# DISCOVERING THE NATURE OF PERIODIC DATA: I. GENERATING DATA WITH A MOTION DETECTOR

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Many natural phenomena follow a cyclic pattern, a pattern that repeats itself at a regular interval in time. The orbital motion of astronomical bodies, climate variables that are tuned to the Earth's seasons, and many oscillating objects in physics are examples of just a few. This activity will give a sample of generating periodic data using the calculator-based ranger (CBR) or any motion detector with a calculator or computer, and getting into the analysis of the data using the sine function with the capabilities of the TI-83 Plus graphing calculator. Keystrokes are shown in bold with [ ], such as **[ON]**.

Getting Engaged

How would you describe the graphs shown? Are they functions? What is different compared to the other functions studied?
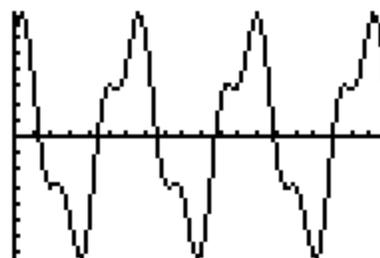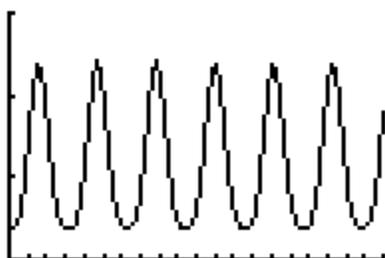
Generating Periodic Data

Connect the CBR to the calculator with the link cable to the TI-83Plus. Press **[APPS]**, and select CBL/CBR, then RANGER, and then select set up on the main menu and set up as real-time for 15 sec as distance in meters (with no smoothing), and then select START NOW.

Revolve the CBR around a circular path as shown below. The CBR must always point toward a wall or other flat surface. Practice the circular path until you get a regular pattern in the results. Sketch and label the graph of the results.
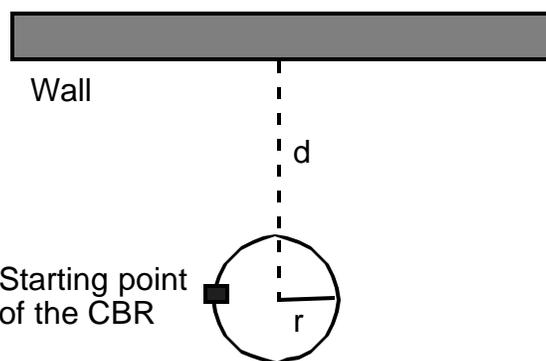
Is the data periodic? Explain.

Wall

d

Starting point
of the CBR

r

Rotate CBR around the circle while
pointing it in the direction of the wall

Investigate how the four parameters given in the table below influence the pattern you generated above. Make sure you describe how you changed the parameter, such as increased the radius of the circle, and give the resulting change in the data pattern.

Parameter	AMPLITUDE	PERIOD	Y-SHIFT	X-SHIFT
How to change the parameter	radius (r) of circle, change radius	time to complete one revolution around circle, move around circle faster or slower	distance from wall (d), move away or closer	starting point on circle, change staring point by moving 45, 90, 180° around the circle
The change				
Result in the pattern				

What happens to the plot of the data if you reverse the direction of rotation (using the same starting point)?   Predict and then perform the experiment.

Predict what the graph would look like for the following motion, and then perform the experiment.

Does your prediction match   the actual results?

Wall

d

Starting point
of the CBR   ±r

Move the CBR back and forth
toward the wall a distance of 2 r.
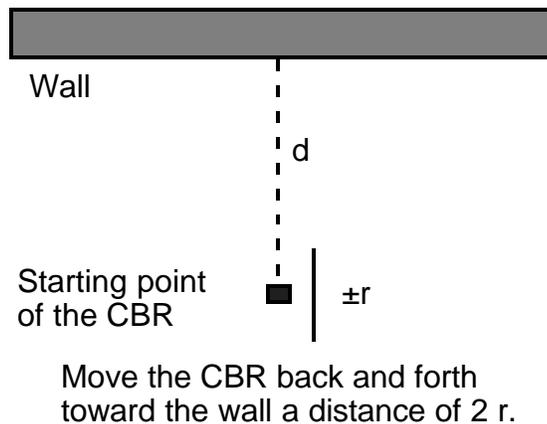
You have discovered how to generate periodic data using circular and oscillating motions.   Parameters that are used to describe this type of data were explored and will be defined shortly.

Examining the Sine Function

In the function editor, **[Y=]**, enter $Y_1 = \sin (X)$. Use the **[X,T,2,n]** key to enter X. Set **[MODE]** to Radians. Set the **[WINDOW]** as shown on the screen below and then press **[GRAPH]**. Sketch the function for positive x values below.

```
WINDOW
 Xmin=0
 Xmax=16
 Xscl=1
 Ymin=-3
 Ymax=3
 Yscl=1
 Xres=1
```

What is one complete cycle on the graph above? Label it. This is called the **period**. It can be measured from any two similar points – two maxima or two minima.

The **amplitude** is the distance from the midline, the x-axis or y = 0, to the maximum or minimum. Label the amplitude on the graph above.

In the function editor, **[Y=]**, enter the following functions listed in the table. Compare, one at a time, the changes of each function, Y_2 to Y_5, to the original function Y_1.

Function	How does the function change with the modifications compared to $Y_1 = \sin (X)$?
$Y_2 = 2\sin (X)$	
$Y_3 = \sin (2X)$	
$Y_4 = \sin (X + 2)$	
$Y_5 = \sin (X) + 2$	

On the TI-83 Graphing Calculator, the sine regression, under **[STAT]** CALC as "SinReg" at the bottom of the menu, is given in the form:

$$Y = a \sin (bX + c) + d$$

where **a** is the amplitude (average of (maxima - minima)/2), **b** is the angular frequency[1] (radians per unit time) which is related to the period, P = 2B/b, **c** is the shift on the x-axis and is proportional to the phase shift, and **d** is the shift on the y-axis or the midline (y = d).

Alternatively, the coefficients can be determined manually from the graph and used to generate a function to fit the data. We will explore manual and regression function fits and judging the goodness of fit in Part II, where we examine and analyze cycles in data from natural phenomena.

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[1] Frequency (f) in cycles per unit time is related to angular frequency: b = 2Bf