

DIRECTIONS FOR DETERMINING THE TEMPERATURE TREND FOR THE PAST 125 YEARS USING LINEAR REGRESSION

- Under the graph for the Global Temperature Anomaly data, click on the Download Data button. A .xlsx file will open in Microsoft Office Excel.
- In the File menu, click *Save* to save your file on your computer. Make sure to periodically save your file.

You are now going to calculate the rate of change or trend using the formula for a linear regression. To do this type of calculation by hand would take a very long time, but with a simple formula in excel, we can calculate this very quickly.

For this activity, you are going to calculate the linear rate of change over several different time periods: 125 years (1885-2010), 100 years, (1910-2010), 75 years (1935-2010), 50 years (1960-2010) and 25 years (1985-2010).

First, you will calculate the rate of temperature change for 1885-2010 using a simple linear regression analysis.

This is the equation that Excel uses to calculate the slope of the line:

$$\text{Slope}(b) = (N\sum XY - (\sum X)(\sum Y)) / (N\sum X^2 - (\sum X)^2) \quad \text{where}$$

X = the year

Y = the temperature anomaly

b = The slope of the regression line

N = Number of data points

$\sum XY$ = Sum of the product of year and the temperature anomaly

$\sum X$ = Sum of years

$\sum Y$ = Sum of temperature anomalies

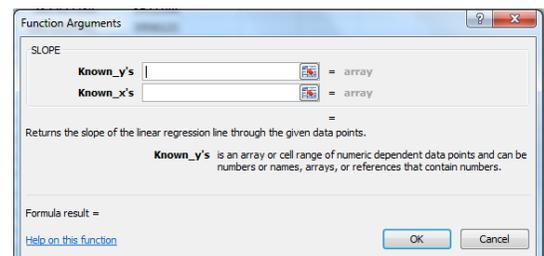
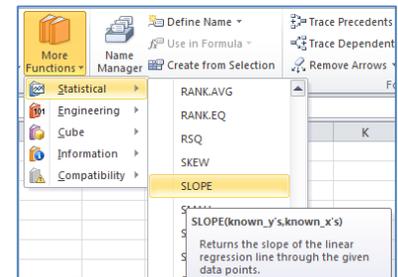
$\sum X^2$ = Sum of the years squared

The great thing about Excel is that it has numerous functions that will calculate a lot of formulas for you.

Let's try using one of those functions now. Click on the Formula tab and then More Functions>Statistical>SLOPE. Select your X and Y values that you want to graph.

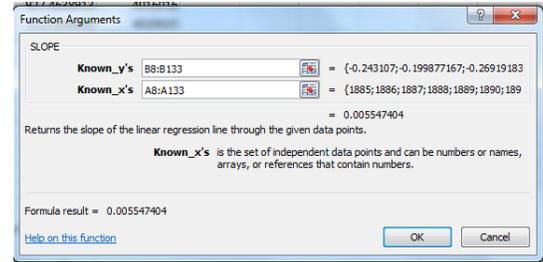
1. Calculate the slope (rate of change) for 1885-2010:

- Click in cell D136.
- Click on the Formula tab and then More Functions>Statistical>SLOPE.
- The Function Arguments box appears. You will now get your Y array. Click on the box with the diagonal red arrow.
- Select cell B8 and scroll down to B133.
- Click the box with the downward red arrow.
- You will now get your X array. Click on the box



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- g. with the diagonal red arrow. 
- h. Select cell A8 and scroll down to A133.
- i. Click the box with the downward red arrow. 
- j. Click on OK.
- k. Cell D136 should now have the slope. The formula bar should read: **=SLOPE(B8:B133,A8:A133)**
- l. Write your answer in the table on your answer sheet.

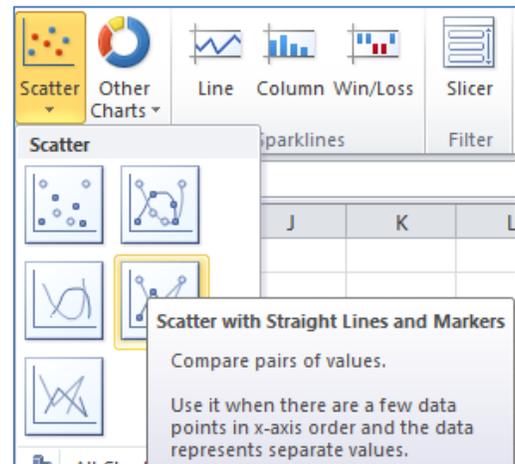


You will now calculate the slope for the other year ranges. But now that we know the formula, there is a shortcut! You just need to change the first value in each Y and X range to match the year.

2. Calculate the slope (rate of change) for 1910-2010:
 - a. Click in cell D137.
 - b. Type: **=SLOPE(B33:B133,A33:A133)** (Notice that we change the first Y and X value here to B33 and A33, respectively. This is the line for 1910.)
 - c. Hit enter.
 - d. Write your answer from cell D137 in the table on your answer sheet.
3. Calculate the slope (rate of change) for 1935-2010:
 - a. Click in cell D138.
 - b. Type: **=SLOPE(B58:B133,A58:A133)**
 - c. Hit enter.
 - d. Write your answer from cell D138 in the table on your answer sheet.
4. Calculate the slope (rate of change) for 1960-2010:
 - a. Click in cell D139.
 - b. Type: **=SLOPE(B83:B133,A83:A133)**
 - c. Hit enter.
 - d. Write your answer from cell D139 in the table on your answer sheet.
5. Calculate the slope (rate of change) for 1985-2010:
 - a. Click in cell D139.
 - b. Type: **=SLOPE(B108:B133,A108:A133)**
 - c. Hit enter.
 - d. Write your answer from cell D139 in the table on your answer sheet.

Let's now create a graph of this data and add two trend lines. The trend line is essentially the slopes that we just calculated above.

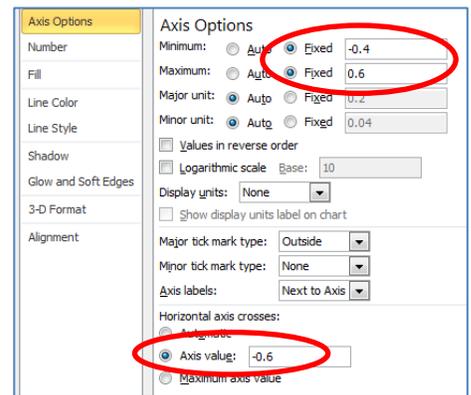
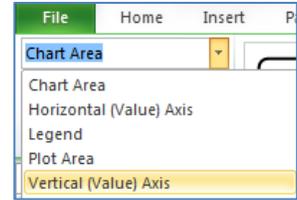
6. Create a graph of the data from 1885-2010 with a trendline for both 1885-2010 and 1985-2010:
 - a. Select data in cells A8 through C133. Those cells should be highlighted blue.
 - b. Click on the Insert tab at the top and then on Scatter>Scatter with Straight Lines and Markers. Your graph now appears in the same sheet.



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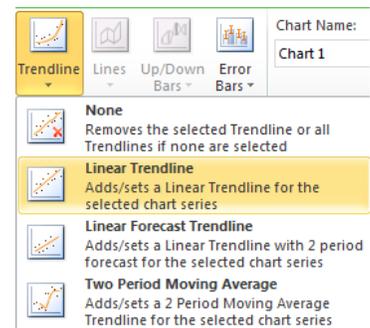
On our graph, there are numerous things that we want to change. Notice that the X and Y axes have a greater range of values than what we need. You will also notice that your X values are located in the wrong place. They are located at 0 and because you have Y values less than 0, there is a problem. But there is a way to fix this!

- c. Edit the Vertical axis.
 - i. Click on the graph.
 - ii. Click on the Format tab and then in the dropdown menu on the left, select Vertical (Value) Axis.
 - iii. Click on Format Selection. The Format Axis box pops up.
 - iv. Change the Minimum axis value from -0.6 by selecting Fixed and typing -0.4 in the space.
 - v. Change the Maximum axis value from 0.8 by selecting Fixed and typing 0.6 in the space.
 - vi. Change the Axis value under Horizontal axis crosses from 0 to -0.6.
- d. Edit the Horizontal axis.
 - i. Click on the graph.
 - ii. Click on the Format tab and then in the dropdown menu on the left, select Horizontal (Value) Axis.
 - iii. Click on Format Selection. The Format Axis box pops up.
 - iv. Change the Minimum axis value from 1860 by selecting Fixed and typing 1870 in the space.



We also have two series of data shown on the graph. Notice that the data in Column C is the same data as in Column B but just show data for 1985-2010. We are doing this because we want to create two trendlines on our graph. To do this, we will first hide the series 2 data and then add the two trendlines.

- e. Hide the Series 2 data.
 - i. Click on (select) the 1985-2010 (Series 2) data in the graph.
 - ii. Select Format Selection. The Format Data Series box should open.
 - iii. Under Marker Option, select None.
 - iv. Under Line Color, select No line.
- f. Add two trendlines.
 - i. Click on the graph (but not on the data).
 - ii. Click on the Layout tab under Chart Tools.
 - iii. Click on the dropdown arrow under Trendline and select Linear Trendline.
 - iv. Click on Series 1 and click OK.
 - v. Repeat steps i. – iv. But now select Series 2.
 - vi. You can change the color of the trendline by selecting it and then click on the Format tab under Chart Tools and select a color under Shape Outline.



DIRECTIONS FOR

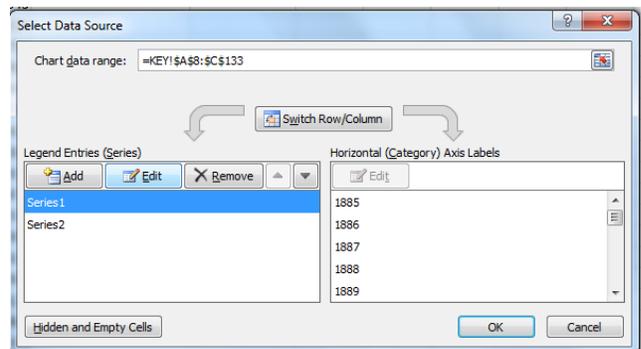
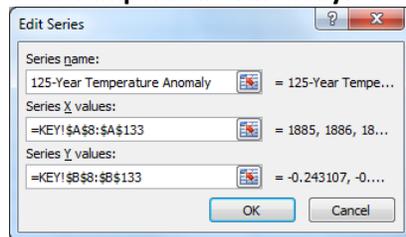
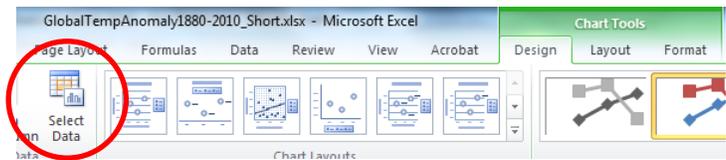
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Now for the finishing touches. We want our graph to look more polished by adding titles and we need to change the legend so that the titles have more meaning.

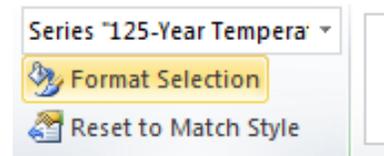
- g. Add titles to your graph.
 - i. Add horizontal axis title by going to Layout>Axis Titles>Primary Horizontal Axis Title>Title Below Axis. You may need to resize your chart to make room for the title. Type in the word **YEAR**.
 - ii. Add vertical axis title by going to Layout>Axis Titles>Primary Vertical Axis Title>Rotated Title. Type in **TEMPERATURE ANOMALY**.
 - iii. **Add** chart title by going to Layout>Chart Title>Centered Overlay Title. Type in **Temperature Anomaly Trends Since the Industrial Revolution**.

h. Change the Legend

- i. To change the Series 1 title in the legend – Click on (select) the data on your chart. Some of the data points will appear selected. Under the Chart Tools Design tab, click Select Data. Select Series 1 and then click on Edit. Add the Series name **125-Year Temperature Anomaly**.



- ii. Rename the 125-Year Temperature Anomaly Trendline in the legend - Under the Chart Tools Format tab, click on the down arrow that shows chart details and select *Series "125-Year Temperature Anomaly" Trendline 1*. Click on Format Selection underneath. Under Trendline options tab and below Trendline Name, click on Custom and type in **1885-2010 Trendline**.



- iii. Rename the Series 2 Trendline in the legend - Under the Chart Tools Format tab, click on the down arrow that shows chart details and select *Series 2*. Click on Format Selection underneath. Under Trendline options tab and below Trendline Name, click on Custom and type in **1985-2010 Trendline**.

