

Lights Out!

Periodic Phenomena

A rocking chair moving back and forth, a ringing telephone, and water dripping from a leaky faucet are all examples of *periodic* phenomena. That means that the phenomenon repeats itself every so often. The *period* is the time required to complete one cycle of the phenomenon. The number of times the cycle occurs per unit time is known as the *frequency*.

In the following activities, you will use a Light Sensor to collect data for two different types of periodic phenomena. You will then analyze this data with the calculator to find the period and the frequency of the observed behavior.

OBJECTIVES

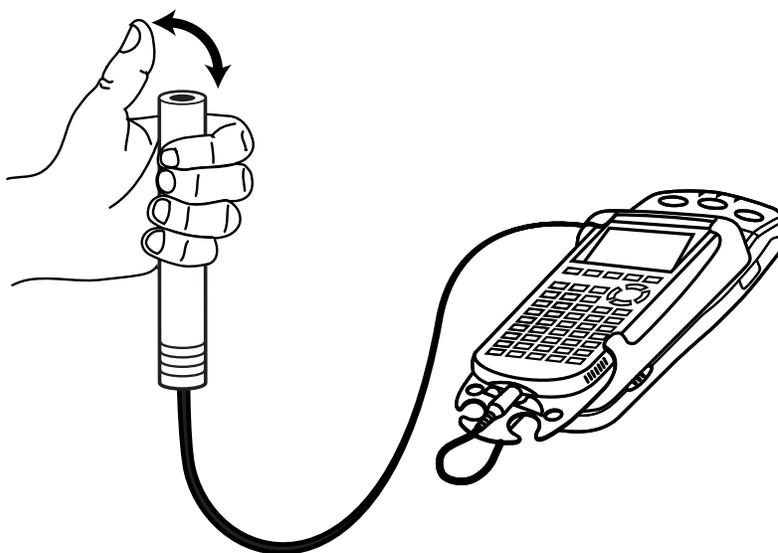
- Record light intensity versus time data for both fast and slow variations of intensity.
- Describe the intensity variations using the concepts of period and frequency.

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator
EasyData application
data-collection interface

Light Sensor
fluorescent light

PROCEDURE I – LONG PERIOD



Activity 24

In this part you will point a light sensor towards a light source such as a window or an overhead lamp. To start, cover the end of the sensor with your thumb. When data collection starts, begin alternately lifting your thumb from the sensor and re-covering it. Light intensity readings will be displayed on the screen of the calculator after data collection is complete.

1. Set up the Light Sensor for data collection.
 - a. Turn on the calculator.
 - b. If you are using the Vernier Light Sensor, set it to 0–6000 lux.
 - c. Connect the Light Sensor, data-collection interface, and calculator.
2. Set up EasyData for data collection.
 - a. Start the EasyData application, if it is not already running.
 - b. Select **(File)** from the Main screen, and then select **New** to reset the application.
3. Once you begin data collection, you will cover and uncover the end of the light sensor using your thumb at roughly a one-covering-per-second rate. For example, you might count “one one thousand two one thousand...” and move your thumb so you cover the sensor on the start of each “thousand.”
 - a. Hold the sensor in your hand, with your thumb ready to cover the end of the sensor. Point the sensor toward a window or other light source.
 - b. Select **(Start)** from the Main screen.
 - c. Move your thumb as described above. Data collection will run for nine seconds.
 - d. The data should show intensity levels, which start at a large value, and then alternate between this value and zero in a regular pattern. The time interval between cycles should be fairly uniform. If the data is not satisfactory, select **(Main)** and return to the beginning of this step.
4. In order to work directly with the data, leave the EasyData application. Select **(Main)** to return to the Main screen. Exit EasyData by selecting **(Quit)** from the Main screen and then selecting **(OK)**.
5. Redisplay the graph outside EasyData.
 - a. Press **(2nd)** [STAT PLOT].
 - b. Press **(ENTER)** to select Plot1 and press **(ENTER)** again to select On.
 - c. Press **(ZOOM)**.
 - d. Press **(↓)** until ZoomStat is highlighted; press **(ENTER)** to display a graph with x and y ranges set to fill the screen with data.
 - e. Press **(TRACE)** to determine the coordinates of a point on the graph using the cursor keys.

ANALYSIS I – LONG PERIOD

⇒ Answer Question 1 – Analysis I on the *Data Collection and Analysis* sheet.

1. The function you see graphed is *periodic*. Determine the period of the cover-uncover function. To do this, use the cursor keys to trace to the first time corresponding to a transition from a plateau to zero or near zero intensity. Record this value as A in the first Data Table on the *Data Collection and Analysis* sheet.
2. Use the cursor keys to trace to another spot on the graph where the function has again gone from a plateau to a near-zero value. Count the number of cycles you traverse as you trace. Record the number of cycles in the first Data Table. (The number of cycles corresponds to the number of times you covered and uncovered the sensor during the time interval.)

Record the time of the new location as B in the first Data Table.

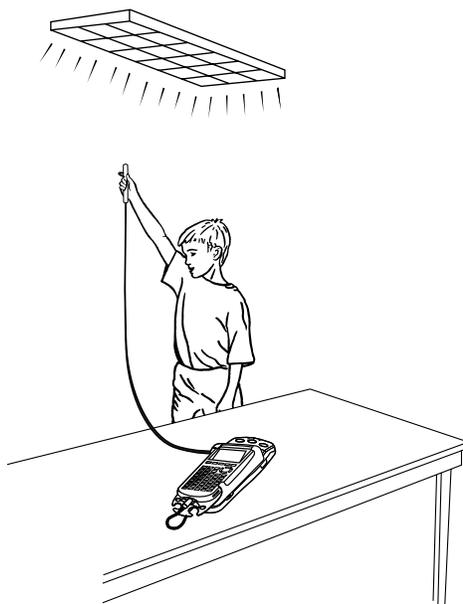
3. Find the average period ΔT during the A to B time interval by dividing the time difference $B - A$ by the number of cycles during this interval. Round this value to the nearest 0.05 seconds, and record it in the first Data Table.
4. While the period represents the number of seconds per cycle, the *frequency* is the number of cycles per second. Find the frequency of the cover-uncover motion by taking the reciprocal of the period you just determined. Record this value as the frequency in the first Data Table.

Multiply the frequency you just determined by 60, and record the value in the first Data Table.

⇒ Answer Question 2 – Analysis I on the *Data Collection and Analysis* sheet.

EXTENSION I

What would happen to the graph if you repeated the cover/uncover cycle twice a second instead of the once a second rate you used before? Predict what would happen to your period and frequency values. Return to EasyData and take another run with the faster cover/uncover rate to check your prediction.

PROCEDURE II – SHORT PERIOD

In this part you will point the light sensor at a single fluorescent light and record its intensity for a very short period of time. The resulting plot of intensity versus time is interesting because it shows that fluorescent lights do not stay on continuously but rather flicker off and on very rapidly. Since the human eye cannot distinguish between flashes that occur more than about 50 times a second, the light appears to be on all the time. The data you collect will be used to determine the period and frequency at which the bulb flickers.

1. Since the rate of flickering of the lights is very fast, you need to first increase the rate of data collection.
 - a. Select **[Setup]** from the Main screen of EasyData, then select **Time Graph...**
 - b. Select **[Edit]** on the Time Graph Settings screen.
 - c. Enter **0.0005** as the time between samples in seconds.
 - d. Select **[Next]**. (Note that the data-collection interface will now record light intensity at a rate of $1/0.0005 = 2000$ times a second!)
 - e. Enter **100** as the number of samples and select **[Next]**.
 - f. Select **[OK]** to return to the Main screen.
2. Collect data of light intensity versus time for the fluorescent light.
 - a. Hold the light sensor near the fluorescent light. Since data collection will run only $1/20^{\text{th}}$ of a second, you must be ready for data collection when you select **[Start]**.
 - b. Select **[Start]** from the Main screen.
 - c. When data collection is complete, a graph will be displayed. The data should show intensity levels which alternate between a high and low value in a regular pattern. The time interval between cycles should be relatively constant. If the data is not satisfactory, select **[Main]** and return to the start of Step 2.

3. In order to work directly with the data, leave the EasyData application. Select $\overline{\text{Main}}$ to return to the Main screen. Exit EasyData by selecting $\overline{\text{Quit}}$, and then selecting $\overline{\text{OK}}$.
4. Redisplay your graph outside EasyData using the same method you used earlier.

ANALYSIS II – SHORT PERIOD

⇒ Answer Question 1 – Analysis II on the *Data Collection and Analysis* sheet.

1. Use the technique you used previously to determine the period and frequency of the pattern from the fluorescent light.

Round these values to the nearest 0.0005 s and record them in the second Data Table.

2. In North America, electric utilities use alternating current at 60 cycles per second, while in most of the world the frequency is 50 cycles per second.

⇒ Answer Question 2 – Analysis II on the *Data Collection and Analysis* sheet.

EXTENSION II

The fluorescent light bulb intensity versus time data you collected in this activity can be modeled with an absolute value sinusoidal equation of the form:

$$y = A|\sin(B(x - C))| + D$$

Can you determine appropriate values for A , B , C , and D so that this equation properly models the data? How do the frequencies of the above equation and

$$y = A\sin(B(x - C)) + D$$

compare? Be sure that the calculator is in radian mode before graphing these functions.

