Abe Mirza **Topics Review** **Statistic**

Part IV

Hypothesis Testing

7 – Step Process

1. Stated 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

General Outline

7-Steps of hypothesis testing

1) From the problem write (**SC: S**tated **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	$\mu > 60$	$\mu \le 60$
	Average time to do a certain task is less than **25** minutes	$\mu < 25$	$\mu \ge 25$
	Average net weight of a certain cereal is **24** oz.	$\mu = 24$	$\mu \ne 24$
	Generally **85%** of DMV applicants pass the driving test.	$P = .85$	$P \ne .85$
	In general less than **13%** of "XYZ" product is defective.	$P < 0.13$	$P \ge 0.13$
	No less than **25%** of students like to take online classes.	$P \ge 0.25$	$P < 0.25$
	At most **21%** of high school dropouts work for minimum wage.	$P \le 0.21$	$P > 0.21$
	Average life of Diehard(μ_1) batteries is longer that Everlast(μ_2)	$\mu_1 > \mu_2$	$\mu_1 \le \mu_2$

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,

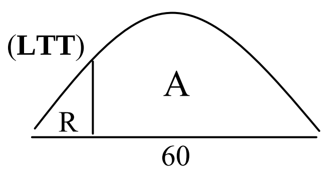
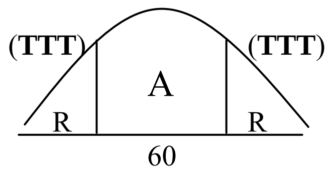
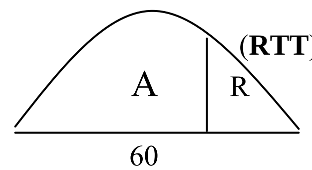
H_0 (Null Hypothesis): (contains equal sign)	$=$	or	$\ge$	or	$\le$
H_1 (Alternative Hypothesis): (contains not equal sign)	$\ne$	or	$<$	or	$>$

Remember that we do not know for certain that if **H_0** is true or false but when **H_0** is written, the test is set up, data collected, and decision is made about **H_0** then we either Accept **H_0**: or Reject **H_0**:

The table below summarizes all possible scenarios that might happens

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

There are **three-possibilities** for setting up the hypothesis (a left-tailed test, two-tailed, right-tailed).
Hint: Use $\mathbf{H_1}$ to determine if it is a left-tailed test ($\mu <$), two-tailed ($\mu \neq$), right-tailed ($\mu >$), or.
All the rejections or acceptances labels are based on $\mathbf{H_0}$.
Also determine the region, by labeling **A** (Accepting H_0), **R** (Rejecting H_0)

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

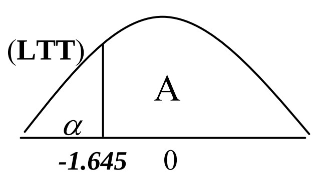
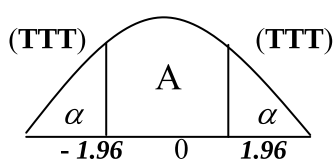
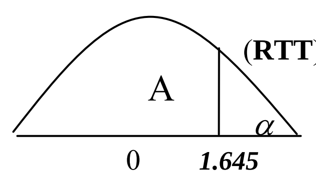
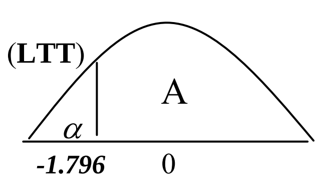
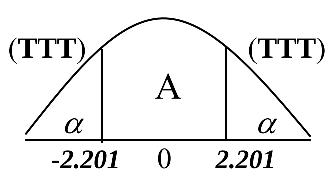
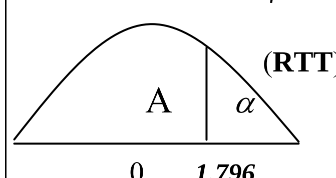
3) What is **Critical value(s)** and how to find it?
Critical value(s) is limit(s) or boundary(ies) that if it is exceeded (by our sample data) then $\mathbf{H_0}$ will be **rejected.**

How to find it? By looking up **table p.4** (table link), 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 to not that to let 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 $n \leq 30$ then use Table p.4 to find critical value(s). Be sure you find df= degree of freedom = $n-1$			
Given α **=.**05 and $n \leq 30$ 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* $\rightarrow$ *test* $\rightarrow$ *Option 1*

---

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* $\rightarrow$ *test* $\rightarrow$ *Option 2*

---

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

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

---

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

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

---

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

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

---

f. $\chi^2 = \sum \dfrac{(O-E)^2}{E}$ **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 $(L_1 - L_2)^2 / L_2$ $\rightarrow$ *stat* $\rightarrow$ *Calc* $\rightarrow$ *Option 1* $\rightarrow$ L_3 *(the answer is* $\sum x$)

`

5) Conclusion: Reject or fail to reject $\mathbf{H_0}$?

Compare **Test Statistics** with **Critical value**, and find where the test statistics falls (inside the **CR**: **C**ritical **R**egion or not) then draw conclusion **on $\mathbf{H_0}$ (Accept or Reject $\mathbf{H_0}$).**

6) Comment: Accept or reject SC? Decide whether the stated claim has been accepted or rejected.

Two possibilities:

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

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

7) P-value: Use the test statistics to find the minimum α - value that is needed to reject the Null hypothesis $\mathbf{H_0}$.

Large Samples about Mean

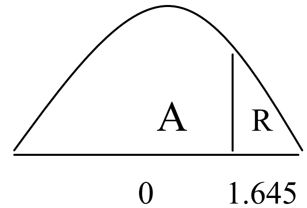
Case 1. **Average** life of "Die Long" batteries **exceeds** 60 months. A sample of 64 batteries had an average life of 63 months and st. dev. of 10 months. Let α **= .05**

SC: $\mu > 60$ **H₀**: $\mu \le 60$ **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 $\mathbf{H_1}$ is more than,** then it is a **RTT**

When α **= .05 ,** n > 30 and one –tailed test then by using bottom row of page 4 of the table link

Critical value = CV= Z = 1.645



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

Conclusion: Accept or reject $\mathbf{H_0}$? Inside ***CR*** then reject **Ho**
Comment: Accept or reject **SC**? **Accept** that the **average** life of batteries **exceeds 60** months.

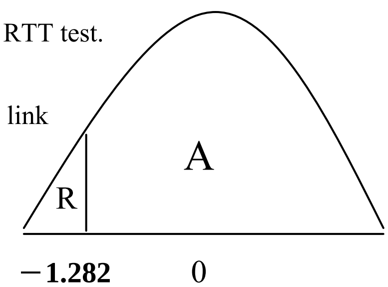
Case 2. **Average** life of "Die Long" batteries is **less than** 60 months. A sample of 64 batteries had an average life of 58 months and st. dev. of 10 months. Let α **= .10**

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 $\mathbf{H_1}$ is less than,** then it is a **LTT**

When α **= .10 ,** n > 30 and one –tailed test then by using bottom row of page 4 of the table link

Critical value = CV=Z = $-$ 1.282



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

Conclusion: Accept or reject $\mathbf{H_0}$? Inside ***CR*** then reject **Ho**
Comment: Accept or reject **SC**? **Accept** that the **average** life of batteries is **less than 60** months

---

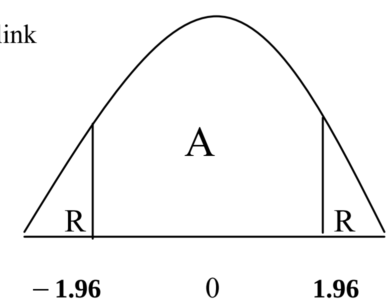
Case 3. **Average** life of "Die Long" batteries **is different** than 60 months. A sample of 64 batteries had an average life of 62 months and st. dev. of 10 months. Let α **= .05**

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

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

When α **= .05** , n > 30 and two –tailed test then by using bottom row of page 4 of the table link

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



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

Conclusion: Accept or reject $\mathbf{H_0}$? Not inside CR then Accept **Ho**
Comment: Accept or reject **SC**? **Reject** that the **average** life of batteries **is different than 60** months

Small Samples about Mean

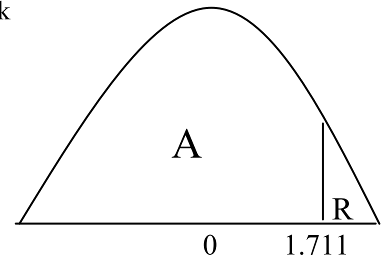
Case 4. **Average** life of "Die Long" batteries **exceeds** 60 months. A sample of 25 batteries had an average life of 63 months and st. dev. of 10 months. Let **α = .05**

SC: $\mu > 60$ **H₀** : $\mu \le 60$ **Hint**: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test

OC: $\mu \le 60$ **H₁** : $\mu > 60$ **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 4 of the table link

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 Accept **Ho**

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

---

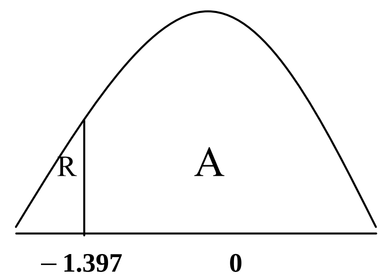
Case 5. **Average** life of "Die Long" batteries is **less than** 60 months. A sample of 9 batteries had an average life of 54 months and st. dev. of 10 months. Let **α = .10**

SC: $\mu < 60$ **H₀**: $\mu \ge 60$ **Hint**: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test

OC: $\mu \ge 60$ **H₁**: $\mu < 60$ **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 4 of the table link

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***

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

---

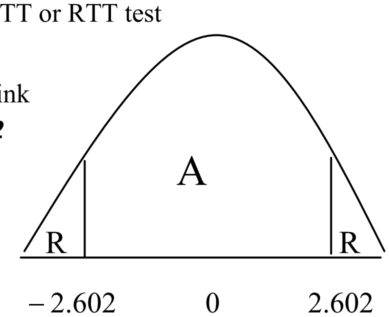
Case 6. **Average** life of "Die Long" batteries **is different** than 60 months. A sample of **16** batteries had an average life of 66 months and st. dev. of 10 months. Let **α = .02**

SC: $\mu \ne 60$ **H₀** : $\mu = 60$ **Hint**: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test

OC: $\mu = 60$ **H₁** : $\mu \ne 60$ **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 4 of the table link

Critical value =*C V*= **t** = ± ***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*

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

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

Proportion

Case 7. 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 | $\mathbf{H_0}$: **P** $=$ .85

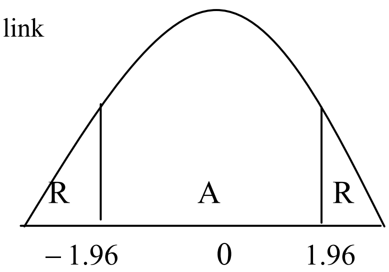
OC: **P** $\neq$ .85 | $\mathbf{H_1}$: **P** $\neq$ .85

Hint: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test

Note: P **in** $\mathbf{H_1}$ **is not equal,** then it is a **TTT**

When α **= .05** , n > 30 and two –tailed test then by using bottom row of page 4 of the table link

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* $\rightarrow$ *test* $\rightarrow$ *Option 5*

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

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

Case 8. 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 | $\mathbf{H_0}$: **P** $\leq$ 0.85

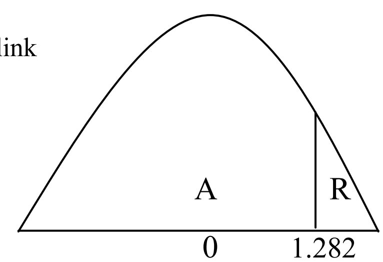
OC: **P** $\leq$ 0.85 | $\mathbf{H_1}$: **P** $>$ 0.85

Hint: Use $\mathbf{H_1}$ to determine if it is LTT ,TTT or RTT test

Note: P **in** $\mathbf{H_1}$ **is more than,** then it is a **RTT**

When α **= .10** , n > 30 and one –tailed test then by using bottom row of page 4 of the table link

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* $\rightarrow$ *test* $\rightarrow$ *Option 5*

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

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

Difference of Two Independent Population Means

Case 9: 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:

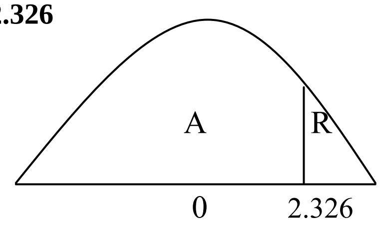
Die Hard	(μ_1)	$n_1 = 44$	$\bar{x}_1 = 51.8$	$s_1 = 8.5$
Everlast	(μ_2)	$n_2 = 36$	$\bar{x}_2 = 47.4$	$s_2 = 10.7$

SC: $\mu_1 > \mu_2$ **H₀** : $\mu_1 \le \mu_2$ **H₀** : $\mu_1 - \mu_2 \le 0$ **Hint**: Use **H_1** 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 H_1 is more than,** then it is a **RTT**

When α **= .01** , n > 30 and one –tailed test then by using bottom row of page 4 of the table link

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



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

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

Falls not inside CR

TI-83/84 *stat* → *test* → *Option 3*

Conclusion: Accept or reject **H_0**? Not inside CR then accept **Ho**

Comment: Accept or reject **SC**? Reject that the average life of Diehard batteries is longer than Everlast brand.

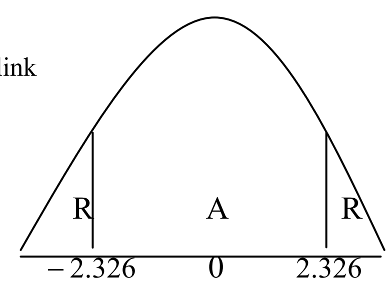
Case 10 : A researcher wants to test if the mean GPA of all male and female college students who participate in sports are different. She took a random sample of 33 male students and 38 female students who are involved in sports. She found out the mean GPAs of the two groups to be 2.62 and 2.74, respectively, 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: $\mu_m \ne \mu_f$ $H_0 : \mu_m = \mu_f$ $H_0 : \mu_m - \mu_f = 0$ **Hint**: Use **H_1** to determine if it is LTT ,TTT or RTT test

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

When α **= .02** , n > 30 and two –tailed test then by using bottom row of page 4 of the table link

Critical value = CV=**Z =** $\pm$ **2.326**



TI-83/84 *stat* → *test* → *Option 3*

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

Falls not inside CR

Conclusion: Accept or reject **H_0**? Not inside CR then accept **Ho**

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

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 11. 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**	$\Sigma d = 25 \quad \bar{d} = 25/6 = 4.17 \quad s_d = 2.64$

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

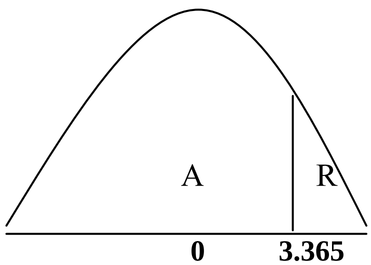
μ_d = Average difference in sales after taking the course.

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 4 of the table link

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



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

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

Conclusion: Accept or reject H_0? Inside ***CR*** then reject **Ho**

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

Case 12: 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**	$\Sigma d = -69 \quad \bar{d} = -69/8 = -8.625 \quad s_d = 9.75$

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

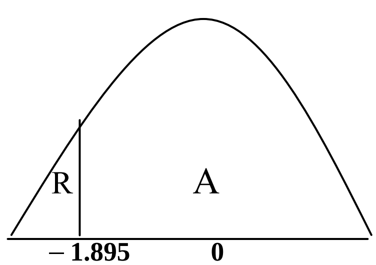
μ_d = Average difference in pain after taking the medication

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 4 of the table link

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***

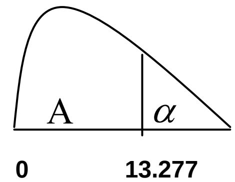
Conclusion: Accept or reject H_0? Inside ***CR*** then reject **Ho**

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

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 page 5** of the table and
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** = $\chi^2 = \sum \frac{(O-E)^2}{E} =$

Hint: There are no **SC** and **OC**. We **start H₀** with by writing what the expected values or percentages are**.**

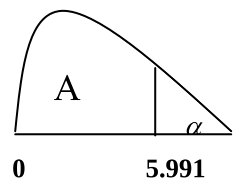
Example. Using the 5% significance level, test the there are the same number of absences on each day of MWF class. To do this Abe has collected data of for number of students who have been absent on any of these days.

The following table lists the number of students who have been absent on any of these days.

Absent	**M**	**W**	**F**	**Total**
Students (Observed) O	10	12	14	**36**

Hint: to find the expected values we divide total (36) by 3.

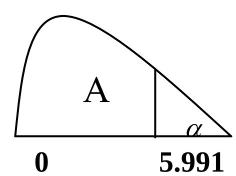
H_0: Equal number of absences on each day of MWF class.
H_1: Unequal number of absences on each day of MWF class.



K= 3, degrees of freedom = 3-1 = 2, **α = .05** Critical value = χ^2 = **5.991**

Absent	**M**	**W**	**F**	**Total**
Students (**O**bserved) **O**	10	12	14	**36**
Students (**E**xpected) **E**	12	12	12	**36**
$(O-E)^2$	$(-2)^2 = 4$	$(0)^2 = 0$	$(2)^2 = 4$	
$(O-E)^2 / E$	4/12 0.33 +	0/12 0 +	4/12 0.33 = 0.66	Test statistics $\chi^2 = \sum \frac{(O-E)^2}{E}$ =**0.66**

H_0: Equal number of absences on each day of MWF class.
H_1: Unequal number of absences on each day of MWF class.



Test statistics = $\chi^2 = $ **0.66** ***Falls not inside CR***

-83/84

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

Conclusion: Not inside CR then fail to reject **Ho**
Comment: Therefore equal number of absences on each day of MWF class.

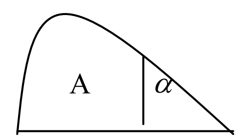
Case 13: Abe Claims that generally in his class grades distribution is as such
A: 20% , **B**: 24% , **C**: 28%, **D**:16% , **F**: 12% "
,est Abe's claim at 10% significance level based on latest data recored from his stat classes last from a sample of 75 students.

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**
$(O-E)^2$	$(16\text{-}15)^2$ **1**	$(18\text{-}18)^2$ **0**	$(20\text{-}21)^2$ **1**	$(14\text{-}12)^2$ **4**	$(7\text{-}9)^2$ **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**

H₀: Stated proportions are correct.
H₁: Stated proportions are **not** correct.



0 *7.779*

K= 5, **α = .10**
degrees of freedom $df = k-1 = 5-1 = 4$ Critical value = χ^2 = **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: **Accept Ho** Comment*:* **Stated proportions are correct.**

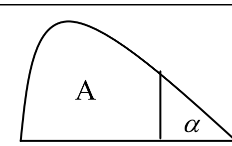
Case 14. At $\alpha = 1\%$, test the hypothesis that the proportions of grades are the same for stat. students?
The following table lists the grade distribution for a sample of 100 students for stat class**,**

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

Hint: to find the expected values we divide total (100) by 5.

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
$(O-E)^2$	$(32\text{-}20)^2$ **144**	$(25\text{-}20)^2$ **25**	$(19\text{-}20)^2$ **1**	$(16\text{-}20)^2$ **16**	$(8\text{-}20)^2$ **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**

H₀: Equal proportions of grades for stat. students.
H₁: Unequal proportions of grades for stat. students.



0 **13.277**

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 **H₀,** **Comment:** Therefore proportions of grades are **not the same** for all students.

Test of Independence (Contingency Table)

Case 15. 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"?

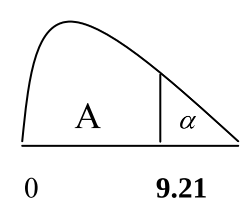
The **E**xpected values

	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.