DESMOS FUNCTIONS FOR AP STATISTICS.

EXCERPTED FROM *ADVANCED HIGH SCHOOL STATISTICS, 4TH ED*, available for free at openintro.org/ahss.

Graphing

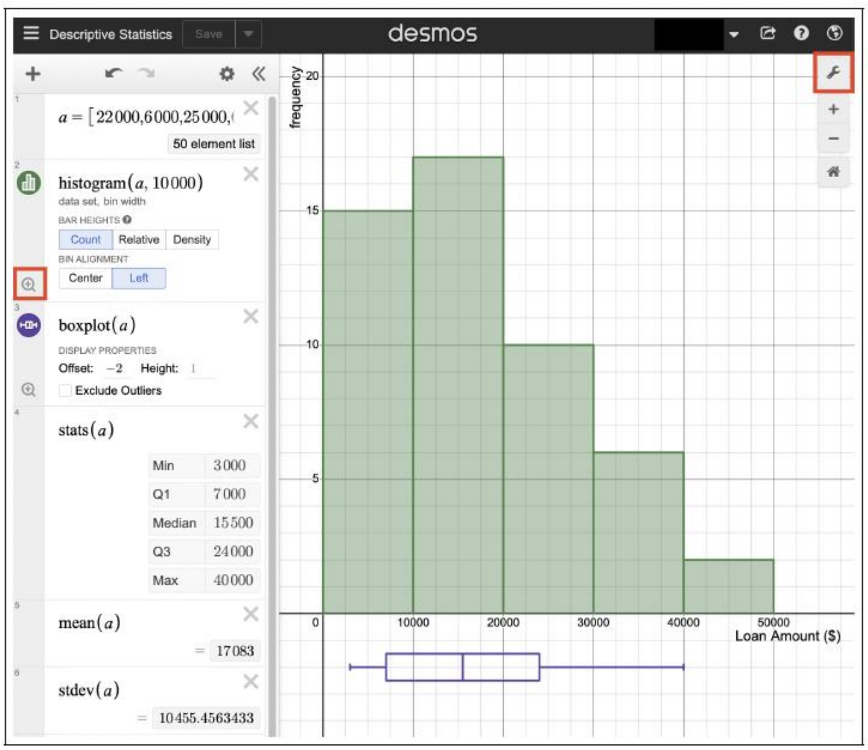
desmos.com/calculator

1.4.8 Technology: summarizing a single variable

Download the `loan50` CSV file from openintro.org/data. Open it and graphically and numerically summarize the `loan_amount` variable.

Desmos: desmos.com/calculator

1. Open the CSV file. Copy the column that corresponds to the `loan_amount` variable.
2. In left panel of Desmos, click in a cell and type: `a =`
   Paste the column that you copied after the = sign and then hit return on your keyboard. You can also manually enter data between the [ ] brackets separated by a comma.
3. Use `histogram(data, bin width)`, replacing `data` and `bin width` with the desired values, as illustrated below. Here, we named our data `a`, but you can name it whatever you like. You can also use `boxplot(data)` and `dotplot(data)`. Click the magnifying glass to Zoom Fit the graphing window and click the wrench icon to add labels to the axes.
4. Use `stats(data)`, `mean(data)`, and `stdev(data)` to numerically summarize the variable as illustrated below.



2.5.7 Technology: binomial probabilities

A spinner has four equally likely options: red, green, blue, yellow. If you spin the spinner 6 times, what is the probability you get:

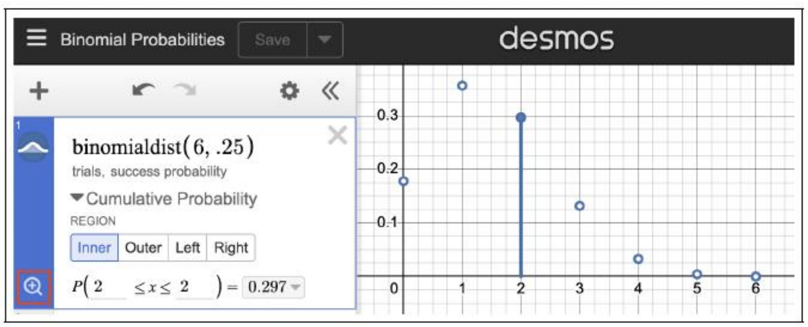
a) Exactly 2 red?
b) Less than 2 red?
c) At least 3 red?

This scenario describes a **binomial distribution** with $n = 6$ and $p = 0.25$.

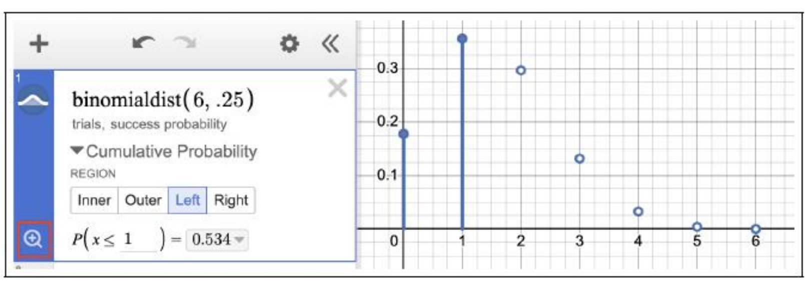
Desmos: Use `binomialdist(n, p)`, replacing `n` and `p` with appropriate values.

1. Type `binomialdist(6, 0.25)`.
2. Click the triangle next to `Cumulative Probability`.
3. Select `Inner`, `Outer`, `Left`, or `Right` as illustrated below.
4. Enter the appropriate boundary value(s) for x as illustrated below.
5. Click the magnifying glass to Zoom Fit the graphing window.

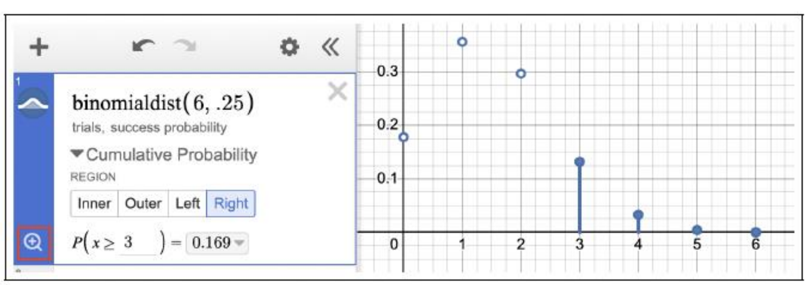
a) P(Exactly 2 red): $P(x = 2)$.



b) P(Less than 2 red): $P(x < 2) = P(x \leq 1)$.



c) P(At least 3 red): $P(x \geq 3)$.



2.6.4 Technology: normal probabilities and boundary values

Given a standard normal distribution ($\mu = 0$, $\sigma = 1$),

(i) find the following probabilities:

(a) Probability of a value between -2 and 2.

(b) Probability of a value less than -1.5.

(ii) find the following boundary values:

(a) The value that corresponds to the 40th percentile.

(b) The value $z^\star$ such that 95% of the distribution lies between $-z^\star$ and $z^\star$.

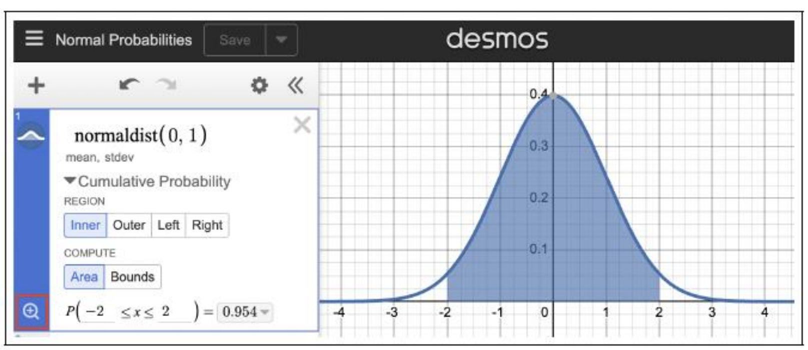
*With the standard normal distribution ($\mu = 0$, $\sigma = 1$), the values of the distribution correspond to Z-scores. If a problem involves a normal distribution with a different mean and standard deviation (e.g. battery life), we can use the mean and standard deviation of that distribution in place of 0 and 1.

Desmos: Use `normaldist(mean, stdev)`, replacing `mean` and `stdev` with appropriate values.

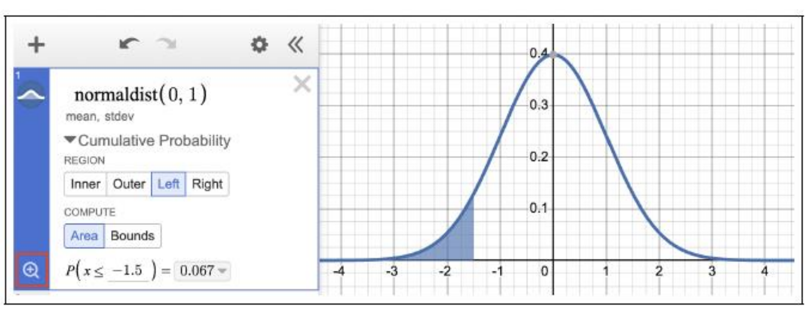
1. Type `normaldist(0,1)`.
2. Click the triangle next to `Cumulative Probability`.
3. Select `Inner`, `Outer`, `Left`, or `Right` as illustrated below.
4. (i) To find a probability, choose `Area` and enter the boundary value(s) for x.
   (ii) To find a boundary value, choose `Bounds` and enter the area as a decimal to the right of the = sign.
5. Click the magnifying glass to Zoom Fit the graphing window.

(i) Finding probabilities/areas.

(a) $P(-2 \leq x \leq 2)$.

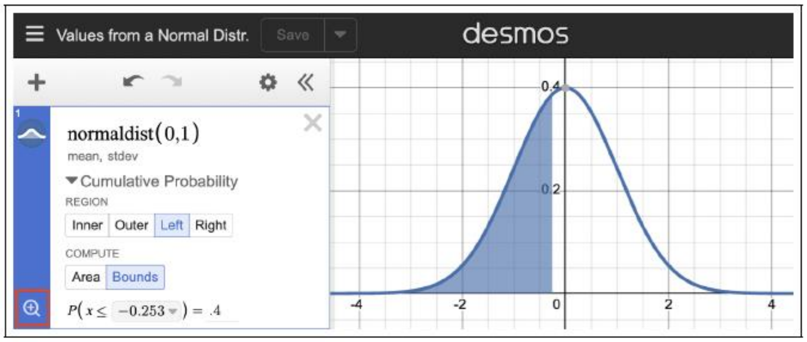


(b) $P(x < -1.5)$. Note: for a continuous distribution $P(x < -1.5) = P(x \leq -1.5)$.

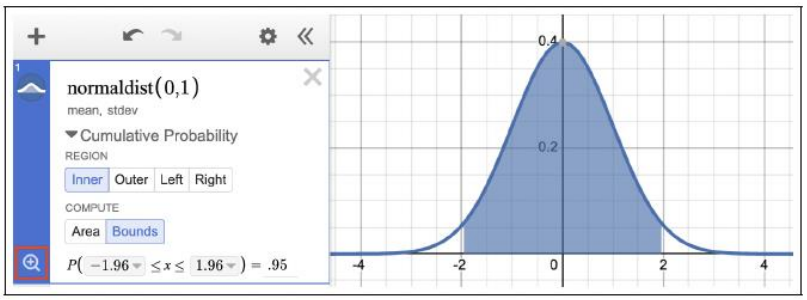


(ii) Finding boundary values.

(a) The value that corresponds to the 40th percentile. P($x \leq ?$) = 0.40.



(b) The value $z^{\star}$ such that 95% of the distribution lies between $-z^{\star}$ and $z^{\star}$. P($-z^{\star} \leq x \leq z^{\star}$) = 0.95.

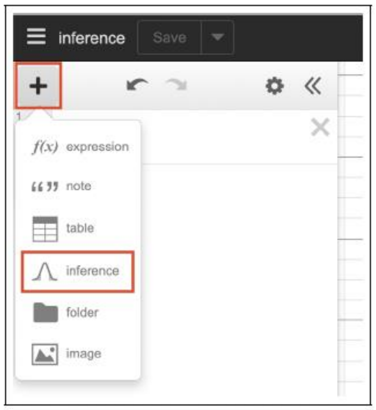


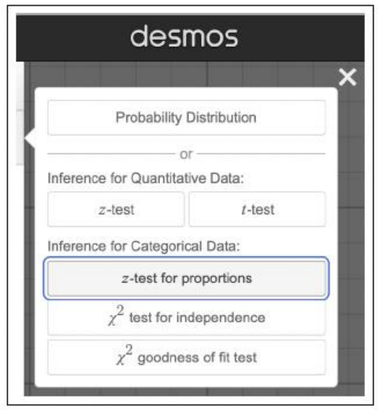
3.4.8 Technology: the one-sample Z-interval and Z-test for p

Evaluate the 95% confidence interval from Example 3.29 to estimate the proportion of US adults who think there is intelligent life on other planets. Also find the test statistic and p-value for a test to see if there is evidence that the true proportion differs from 0.70. The sample percent was 68% and the sample size was 1,033. Conditions were verified to be met.

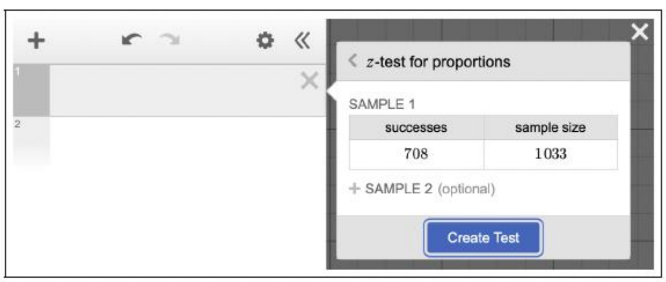
Desmos: Use the `zproptest(x, n)` function as explained below.

1. Click + in the upper left, then choose `inference`.
2. Choose `z-test for proportions` in the pop-up window.



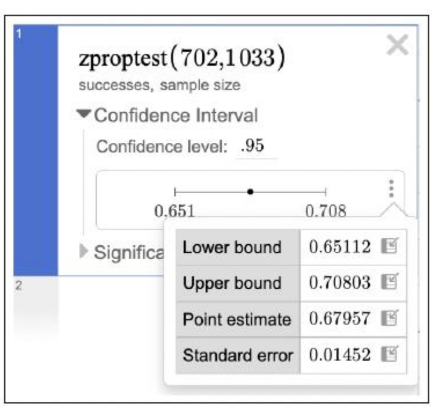


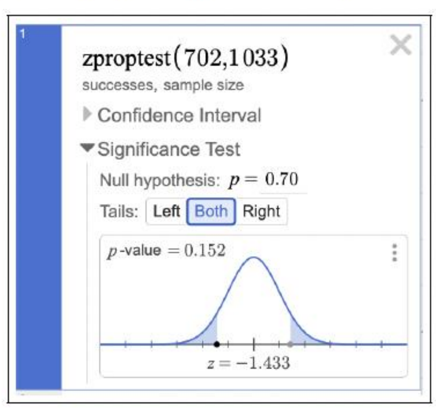
3. Enter `successes` (x) and `sample size` (n). Here, successes = $0.68 * 1,033 = 702.44$, and we need to round this to an integer. So we enter 702 for successes and 1033 for sample size. Click `Create Test`.



* You can type `zproptest(702, 1033)` in place of steps 1-3 above.

4. Click the triangle next to `Confidence Interval` and input the desired `Confidence level`. Here we use 0.95, which is entered by default. Click the ⋮ to the right of the confidence interval to see more information. Hover over the dot in the middle of the confidence interval to see the point estimate.
5. Click the triangle next to `Significance Test`. Enter the hypothesized value for `p` and select `Tails` to be `Left`, `Right` or `Both` depending on the direction of the alternative hypothesis. Here the hypothesized value of p is 0.70 and H_A uses a $\neq$, so we select Tails to be Both.



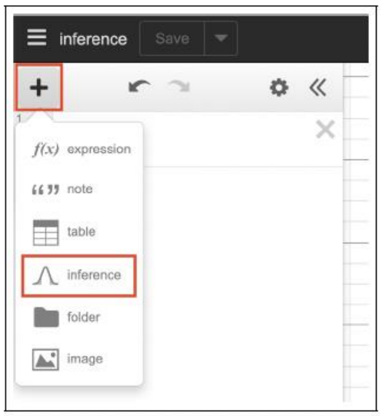


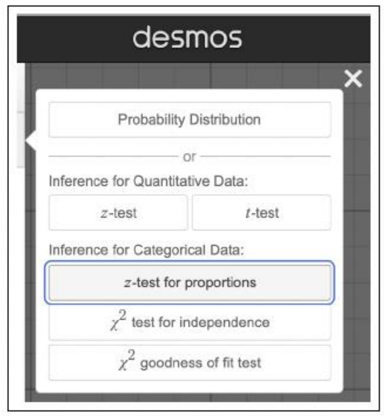
3.7.4 Technology: the two-sample Z-interval and Z-test for $p_1 - p_2$

Figure 3.16, summarizes an experiment involving patients admitted to a hospital for a heart attack. 14 out of the 40 patients assigned to the treatment (blood thinner) group survived versus 11 out of 50 assigned to the control group. Calculate a 95% confidence interval for a difference in the proportion (treatment – control) that would survive. Also calculate the test statistic and p-value to test whether there is evidence that the true proportions *differ*. Conditions have been verified.

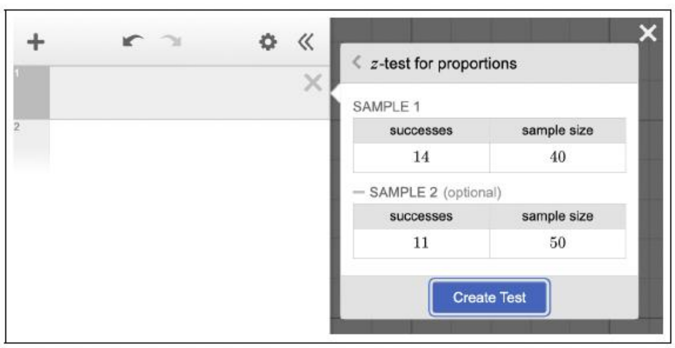
Desmos: Use the `zproptest(x1, n1, x2, n2)` function as explained below.

1. Click + in the upper left, then choose `inference`.
2. Choose `z-test for proportions` in the pop-up window.



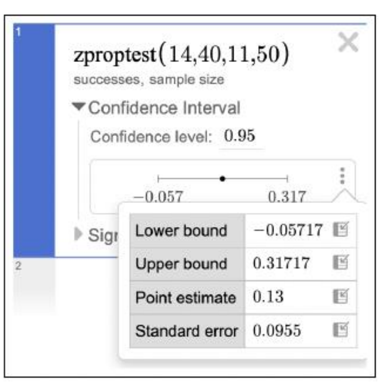


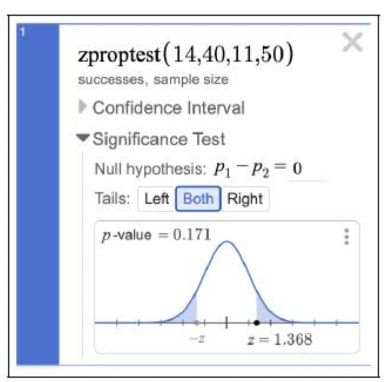
3. Under `SAMPLE 1`, enter `successes` (x_1) and `sample size` (n_1) for group 1. Click `SAMPLE 2`, enter `successes` (x_2) and `sample size` (n_2) for group 2. Click `Create Test`.



* You can type `zproptest(14, 40, 11, 50)` in place of steps 1-3 above.

4. Click the triangle next to `Confidence Interval` and input the desired `Confidence level`. Click the ⋮ to the right of the confidence interval to see additional information. Hover over the dot in the middle of the confidence interval to see the point estimate.
5. Click the triangle next to `Significance Test`. Enter the hypothesized value for the difference. Usually this will be 0. Select a value for `Tails` based on the direction of H_A.



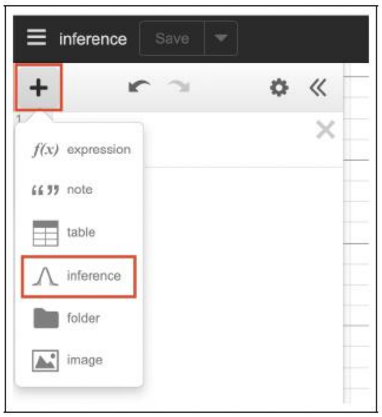


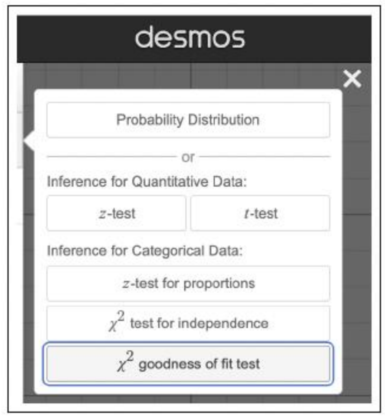
3.8.5 Technology: the chi-square goodness of fit test

A spinner has four colors that are supposed to be equally likely: red, green, blue, yellow. Someone records the number of each color after many spins in a game. After 200 spins, there are 59 red, 44 green, 54 blue and 41 yellow. Use technology to find the test statistic, df, and p-value for a chi-square goodness of fit test, testing whether there is evidence that the colors do not have the same likelihood of coming up. Also find the expected values and chi-square contributions for the test. Assume conditions for the test are met.

Desmos: Use the `chisqtest()` function as explained below.

1. Click + in the upper left, then choose `inference`.
2. Choose χ^2 `goodness of fit test` in the pop-up window.

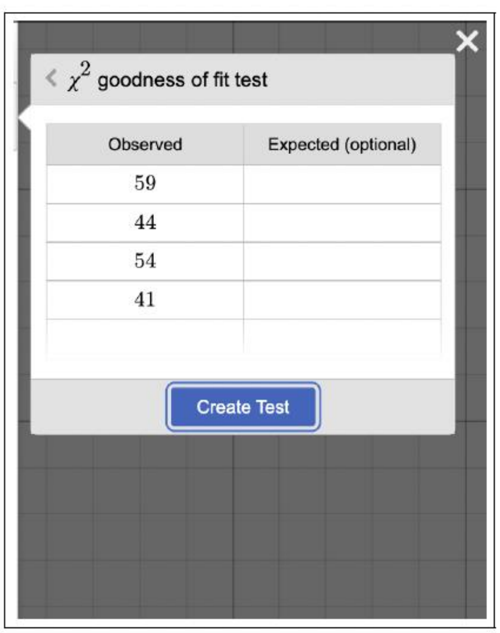


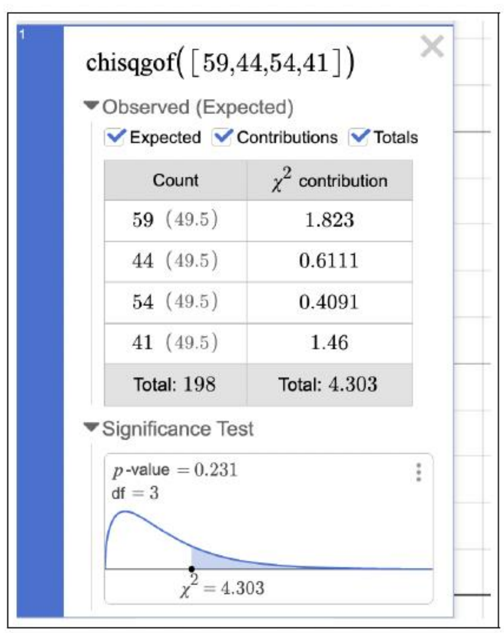


3. Enter the observed counts in the `Observed` column. If the null hypothesis is that the categories are equally likely, you can leave the `Expected` column blank. Otherwise, enter the expected values based on H_0. Click `Create Test`.

* You can type `chisqgof([59, 44, 54, 41])` in place of steps 1-3 above.

4. Click the triangle next to `Observed (Expected)`, then click the checkbox next to `Expected` to see the expected counts. Click the checkbox next to `Contributions` to see each value's contribution to the chi-square statistic. Click the checkbox next to `Totals` to see the column totals.
5. Click the triangle next to `Significance Test` to see the test statistic, df, and p-value.



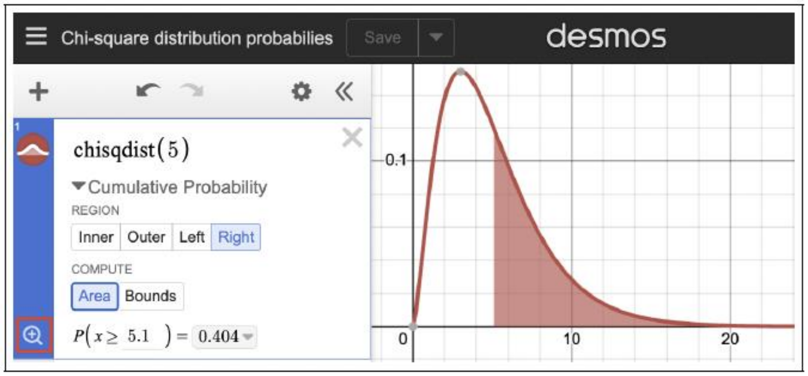


3.9.7 Technology: chi-square distribution probabilities

Use technology to find the upper tail area for a chi-square distribution with 5 degrees of freedom and a cutoff of 5.1.

Desmos: Use the `chsqdist(df)` function, replacing `df` with the degrees of freedom.

1. Type `chisqdist(5)`.
2. Click the triangle next to `Cumulative Probability`.
3. Choose `Inner`, `Outer`, `Left` or `Right` as illustrated below. Usually you will want Right.
4. Choose `Area` and enter the desired boundary value(s) as illustrated below.
5. Click the magnifying glass to Zoom Fit the graphing window.



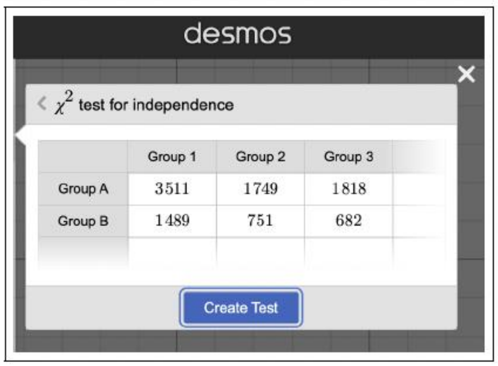
3.9.8 Technology: the chi-square test for two-way tables

Consider the data from the search algorithm experiment introduced in Example 3.9.1. Use technology to find the test statistic, df, and p-value for a chi-square test for homogeneity, testing whether there is evidence that the algorithms do not perform equally well. Also find the expected values and chi-square contributions for this test. Conditions were verified to be met.

		Search algorithm			
		current	test 1	test 2	Total
outcome	success	3511	1749	1818	7078
	failure	1489	751	682	2922
	Total	5000	2500	2500	10000

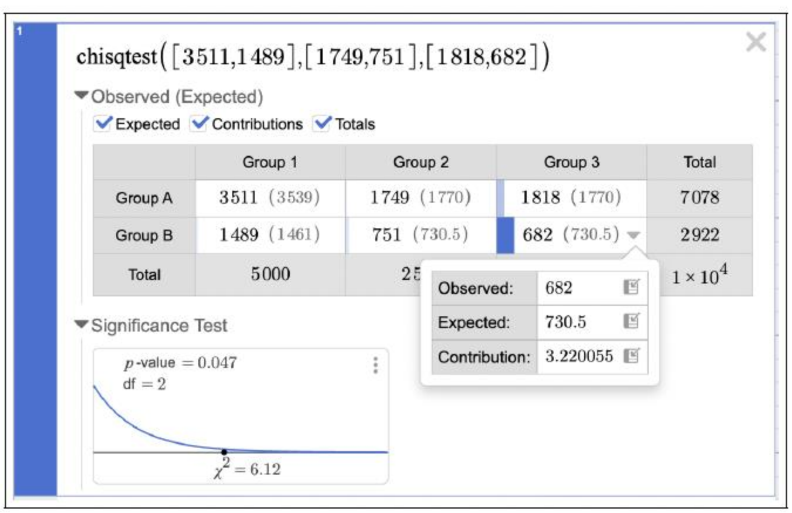
Desmos: Use the `chisqtest()` function as explained below.

1. Click + in the upper left, then choose `inference`.
2. Choose χ^2 `test for independence` in the pop-up window. The calculations for the chi-square test for homogeneity and independence are the same and both use this test.
3. Enter the observed counts in the table. Use the down arrow and right arrow to enter additional row and column values. Do not enter the row and column totals. Click `Create Test`.



* You can type `chisqtest([3511,1489], [1749,751], [1818,682])` in place of steps 1-3.

4. Click the triangle next to `Observed (Expected)`. Click the checkbox next to `Expected` to see the expected counts in parentheses in each cell. Click the checkbox next to `Contributions` to see a graphical representation of the size of each value's contribution to the chi-square statistic. Click the checkbox next to `Totals` to see the row and column totals. Also, click any cell in the table to produce a pop-up box with the corresponding Observed value, Expected value, and the Contribution to the chi-square statistic.
5. Click the triangle next to `Significance Test` to see the test statistic, df, and p-value.



4.2.3 Technology: t-distribution probabilities and boundary values

Given a t-distribution with 3 degrees of freedom:

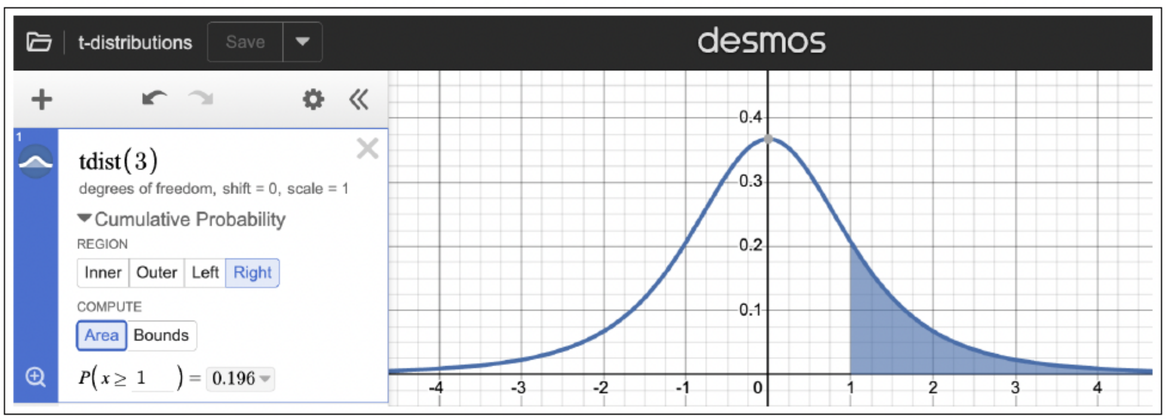
(i) Find the area to the right of $t = 1$.

(ii) Find the boundary value t^* such that 95% of the area is between $-t^*$ and t^*.

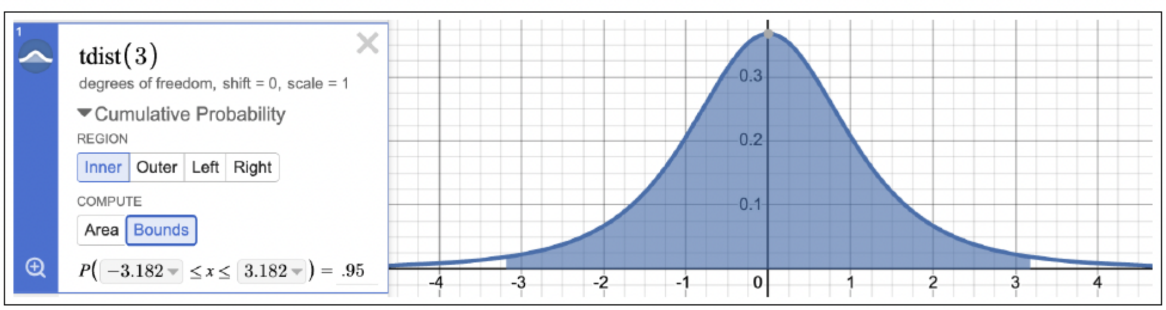
Desmos: Use the `tdist(df)` function, replacing `df` with the degrees of freedom.

1. Type `tdist(3)`.
2. Click the triangle next to `Cumulative Probability`.
3. Choose `Inner`, `Outer`, `Left` or `Right` as illustrated below.
   (i) To find a probability/area, choose `Area` and enter the boundary value(s).
   (ii) To find a boundary value, choose `Bounds` and enter the desired proportion to the right of the = sign.
4. Click the magnifying glass to Zoom Fit the graphing window.

(i) Finding probabilities/areas.



(ii) Finding boundary value(s).

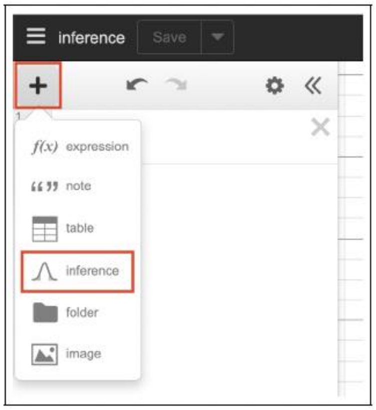


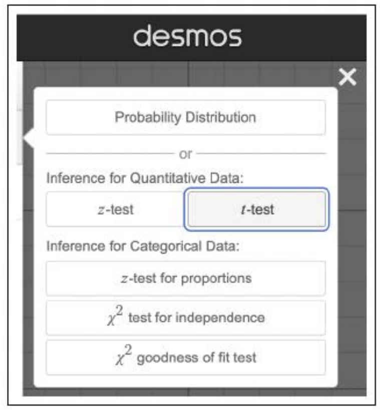
4.3.4 Technology: the one-sample t-interval and t-test for μ

The data set `loan50`, introduced in Chapter 1, contains information on randomly sampled loans. Download the `loan50` CSV file from openintro.org/data. Open it and calculate a 95% confidence interval for the true mean of `loan_amount`. Also find the test statistic, df, and p-value for a test with the alternative hypothesis that the true mean is less than \$20,000.

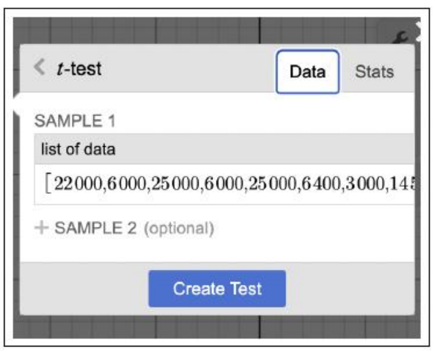
Desmos: Use the `ttest([data])` or `ttest(n, mean, stdev)` function as explained below.

1. Click + in the upper left, then choose `inference`.
2. Choose `t-test` in the pop-up window.

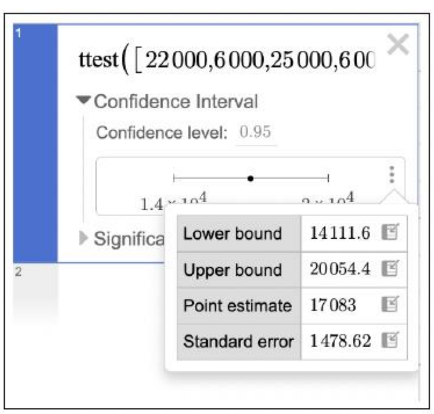


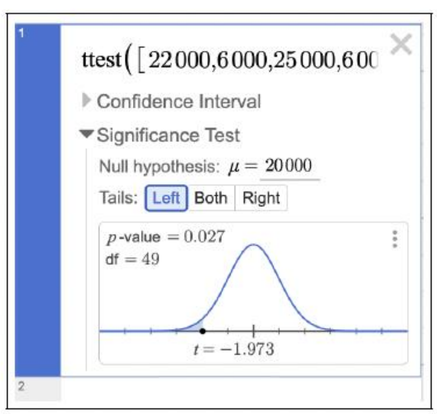


3. If you have all the data, enter the data separated by commas or copy and paste it in the box. Here we highlight the `loan_amount` column and paste it in the box. If you have the summary stats, click on `Stats` and then enter the `sample size`, `mean` and `stdev`. Click `Create Test`.



4. Click the triangle next to `Confidence Interval` and input the desired `Confidence level`. Here we use 0.95, which is entered by default. Click the ⋮ to the right of the confidence interval to more information.
5. Click the triangle next to `Significance Test`. Enter the hypothesized value for `mu` and select `Tails` to be `Left`, `Right` or `Both` depending on the direction of the alternative hypothesis. Here the hypothesized value of μ is 20,000 and H_A uses a <, so we select Tails to be Left.





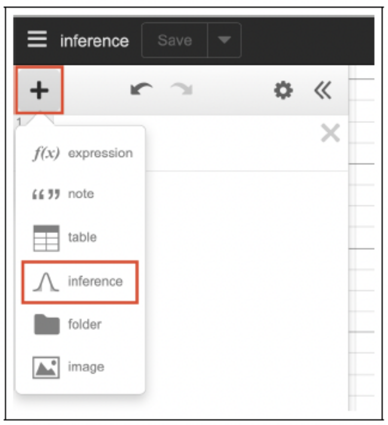
4.6.4 Technology: the two-sample t-interval and t-test for $\mu_1 - \mu_2$

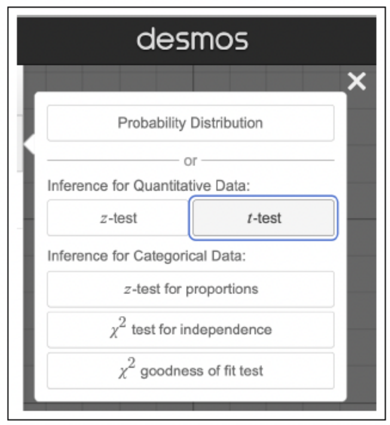
Use technology to find a 95% confidence interval for a difference in true average scores between Version A and Version B of the exam, as described in Example 4.5.4. Also find the test statistic and p-value for a two-sided test to evaluate whether there is evidence that the true means differ. Conditions were verified to be met.

Version	n	$\bar{x}$	s	min	max
A	30	79.4	14	45	100
B	30	74.1	20	32	100

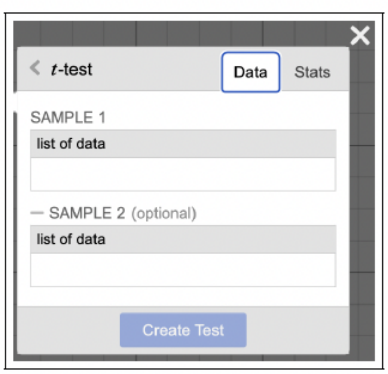
Desmos: Use the `ttest([data],[data])` or `ttest(n1, mean1, stdev1, n2, mean1, stdev2)` function as explained below.

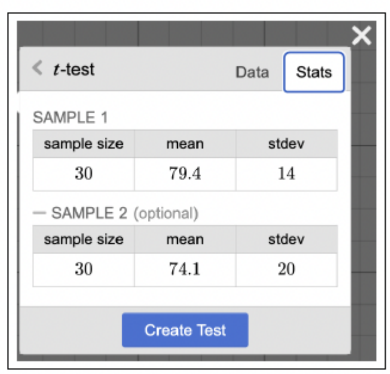
1. Click + in the upper left, then choose `inference`.
2. Choose `t-test` in the pop-up window.





3. If you have all the data: under `SAMPLE 1` enter the first data set separated by commas or copy and paste it in the box, then click on `SAMPLE 2` and enter the second data set separated by commas or copy and paste it in the box.
   If you have the summary statistics: click on `Stats` and under `SAMPLE 1`, enter the first group's `sample size`, `mean` and `stdev`, then click on `SAMPLE 2` and enter the second group's `sample size`, `mean` and `stdev`. Then click `Create Test`. Here we have summary statistics, so we click `Stats`, enter the relevant values from the table above, then click Create Test.

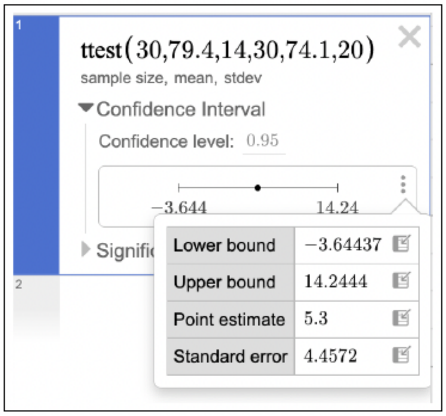


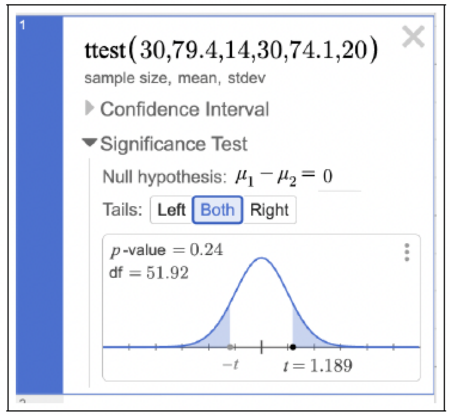


* You can type `ttest(30, 79.4, 14, 30, 74.1, 20)` in place of steps 1-3 above.

4. Click the triangle next to `Confidence Interval` and input the desired `Confidence level`. Here we use 0.95, which is entered by default. Click on ⋮ to the right of the confidence interval to see additional information. You can also hover over the dot in the middle of the confidence interval to see the point estimate. Find df by clicking Significance Test.

5. Click the triangle next to `Significance Test`. Enter the hypothesized difference for the null hypothesis. Select `Tails` to be `Left`, `Right` or `Both` depending on the direction of the alternative hypothesis. Here the hypothesized difference 0 and H_A uses a $\neq$, so we select Tails to be Both.





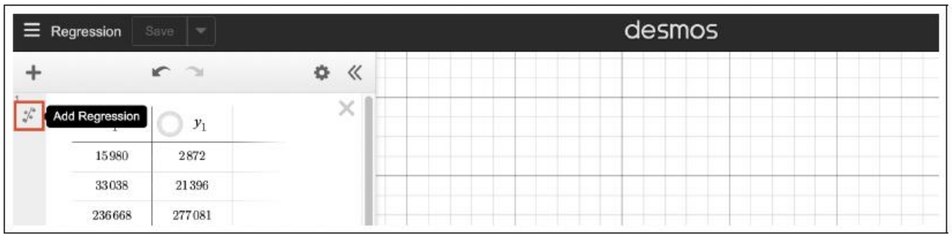
5.3.5 Technology: Scatterplots and regression analysis

The data set `loan50`, introduced in Chapter 1, contains information on randomly sampled loans. Download the `loan50` CSV file from openintro.org/data. Open it and perform linear regression analysis for predicting `total_credit_utilized` from `total_credit_limit`.

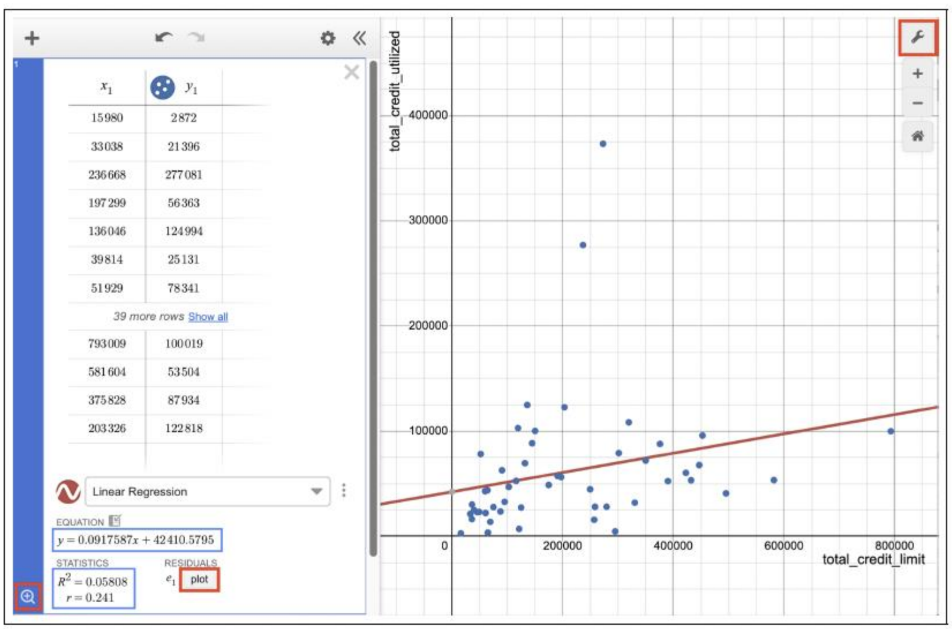
Desmos:

1. ENTER DATA: Open the CSV file. Copy the two columns that correspond to x and y (the x variable should be on the left). Here we copy the columns `total_credit_limit` and `total_credit_utilized`. In a Desmos cell, paste what you copied. You will see the data presented in a table.

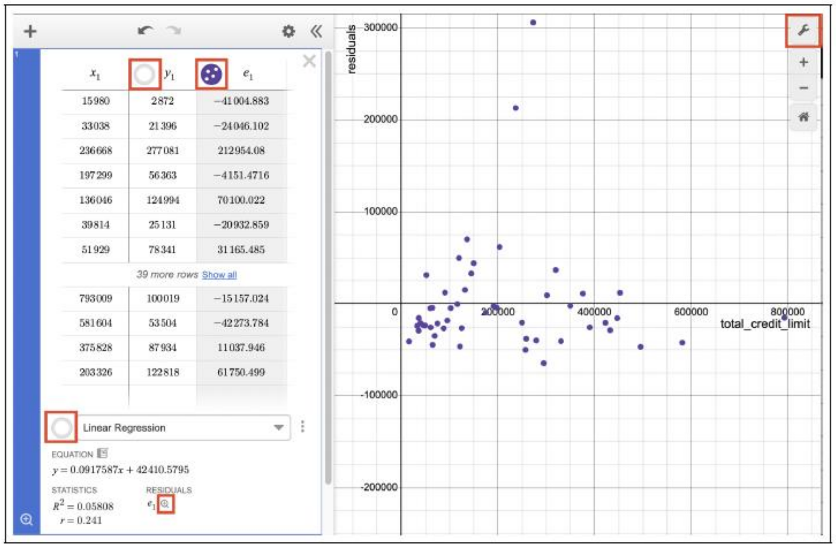
* For small data sets, click + in the upper left, choose `table` and enter x and y values.



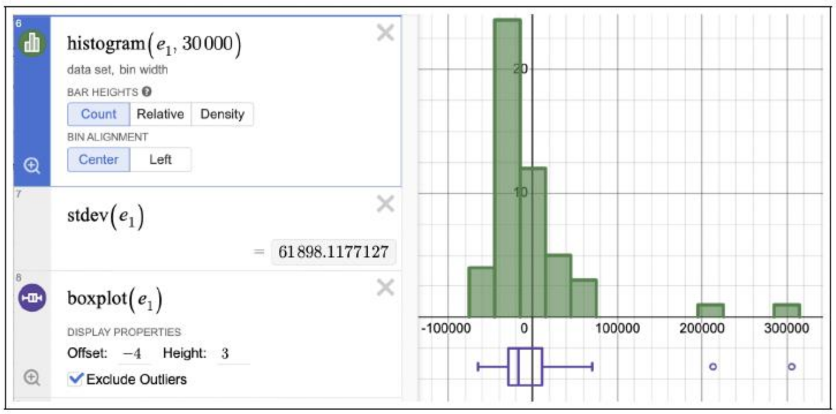
2. SCATTER PLOT and REGRESSION OUTPUT: Click the Add Regression icon shown above. This will return the least squares regression line in the $y = mx + b$ format, R^2, and r as shown below. Click the magnifying glass in the lower left to Zoom Fit the graphing window. Click the wrench icon in the upper right to specify the min, max, and step for the X-Axis and Y-Axis and to add labels to the axes.



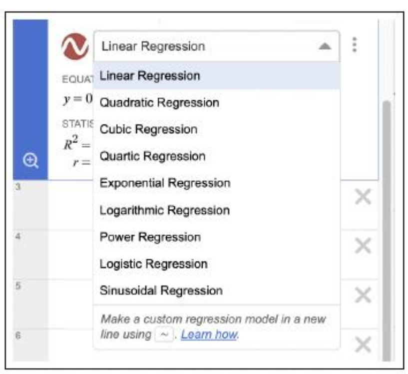
3. RESIDUALS and RESIDUAL PLOT: Click $\boxed{\text{plot}}$ below the word RESIDUALS. This will add the residuals to the table and plot them against the x-variable. To make a residual plot, click the circle next to y in the table to deselect it and click the circle next to "Linear Regression" to deselect it. Then click the magnifying glass to recenter. Adjust the Y-axis label to be "residuals".



4. SUMMARIZE RESIDUALS: Summarize the residuals, here e_1, as we did in Chapter 1.



5. NONLINEAR REGRESSION: Make sure the circle next to `Linear Regression` is selected. Click on Linear Regression to choose other models. Note that the residuals will update in the table and on the graph based on the model you select.



6. MANUALLY CREATE regression model: To see the linear regression model in the form $y = a + bx$, you can type y1 ~ a + bx1. The ~ is in the upper left of keyboard. Adjust the number after y and x to match the subscript on your data table. You can also use this method to manually generate models of your choosing.