A Fluorescent Light Experiment

In this experiment, we use the StreamSmart 410 with a light sensor and the HP Prime DataStreamer App to measure the intensity of light from a fluorescent bulb.

Materials:

- 1 lamp with a fluorescent bulb
- 1 StreamSmart 410 and cable
- 1Fourier light sensor and cable
- 1 HP Prime graphing calculator

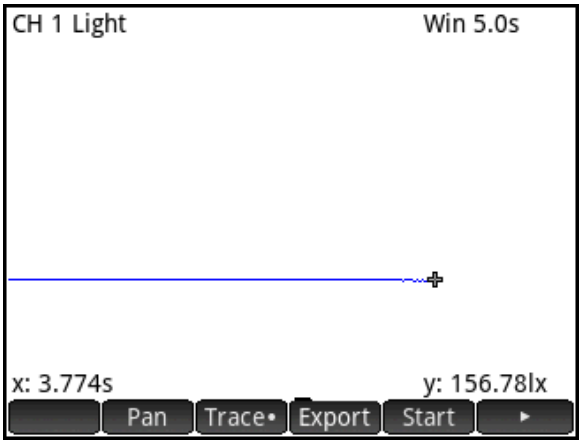
Setup:

1. Plug the Fourier light sensor into the StreamSmart 410 using the appropriate cable.
2. Plug the StreamSmart 410 into the HP Prime graphing calculator using the appropriate cable.
3. Turn on the HP Prime, press Apps Info to open the App Library, and select the DataStreamer App.
4. Turn on the lamp and aim the light sensor at the bulb from a distance of a meter or so.

Experiment Steps

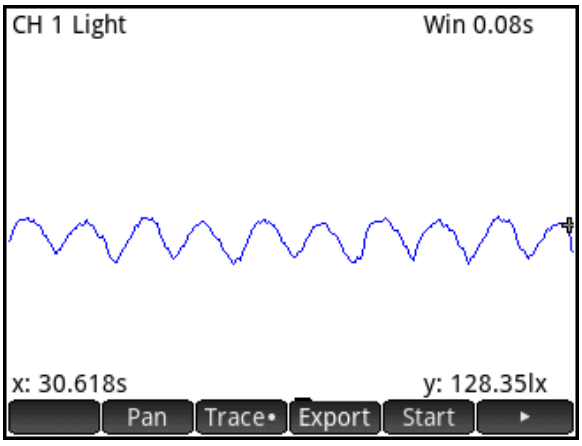
The DataStreamer App displays a message "Waiting to Start…".

1. Tap Start to begin streaming data from the light sensor. The light intensity appears constant.



The data appears as a time plot, with time in seconds horizontally and light intensity (in lux) vertically. Clockwise from the top left, the 4 corners display the channel and sensor, the width of the window in seconds, the current sensor reading, and the current time-stamp value. The width of the window (5 seconds) and the vertical range are chosen automatically to ensure that the data stream is visible. You can pan and zoom the data stream while data is streaming in.

2. Tap Pan• to toggle to Zoom. Press ▶ to zoom in all the way until the window is less than 0.1 seconds. Press ▲ to zoom in vertically to see the light data is actually sinusoidal.



 Author: GT Springer

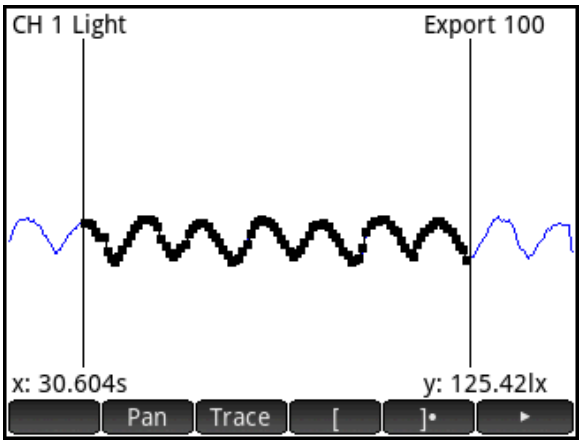
3. Tap Export to select the dataset you wish to export to the Statistics 2Var App. Tap [and then press ▶ to crop data from the left. Tap] and ◀ to crop data from the right. When you have the data you want, tap ▶ and OK.

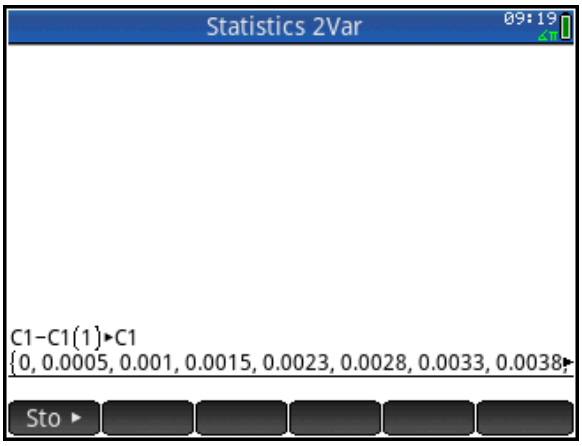
When you tap OK, the *Export to Statistics* screen opens. Here you can choose which app to send to and which columns in the app to use to store your data. In general, you can just accept the defaults.

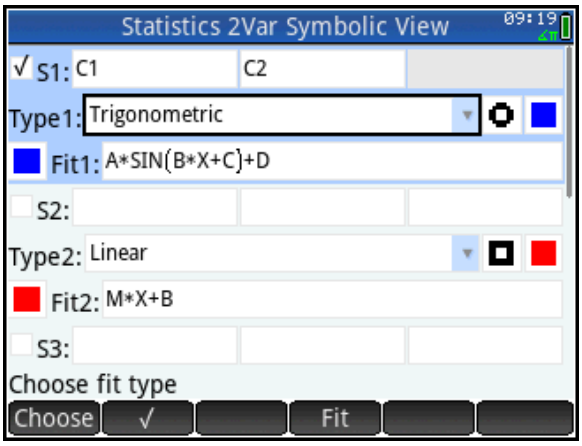
4. Tap OK again to accept the defaults.

The Statistics 2Var app opens, with the time data in C1 and the light intensity data in C2. Since we streamed data for a while before selecting our dataset, the first time-value is not zero. We will reset the time values so the first time-value is zero.

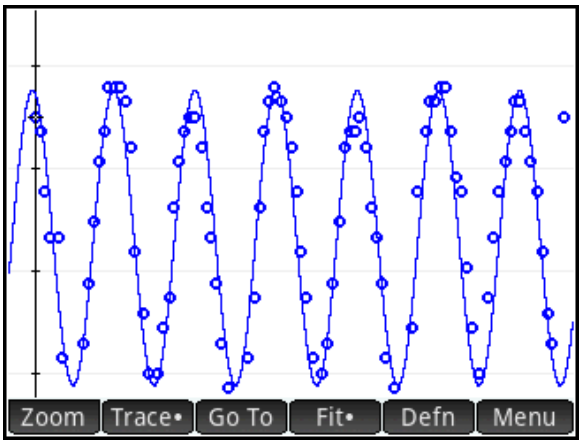
5. Press Settings to open Home view. Enter C1-C1(1), then tap Sto ▸ and enter C1 and press Enter.
6. Press Symb Setup to open Symbolic view. Here, S1 is already defined to use C1 for the independent data and C2 for the dependent data. Tap on the **Type 1** field and tap Choose. From the dropdown menu, select **Trigonometric** for your fit.





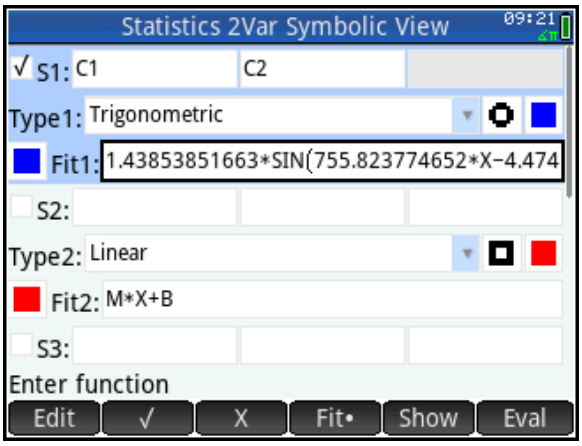


7. Press View Copy and select Autoscale to see the scatter plot. Tap Fit to activate the fit.



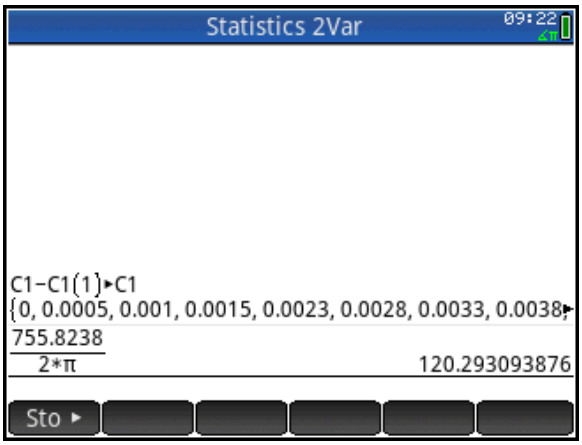
The period of the sinusoidal fit represents the frequency of the oscillation of light intensity coming from the fluorescent lamp. This in turn is related to the frequency of the alternating current that powers the lamp.

8. Press Symb Setup to return to Symbolic view. The Fit1 field now displays the expression for our sinusoidal fit. Tap on the expression. With the expression selected, you can tap Show to see the expression displayed full-screen. Tap OK when you are done.



The coefficient of X is approximately 755.8238. The quotient when this value is divided by 2π is the frequency of the alternating current. In the USA, where this experiment was run, AC current runs at 120 Hz.

9. Press Settings to return to Home view and enter $\frac{755.8238}{2\pi}$. The result, as shown to the right, is very close to 120.



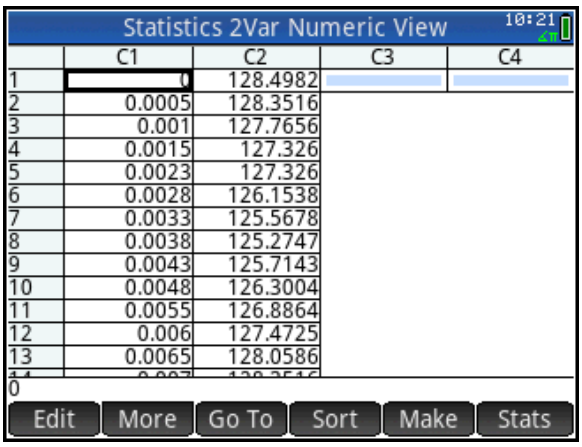
HP Prime, with the StreamSmart 410 and Fourier sensors, is a portable and self-contained laboratory that you can take anywhere. It streams data with little or no setup and allows for analysis and testing of conjectures in a manner consistent with scientific processes. The result is fast and efficient collection and analysis of data.

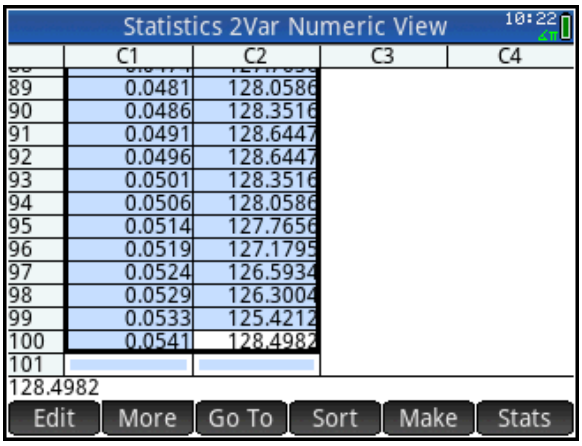
In the next section, we export the data to a spreadsheet.

Exporting Data to a Spreadsheet

To export data from HP Prime to a spreadsheet, the data must be on the HP Prime Virtual Calculator. If you ran the experiment using a physical HP Prime, then you can use the Connectivity Kit to transfer the Statistics 2Var App that contains the data from the physical HP Prime to the Virtual HP Prime on your PC. The steps below begin with the data in the Statistics 2Var App on the HP Prime Virtual Calculator.

1. Open the Statistics 2Var App that contains your data. In the figure to the right, we see the data from our previous light experiment.
2. Tap and hold on the cell C1(1), the cell that contains 0, until the cell is outlined in black (as shown). Now drag down until the entire first column of data has been selected. Then drag to the right to select the entire second column as well.
3. In the HP Prime Virtual calculator menu, click on **Edit** and select **Copy**. The data is now on your PC clipboard.
4. Open your spreadsheet and select the starting cell for pasting your data.
5. Use the spreadsheet **Paste** command to paste the data, starting at the cell you selected.





You can easily copy data to and from the HP Prime Virtual calculator. Use the calculator's own copy and paste clipboard (Shift View Copy for Copy and Shift Menu Paste for Paste) to copy data anywhere within the HP Prime. In the next section, we copy data from the Internet to the HP Prime Virtual calculator. From there, it can be easily sent to the class, either wirelessly all at once, or via the unit-to-unit cable.

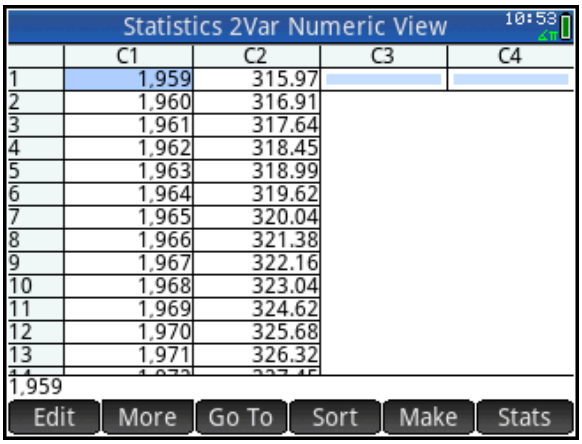
Importing Data to the HP Prime

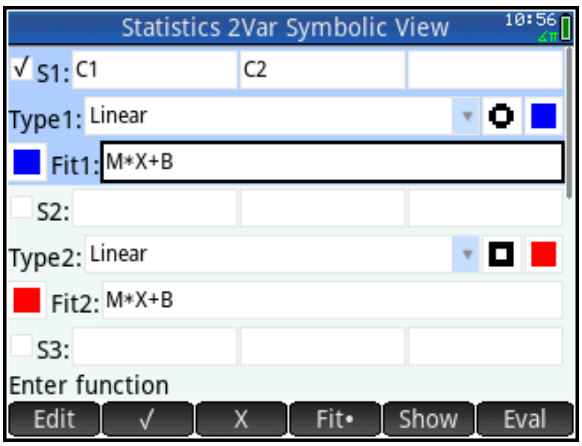
Data can be easily imported from many sources into the HP Prime Virtual calculator. In this section, we import data from the Internet, first to MS Excel, and then to the HP Prime Virtual Calculator. David Keeling started taking CO_2 readings at the Mauna Loa Observatory in 1958. NOAA continued taking these reading from 1974. The data can be found at this URL:

http://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

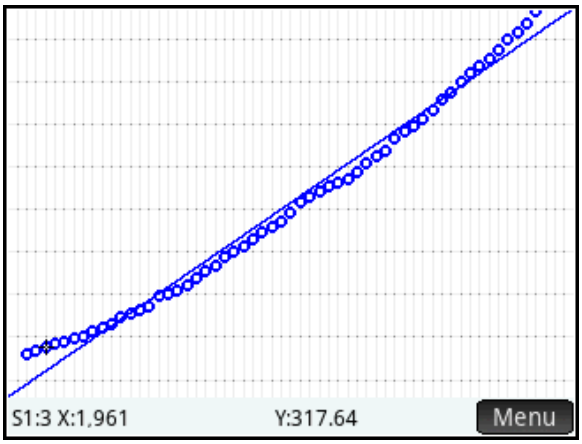
1. Click the **Data** tab and open the **annual mean data**. Select all of the data and copy it to the PC clipboard using Ctrl-C.
2. Open MS Excel. Select a cell and paste the data (Ctrl-V), starting at that cell. Usually, the paste command is sufficient and the data is separated correctly into columns. In some cases, you must take additional steps in Excel. In this example, the following additional step is needed.
3. Click the **Data** tab and click **Text to Columns**. Follow the wizard and the data will be separated into 3 columns: Year, CO_2 annual mean, and unc. Select all the data in the first two columns and copy them to your PC clipboard (Ctrl-C).

1. Launch the HP Prime Virtual calculator. Press Apps Info to open the App Library. Navigate to the Statistics 2Var app and tap Reset to delete all data currently in the app. Tap Start to open the app.
2. The app opens in Numeric view. With C1(1) selected, click **Edit** in the HP Prime Virtual calculator menu and select **Paste**. The year data is pasted into C1 and the CO_2 data is pasted into C2.
3. Press Symb Setup to open Symbolic view. By default, S1 is defined to use C1 as the independent data, C2 as the dependent data, and use a linear fit. Thus, there is nothing for us to do here. If you want a different fit type, select that field, tap Choose and select another type.

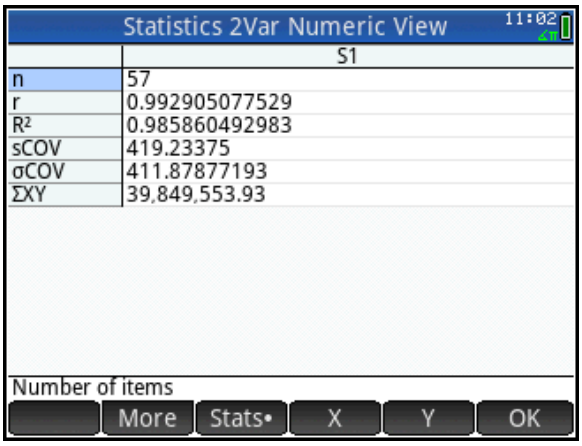




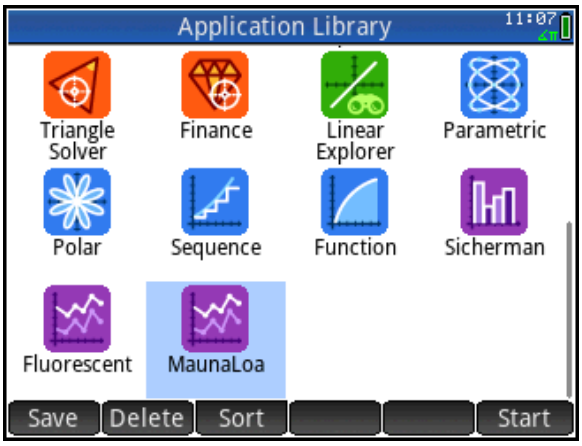
4. Press View Copy and select **Autoscale** to see the scatter plot. Tap Menu and then Fit to display the linear fit. Tap anywhere to move the tracer to the nearest data point, Press ▼ to move the tracer from the data to the fit.



5. Press Num Setup to return to Numeric view and tap Stats to see the *r* and R^2 values.



6. Press Apps Info to open the App Library and tap Save. Enter a name for the app and tap OK twice. You now have a dedicated app that contains these data. In the figure to the right, the app named MaunaLoa contains the data. You can now reset the original Statistics 2Var app and use it for something else. The MaunaLoa app will always have your data, fit, etc. as you left it.



You can now send the MaunaLoa app to an entire class using the HP Prime Wireless Classroom Network. You can also send it to a single HP Prime via the USB cable. From there, students can pick it up one by one using the unit-to-unit cable. Again, the HP Prime is a highly portable and powerful laboratory system that can collect data from sensors, or import data from many sources for analysis, discovery, and to test conjectures.