

# Feeling hot, hot, hot

## - modeling with sine waves -

### Objective

To discover the relevance of  $a$ ,  $b$ ,  $c$  and  $d$  in the sine curve  $y = a \sin (bx+c) + d$ .

### Background

For students in the city of Adelaide, Australia, December marks the start of their long summer vacation. For the next eight weeks temperatures often soar above  $30^{\circ}\text{C}$ , sometimes reaching  $45^{\circ}\text{C}$  for the start of the new school year in February. By contrast the winter days of July and August are mild.

In Toronto, Canada, the climate is very different. The average maximum temperatures in January and February are below freezing. Homes, schools and shops are equipped with central heating, and parking garages have special warmers to keep car batteries working effectively. Thankfully there is a large variation in temperature between the icy winters and warm summers.

And in tropical Singapore the weather is always hot, hot, hot!

### Activity 1: Adelaide



Table 1 shows some temperature data sourced from [www.worldweather.org](http://www.worldweather.org).


month (Jan = 1)	Average maxima ( $^{\circ}\text{C}$ )		
	Adelaide	Toronto	Singapore
1	27.9	-1.1	29.9
2	28.1	-0.2	31.0
3	25.3	4.6	31.4
4	22.0	11.3	31.7
5	18.4	18.5	31.6
6	15.9	23.5	31.2
7	14.9	26.4	30.8
8	15.8	25.3	30.8
9	18.0	20.7	30.7
10	20.8	13.8	31.1
11	23.5	7.4	30.5
12	25.5	1.8	29.6

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Look at the temperature data for Adelaide.

1. What is the highest monthly average, and in what month does it occur?
2. What is the lowest monthly average, and in what month does it occur?
3. What is the median temperature throughout the year?
4. By how much do the highest and lowest temperatures differ from the median?





Open the Statistics application  and press the **Keyboard** button to show the on-screen keyboard. At the top of this on-screen keyboard, tap the alphabet tab **abc**.

Tap the heading for List 1 and use the on-screen keyboard to type **month**. Change the heading for List 2, 3 and 4 to read **adel**, **toro** and **sing**.

Enter the four columns of data from Table 1 into your calculator.




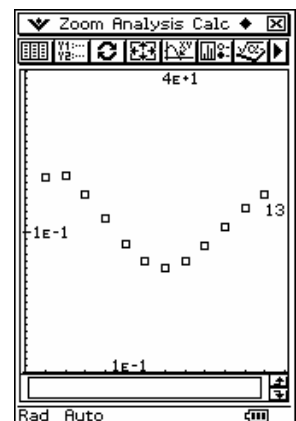
Next follow these steps to plot Adelaide's temperature against time.

1. From the menu bar, tap SetGraph, then select StatGraph1.
2. From the tool bar, tap StatGraph . The first tab is for StatGraph1.
3. Choose these settings, using the down arrow  as necessary.

Draw: On  
Type: Scatter  
XList: main\month  
YList: main\adel  
Freq: 1  
Mark: square

Then tap Set.

4. Plot the points by tapping DrawGraph  from the tool bar.  
The points follow a sinusoidal curve.



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To find the equation of the curve of best fit, tap **Calc** on the menu bar and choose sinusoidal regression (*Sinusoidal Reg*).

Our XList is the time in months (*main\mth*).

Our YList is Adelaide's average maximum temperatures (*main\adel*).

Leave Copy Formula - Off and Copy Residual - Off. Then tap OK.

Copy the values of  $a$ ,  $b$ ,  $c$  and  $d$  into the formula  $Y = a \sin(bx + c) + d$ .

The average maximum temperature in Adelaide,  $y$ , is modeled by the formula

$$Y = \_\_\_ \sin(\_\_\_x + \_\_\_) + \_\_\_$$

where  $x$  is the time in months since December, so January is  $x = 1$ .

Now rewrite this formula as  $Y = a \sin \mathbf{b(x + C_{new})} + d$

$$Y = \_\_\_ \sin \_\_\_(x + \_\_\_) + \_\_\_$$

Look again at the values of  $a$ ,  $b$ ,  $C_{new}$  and  $d$ . In what ways do they match your answers on page 2?

## Checkpoint



### Activity 2: Toronto

Look at the temperature data for Toronto.

1. What is the highest monthly average, and in what month does it occur?
2. What is the lowest monthly average, and in what month does it occur?
3. What is the median temperature throughout the year?
4. By how much do the highest and lowest temperatures differ from the median?

# Feeling hot

Follow the method of Activity 1 to find a formula that models the average maximum temperatures in Toronto.

The average maximum temperature in Toronto,  $y$ , is modeled by the formula

$$Y = \_\_\_ \sin(\_\_\_x + \_\_\_) + \_\_\_$$

where  $x$  is the time in months since December, so January is  $x = 1$ .

We can rewrite this formula as  $Y = \_\_\_ \sin \_\_\_(x + \_\_\_) + \_\_\_$

How do these values compare with those you found at the start of Activity 2?

## Apply your skills

The median value for maximum temperatures in Madrid is 18.3 °C. Its warmest month is July, with an average maximum temperature of 31.2 °C. Predict a formula to model the average maximum temperature in Madrid.

Checkpoint



## Activity 3: Singapore

Follow the method of Activity 1 to find a formula that models the average maximum temperatures in Singapore. Note that Singapore lies near the equator and does not have the summer/winter variations of Adelaide and Toronto.

The average maximum temperature in Singapore,  $y$ , is modeled by the formula

$$Y = \_\_\_ \sin(\_\_\_x + \_\_\_) + \_\_\_$$

where  $x$  is the time in months since December, so January is  $x = 1$ .

We can rewrite this formula as  $Y = \_\_\_ \sin \_\_\_(x + \_\_\_) + \_\_\_$