Chapter 8: Hypothesis Testing

Section 8.1: Basics of Hypothesis Testing

Stat 50

GOAL: Make a decision about p or μ based on $\hat{p}$ or $\bar{x}$ using probability. p̂ μ

pop. sample

Chapter 7: Find a sample then **estimate** whether the population fits within a certain interval. CI	**Chapter 8**: Given a past claim of the parameter, we will test whether or not it has changed. ≠

STRUCTURE OF A HYPOTHESIS TEST

1) Make an assumption about reality	• make a hypothesis about population parameter
2) Look at a sample evidence	• find a point estimate to test pop. parameter
3) Determine whether it contradicts our assumption.	• make a descision if p or μ has changed.

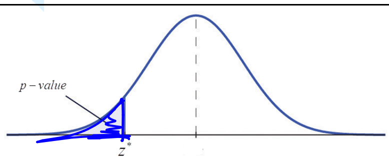
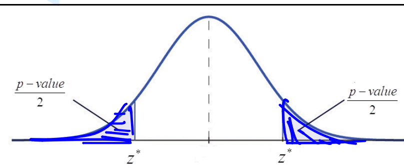
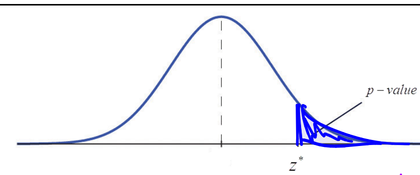
We won't be 100% certain, we will just be able to tell if sample data substantiates / supports a statement or not.

HYPOTHESES STATEMENTS (GTK)

NULL HYPOTHESIS (H_0) → nothing = 0	ALTERNATIVE HYPOTHESIS (H_1) or H_A
A statement of no change, no effect, no difference and is assumed true until statistical evidence indicates otherwise.	A statement that we are trying to find evidence to support ~~instead of~~ that Null Hyp (H_0) is "not true".

THREE TYPES OF HYPOTHESIS TESTS

GTK

LEFT-TAILED	TWO-TAILED	RIGHT-TAILED
H_0: $parameter = \#$ H_1: $parameter$ < #	H_0: $parameter = \#$ H_1: $parameter$ ≠ #	H_0: $parameter = \#$ H_1: $parameter$ > #
		
(H_A: para changes smaller	H_A: Parameter changes	H_A: parameter changes bigger

GTK!

Ex: **1)** What's the parameter? p μ **2)** What do "they say"? "past claim" **3)** What do we think? "H_A" **4)** What type of test? tail

The packaging on a light bulb says it should last 500 hours. Consumer Reports wants to know if the mean lifetime is actually less than that.	The standard deviation of the rate of return for some mutual funds is 0.08%. A manager believes the standard deviation might be higher than that.	According to a Gallup poll in 2008, 80% of Americans felt satisfied with the way things are going in their lives. A researcher wonders if the percentage is different now.
1) parameter : μ 2) and 3) past claim: H_0 : μ = 500 hr/life think : H_A : μ < 500 hrs/life 4) Test : left tailed Test	1) parameter: σ 2) and 3) past H_0: σ = 0.0008 think H_1 : σ > 0.0008 4) Test: Right-Tailed Test	1) parameter: proportion 2) and 3) past: H_0: p = 0.8 think H_A: p ≠ 0.8 4) Two tailed test

TWO POSSIBLY CORRECT CONCLUSIONS: ANOTE we are not saying "accept H_0" or not saying we "proved" is H_0 true

1) We decide there is evidence to support H_1	2) We decide there is NOT enough evidence to support H_1
"reject the null hypothesis" or "reject H_0"	"failed to reject the null hypothesis" → "failed to reject H_0"

Ex: Historically, Jimbo's pizza had a mean (μ) delivery time of 48 minutes. After getting a new pizza oven, he takes a sample of 50 orders and finds that the mean delivery time is now 45 minutes, which makes Jimbo think that the mean delivery time has been reduced. Note is $\mu = 45$ statistically less or is it simply due to "sample variability"

State Jimbo's hypotheses in statistical notation:

$H_0: \mu = 48$ min/deliv.

$H_A: \mu < 48$ min/deliv.

State the conclusion if the **null is rejected:**

"There is enough statistical evidence to support that the true (pop. para.) mean pizza delivery time is less than 48 min/deliv."

State the conclusion if the **null is *not* rejected:**

"There is not enough statistical evidence to support that the true mean delivery time is less than 48 min/deliv."

NOT SAYING "we proved that mean is 48..."

FOUR POSSIBLE OUTCOMES (2 ERRORS)

Example: In a court case
H_0: the defendant is innocent
H_1: the defendant is guilty

		Truth about the Population (**Reality**)	
		H_0 is true (innocent)	H_0 is false (guilty) — Worse type of Error
Decision Based On Sample **(Our Conclusion)**	Fail to Reject H_0 "keep"	Conclude innocent when innocent. Good! ☺	Conclude innocent when guilty. Bad ☹ Type II Error
	Reject H_0	Conclude guilty when innocent. Bad ☹ Type I Error	Conclude guilty when guilty. Good ☺

***NOTE:** The defendant is NEVER declared INNOCENT!!

TYPE I AND TYPE II ERRORS

$\alpha = P(\text{Type I Error})$

α **Type I error:** The mistake of rejecting the null hypothesis when it is actually true.
The symbol α (alpha) is used to represent the probability of such an error.

β **Type II error:** The mistake of failing to reject the null hypothesis when it is actually false.
The symbol β (beta) is used to represent the probability of such an error

$\beta = P(\text{Type II Error})$

Ex: On average (μ), it used to take 30 minutes to find parking, but we think we have sufficient evidence to say that the time has decreased. But, in fact, the true parking time is still 30 minutes. What kind of error did we make?

$H_0: \mu = 30$ min

$H_A: \mu < 30$ min

conclude statistically: reject H_0 (ie time decreased support H_A)

in reality: H_0 is true

→ this is Type I Error

Note: The majority is a number or percentage equaling more than 50% of a total. To test a claim about a majority, your null hypothesis will be $p =$ 0.5. So $H_A: p > 0.5$. "Right Tailed Test"

EX: A Gallup survey reports that 57% of 504 randomly selected gun owners support stricter gun laws. Test the claim that a majority of gun owners favor stricter gun laws. Write out the hypotheses for this example. What would a Type II error be in this scenario?

Hypotheses

$H_0: p = 0.5$ ← when testing majority

$H_A: p > 0.5$

	H_0 T	H_0 F
FTR H_0		II
R H_0	I	

• H_0 F: it is not true that the proportion of gun owners support stricter gun laws is 0.5.

• FTR H_0: FTR that proportion of gun owners support stricter gun laws is 0.5

Type II Error: "We conclude that there's no majority of gun owners that supp. str. gun laws when in that fact there is a majority support."

EX: Your company markets a computerized device to test a patient's mean resting heart rate. Based on the sample results, the device determines whether there is significant evidence that the patient's mean resting heart rate is greater than 100 beats per minute. If so, your company recommends that the person seeks medical attention.

parameter: mean # beats/min (μ)

a. State appropriate null and alternative hypotheses in this setting.

H_0: $\mu = 100$ bpm

H_1: $\mu > 100$ beats/min

b. Which error is worse for your company?

conclusion \ reality	H_0 is true	H_0 is false
Fail to Reject H_0		**Type II Error** conclude: $\mu = 100$; reality: $\mu > 100$
Reject H_0	**Type I Error** conclude: $\mu > 100$; reality: $\mu = 100$	

WORSE for client

Seek Med Attention?	YES	NO
Did They Need It?	YES	NO

Seek Med Attention?	YES	NO
Did They Need It?	YES	NO

We will NOT know 100% if our conclusion of our Hypothesis Test is correct, but we can assign probabilities to making Type I and Type II Errors when we complete a hypothesis test.

α β "α" alpha "β" beta

Level of Significance α	The probability of making a Type I Error. In other words, we take a sample that makes H_0 look WRONG when it's actually TRUE. $\alpha = P(\text{Type I Error})$ $\alpha = P(\text{Reject } H_0 \mid H_0 \text{ True})$

Note: As you decrease the probability of one type of error, then the probability of the other type increases. In math terminology: say α & β are inversely related G+Q

Choosing a Significance Level

Typically the significance level, α is given to be ~~greater than~~ between 0.01 (1%) and ~~less than~~ 0.10 (10%).

When a Type I error is…

α (level of sig)

Type I Error is serious — $\alpha =$ 0.01

T I E not so serious — $\alpha =$ 0.05

T I E is not serious — $\alpha =$ 0.10 ← this is prefered because making α bigger makes β (Prob Type II E) smaller!

α bigger →

β smaller →

β smallest here

HYPOTHESIS TESTING: CLAIM ABOUT A PROPORTION

Requirements (need to verify: in exams need to check)

1. The sample observations are a simple random sample. (SRS)
2. The conditions for a binomial distribution are satisfied. 4 conditions: 1) fixed trials (n) 2) 2 outcomes "S" or "F" 3) trials independent 4) probability of one trial success is constant
3. If $np \geq 5$ and $nq \geq 5$, then the normal distribution can be used to approximate the distribution of sample proportions with mean $\mu = np$ and standard deviation $\sigma = \sqrt{npq}$. $p = P(\text{success})$ $q = P(\text{fail})$

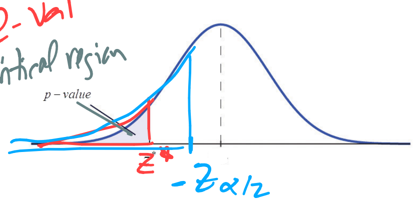
Steps for *a* Hypothesis Test When Applied to Testing *p*	
Pre-Step: *Check Requirements* ● It is a valid simple random sample ● The requirements are met to use the needed distribution.	binomial (1) (2) (3) (4)
Step 1: *Hypotheses* (Pick one) H_0: $p = p_0$ p_0 "past proportion" H_1: $p < p_0$ or $p \neq p_0$ or $p > p_0$	***Step 2:*** *Level of Significance* α • either problem tells you this • if not, assume $\alpha = 0.05$
Step 3: *Test Statistic* (Find a *z*-score, *t*-value or X^2 value) (depends on parameter) ← for proportions $z^* = \dfrac{\hat{p} - p_0}{\sqrt{\dfrac{p_0 q_0}{n}}}$ • $\hat{p}$ - sample proportion, n sample size • p_0 - "past" proportion • $q_0 = 1 - p_0$ "complement"	z^* says: # of "standard deviations" away from ("mean") p_0 w/ st. dev $\sigma_{p_0} = \sqrt{\dfrac{p_0 q_0}{n}}$
Step 4: *Find a critical value or P-value to check using either the Critical Value or P-value method.*	$z_{\alpha/2}$ or z_α $P = \text{Prob}(\text{Critical Region})$
Step 5: *Make a decision and draw a conclusion*	

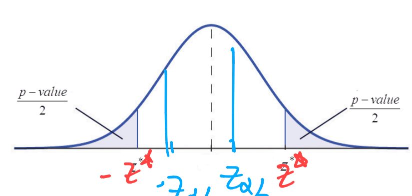
NULL AND ALTERNATIVE HYPOTHESIS

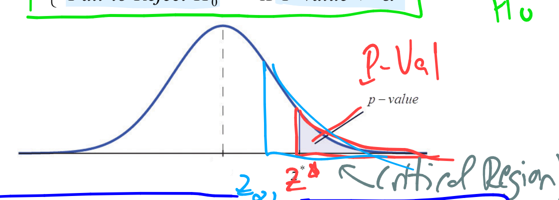
LEFT-TAILED	TWO-TAILED	RIGHT-TAILED
$H_0: \; p = p_0$ $H_1: \; p < p_0$	$H_0: \; p = p_0$ $H_1: \; p \neq p_0$	$H_0: \; p = p_0$ $H_1: \; p > p_0$

P-VALUE METHOD → DECISION (for all tests)

Reject H_0 ~ if *P-value* $\leq \alpha$ (ie supports H_A)
Fail to Reject H_0 ~ if *P-value* $> \alpha$ ("keep" H_0)

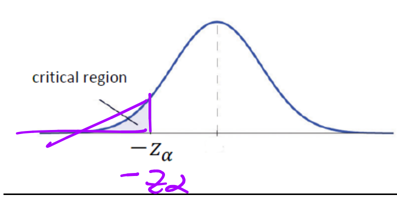


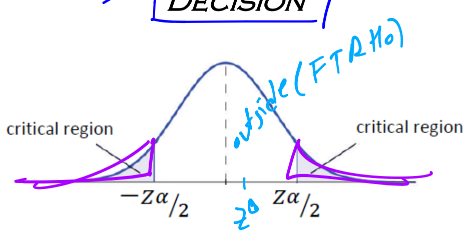


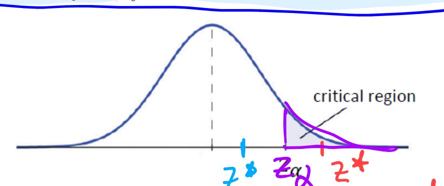


CRITICAL VALUE METHOD → DECISION

Reject H_0 ~ if z^* lies in the critical region
Fail to Reject H_0 ~ if z^* doesn't lie in the critical region







$-z_{\alpha/2}$ $z_{\alpha/2}$

past

Ex: According to the Census Bureau, 8.8% of the U.S. population had no health insurance coverage in 2017. Suppose that in a recent random sample of 1200 Americans, 130 had no health insurance. Use a 0.02 significance level to test the claim that the current percentage of Americans who have no health insurance coverage is greater than 8.8%. Use the Crical Value method.

pop. parameter : proportion of US w/ no Health insurance

Step 0 Check Requirements

① SRS ✓ ② Binomial dist
i) fixed ✓
ii) independent ✓
iii) bi? Y or N ✓
iv) prob sucess cont. ✓

③ $n \cdot p_0 \geq 5$
$n \cdot q_0 \geq 5$

$n = 1200$
$p_0 = 0.088$
$q_0 = 0.912$

$1200 * 0.088 = 105.6 \geq 5$ ✓
$1200 * 0.912 = 1094.9 \geq 5$ ✓

Null and Alternative Hypothesis

Step 1

$p_0 = 0.088$

$H_0: p = p_0 \quad p = 0.088$
$H_A: p > p_0 \quad p > 0.088$

Test Statistic step 3

Step 2

$\alpha = 0.02$

$\hat{p}$ sample

$\hat{p} = \frac{130}{1200}$

$\hat{p} = 0.108$

$$z^* = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0 q_0}{n}}} = \frac{(0.108 - 0.088)}{\sqrt{\frac{0.088 * 0.912}{1200}}}$$

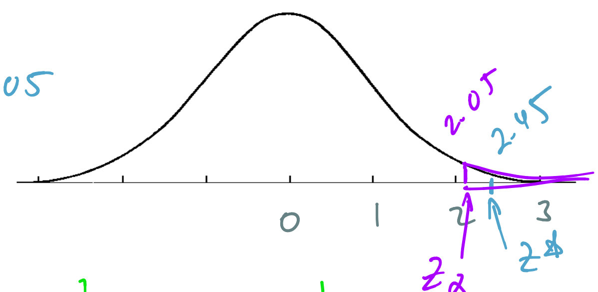
$$\boxed{z^* = 2.45}$$

P-value/Critical Region

Critical value

$z_\alpha = \text{invNorm}(0.02, 0, 1, \text{RIGHT}) = 2.05$

Use Right Tailed Test



Decision about Null Hypothesis

Is z^* inside critical region?

RTT: $z^* > z_\alpha$? $2.45 > 2.05$? Yes! z^* is inside

Conclusion

Reject H_0, support H_A

(M→E) "There's enough statistical evidence to support the claim that (the true pop. proportion) proportion of Americans with no Health insurance is greater than 8.8% (or 0.088)."

Identify the Type I error

$\alpha = P(\underbrace{R\,H_0}_{\text{support } H_A} \mid H_0 \text{ True})$

"We erroneously conclude the US population w/ no Health Ins. is greater than 8.8% but in reality is is exactly 8.8%."

Identify the Type II error

$\beta = P(\text{FTR } H_0 \mid H_0 \text{ F})$

"We erroneously conclude the US population w/ no Health insurance is exactly 8.8% but in reality it is greater than 8.8%."

Ex: According to NPR, in 2016 32.1% of adults aged 18-34 lived at ~~home~~ x with their parents. A sociologist recently randomly surveyed 500 people aged 18-34 and found that 143 of them did. At $\alpha = 0.05$, do we think the proportion has changed? Use the P-Val method.

Step 0
1) SRS ✓
2) bi ✓
3) $np_0 \geq 5$
$(500)(0.321) \approx 160$ ✓
$nq_0 \geq 5$
$(500)(0.679) \approx 339$ ✓

$n = 500$
$x = 143$
$\hat{p} = \frac{x}{n}$
$\hat{p} = \frac{143}{500}$
$\hat{p} = 0.286$

Null and Alternative Hypothesis

$$\begin{cases} H_0: p = 0.321 & (p_0 = 0.321) \\ H_A: p \neq 0.321 & (\text{two-tailed test}) \end{cases}$$

Test Statistic

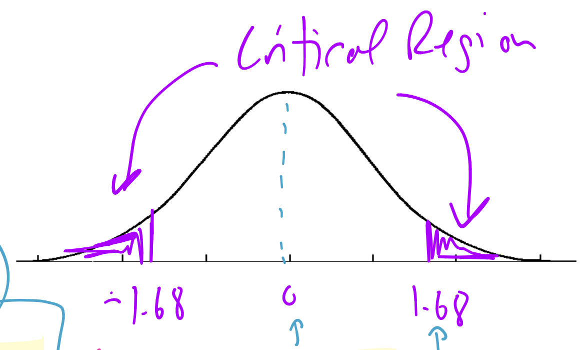
for proportions

$$z^* = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0 q_0}{n}}} = \frac{(0.286 - 0.321)}{\sqrt{\frac{(0.321)(0.679)}{500}}} = -1.676\ldots$$

$$\boxed{z^* = -1.68}$$

P-value/Critical Region

↳ critical region based on z^*



$$P(\text{Critical Region}) = 2 * P(x > 1.68)$$
$$= 2 * (0.5 - \text{normalcdf}(0, 1.68, 0, 1))$$
$$= 0.09295\ldots \qquad \boxed{P = 0.0930}$$

(Cl use BETTER! $P = 1 - \text{normalcdf}(-1.68, 1.68, 0, 1)$)

Decision about Null Hypothesis

$\alpha = 0.05$
$P = 0.0930$

$P > \alpha$

"P is high, null will fly" → $\boxed{\text{FTR } H_0}$

Conclusion

(M→E) "There is NOT enough statistical evidence to support the claim that the proportion of adults (ages 18-34) that live w/ parents has changed from 32.1% since 2016."

GRAPHING CALCULATOR (TI-83 OR 84)

★ RECOMMEND KNOW THIS

Instructions: (a) STAT ⇒ TESTS ⇒ 1-PropZTest

1-PropZ Test

(b) Enter
- p_0 = population proportion stated in H_0 — $p_0 = 0.321$
- x = number of successes — $x = 143$
- n = number of trials — $n = 500$
- $prop \sim$ alternative hypothesis — (Two-Tailed) $p \neq p_0$

Ex: In a 2016 Gallup poll, 34% of people said that it was morally acceptable to clone animals. In 2017, a survey found that 192 out of 600 randomly selected people believed that it was morally acceptable to clone animals. Use a 0.10 significance level to test the claim that less than 34% of all adults say that it is morally acceptable to clone animals. Use the P-Value method.

Null and Alternative Hypothesis

$H_0: p = 0.34$

$H_A: p < 0.34$

* Check Req *

① ...

② ...

③ ... $np \geq 5$ ✓

$nq \geq 5$ ✓

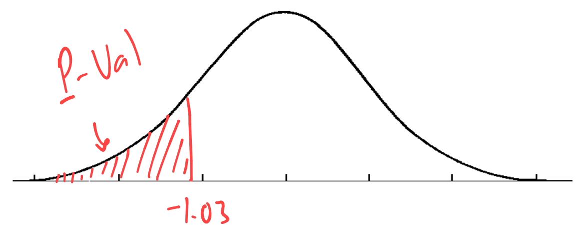
Test Statistic

$z^* = -1.03$

P-value/Critical Region

$P(\text{Critical Region}) = P(z < -1.03)$

$\text{P-Val} = 0.152$



Decision about Null Hypothesis

$\alpha = 0.1$

$P = 0.152$

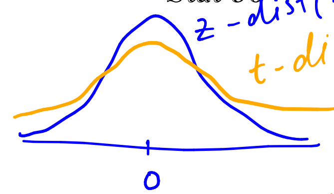
$P > \alpha \rightarrow$ Fail to Reject H_0

Conclusion

(M→E) "There is not enough stat evid. to support claim that the proportion of people who believe it is morally acceptable to clone animals is less than 34% in 2016."

Big Question: Is this STATISTICALLY SIGNIFICANT?

*! *Def* ***Statistically Significant*** When observed results are unlikely under the assumption that the null hypothesis is true and we reject the null hypothesis.



HYPOTHESIS TESTING: CLAIM ABOUT A $\boxed{\text{MEAN}}$ (σ NOT KNOWN)

Requirements

1. The sample is a simple random sample. (SRS)
2. The value of the population standard deviation σ is not known.
3. Either or both of the given conditions are satisfied: $\left\{\begin{array}{l}\text{The population is normally distributed} \\ \text{or} \\ n > 30^{*}\end{array}\right\}$ so that you can use t-distr.

"Alt"

Ex: Recall the logic behind a hypothesis test: Say $H_0: \mu = 10$ and $\boxed{H_1: \mu < 10}$ (left)

If we take a sample and find the point estimate… "by a little, or a lot"

- $\bar{x} = 10$ then we <u>fail to reject</u> H_0
- $\bar{x} > 10$ then we <u>fail to reject</u> H_0
- $\bar{x} < 10$ by "a little", then we <u>fail to reject</u> H_0
- $\bar{x} < 10$ by "a lot", then we <u>REJECT</u> H_0

Steps for *a* Hypothesis Test When Applied to Testing μ	
Pre-Step: *Check Requirements* ① (SRS) ② population normally dist OR $n > 30$	
• It is a valid <u>(simple) random</u> sample	• The requirements are met to use the needed distribution.
Step 1: *Hypotheses* now $H_0: \mu = \mu_0$ ← "past" H_1: <u>$\mu < \mu_0$</u> or <u>$\mu \neq \mu_0$</u> or <u>$\mu > \mu_0$</u>	***Step 2:*** *Level of Significance* α given or if not use $\alpha = 0.05$
Step 3: *Test Statistic* (Find a ~~z-score~~, *t*-value or ~~X^2-value~~) $\boxed{t^{*} = \dfrac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}}$ $\quad t^{*} = \dfrac{\bar{x} - \mu_0}{\sigma_{\mu_0}}$ Sampling Dist $\left\{\begin{array}{l}\mu_{\mu_0} = \mu_0 \\ \sigma_{\mu_0} = \frac{s}{\sqrt{n}}\end{array}\right.$	
Step 4: *Find a Critical Value or P-Value to check using either the Critical Value or P-value method.*	
Step 5: *Make a decision and draw a conclusion.*	

- P-low → null must go (Reject H_0)
- P-high → null will fly (Fail to Reject H_0)

NULL AND ALTERNATIVE HYPOTHESIS

LEFT-TAILED	TWO-TAILED	RIGHT-TAILED
$H_0: \quad \mu = \mu_0$ $H_1: \quad \mu < \mu_0$	$H_0: \quad \mu = \mu_0$ $H_1: \quad \mu \neq \mu_0$	$H_0: \quad \mu = \mu_0$ $H_1: \quad \mu > \mu_0$

use t^{*}

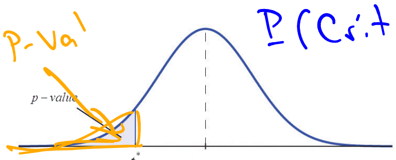
P-VALUE METHOD P-value = P(Crit Region)

DECISION

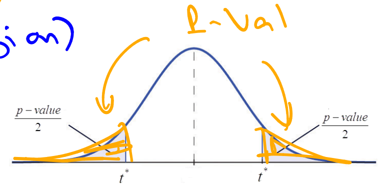
$\left\{\begin{array}{l}\textit{Reject } H_0 \sim \text{ if } P\text{-value} \le \alpha \\ \textit{Fail to Reject } H_0 \sim \text{ if } P\text{-value} > \alpha\end{array}\right.$

use t^{*}

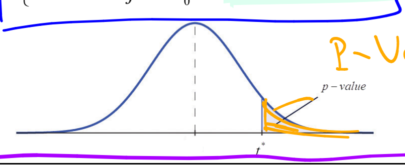
P-Val



P-Val



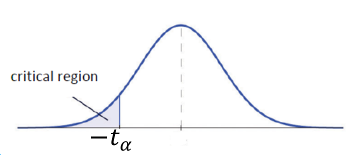
P-Val

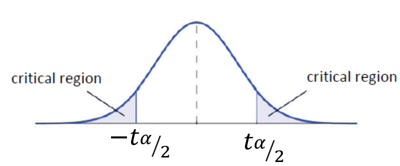


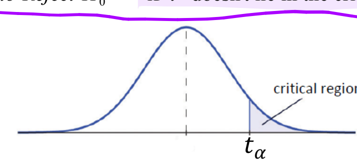
CRITICAL VALUE METHOD

DECISION

$\left\{\begin{array}{l}\textit{Reject } H_0 \sim \text{ if } t^{*} \text{ lies in the critical region} \\ \textit{Fail to Reject } H_0 \sim \text{ if } t^{*} \text{ doesn't lie in the critical region}\end{array}\right.$







critical Region (use α)
Recall: $t_\alpha = \text{invT}(1-\alpha, df)$

USE α "It's a trap"

past $\mu_0 = 20$

<u>Ex</u>: Kaiser Foundation hospital claims that the mean waiting time for patients to be seen in the emergency room is 20 minutes. A random sample of 40 patients produced a mean waiting time of 18.5 minutes and a standard deviation of 4.0 minutes. Use a 0.10 significance level to test the claim that the mean waiting time is equal to 20 minutes. Use the P-Value method.

Step 0 Check req. → H_A: not!

① SRS ✓

② σ unknown? ✓ (σ ← pop.)

③ pop. norm. dis (probably this too) OR $n > 30$ ✓

Step 1

Null and Alternative Hypothesis past

$$\begin{cases} H_0: \mu = 20 \text{ min / patient} \\ H_A: \mu \neq 20 \text{ min/p.} \ (\text{two-tailed test}) \end{cases}$$

Test Statistic

$\mu_0 = 20$

$\bar{x} = 18.5$

$s = 4.0$

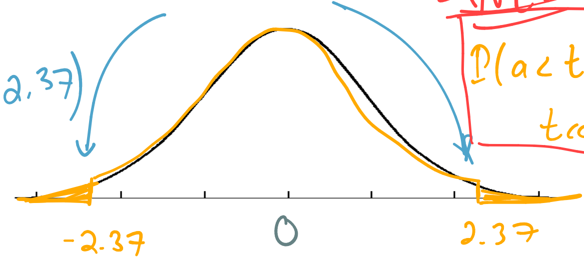
$n = 40$

$df = 39$

$$t^* = \frac{(\bar{x} - \mu_0)}{\left(\frac{s}{\sqrt{n}}\right)} = \frac{(18.5 - 20)}{\left(\frac{4.0}{\sqrt{40}}\right)} = \boxed{-2.37}$$

P-value/Critical Region

2 tailed critical Region t^*



☆NEW☆

$$\boxed{P(a < t < b) = \text{tcd}(a, b, df)}$$

P-Val:

$$P(\text{Crit Region using } t^*) = 1 - P(-2.37 < t < 2.37)$$

$$= 1 - \text{tcdf}(-2.37, 2.37, 39)$$

$$P = \boxed{0.0228}$$

Decision about Null Hypothesis

$\alpha = 0.1$

$P = 0.0228$

$\alpha > P$ ⟶ if P is low, null must go! ⟶ $\boxed{\text{Reject } H_0}$

Conclusion

(M⇒E) "There is enough statistical evidence to support the claim that the mean wait time at Kaiser ERs is not 20 minutes."

Identify the Type I error $P(R\,H_0 \mid H_0\,T)$

(I) "We mistakenly conclude that the wait time is not 20 min when in fact it is 20 min."

	H_0 T	H_0 F
FTR H_0		II
R H_0	I	

Identify the Type II error $P(FTR\,H_0 \mid H_0\,F)$

(II) "We mistakenly conclude that the wait tim is 20 min when in fact it is not 20 min."

Mr T is Mean

Ex: According to the Bureau of Labor Statistics, the mean amount of money spent by a household on alcohol in the US is \$565 per year. A church group wants to check this claim and took a random sample of 45 households and found that mean amount spent on alcohol per year was \$520 with a standard deviation of \$167. Test the church group's claim that the mean amount of money spent on alcohol per year is less than \$565. Use the P-Value method.

Step 0 Check requirements
1. SRS ✓
2. σ unknown ✓
3. $n = 45 > 30$ ✓ or normal?

Step 2 $\alpha = 0.05$

Null and Alternative Hypothesis

$$\begin{cases} H_0: \mu = 565 \ \$/yr \\ H_A: \mu < 565 \ \$/yr \end{cases}$$

(Left tail Test)

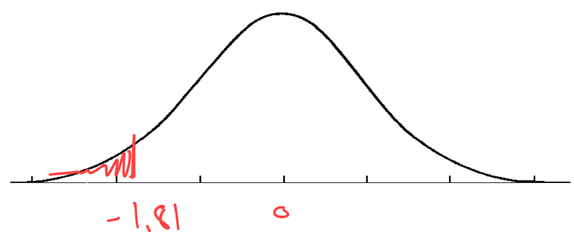
Test Statistic

$$\boxed{t^* = -1.81}$$

P-value/Critical Region

$P = 0.5 - \text{tcdf}(-1.81, 0, 44)$

$$\boxed{P = 0.0386}$$



Decision about Null Hypothesis

$\alpha = 0.05$

$P = 0.0386$

$\alpha > P$

P low, null must go

$\boxed{\text{Reject } H_0}$

Conclusion

" There is enough statistical evidence to support the claim that the true mean amount of dollars spent on alcohol per year is less than \$565 in the US."

GRAPHING CALCULATOR (TI-83 OR 84)

Instructions: (a) $\boxed{\text{STAT} \Rightarrow \text{TESTS} \Rightarrow \boxed{\text{T-Test}}}$

* Note Be sure to use "Stats" if not entering stats "Data" if

(b) Enter
$$\begin{cases} \mu_0 = \text{population mean stated in } H_0 \\ s = \text{sample standard deviation} \\ \bar{x} = \text{sample mean} \\ n = \text{sample size} \\ \mu \sim \text{alternative hypothesis} \end{cases}$$

Ex: The Instagram handle @getfollowers claims that they can increase the number of followers someone has on Instagram. In March 2015 the mean number of followers for a US teen was 150, so a random sample of 12 US teens with 150 followers was taken. The following is the number of followers, which is normally distributed, these US teens had after they paid @getfollowers for their help. Using a 0.01 level of significance, determine whether @getfollowers is effective at increasing the number of Instagram followers. Use the Critical Value method.

160	200	152	150	145	151	162	158	156	149	154	170

Enter List
1-VAR STATS
$\bar{x} = 158.9$
$s = 14.6$
$n = 12$
$df = 11$

Step 0 Check Requirements

Null and Alternative Hypothesis

$$\begin{cases} H_0: \mu = 150 \text{ followers} \\ H_A: \mu > 150 \text{ followers} \end{cases}$$

Test Statistic

$$t^* = \frac{(158.9 - 150)}{\left(\frac{14.6}{\sqrt{12}}\right)} = \boxed{2.11}$$

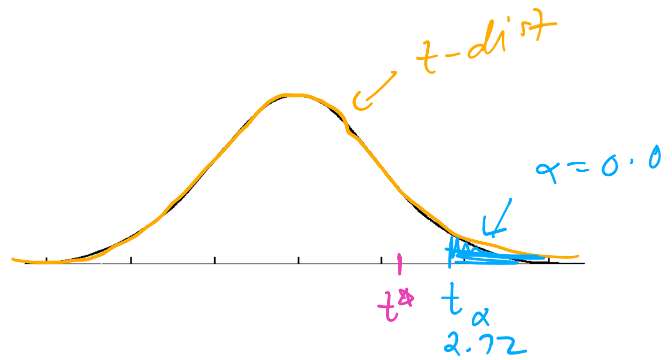
P-value/Critical Region

↳ based on α

$\alpha = 0.01$

$t_\alpha = \text{invT}(1 - 0.01, 11)$

$t_\alpha = 2.72$



Decision about Null Hypothesis

$t^* = 2.11$ is outside critical region → $\boxed{\text{Fail to Reject } H_0}$

Conclusion

"There is NOT enough statistical evidence to support the claim that @getfollowers can increase the mean Instagram followers from 150."