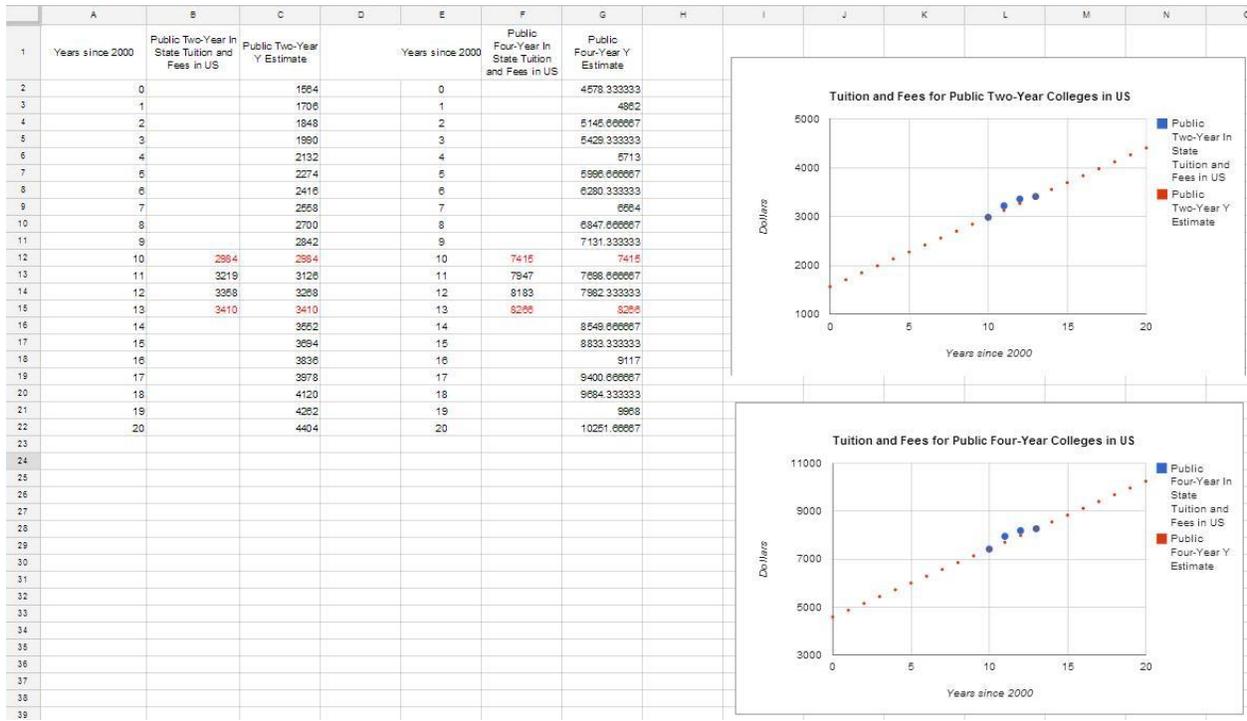In a previous assignment, you created graphs showing the data for college costs and a corresponding linear model. Your worksheet probably looks something like the one below.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Years since 2000 | Public Two-Year In State Tuition and Fees in US | Public Two-Year Y Estimate | | Years since 2000 | Public Four-Year In State Tuition and Fees in US | Public Four-Year Y Estimate | | | | | | | |
| 2 | 0 | | 1564 | | 0 | | 4578.333333 | | | | | | | |
| 3 | 1 | | 1706 | | 1 | | 4862 | | | | | | | |
| 4 | 2 | | 1848 | | 2 | | 5145.666667 | | | | | | | |
| 5 | 3 | | 1990 | | 3 | | 5429.333333 | | | | | | | |
| 6 | 4 | | 2132 | | 4 | | 5713 | | | | | | | |
| 7 | 5 | | 2274 | | 5 | | 5996.666667 | | | | | | | |
| 8 | 6 | | 2416 | | 6 | | 6280.333333 | | | | | | | |
| 9 | 7 | | 2558 | | 7 | | 6564 | | | | | | | |
| 10 | 8 | | 2700 | | 8 | | 6847.666667 | | | | | | | |
| 11 | 9 | | 2842 | | 9 | | 7131.333333 | | | | | | | |
| 12 | 10 | 2984 | 2984 | | 10 | 7415 | 7415 | | | | | | | |
| 13 | 11 | 3219 | 3126 | | 11 | 7947 | 7698.666667 | | | | | | | |
| 14 | 12 | 3358 | 3268 | | 12 | 8183 | 7982.333333 | | | | | | | |
| 15 | 13 | 3410 | 3410 | | 13 | 8266 | 8266 | | | | | | | |
| 16 | 14 | | 3552 | | 14 | | 8549.666667 | | | | | | | |
| 17 | 15 | | 3694 | | 15 | | 8833.333333 | | | | | | | |
| 18 | 16 | | 3836 | | 16 | | 9117 | | | | | | | |
| 19 | 17 | | 3978 | | 17 | | 9400.666667 | | | | | | | |
| 20 | 18 | | 4120 | | 18 | | 9684.333333 | | | | | | | |
| 21 | 19 | | 4262 | | 19 | | 9968 | | | | | | | |
| 22 | 20 | | 4404 | | 20 | | 10251.66667 | | | | | | | |



Notice the red highlights. Let's look at these cells closer.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | 10 | 2984 | 2984 | 10 | 7415 | 7415 |
| 13 | 11 | 3219 | 3126 | 11 | 7947 | 7698.666667 |
| 14 | 12 | 3358 | 3268 | 12 | 8183 | 7982.333333 |
| 15 | 13 | 3410 | 3410 | 13 | 8266 | 8266 |

The numbers in red match because I used these pairs of points to create the linear models. You should find that your points match. Which ones match depends on what pairs of points you used to create the model.

The other two data points do not lie along line we found in an earlier assignment. To help us measure how far the line is from the data points, we'll measure the percentage error between the line and the data points at each $x$ value, $x = 10, 11, 12,$ and $13$. For instance, the percentage error at the second data point is

$$\text{Percent Error} = \frac{3126 - 3219}{3219} \approx -0.029$$

*y* value on line at *x* = 11

Data value at *x* = 11

This indicates that the estimate of cost at *x* = 11 is 2.9% <u>lower</u> than the actual data value.

Let's think of each data value with subscripts like

$$(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)$$

The percentage error at a particular data point is

$$\text{Percentage Error} = \frac{y - y_i}{y_i}$$

where *i* is 1, 2, 3, or 4. For instance, if *i* = 3, the percentage error at the third data point is

$$\text{Percentage Error} = \frac{y - y_3}{y_3}$$
$$= \frac{3268 - 3358}{3358}$$
$$= -0.027$$

This means that the line is 2.7% lower than the data point at *x* = 12.

The goal of this technology assignment is calculate the percentage error at each data point. This will help you to see how well your line matches the data values.

## Measure the Percentage Error

1. Make a copy of your previous technology assignment. To do this, right click on the tab at the bottom of your Google Sheet that you want to make a copy of.
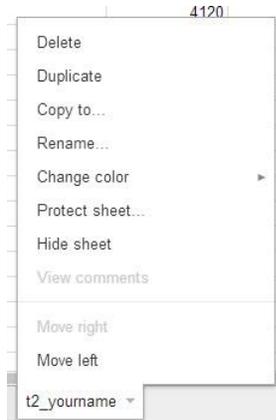
Select Duplicate.

2. This will add a new sheet called Copy of t2_yourname. Double click on this tab and rename the sheet to something like t3_yourname.



We'll add to this worksheet the required formulas to calculate the percentage error.

3. Click your mouse in the cell to the right of the estimate for the first data point (probably D12). In this cell type



Press Enter to see the calculated value.

Since the line passes through this data point, the percentage error is 0. If you did not use the first data point to calculate the equation of the line, you probably will not get 0.
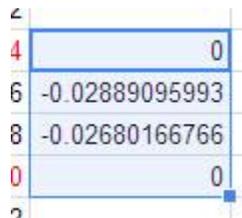
4.  Click in cell D12 again. Use the mouse to grab the fill handle.



While holding the left mouse button down, drag the cursor to cell D15.
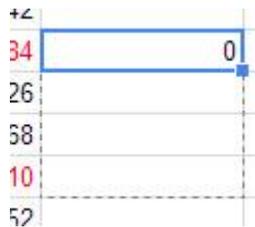


When you release the button, the percentage error should be calculated for cells D13 through D15.



The numbers should be selected (highlighted) now. To change these decimals to percentages, press  on the button bar at the top of the worksheet. The numbers will change to percentages. Note that you must select the numbers you want to change before pressing the button.

| 4 | 0.00% |
| 6 | -2.89% |
| 8 | -2.68% |
| 0 | 0.00% |

5. Once you have completed these steps, your worksheet should look similar to the one below.

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Years since 2000 | Public Two-Year In State Tuition and Fees in US | Public Two-Year Y Estimate | | Years since 2000 | Public Four-Year In State Tuition and Fees in US | Public Four-Year Y Estimate | |
| 2 | 0 | | 1564 | | 0 | | 4578.333333 | |
| 3 | 1 | | 1706 | | 1 | | 4862 | |
| 4 | 2 | | 1848 | | 2 | | 5145.666667 | |
| 5 | 3 | | 1990 | | 3 | | 5429.333333 | |
| 6 | 4 | | 2132 | | 4 | | 5713 | |
| 7 | 5 | | 2274 | | 5 | | 5996.666667 | |
| 8 | 6 | | 2416 | | 6 | | 6280.333333 | |
| 9 | 7 | | 2558 | | 7 | | 6564 | |
| 10 | 8 | | 2700 | | 8 | | 6847.666667 | |
| 11 | 9 | | 2842 | | 9 | | 7131.333333 | |
| 12 | 10 | 2984 | 2984 | 0.00% | 10 | 7415 | 7415 | |
| 13 | 11 | 3219 | 3126 | -2.89% | 11 | 7947 | 7698.666667 | |
| 14 | 12 | 3358 | 3268 | -2.68% | 12 | 8183 | 7982.333333 | |
| 15 | 13 | 3410 | 3410 | 0.00% | 13 | 8266 | 8266 | |
| 16 | 14 | | 3552 | | 14 | | 8549.666667 | |
| 17 | 15 | | 3694 | | 15 | | 8833.333333 | |
| 18 | 16 | | 3836 | | 16 | | 9117 | |
| 19 | 17 | | 3978 | | 17 | | 9400.666667 | |
| 20 | 18 | | 4120 | | 18 | | 9684.333333 | |
| 21 | 19 | | 4262 | | 19 | | 9968 | |
| 22 | 20 | | 4404 | | 20 | | 10251.66667 | |

Label the top of the column (in cell D1) Percentage Error.

6. Repeat these step to find the percentage error for the second line. The percentage error should be in the cells to the right of the estimate for the second line. In the picture below, the percentage errors are boxed in blue.

|   | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Years since 2000 | Public Two-Year In State Tuition and Fees in US | Public Two-Year Y Estimate | Percentage Error | Years since 2000 | Public Four-Year In State Tuition and Fees in US | Public Four-Year Y Estimate | Percentage Error |
| 2 | 0 | | 1564 | | 0 | | 4578.333333 | |
| 3 | 1 | | 1706 | | 1 | | 4862 | |
| 4 | 2 | | 1848 | | 2 | | 5145.666667 | |
| 5 | 3 | | 1990 | | 3 | | 5429.333333 | |
| 6 | 4 | | 2132 | | 4 | | 5713 | |
| 7 | 5 | | 2274 | | 5 | | 5996.666667 | |
| 8 | 6 | | 2416 | | 6 | | 6280.333333 | |
| 9 | 7 | | 2558 | | 7 | | 6564 | |
| 10 | 8 | | 2700 | | 8 | | 6847.666667 | |
| 11 | 9 | | 2842 | | 9 | | 7131.333333 | |
| 12 | 10 | 2984 | 2984 | 0.00% | 10 | 7415 | 7415 | 0.00% |
| 13 | 11 | 3219 | 3126 | -2.89% | 11 | 7947 | 7698.666667 | -3.12% |
| 14 | 12 | 3358 | 3268 | -2.68% | 12 | 8183 | 7982.333333 | -2.45% |
| 15 | 13 | 3410 | 3410 | 0.00% | 13 | 8266 | 8266 | 0.00% |
| 16 | 14 | | 3552 | | 14 | | 8549.666667 | |
| 17 | 15 | | 3694 | | 15 | | 8833.333333 | |
| 18 | 16 | | 3836 | | 16 | | 9117 | |
| 19 | 17 | | 3978 | | 17 | | 9400.666667 | |
| 20 | 18 | | 4120 | | 18 | | 9684.333333 | |
| 21 | 19 | | 4262 | | 19 | | 9968 | |
| 22 | 20 | | 4404 | | 20 | | 10251.66667 | |
| 23 | | | | | | | | |

Notice that the lines fall at or below all of the data points. A better fit would likely have some of the line above the data points and some below.