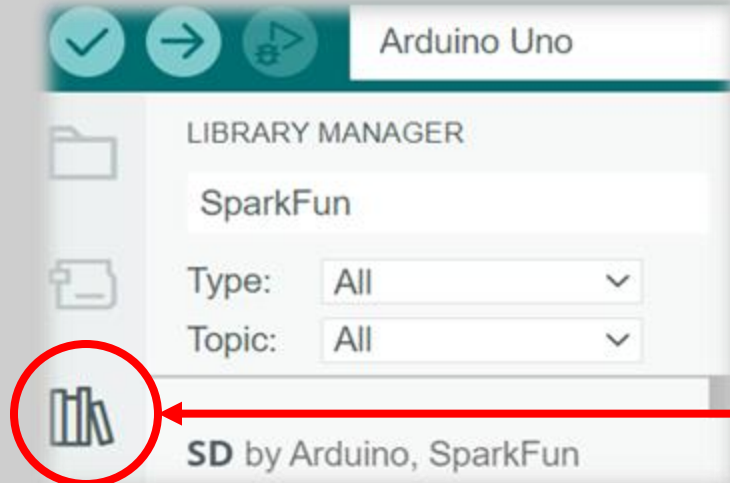


SPARKFUN LIBRARY

1. Once installed, open Arduino IDE.

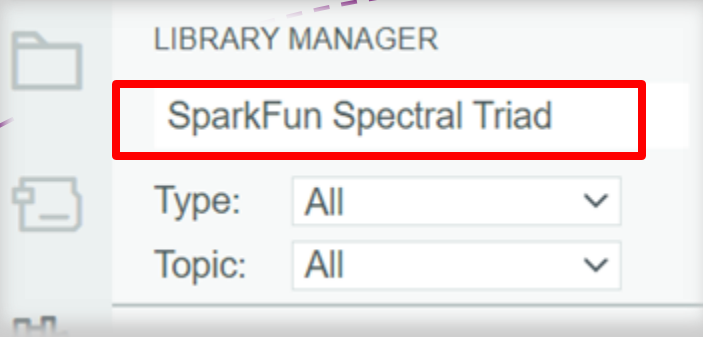


2. Click on the books icon on the task bar located on the left-hand side.

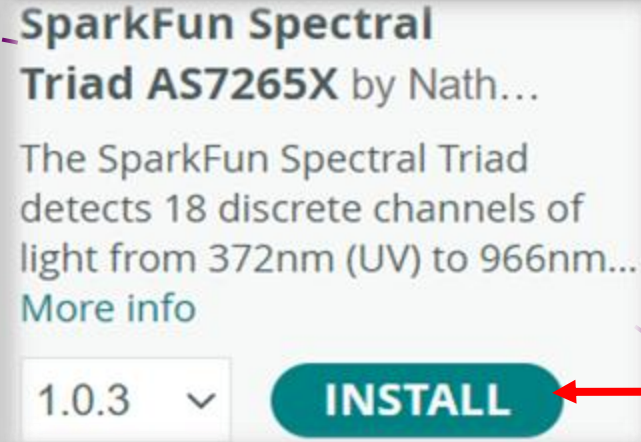


SPARKFUN LIBRARY (cont.)

3. Type "SparkFun Spectral Triad" into the search bar.



4. Select Install.



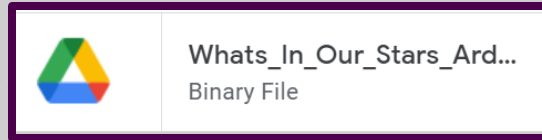
ACTIVITY CODE

1. Google Classroom



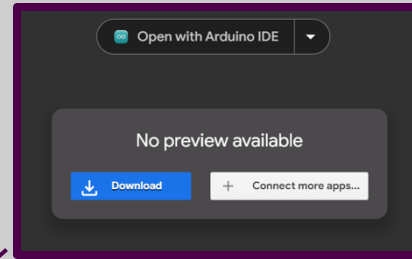
Go to the assignment posted in Google classroom.

2. Select



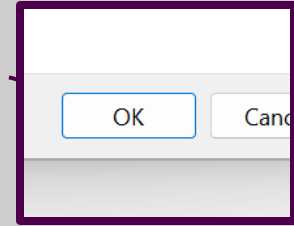
Click on the attachment labeled "Whats_In_Our_Stars_Arduino_Code."

3. Open



Select the option at the top that says "Open with Arduino IDE."

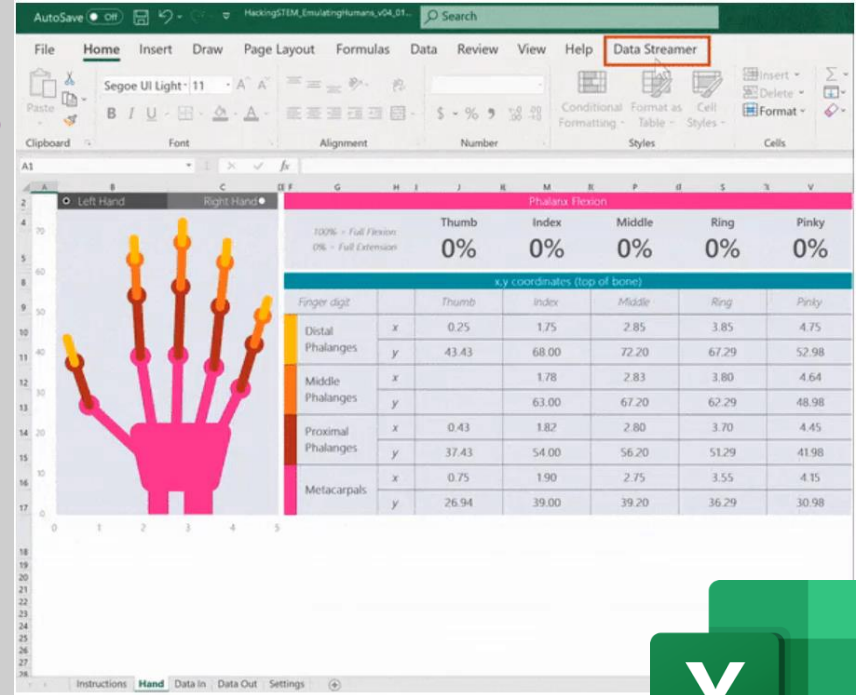
4. OK!



Click "Okay."
(This just creates a file within the Arduino sketchbook.)

EXCEL DATA STREAMER

1. Open Microsoft **Excel**. (You may have to type it into your Windows search bar.)
2. Go to **File > Options > Add-Ins**.
3. Make sure **COM Add-ins** is selected in the **Manage** box and click **Go**.
4. In the COM add-Ins dialog box, make sure to select the box next to **Microsoft Data Streamer for Excel** add-in, then click **OK**.



Video Source: Microsoft Support [LINK](#)



DATA DASHBOARD

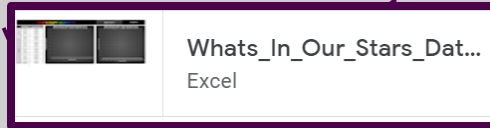
1. Google Classroom

Go to the assignment posted in Google classroom.



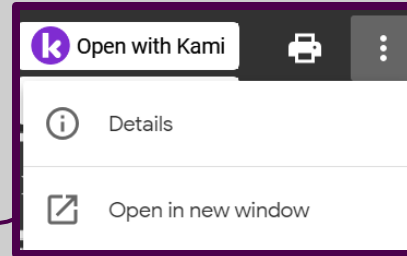
2. Select

Click on the attachment labeled "Whats_In_Our_Stars_Data_Dashboard."



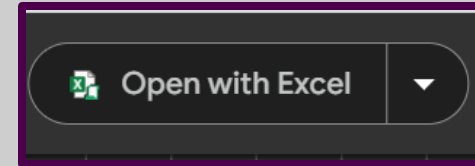
3. New Window

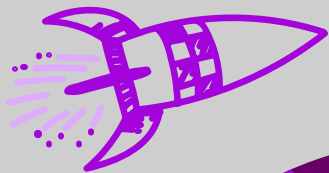
Select the three dots in the upper right-hand corner and then click "Open in new window."



4. Open

When the new window loads, select "Open with Excel" at the top of the screen.





2. Equipment Prep

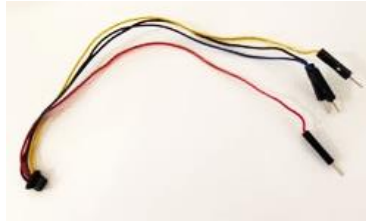
This section includes procedures for wiring/hooksing up the spectrometer.



SPECTROMETER SETUP



SparkFun Triad
Spectroscopy Sensor



SparkFun 4-pin Qwiic
connect cable (or 4
jumper cables)



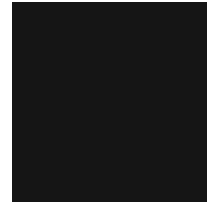
Scissors



Arduino Uno Board

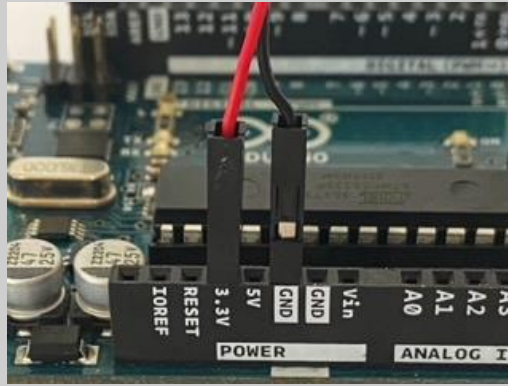
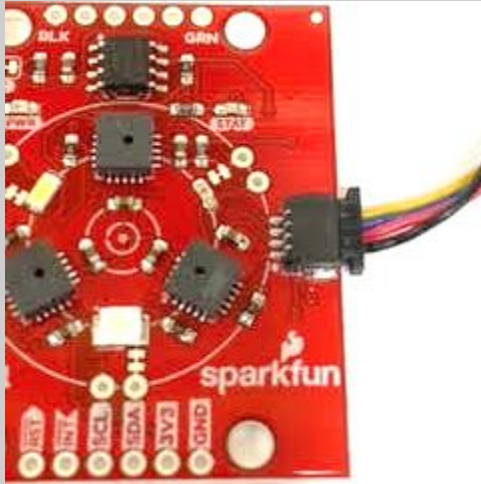


USB-C to USB-A cable

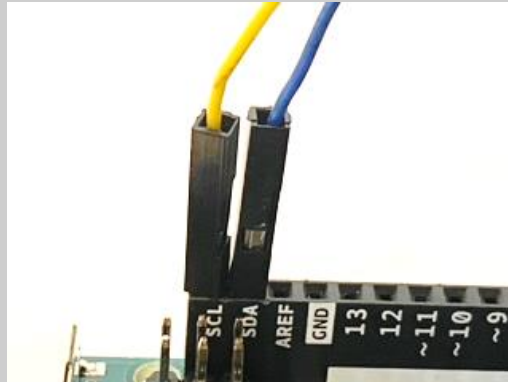


Black cardstock or
thin cardboard cut
into a 3"x 3" square

SPECTROMETER SETUP

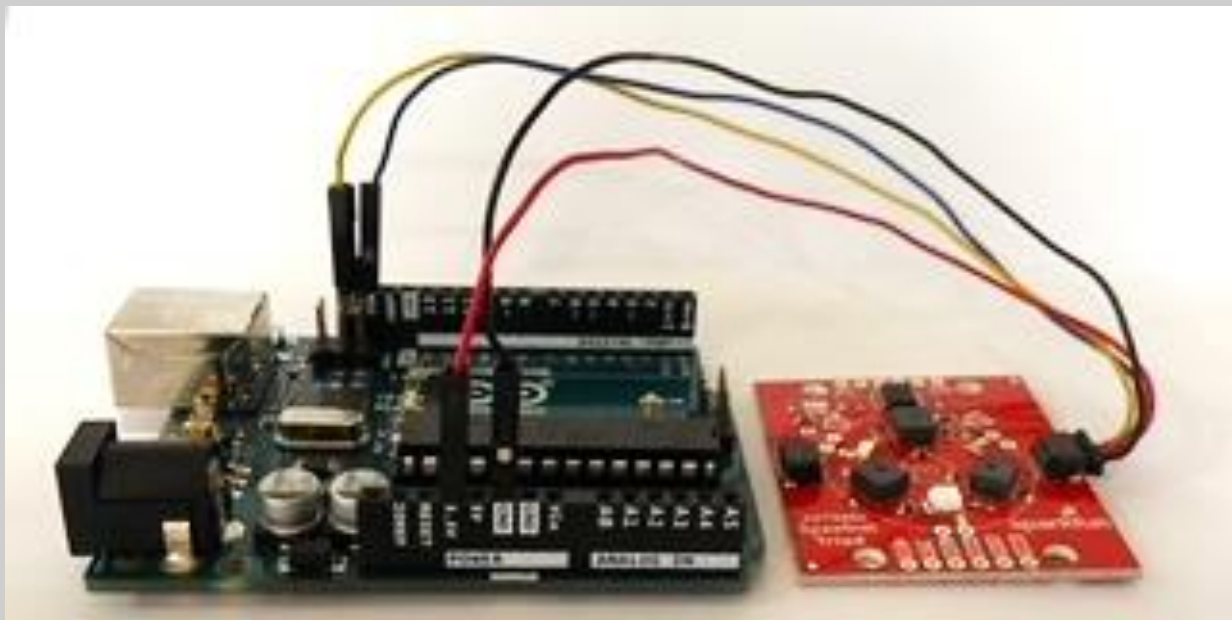


- Black = GND
- Red = 3.3V
- Blue = SDA
- Yellow = SCL



Connect the triad sensor to the Arduino, making sure that each colored cable goes to the correct pin!
(see above)

SPECTROMETER SETUP

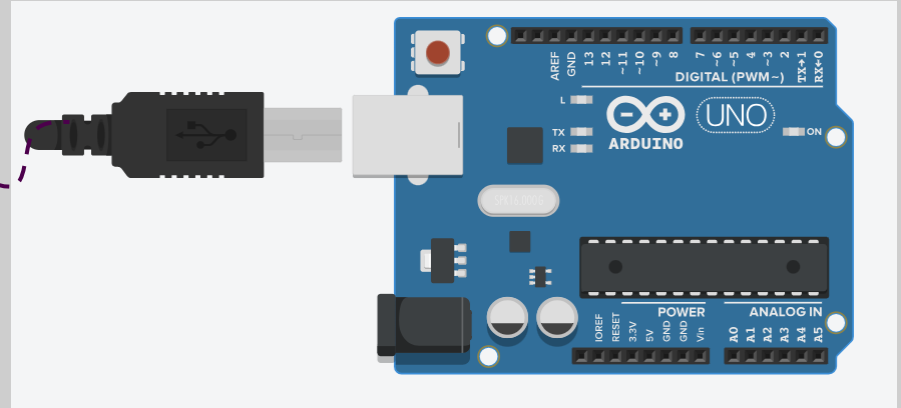


- Black = GND
- Red = 3.3V
- Blue = SDA
- Yellow = SCL

Connect the triad sensor to the Arduino, making sure that each colored cable goes to the correct pin! (see above)

SPECTROMETER SETUP

Use the provided USB cable to connect the spectrometer to your device.



SAMPLES SETUP

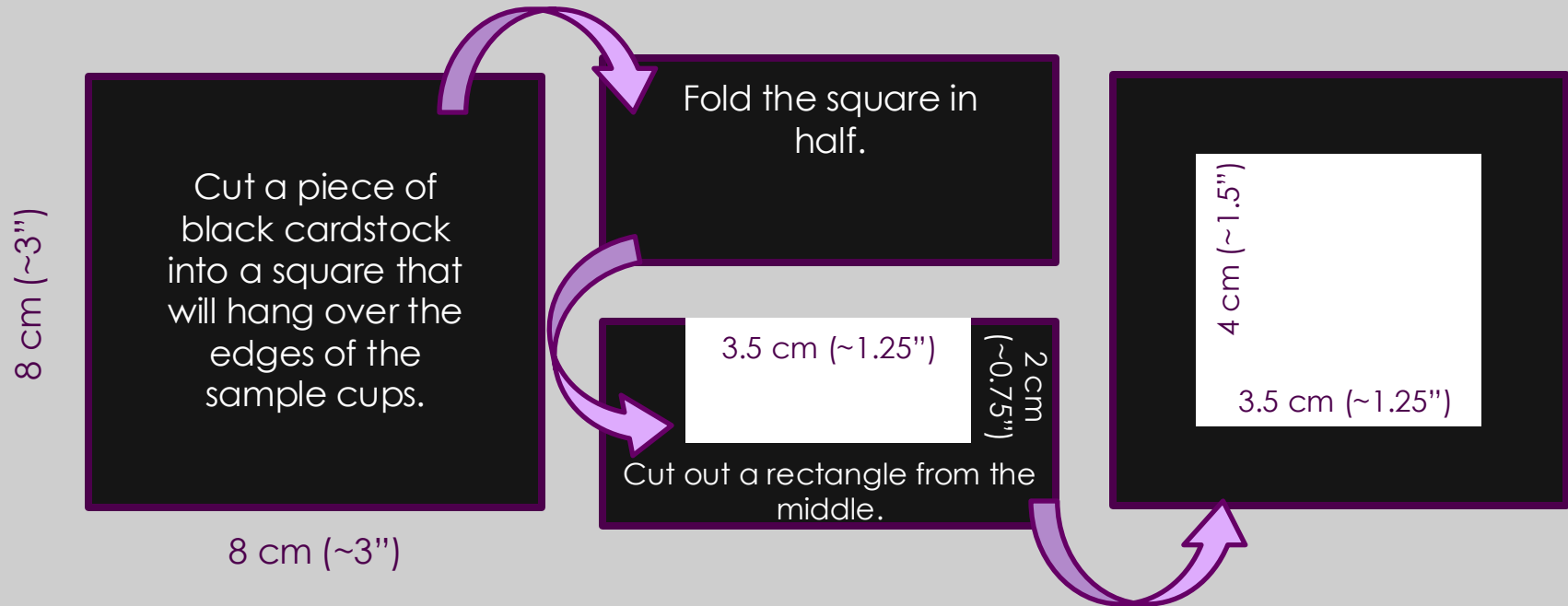
Grab one cup of each substance and one unknown for your group to have a set of 4 samples.

The name of the substance will be on each sample cup. (e.g., Iron Filings)



SAMPLE SETUP

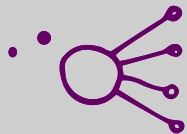
Once you have your spectrometer set up, and your samples selected and portioned into containers, you'll need to create a "cover" to place over the sample cup for the sensor to sit on and to eliminate ambient light.



COMPLETE SETUP

When your setup is complete, it should look like this:





3. Data Collection

Part 3 describes how to conduct the experiment and collect data on “lab day.”

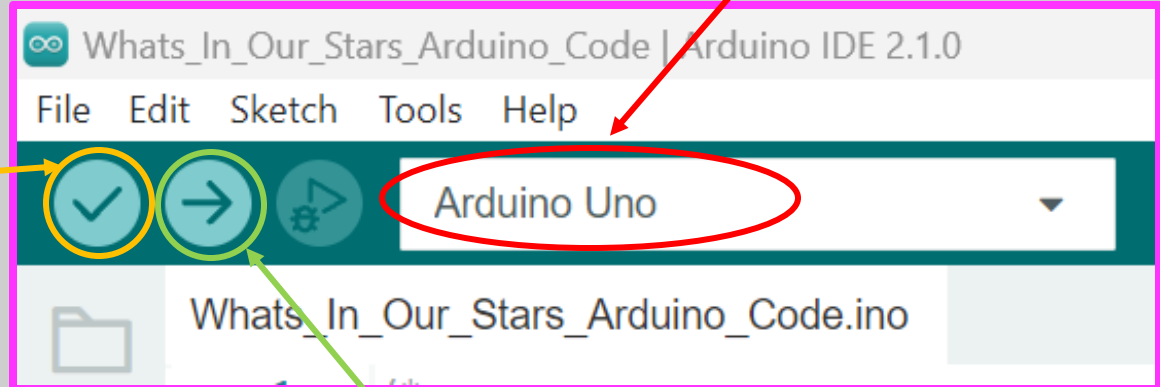


DATA COLLECTION –

Part 1: Arduino IDE

1. Select your device from the dropdown menu.

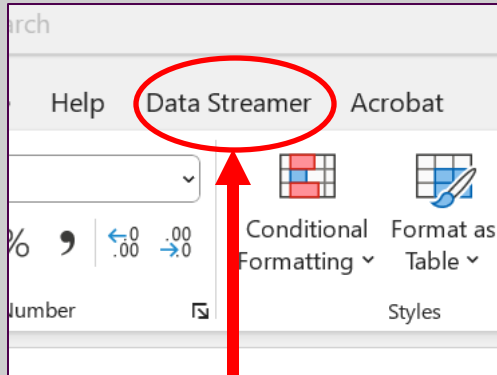
2. Verify the sketch code.



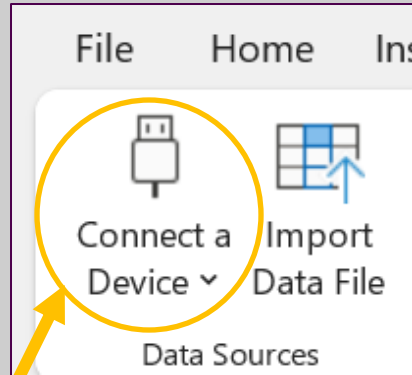
3. Upload the code to the Arduino.

DATA COLLECTION –

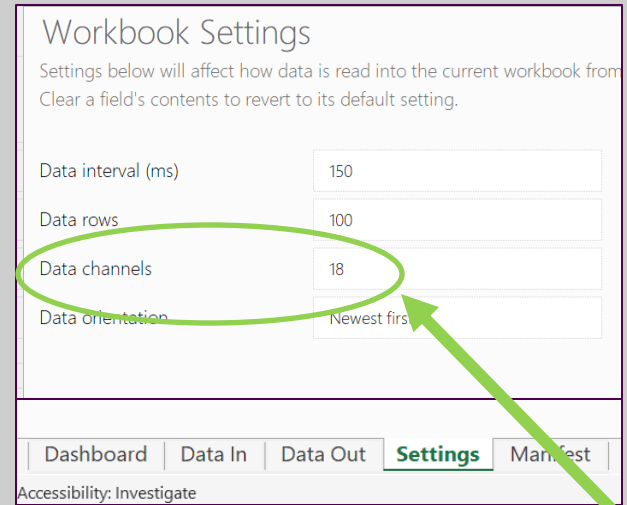
Part 2: Excel Dashboard



1. Select "Data Streamer" from the top menu bar.



2. Select "Connect a Device" from the top menu bar, then "Arduino."



3. Select the "Settings" Sheet from the bottom menu and make sure "Data channels" is set to **18**.

DATA COLLECTION —

Part 3: Check Dashboard Data Table

- The table on the first sheet should look like the one to the right. →
- If it does, you are good to go! You can skip to Slide 25.
- If you have any of the “Average Intensity” cells showing the error “#REF”, follow the directions on the next slide.

	Wavelength	Average Intensity
INFRARED	410nm	#DIV/0!
	435nm	#DIV/0!
	460nm	#DIV/0!
	485nm	#DIV/0!
	510nm	#DIV/0!
VISIBLE	535nm	#DIV/0!
	560nm	#DIV/0!
	585nm	#DIV/0!
	610nm	#DIV/0!
	645nm	#DIV/0!
	680nm	#DIV/0!
	705nm	#DIV/0!
	730nm	#DIV/0!
	760nm	#DIV/0!
	810nm	#DIV/0!
	860nm	#DIV/0!
	900nm	#DIV/0!
	940nm	#DIV/0!

DATA COLLECTION –

*Part 3A: Dashboard

Data Table TROUBLESHOOTING

1. The error “#REF” indicates that the reference cells for the formula are not found, but the good news is, it’s an easy fix!
2. Click on the Average Intensity for 410nm.
3. Type the following formula into the cell: **=AVERAGE(TBL_HST[CH1])**

	Wavelength	Average Intensity
IRARED	410nm	#REF
	435nm	#DIV/0!
	460nm	#DIV/0!

The screenshot shows an Excel spreadsheet. The formula bar at the top contains the formula `=AVERAGE(TBL_HST[CH1])`. Below the formula bar, the spreadsheet grid shows a table with the following content:

	D	E	F	G	H
	Table Salt (NaCl)				
Average Intensity					
	#DIV/0!				
	#DIV/0!				

At the bottom right of the grid, there is a dark grey cell containing the number '1' and the text 'SPE'.

DATA COLLECTION –

*Part 3A: Dashboard

Data Table TROUBLESHOOTING

4. Each cell formula going down the column should increase by 1 channel.

5. See the table to the right for the correct formulas for Average Intensity at each wavelength.

6. You can copy and paste the formulas for each wavelength from the next slide!

	Wavelength	Average Intensity
INFRARED	410nm	=AVERAGE(TBL_HST[CH1])
	435nm	=AVERAGE(TBL_HST[CH2])
	460nm	=AVERAGE(TBL_HST[CH3])
	485nm	=AVERAGE(TBL_HST[CH4])
	510nm	=AVERAGE(TBL_HST[CH5])
VISIBLE	535nm	=AVERAGE(TBL_HST[CH6])
	560nm	=AVERAGE(TBL_HST[CH7])
	585nm	=AVERAGE(TBL_HST[CH8])
	610nm	=AVERAGE(TBL_HST[CH8])
	645nm	=AVERAGE(TBL_HST[CH10])
	680nm	=AVERAGE(TBL_HST[CH11])
	705nm	=AVERAGE(TBL_HST[CH12])
	730nm	=AVERAGE(TBL_HST[CH13])
	760nm	=AVERAGE(TBL_HST[CH14])
	810nm	=AVERAGE(TBL_HST[CH15])
	860nm	=AVERAGE(TBL_HST[CH16])
	900nm	=AVERAGE(TBL_HST[CH17])
	940nm	=AVERAGE(TBL_HST[CH18])

DATA COLLECTION –

*Part **3A**: Dashboard

Data Table **TROUBLESHOOTING**

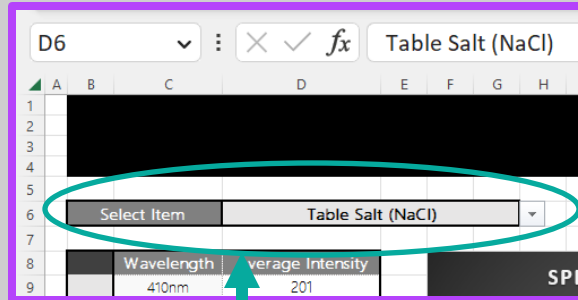
Click on the text box to the right →,

Select all the text, then copy, and paste!

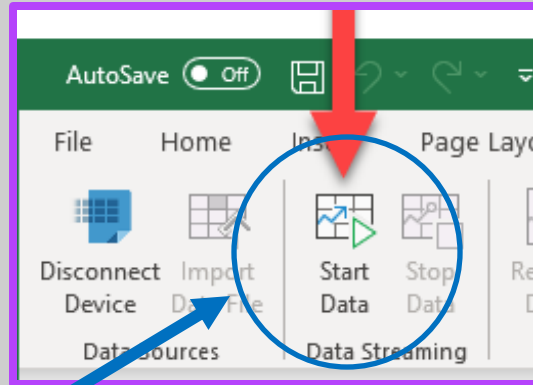
```
=AVERAGE(TBL_HST[CH1])  
=AVERAGE(TBL_HST[CH2])  
=AVERAGE(TBL_HST[CH3])  
=AVERAGE(TBL_HST[CH4])  
=AVERAGE(TBL_HST[CH5])  
=AVERAGE(TBL_HST[CH6])  
=AVERAGE(TBL_HST[CH7])  
=AVERAGE(TBL_HST[CH8])  
=AVERAGE(TBL_HST[CH9])  
=AVERAGE(TBL_HST[CH10])  
=AVERAGE(TBL_HST[CH11])  
=AVERAGE(TBL_HST[CH12])  
=AVERAGE(TBL_HST[CH13])  
=AVERAGE(TBL_HST[CH14])  
=AVERAGE(TBL_HST[CH15])  
=AVERAGE(TBL_HST[CH16])  
=AVERAGE(TBL_HST[CH17])  
=AVERAGE(TBL_HST[CH18])
```


DATA COLLECTION –

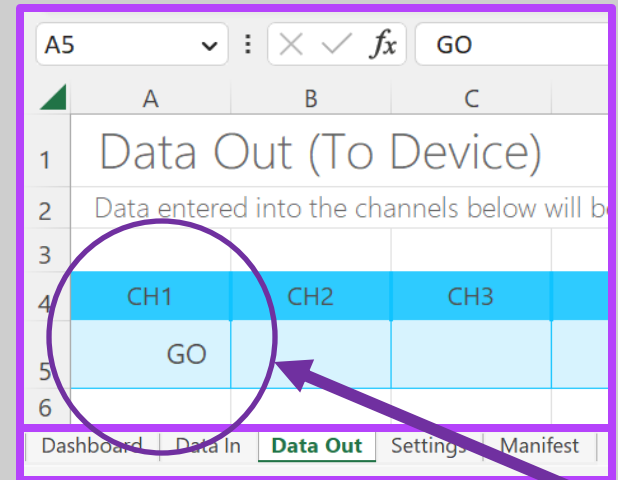
Part 4: Start Data



4. On the Dashboard Sheet, select the substance name from the dropdown menu.



5. Click "Start Data" from the Data Streamer menu bar.



6. Click on the "Data Out" Sheet from the bottom menu. Then type "GO" into cell A5 and hit Enter.

DATA COLLECTION –

Part 5: Collect Data

The screenshot shows a spreadsheet application with a dashboard titled "SPECTROSCOPY DASHBOARD". The dashboard contains a data table, a bar graph, and a line graph. A red circle highlights the "Stop Data" button in the top right corner of the dashboard interface.

Select Item	Table Salt (NaCl)
INFRARED	
410nm	201
435nm	65
460nm	82
485nm	140
510nm	81
535nm	66
560nm	61
585nm	88
610nm	88
645nm	117
680nm	53
705nm	19
730nm	19
760nm	16
810nm	40
860nm	62
900nm	29
940nm	20
VISIBLE	

SPECTROSCOPY BAR GRAPH DATA

Wavelength (nm)	Average Intensity
410	201
435	65
460	82
485	140
510	81
535	66
560	61
585	88
610	88
645	117
680	53
705	19
730	19
760	16
810	40
860	62
900	29
940	20

SPECTROSCOPY LINE GRAPH DATA

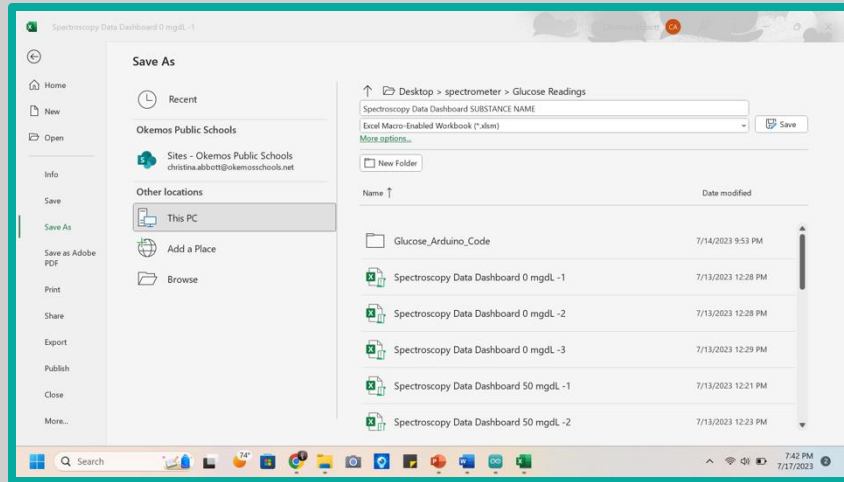
Wavelength (nm)	Average Intensity
410	201
435	65
460	82
485	140
510	81
535	66
560	61
585	88
610	88
645	117
680	53
705	19
730	19
760	16
810	40
860	62
900	29
940	20

Return to the Dashboard Sheet using the menu at the bottom of the screen. You should now see values in the data table for average intensity, a bar graph, and a line graph created for you.

Once the values have stabilized (~10 seconds), click "Stop Data" toward the top of the screen.

DATA COLLECTION –

Part 6: Save Data



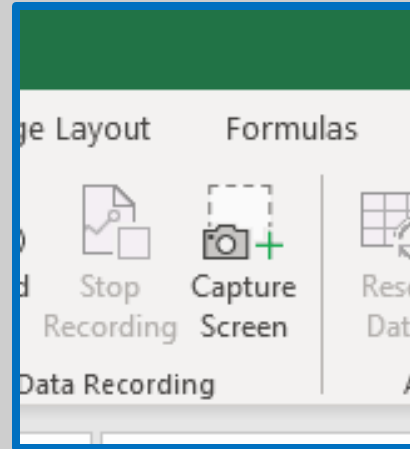
OPTION #1: Select “File” then “Save As.”

Suggestion: Save files using the following pattern:

“ClassPeriod_Group#_SameName”

“ClassPeriod_GroupInitials_SameName”

e.g., “Hr1_ABC_TableSalt”



OPTION #2: Select “Capture Screen”

Within the Data Streamer menu is “capture screen”; this creates an image of the sheet shown that students can save.

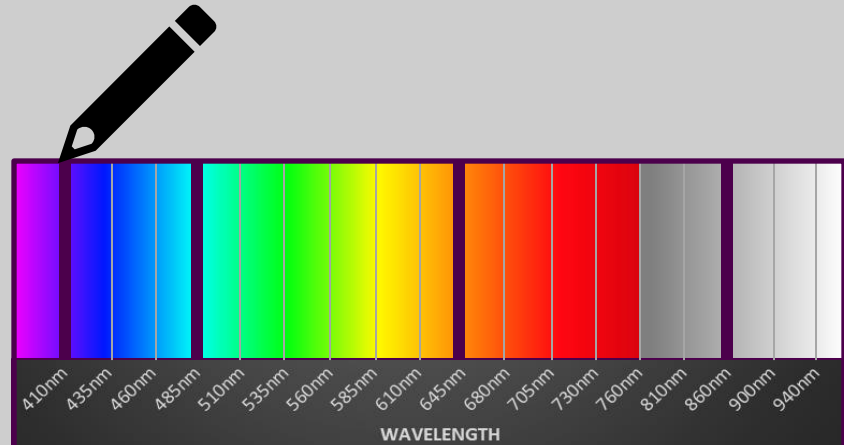
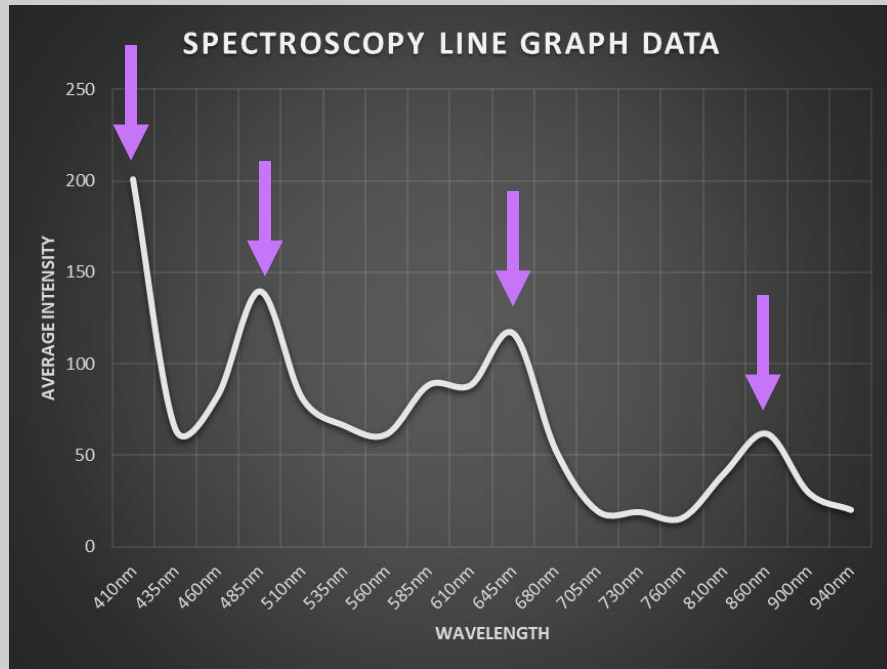


OPTION #3: Use the “Print Screen” shortcut.

Using this keyboard shortcut does the same thing as screen capture above, but automatically saves the image to your “screenshots” folder.

DATA COLLECTION –

Part 7: Record Data

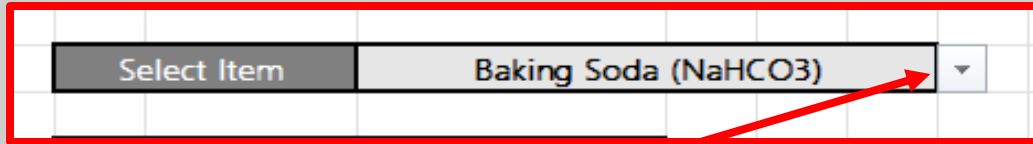


Identify the wavelength values where "peaks" occur on the line graph (see left).

On the student worksheet, use a black marker to draw lines on the provided spectrum at each of the wavelengths where a peak occurred.

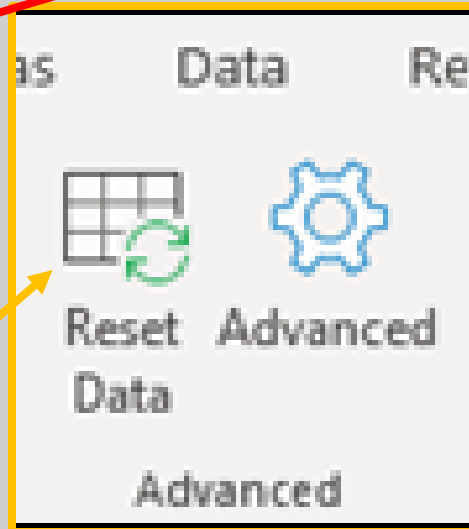
DATA COLLECTION –

Part 8: Reset Data



1. Select the next substance to be sampled from the dropdown menu on the dashboard.

2. Click on the "Reset Data" icon under the data streamer menu.



3. Press the reset button on the Arduino.



DATA COLLECTION –

Part 9: Repeat

Repeat the steps to collect data for each of the known samples and the unknown sample.



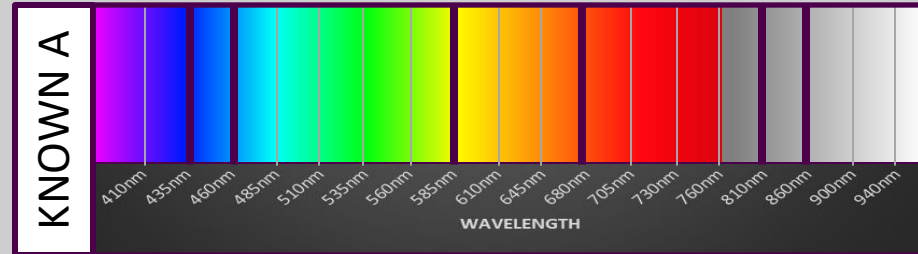
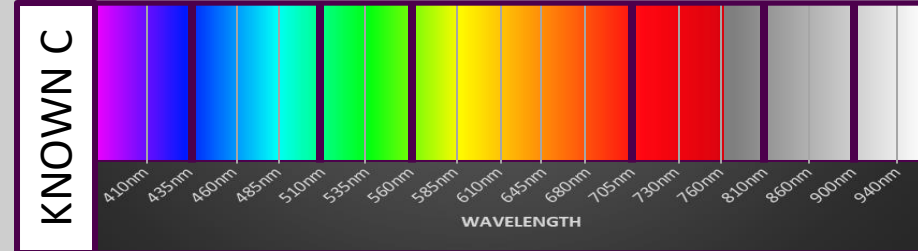
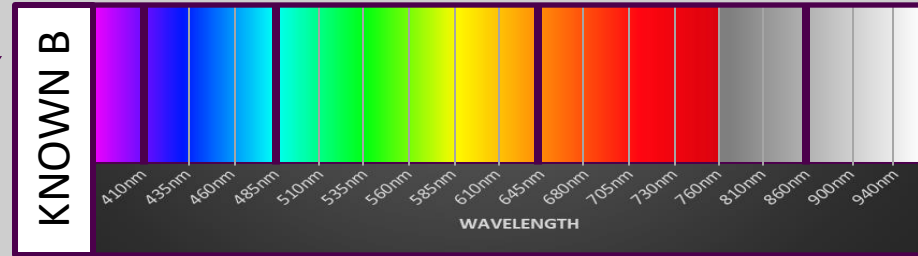
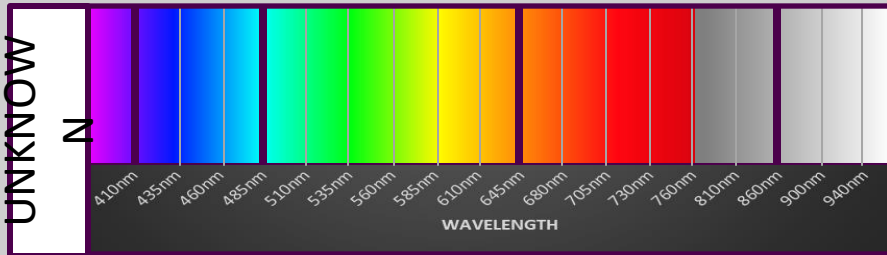


4. Post Lab

Final steps of the lab activity are provided in this section, including how to analyze the data collected and identify the unknown substance.

DATA ANALYSIS


MATCH!




Once data and graphs are collected for the 3 known samples and 1 unknown, compare the unknown graph and spectrum to the knowns to identify the sample.

COMPLETE STUDENT HANDOUT

After identifying the unknown substance, complete the analysis questions on the student handout.

 Name _____ Hour _____







WHAT'S IN OUR STARS?



AFTER THE LAB:

ANALYSIS: Answer the questions below.

- Using the spectra diagrams you created, identify the substance in the unknown sample.
- What are 2 specific limitations (challenges) that the spectrometer you built/used has?
 -
 -
- Refer to the limitations you listed above. What do you think an engineer might have to change in order to allow for determining the composition of a star (2 minimum).
 -
 -
- Analyze the spectra data of our Sun and various elements below. What elements are found in our sun?

Sun	
H	
He	
C	
O	
Na	

Sources

Kramida, A., Ralchenko, Yu., Reader, J. and NIST ASD Team (2022). NIST Atomic Spectra Database (version 5.10), [Online]. Available: <https://physics.nist.gov/asd>. National Institute of Standards and Technology, Gaithersburg, MD. DOI: <https://doi.org/10.18434/T4W30F>

Seidle, Nathan (Nate). Spectral Triad (AS7265x) Hookup Guide, [Online]. Available: https://learn.sparkfun.com/tutorials/spectral-triad-as7265x-hookup-guide?_ga=2.208195537.274963032.1659022095-1771007873.1658366162. SparkFun Electronics. Licensed by CC BY-SA 4.0