Abe Mirza **Topics Review** **Statistics**

Part IV

Hypothesis Testing

7 – Step Process

1. **Starting Claim, Opposite Claim**
2. **Standard Set –up,** H_0, H_1
3. **Establishing Guideline**
4. **Collecting Sample (Test Statistics)**
5. **Drawing Conclusion**
6. **Comment**
7. **P-value**

Learning Objectives

What do we hypothesize? **Population Parameter** such as **Mean** ($\mu = ?$) or **Proportion** ($P = ?$)
Why do we hypothesize? To investigate any claim about **Population Parameter**
Is **average** weight of cereal boxes 24 oz? Do **average** life of Die hard batteries exceed 60 months?
Is less than **10%** of drivers text while driving? Will more than **45%** of people vote in the next election?

7-Step Process

From topics review you **must** read **step 1** and then look at the page one of **work sheet** to see how **step 1** is done and then go to page 2 of **work sheet** do step 1 and check your answer on the third page. Do this for every step of hypothesis testing.
The **first 3 steps** are setting the problem in the right format.

Step 1: Finding what the starting claim is. Is that about the average or proportopn(%);
Write the starting claim as **SC** and try to oppose it as **OC** in statistical notation

Step 2: Rewriting **SC** and **OC** as H_0 and H_1
H_0 (**must** have one of the $=$ or $\leq$ or $\geq$ sign) and H_1 (**must** have one of the $\neq$ or $<$ or $>$ sign).
Draw the appropriate graph as **Left tail**, **two tails** or **right tail**.

Step 3: Finding critical value or values by using the **t- table**,. Critical value depends on **three factors**
a) significance level (α)
b) being one-tailed or two-tailed.
c) sample size (Hint: if $n > 30$ use the bottom of the table otherwise use the top.)

Step 4: (called **Test Statistics**) is using the evidence from our sample and converting that to **Z or t score** that can be done by **formula or Ti**

Step 5: (called conclusion) is about **step 2** to see if to accept or reject H_0 .

Step 6: (called comment) is about **step 1** to see if to accept or reject **SC (Starting Claim)**.

Step 7: (**p-value**) to read the **p-value** from **TI** screen on step 4 and to find out if it is smaller or larger that significance level (α).

After finishing all steps in quick start you work on practice problems.
For Multinomial topics you need to use table page for Chi-Square

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4 Quizzes for Part 4

Quiz 12: This quiz covers **pages 3 through 9**

Quiz 13: This quiz covers **pages 3 through 11**

Quiz 14: This quiz covers **pages 3 through 16**

Quiz 15: This quiz covers **pages 3 through 18**

General Outline

7-Steps of hypothesis testing

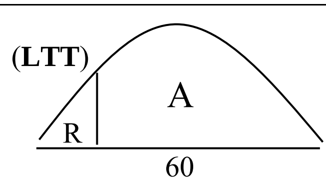
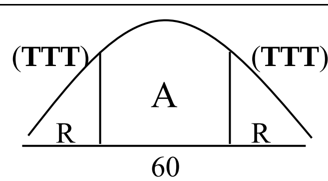
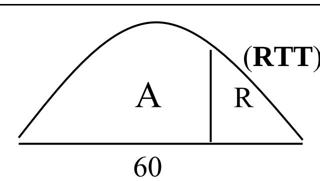
1) From the problem write (**SC: S**tarting **C**laim) and then write its (**OC: O**pposite **C**laim) in statistical notation.

		SC	**OC**
Examples:	**Average** life of "Diehard" batteries exceeds **60** months	$\mu > \mathbf{60}$	$\mu \leq \mathbf{60}$
	Average time to do a certain task is less than **25** minutes	$\mu < \mathbf{25}$	$\mu \geq \mathbf{25}$
	Average net weight of a certain cereal is **24** oz.	$\mu = \mathbf{24}$	$\mu \neq \mathbf{24}$
	Less than **13%** of drivers text while driving.	**P** $<$ **0.10**	**P** $\geq$ **0.13**
	At least **55%** of college students have Facebook account.	**P** $\geq$**0.55**	**P** $<$ **0 .55**
	At most **21%** of tablets in the market are made by Samsung .	**P** $\leq$**0.21**	**P** $>$ **0 .21**
	Average life of Diehard(μ_1) batteries is longer that Everlast(μ_2)	$\mu_1 > \mu_2$	$\mu_1 \leq \mu_2$

2) The next step is rewriting SC, and OC in a new set up called **H_0** (Null Hypothesis), and **H_1** (Alternative Hypothesis):
As how to change **SC,** and **OC** to **H_0**, and **H_1**, you need to follow the next rule remembering that **H_0** (Null Hypothesis) **must** contain some form of equality, and **H_1** (Alternative Hypothesis) **must** contain **no** form of equality. The mathematical setup is explained right below,

H_0 (Null Hypothesis): (contains equal sign) $=$ or $\geq$ or $\leq$
H_1 (Alternative Hypothesis): (contains not equal sign) $\neq$ or $<$ or $>$

There are **three-possibilities** for setting up the hypothesis (a left-tailed test, two-tailed, right-tailed).
Hint: if **H_1**: $\mu <$ it is a left-tailed test
if **H_1**: $\mu \neq$ it is a two-tailed test
if **H_1**: $\mu >$ it is a right-tailed test
Label the region, as **A** (Accepting H_0), or **R** (Rejecting H_0) Rejections or acceptances labels are based on **H_0**.

three -possibilities	**H_0**: $\mu \geq 60$ **H_1**: $\mu < 60$	**H_0** : $\mu = 60$ **H_1** : $\mu \neq 60$	**H_0** : $\mu \leq 60$ **H_1** : $\mu > 60$
left-tailed (**LTT**) two-tailed, (**TTT**) right-tailed (**RTT**)			

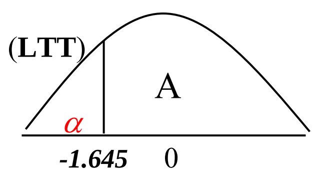
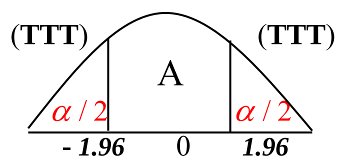
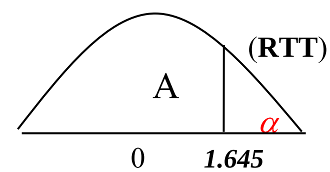
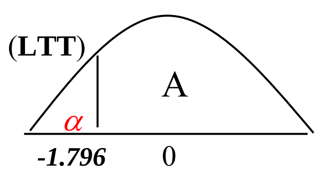
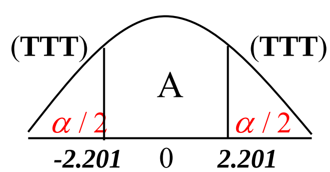
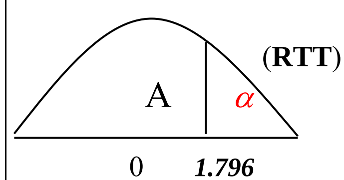
3) What is **Critical value(s)** and how to find it?
Critical value(s) is limit(s) or boundary(ies) that if it is exceeded (by our sample data) then **H_0** will be **rejected.**

How to find it? By looking up **t- table**, when we know the followings;

a) Significance level = α (Alpha Level) = Critical Region = Critical area = **type I** error
In other words the determining the probability of rejectioing $\mathbf{H_0}$, when $\mathbf{H_0}$ is true.
It is like finding some one to be quilty when he is innocent.
So not that to let that happen we choose **significance level** or **α value** to be small between 1% to 10%.
Hint: If significance level = α is not given assume α =.05 = 5%
Critical Region is also the area designated by Significance level and is shown by α or **R**
Also remember if our sample size is 30 or less, then on **table p.4** use **df** = degree of freedom = $n-1$

b) **One-tailed or two-tailed**, and

For sample sizes $n > 30$ then use **last row** of **table p.4** to find the critical value(s)..

Given α =.05 and $n > 30$			
For sample sizes $n \le 30$ then use **t- table**, to find critical value(s). Be sure you find df= degree of freedom = $n-1$			
Given α =.05 and $n \le 30$ Need to find degree of freedom first!	α =.05 $n = 12$ $df = 11$ 	α =.05 $n = 12$ $df = 11$ 	α =.05 $n = 12$ $df = 11$ 

4. Compute **Test Statistics** (based on sample information) from the following formulas.

a. $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s}$ To test the Mean (μ) for large sample sizes

TI-83/84 *stat* ⟶ *test* ⟶ *Option 1*

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b. $t = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s}$ To test the Mean (μ) for $n \le 30$ and, when σ is unknown

TI-83/84 *stat* ⟶ *test* ⟶ *Option 2*

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c. $Z = \dfrac{\hat{p}-p}{\sqrt{\dfrac{p(1-p)}{n}}}$ To test population proportion (**P**)

TI-83/84 *stat* ⟶ *test* ⟶ *Option 5*

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d. $Z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$ Two independent population μ_1, μ_2

TI-83/84 *stat* $\to$ *test* $\to$ *Option 3*

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e. $t = \frac{\sqrt{n}(\bar{d} - \mu_d)}{s_d}$ For **P**aired **S**amples

TI-83/84 Input d values in L_1 $\to$ *stat* $\to$ *test* $\to$ *Option 2* $\to$ *data* $\to$

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f. $\chi^2 = \sum \frac{(O-E)^2}{E}$ **O**bserved, **E**xpected, for **M**ultinomial or **I**ndependency Test

TI-83/84 Input **O**bserved values into L1 and **E**xpected Values into L2 and then go to the top of L3 to write $(L_1 - L_2)^2 / L_2$ $\to$ *stat* $\to$ *Calc* $\to$ *Option 1* $\to$ L_3 *(the answer is* $\sum x$)

`**5) Conclusion**: The decision is made by comparing **Test Statistics** with **Critical value**, and find where the test statistics falls (inside the **CR**: **C**ritical **R**egion or not);
If **Test Statistics** falls inside the **CR**: **C**ritical **R**egion the decision is to **Reject** H_0 or saying that there is sufficient evidence to Reject H_0. If it falls outside the **CR**: **C**ritical **R**egion the decision is to **Fail to Reject** H_0 or **Accept** H_0 that there is not sufficient evidence to Reject H_0. **When the result of a hypothesis test are determined to be significant then we reject the null hypotheses.**

6) Comment: Decision as to accept or reject **SC(** the stated claim)? **Two possibilities:**

1) If **SC** and H_0 are the same then any decision you make for H_0 will be the same for **SC** and you write that as your comment.

2) If **SC** and H_0 are different then whatever decision you make for H_0, you should make the opposite decision of that for **SC** and you write that as your comment.

7) P-value: It is the **area corresponding to the test statistics** and is always shown on the display of **TI-8 3/84** **as** $P =$ (when you compute the test statistics). Basically it is the minimum α - value that is needed to reject the Null hypothesis H_0. **As a rule** you **reject** reject the Null hypothesis **when P-value** is smaller than α **- value**

Type I and Tpe II errors

Remember that we do not know for certain that if H_0 is true or false but after the test is set up, data collected, then we either Accept H_0: or Reject H_0:

The table below summarizes all possible scenarios that might happen when testing procedure is completed.

	H_0: True	H_0: False
Accept H_0:	Correct Decision	Type **II** error or called **Beta**(β)
Reject H_0:	Type *I* error or called **Alpha**(α)	Correct Decision = **Power** of a test $1-\beta$

Large Samples about Mean

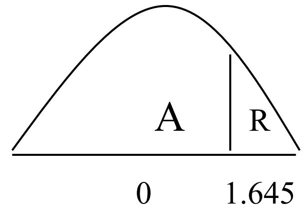
Case 1. **Average** life of "Die Long" batteries **exceeds** 60 months. A sample of 64 batteries had an average life of 63 months and st. dev. of 10 months. Let **α = .05**

SC: $\mu > 60$ **H₀** : $\mu \le 60$

OC: $\mu \le 60$ **H₁** : $\mu > 60$

Hint: Use **H₁** to determine if it is LTT ,TTT or RTT test

Note: μ **in H₁ is more than,** then it is a **RTT**

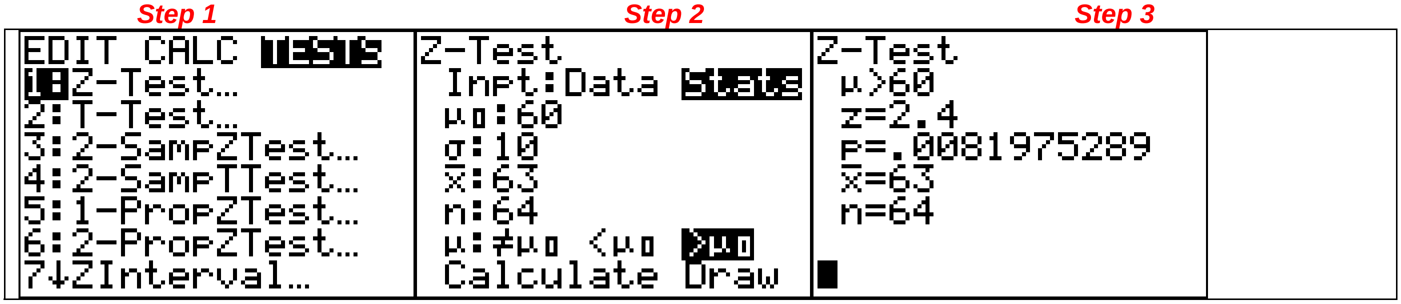


When **α = .05 ,** n > 30 and one –tailed test then by using bottom row of **t- table.**

Critical value = CV= Z = 1.645

Test Statistics = $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{64}(63-60)}{10} = 2.4$ ***Falls inside CR*** **TI-83/84** *stat* → *test* → *Option 1*

Step 1 **Step 2** **Step 3**



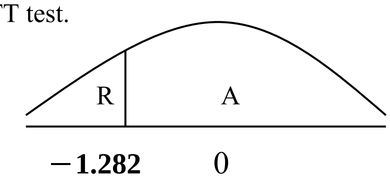
Conclusion: Accept or reject **H₀**? Inside ***CR*** then reject **Ho**
Comment: Accept or reject **SC**? **Accept** that the **average** life of batteries **exceeds 60** months.
P-value: 0 .008 less than **α = .05** reject **Ho**

Case 2. **Average** life of "Die Long" batteries is **less than** 60 months. A sample of 64 batteries had an average life of 58 months and st. dev. of 10 months. Let **α =0 .10**

SC: $\mu < 60$ **H₀**: $\mu \ge 60$ **Hint**: Use **H₁** to determine if it is LTT ,TTT or RTT test.

OC: $\mu \ge 60$ **H₁**: $\mu < 60$ **Note:** μ **in H₁ is less than,** then it is a **LTT**

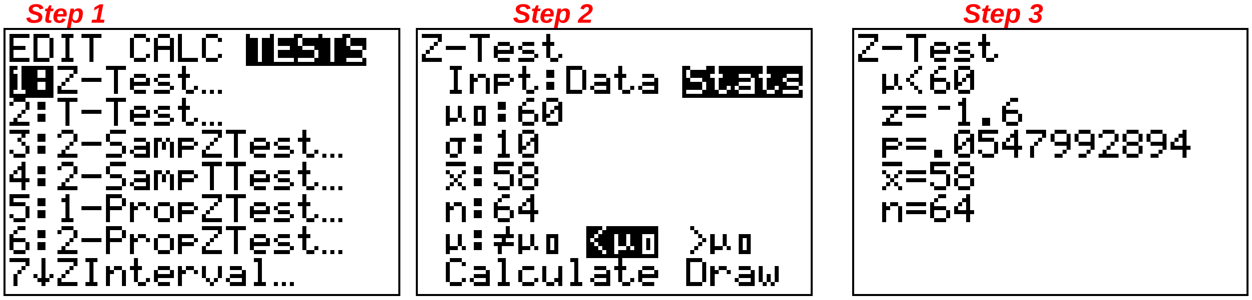
When **α = .10 ,** n > 30 and one –tailed test then by using bottom row of **t- table.**



Critical value = CV=Z = − 1.282

Test Statistics = $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{64}(58-60)}{10} = -1.6$ ***Falls inside CR*** **TI-83/84** *stat* → *tes* → *Option 1*

Step 1 **Step 2** **Step 3**



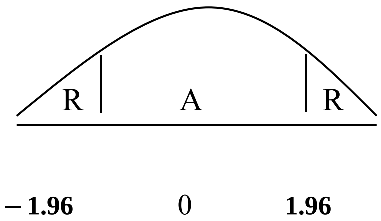
Conclusion: Accept or reject **H₀**? Inside ***CR*** then reject **Ho**
Comment: Accept or reject **SC**? **Accept** that the **average** life of batteries is **less than 60** months
P-value: 0 .0548 less than **α = 0.10** reject **Ho**

Case 3. **Average** life of "Die Long" batteries **is different** than 60 months. A sample of 64 batteries had an average life of 62 months and st. dev. of 10 months. Let α **= .05**

SC: $\mu \neq 60$ **H_0** : $\mu = 60$ **Hint**: Use **H_1** to determine if it is LTT ,TTT or RTT test.

OC: $\mu = 60$ **H_1** : $\mu \neq 60$ **Note:** μ **in H_1 is not equal,** then it is a **TTT**

When α **= .05** , n > 30 and two –tailed test then by using bottom row of page **t- table.**

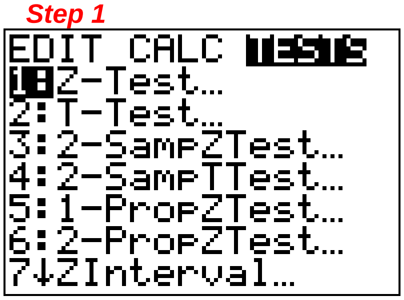


Critical value = CV= **Z =** $\pm$**1.960**

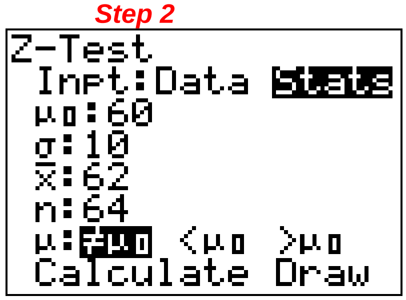
Test Statistics = $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{64}(62-60)}{10} = 1.6$ ***Falls not inside CR***

TI-83/84 *stat* $\longrightarrow$ *tes* $\longrightarrow$ *Option 1*

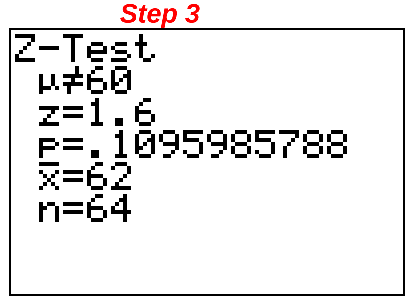
Step 1



Step 2



Step 3



Conclusion: Accept or reject **H_0**? Not inside CR then **Fail to Reject H_0** or **Accept H_0**

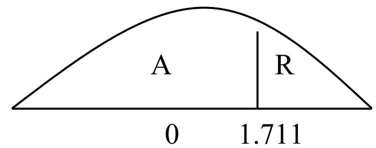
Comment: Accept or reject **SC**? **Reject** that the **average** life of batteries **is different than 60** months

P-value: 0 .1096 more than α **= 0.05** accept **Ho**

Small Samples about Mean

Case 4. **Average** life of "Die Long" batteries **exceeds** 60 months. A sample of 25 batteries had an average life of 63 months and st. dev. of 10 months. Let **α = .05**

SC:	$\mu > 60$	$\mathbf{H_0}: \mu \le 60$	**Hint**: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test
OC:	$\mu \le 60$	$\mathbf{H_1}: \mu > 60$	**Note:** μ **in H_1 is more than,** then it is a **RTT**

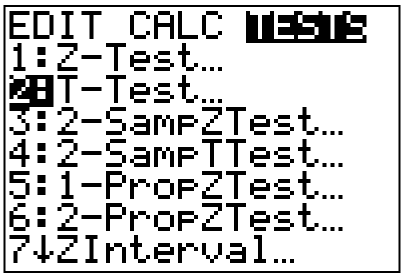


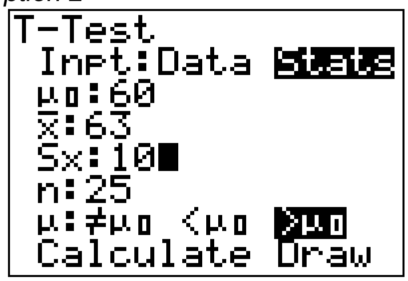
When α = **.05** , n < 30 and one –tailed test then by using **24th** row of page **t- table.**

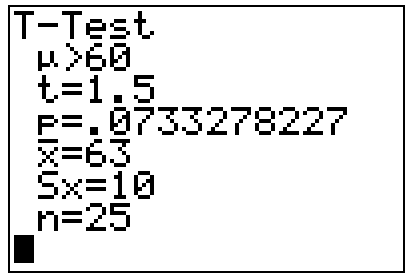
Critical value = CV= **t = 1.711**

Test Statistics = $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{25}(63-60)}{10} = 1.5$ ***Falls not inside CR***

TI-83/84 *stat* ⟶ *test* ⟶ *Option 2*







Conclusion: Accept or reject $\mathbf{H_0}$? Not inside CR then **Fail to Reject H_0** or **Accept H_0**

Comment: Accept or reject **SC**? **Reject** that the **average** life of "Die Easy" batteries **exceeds 60** months

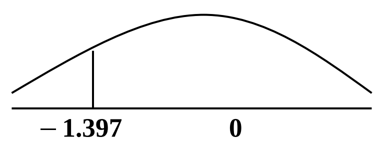
P-value: 0 .0733 more than α = **0.05** accept **Ho**

Case 5. **Average** life of "Die Long" batteries is **less than** 60 months. A sample of 9 batteries had an average life of 54 months and st. dev. of 10 months. Let **α = .10**

SC:	$\mu < 60$	$\mathbf{H_0}: \mu \ge 60$	**Hint**: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test
OC:	$\mu \ge 60$	$\mathbf{H_1}: \mu < 60$	**Note:** μ **in H_1 is less than,** then it is a **LTT**

When α = **.10** , n < 30 and one –tailed test then by using **8th** row of page **t- table.**

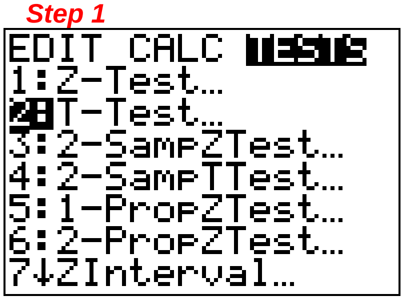
Critical value = CV= **t = −1.397**



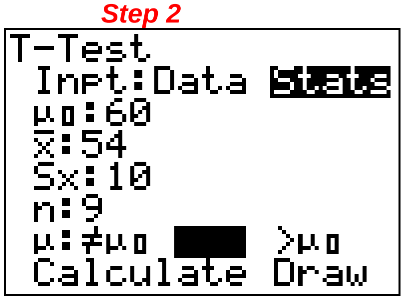
Test Statistics = $z = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{9}(54-60)}{10} = -1.8$ ***Falls inside CR***

TI-83/84 *stat* ⟶ *test* ⟶ *Option 2*

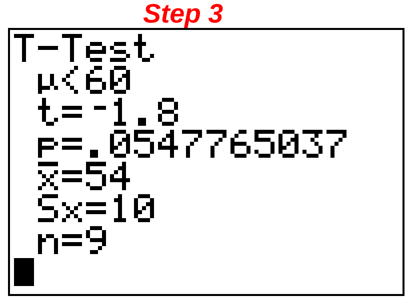
Step 1



Step 2



Step 3



Conclusion: Accept or reject $\mathbf{H_0}$? Inside ***CR*** then reject **Ho**

Comment: Accept or reject **SC**? **Accept** that the **average** life of "Die Easy" batteries is **less than 60** months

P-value: 0 .05478 less than α = **0.10** reject **Ho**

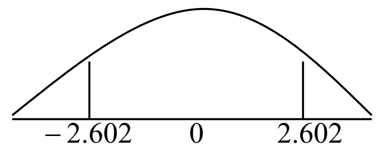
Case 6. **Average** life of "Die Long" batteries **is different** than 60 months. A sample of **16** batteries had an average life of 66 months and st. dev. of 10 months. Let **α = .02**

SC: $\mu \neq 60$ **H$_0$** : $\mu = 60$ **Hint**: Use **H$_1$** to determine if it is LTT ,TTT or RTT test

OC: $\mu = 60$ **H$_1$** : $\mu \neq 60$ **Note:** μ **in H$_1$ is not equal,** then it is a **TTT**

When **α = .02** , n < 30 and two –tailed test then by using **15th** row of page **t- table.**

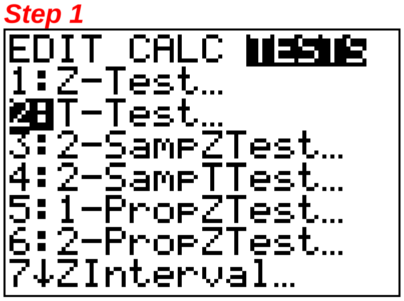
Critical value $= C\,V = \mathbf{t} = \pm 2.602$



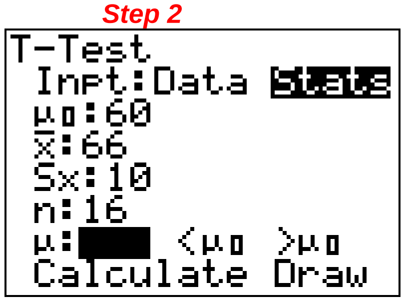
Test Statistics = $t = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{16}(66-60)}{10} = 2.4$ ***Falls not inside CR***

TI-83/84 *stat* ⟶ *test* ⟶ *Option 2*

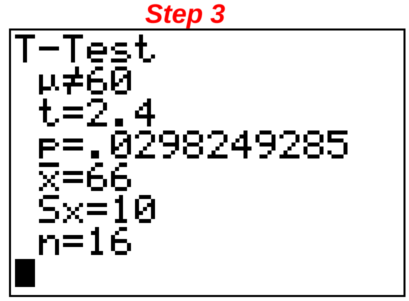
Step 1



Step 2



Step 3



Conclusion: Accept or reject **H$_0$**? Not inside CR then **Fail to Reject H$_0$** or **Accept H$_0$**
Comment: Accept or reject **SC**? **Reject** that the **average** life of "Die Easy" batteries **is different than 60** months.

P-value: **0 .0298** more than **α = 0.02** accept **Ho**

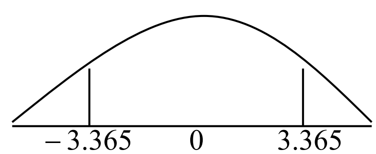
Case 7) Leno Co. claims that the mean life of their batteries is 60 months. Test this claim with $\alpha = 0.02$ if a sample of 6 batteries has a life of 62, 58, 59, 64, 63, 61, months.

SC: $\mu = 60$ **H$_0$** : $\mu = 60$ **Hint**: Use **H$_1$** to determine if it is LTT ,TTT or RTT test

OC: $\mu \neq 60$ **H$_1$** : $\mu \neq 60$ **Note:** μ **in H$_1$ is not equal,** then it is a **TTT**

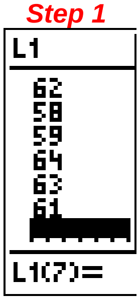
When **α = .02** , n < 30 and two –tailed test then by using **5th** row of page 4 of **t- table.**

Critical value $= C\,V = \mathbf{t} = \pm 3.365$

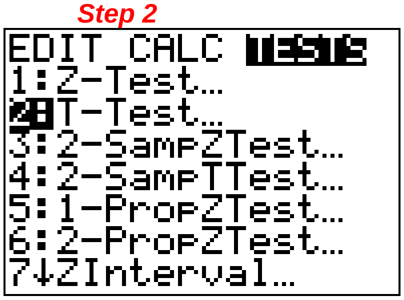


Test Statistics = $t = \dfrac{\sqrt{n}(\bar{x}-\mu)}{s} = \dfrac{\sqrt{6}(61.17-60)}{2.317} = 1.23$ ***Falls not inside CR***

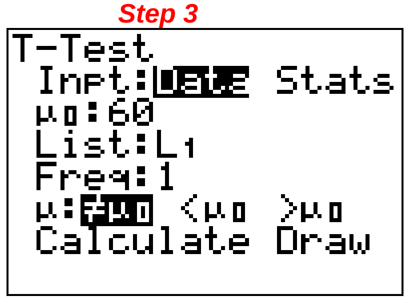
Step 1



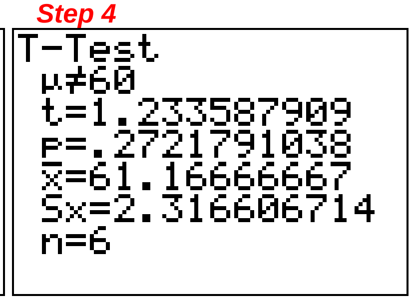
Step 2



Step 3



Step 4



Conclusion: Accept or reject **H$_0$**? Not inside CR then **Fail to Reject H$_0$** or **Accept H$_0$**

Comment: Accept or reject **SC**? **Fail to Reject** or **Accept** that the **average** life of "Die Easy" batteries **exceeds 60** months

P-value: **0 .0272** more than **α = 0.02** accept **Ho**

Proportion

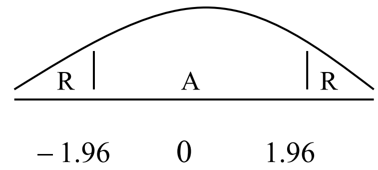
Case 8. At α **= .05** test that **85%** of stat students pass the course. Out of 200 students only 156 students passed the course.

SC: **P** = .85 — **H₀** : **P** = .85

OC: **P** $\neq$ .85 — **H₁** : **P** $\neq$ .85

Hint: Use **H₁** to determine if it is LTT ,TTT or RTT test

Note: P **in H₁ is not equal,** then it is a **TTT**



When α **= .05** , n > 30 and two –tailed test then by using bottom row of page **t- table.**

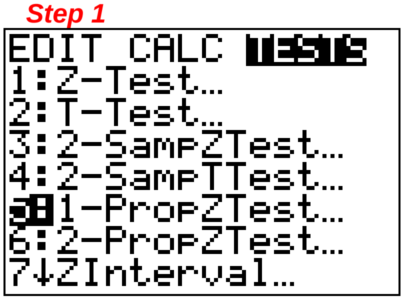
Critical value = CV = **Z =** $\pm$ **1.96**

Sample proportion = $\hat{p} = \dfrac{156}{200} = .78$

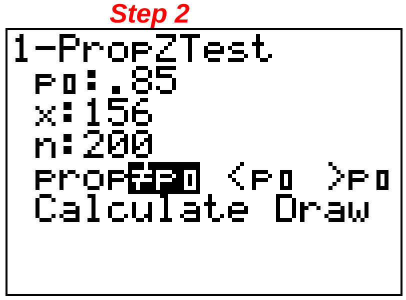
Test Statistics $= z = \dfrac{\hat{p}-p}{\sqrt{\dfrac{p(1-p)}{n}}} = z = \dfrac{.78-.85}{\sqrt{\dfrac{.85(1-.85)}{200}}} = \dfrac{-.07}{0.02525} = -2.77$ ***Falls inside CR***

TI-83/84 *stat* $\longrightarrow$ *test* $\longrightarrow$ *Option 5*

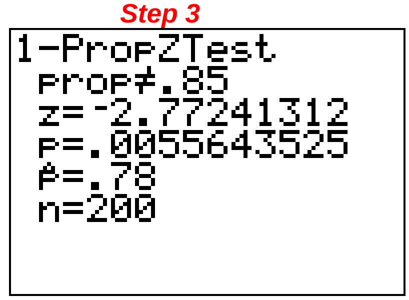
Step 1



Step 2



Step 3



Conclusion: Accept or reject **H₀**? Inside ***CR*** then reject **Ho**

Comment: Accept or reject **SC**? Reject that **85%** of stat students pass the course.

P-value: 0 .005564 less than α **= 0.05** reject **Ho**

Case 9. At α **= .10** test that **more than 85%** of stat students pass the course. Out of 200 students only 172 students passed the course.

SC: **P** > 0.85 — **H₀** : **P** $\leq$ 0.85

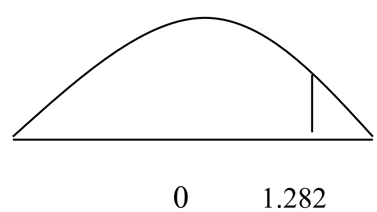
OC: **P** $\leq$ 0.85 — **H₁** : **P** > 0.85

Hint: Use **H₁** to determine if it is LTT ,TTT or RTT test

Note: P **in H₁ is more than,** then it is a **RTT**

When α **= .10** , n > 30 and one –tailed test then by using bottom row of page **t- table.**

Critical value = CV = **Z = 1.282**

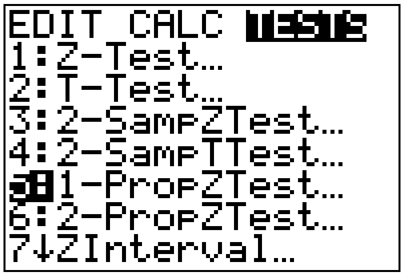


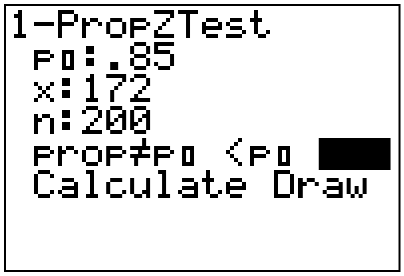
Sample proportion = $\hat{p} = \dfrac{172}{200} = .86$

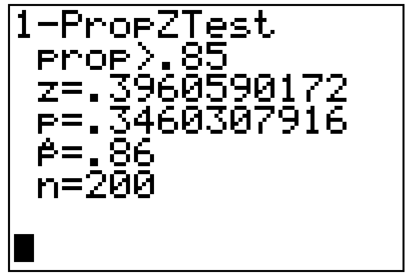
Test Statistics $= z = \dfrac{\hat{p}-p}{\sqrt{\dfrac{p(1-p)}{n}}} = z = \dfrac{.86-.85}{\sqrt{\dfrac{.85(1-.85)}{200}}} = \dfrac{0.01}{0.02525} = 0.3960$ ***Falls not inside CR***

TI-83/84 *stat* $\longrightarrow$ *test* $\longrightarrow$ *Option 5*

Step 1 **Step 2** **Step 3**







Conclusion: Accept or reject H_0? Not inside CR then **Fail to Reject H_0** or **Accept H_0**

Comment: Accept or reject **SC**? Reject that **more than 85%** of stat students pass the course.

P-value: 0 .3960 more than α = **0.10** accept **Ho**

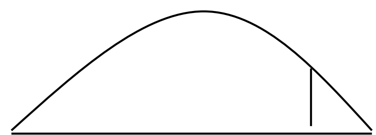
Case 10. Prior to election day, an opinion poll among registered voters indicate that 433 voters will vote for incumbent President and 367 will not., Can it be claimed at $\alpha = 0.01$ that incumbent President will win the majoraity of the votes(getting above 50% of the vote?

SC: **P** > 0.50 **H₀** : **P** ≤ 0.50 **Hint**: Use **H_1** to determine if it is LTT ,TTT or RTT test

OC: **P** ≤ 0.50 **H_1** : **P** > 0.50 **Note:** P **in H_1 is more than,** then it is a **RTT**

When α = **0.01** , n > 30 and one –tailed test then by using bottom row of page **t- table.**

Critical value = CV = **Z = 2.326**



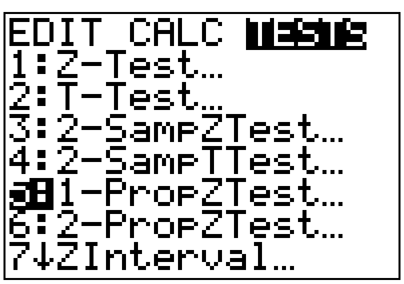
0 2.326

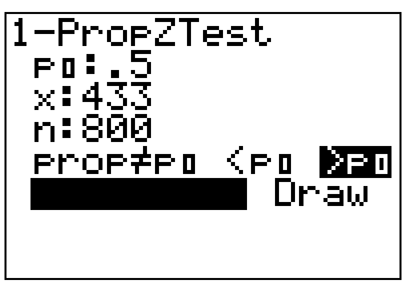
Sample proportion = $\hat{p} = \dfrac{433}{800} = .54125$

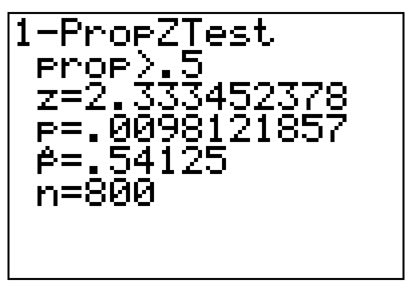
Test Statistics $= z = \dfrac{\hat{p} - p}{\sqrt{\dfrac{p(1-p)}{n}}} = z = \dfrac{.54125 - .50}{\sqrt{\dfrac{.50(1-.50)}{800}}} = 2.33$ ***Very close to CR***

TI-83/84 stat ⟶ test ⟶ Option 5

Step 1 **Step 2** **Step 3**







Conclusion: Accept or reject H_0? **Test Statistics is too close to Critical value,** so decision is **inconclusive**

Comment: Accept or reject **SC**? **Inconclusive** as who the winner will be.

P-value: 0 .098 more than α = **0.001 Inconclusive**.

Difference of Two Independent Population Means

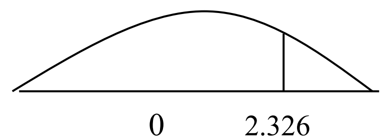
Case 11 : Test at the 1% significance level whether the average life of Diehard batteries is longer than Everlast. brand. Sample from these two type of batteries are as such:

Die Hard	(μ_1)	$n_1 = 44$	$\bar{x}_1 = 51.8$	$s_1 = 8.5$
Everlast	(μ_2)	$n_2 = 36$	$\bar{x}_2 = 47.4$	$s_2 = 10.7$

SC: $\mu_1 > \mu_2$ **H₀** : $\mu_1 \le \mu_2$ **H₀** : $\mu_1 - \mu_2 \le 0$ **Hint**: Use **H₁** to determine if it is LTT ,TTT or RTT test

OC: $\mu_1 \le \mu_2$ **H₁** : $\mu_1 > \mu_2$ **H₁** : $\mu_1 - \mu_2 > 0$ **Note:** $\mu_1 - \mu_2$ **in H₁ is more than,** then it is a **RTT**

When α **= .01** , n > 30 and one –tailed test then by using bottom row of page **t- table.**



Critical value = CV=**Z = 2.326**

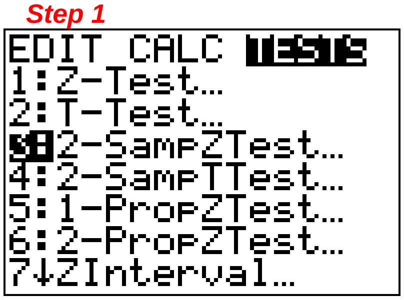
CPoint Estimate $(\bar{x}_1 - \bar{x}_2) = (51.8 - 47.4) = 4.4$

$$z = \frac{(\bar{x}_1 - \bar{x}_2) - 0}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{(51.8 - 47.4) - 0}{\sqrt{\frac{8.5^2}{44} + \frac{10.7^2}{36}}} = \frac{4.4}{\sqrt{1.6420 + 3.1802}} = \frac{4.4}{2.1960} = 2.003$$

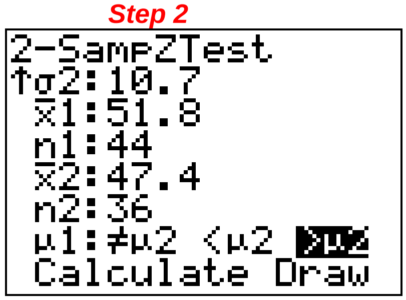
Falls not inside CR

TI-83/84 *stat* $\longrightarrow$ *test* $\longrightarrow$ *Option 3*

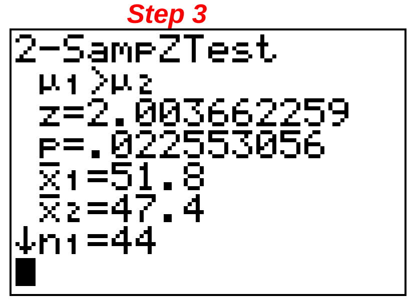
Step 1



Step 2



Step 3



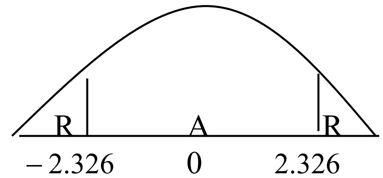
Conclusion: Accept or reject **H₀**? Not inside CR then **Fail to Reject H₀** or **Accept H₀**

Comment: Accept or reject **SC**? Reject that the average life of Diehard batteries is longer than Everlast brand.
P-value: 0 .02256 more than **α = 0.01** accept **Ho**

Case 12 : A researcher wants to test if the mean GPA of all male and female college students who participate in sports are different. She took a random sample of 33 male students and 38 female students who are involved in sports. She found out the mean GPAs of the two groups to be 2.62 and 2.74, respectively, with the corresponding standard deviations equal to .43 and .38. At 2% significance level, test whether the **mean** GPAs of the two populations **are different**.

SC: $\mu_m \neq \mu_f$ $\quad H_0 : \mu_m = \mu_f$ $\quad H_0 : \mu_m - \mu_f = 0$ $\quad$ **Hint**: Use **H1** to determine if it is LTT ,TTT or RTT test

OC: $\mu_m = \mu_f$ $\quad H_1 : \mu_m \neq \mu_f$ $\quad H_1 : \mu_m - \mu_f \neq 0$ $\quad$ **Note:** $\mu_m - \mu_f$ **in H1 is not equal** then it is a **TTT**



When **α = .02** , n > 30 and two –tailed test then by using bottom row of page **t- table.**

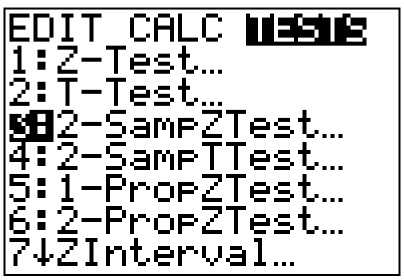
Critical value = CV=**Z** = ± **2.326**

$$z = \frac{(2.62 - 2.74) - 0}{\sqrt{\frac{.43^2}{33} + \frac{.38^2}{38}}} = \frac{-.12}{\sqrt{.0094}} = -1.24$$

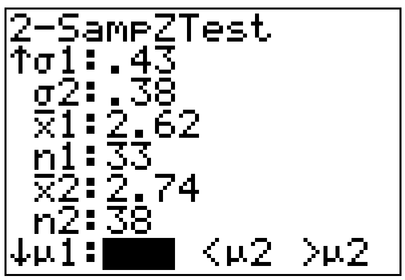
Falls not inside CR

TI-83/84 *stat* → *test* → *Option 3*

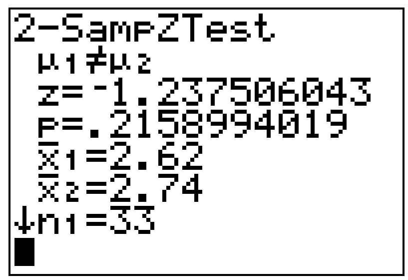
Step 1



Step 2



Step 3



Conclusion: Accept or reject **H0**? Not inside CR then **Fail to Reject H0** or **Accept H0**

Comment: Accept or reject **SC**? Reject that the **mean** GPAs of the two populations **are different**.

P-value: 0 .2159 more than α = **0.02** accept **Ho**

Paired Samples

Objective: To test if a course/program/treatment/medication is effective as it promises?

Examples: Super Course to increase the self confidence
Weight reduction program
Pain relief medications
SAT prep. class
New medication is not effective

The difference for **one person** who participates in the course/program/treatment/medication

d = A-B = Score **A**fter **–** Score **B**efore

μ_d = Average difference for all people who may participate in the course/program/treatment/medication

B = Before		**A = A**fter	**SC**
	Higher results after		
	Super Course to increase the self confidence		$\mu_d > 0$
	SAT prep. Class to increase the scores		$\mu_d > 0$
	New medicine to increase blood flow		$\mu_d > 0$
	New treatment to increase body metabolism		$\mu_d > 0$
	Lower results after		
	Weight reduction program		$\mu_d < 0$
	Pain relief medications		$\mu_d < 0$
	New drug to reduce blood pressure		$\mu_d < 0$
	difference or no difference in results		
	New drug is not effective		$\mu_d = 0$
	New drug is effective		$\mu_d \neq 0$

1) SC : μ_d
OC: μ_d

2) $H_0 : \mu_d$
$H_1 : \mu_d$

3) To find critical value based on df = n -1
Use page 3 of the table

4) Test Statistics = $t = \dfrac{\sqrt{n}(\bar{d} - \mu_d)}{s_d}$

5) Conclusions

6) Comment

Paired Samples

Case 13. A course is intended ***to increase*** the average sales of salespersons, a random sample of six salespersons and their corresponding sales before and after the course is tabulated as such:

Before	12	18	25	9	14	16	
After	18	24	24	14	19	20	
d=A - B	**6**	**6**	**-1**	**5**	**5**	**4**	$\Sigma d = 25$ $\bar{d} = 25/6 = 4.17$ $s_d = 2.64$

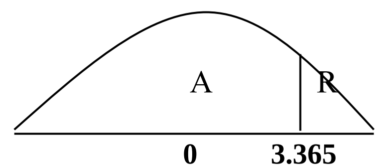
At $\alpha = 1\%$, can you conclude that attending this course increases the sales?

μ_d = Average difference in sales after taking the course.

SC: After the course the sales is higher $\mu_d > 0$ $H_0 : \mu_d \le 0$

OC: After the course the sales is same or lower $\mu_d \le 0$ $H_1 : \mu_d > 0$

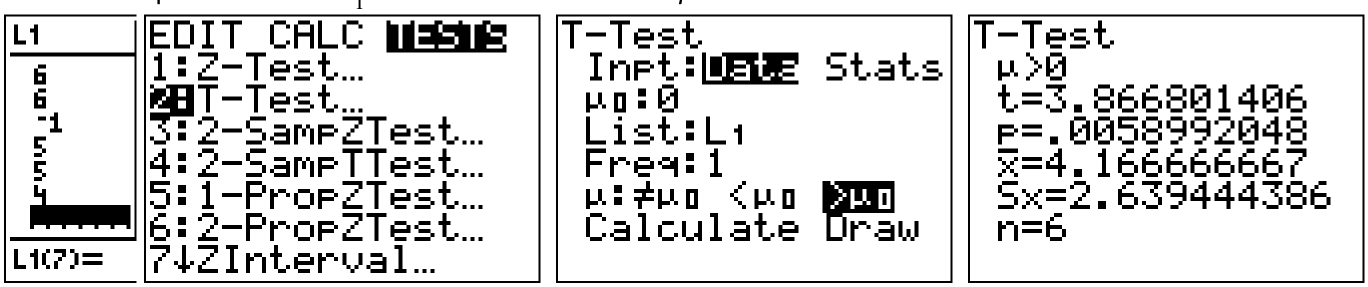
When α = **.01**, n < 30 and one –tailed test then by using **5th** row of page of **t- table.**



Critical value = CV= **t = 3.365**

$$t = \frac{\sqrt{n}(\bar{d} - \mu_d)}{s_d} = \frac{\sqrt{6}(4.17 - 0)}{2.64} = 3.87$$ ***Falls inside CR***

TI-83/84 Input d values in L_1 → *stat* → *test* → *Option 2* → *data*



Conclusion: Accept or reject **H₀**? Inside ***CR*** then reject **Ho**

Comment: Accept or reject **SC**? **Accept** that attending this course increases the sales.

P-value: 0 .005899 less than α **= 0.01** reject **Ho**

Case 14: A new medication claims that it reduces the pain of arthritis. The following table gives the pain reduction measurement score of eight patients before and after the medication is administrated.

Before	97	72	93	110	78	69	115	72	
After	93	75	89	91	65	70	90	64	
d=A - B	**-4**	**3**	**-4**	**-19**	**-13**	**1**	**-25**	**- 8**	$\Sigma d = -69$ $\bar{d} = -69/8 = -8.625$ $s_d = 9.75$

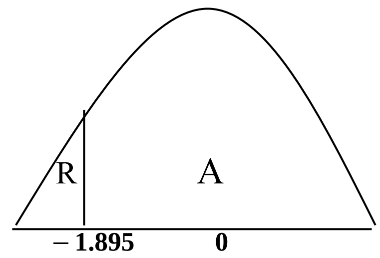
At $\alpha = 5\%$, can you conclude that new medication reduces arthritis pain?

μ_d = Average difference in pain after taking the medication

SC: After the new medication the pain is lower $\mu_d < 0$ $H_0 : \mu_d \ge 0$

OC: After the new medication the pain is same or higher: $\mu_d \ge 0$ $H_1 : \mu_d < 0$

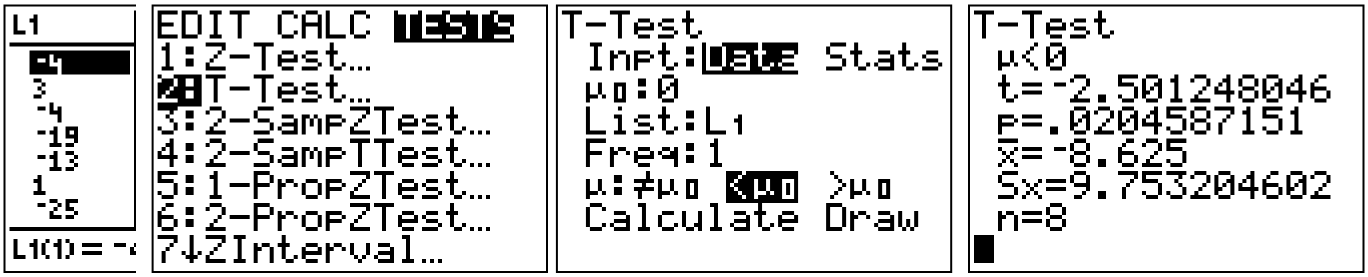
When α = **.05**, n < 30 and one –tailed test then by using **7th** row of page of **t- table.**



Critical value = CV= **t** = – **1.895**

$$t = \frac{\sqrt{n}(\bar{d} - \mu_d)}{s_d} = \frac{\sqrt{8}(-8.625 - 0)}{9.75} = -2.5$$

Falls inside CR



Conclusion: Accept or reject **H0**? Inside ***CR*** then reject **Ho**

Comment: Accept or reject **SC**? Accept that after the new medication reduces of arthritis pain.

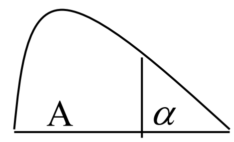
P-value: 0 .020459 less than **α = 0.05** reject **Ho**

Multinomial

Objective: To test if **O**bserved values/percentages meet the **E**xpected values/percentages?
In these hypotheses the SC and **H_0** are the same and both represent the expectations.
To find the critical value we use **Chi-square (χ^2) table.**
it is **always a right tail test starting at zero**.
df = k -1 where k = # of groups.

Example K= 5 **df** = 5-1 = 4 and let's α = .01 then critical value = CV = 13.277 .

The Test statistics formula =**TS** = $\chi^2 = \sum \frac{(O-E)^2}{E}$ =



0 13.277

Hint: There are no **SC** and **OC**. We **start H_0** with by writing what the expected values or percentages are**.**

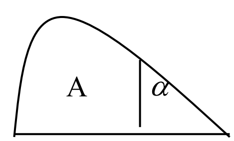
Case 15: Abe Claims that generally in his class grades distribution is as such
A: 20% , **B**: 24% , **C**: 28%, **D**:16% , **F**: 12% " Test Abe's claim at 10% significance level based on latest data recored from his stat classes last from a sample of 75 students.

Grade	**A**	**B**	**C**	**D**	**F**	**Total**
O(Observed)=Students	**16**	**18**	**20**	**14**	**7**	**75**

To find the expected values we **multiply** the given **percentages** by total (75).

Grade	**A**	**B**	**C**	**D**	**F**	**Total**
O(Observed)=Students	**16**	**18**	**20**	**14**	**7**	**75**
E(Expected) =Students	.2(75) **15**	.24(75) **18**	.28(75) **21**	.16(75) **12**	.12(75) **9**	**75**
$(O-E)^2$	$(16-15)^2$ **1**	$(18-18)^2$ **0**	$(20-21)^2$ **1**	$(14-12)^2$ **4**	$(7-9)^2$ **4**	
$(O-E)^2/E$	1/15 + .067 +	0/18 + 0 +	1/21 + .048 +	4/12 + 0.33	4/9 + 0.44 = .885	$\sum (O-E)^2/E$ = **.885**

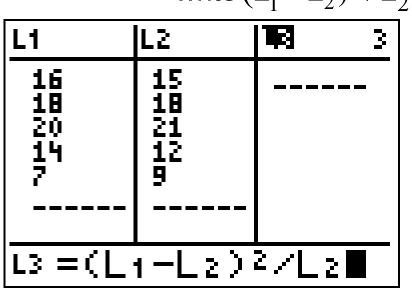
H_0: Stated proportions are correct.
H_1: Stated proportions are **not** correct.

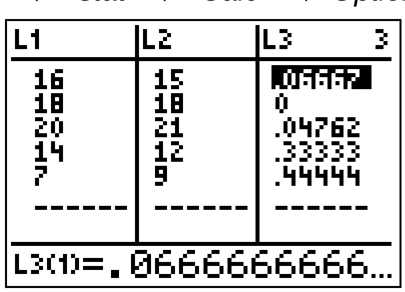


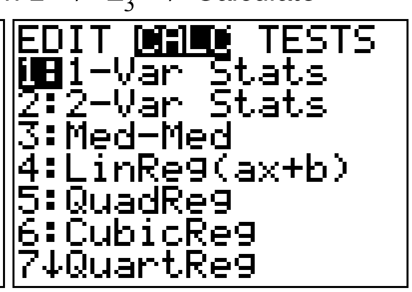
K= 5, **α = .10**
degrees of freedom $df = k-1 = 5-1 = 4$ Critical value = χ^2 = **7.779** 0 *7.779*

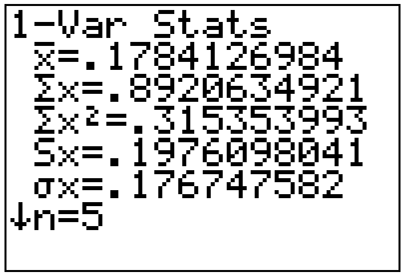
Test Statistic = $\chi^2 = 0.885$ ***Falls not inside CR***

TI-83/84 Input **O**bserved values into L1 and **E**xpected Values into L2 and then use L3 to write $(L_1 - L_2)^2 / L_2$ → *stat* → *Calc* → *Option 1* → L_3 → *Calculate*









Conclusion: Not inside CR then **Fail to Reject H_0** or **Accept H_0**
Comment: **Fail to Reject** or **Accept** stated proportions are correct.

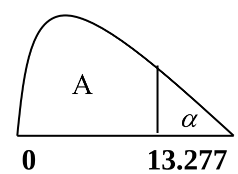
Case 16. At $\alpha = 1\%$, test the hypothesis that **the proportions of grades are the same** for stat. students? The following table lists the grade distribution for a sample of 100 students for stat class,

Grade	A	B	C	D	F	Total
Students (Observed) O	32	25	19	16	8	**100**

Hint: to find the expected values by expecting that the proportions of grades are the same, we ***divide*** total of 100 students by 5(different grades).

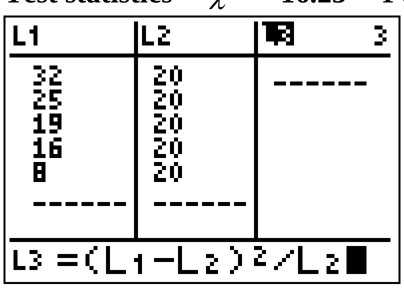
Grade	A	B	C	D	F	Total
Students (Observed) O	32	25	19	16	8	100
Students (Expected) E	20	20	20	20	20	100
$(O-E)^2$	$(32-20)^2$ **144**	$(25-20)^2$ **25**	$(19-20)^2$ **1**	$(16-20)^2$ **16**	$(8-20)^2$ **144**	
$(O-E)^2/E$	144/20 **7.2** +	25/20 **1.25** +	1/20 **.05** +	16/20 **0.8** +	144/20 **7.2 =16.25**	Test statistics $\chi^2 = \sum \frac{(O-E)^2}{E}$ **=16.25**

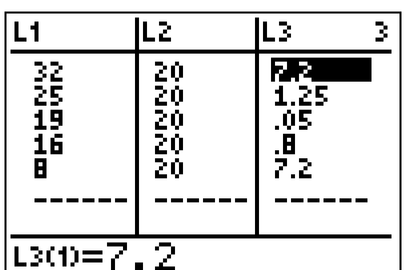
H_0: Equal proportions of grades for stat. students.
H_1: Unequal proportions of grades for stat. students.

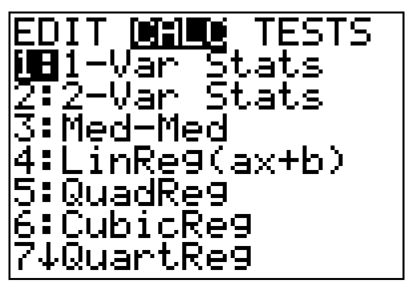


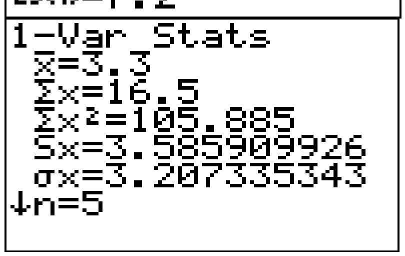
K= 5, degrees of freedom = 5-1 = 4, **α = .01** Critical value = χ^2 = **13.277**

Test statistics = χ^2 = **16.25** ***Falls inside CR***









Conclusion: Reject **H_0**,
Comment: Therefore proportions of grades are **not the same** for all students.

Test of Independence (Contingency Table)

Case 17. In a certain town, there are about one million eligible voters. A simple random sample of 1000 eligible voters was chosen to study the relationship between sex and participation in the last election. The results are summarized in the following 2X2 (read two by two) contingency table:

The **O**bserved values

	Men(**M**)	Women(**W**)	***Total***
Voted	280	360	***640***
Didn't vote	150	210	***360***
	430	***570***	***1000***

We want to check whether being a man or a woman (columns) is independent of having voted in the last election (rows). In other words is "sex and voting independent"?

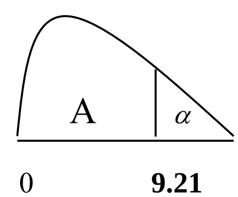
The **E**xpected values

	Men(**M**)	Women(**W**)	***Total***
Voted	$\frac{(430)(640)}{1000} = \mathbf{275.2}$	$\frac{(570)(640)}{1000} = \mathbf{364.8}$	***640***
Didn't vote	$\frac{(430)(360)}{1000} = \mathbf{154.8}$	$\frac{(570)(360)}{1000} = \mathbf{205.2}$	***360***
	430	***570***	***1000***

O	280	360	150	210	
E	275.2	364.8	154.8	205.2	
$(O-E)^2$	23.04	23.04	23.04	23.04	
$(O-E)^2/E$	23.04/275.5 0.084 +	23.04/364.8 0.063 +	23.04/275.5 0.149 +	23.04/275.5 0.084 = ***0.38***	$\chi^2 = \sum \frac{(O-E)^2}{E}$ = ***0.38***

Test at **1%** significance level whether that ***gender*** and ***opinions of adults*** are ***independent*** on this issue.

Test statistic = $\chi^2 = \sum \frac{(O-E)^2}{E}$ **= 8.252** ***Falls not inside CR***



Conclusion: We accept $\mathbf{H_0}$ that ***gender*** and ***opinions of adults*** are ***independent*** on this issue.

Comment: opinions of adults are **dependent** on their gender.