1. The Elements of a Test of Hypothesis
2. Formulating Hypotheses and Setting Up the Rejection Region
3. Test of Hypothesis about a Population Mean: Normal (*z*) Statistic
4. Observed Significance Levels: *p*-Values
5. Test of Hypothesis about a Population Mean: Student's *t*-Statistic
6. Large-Sample Test of Hypothesis about a Population Proportion

After reading this chapter you should be able to:

- Perform hypothesis testing
- Provide a measure of reliability for the hypothesis test, called the *significance level* of the test
- Identify Type I and Type II errors and interpret them
- Interpret the confidence level, and the significance level
- Compute and interpret *p*-values

Chapter 7.1 Intro to hypothesis testing

Problem*:* ***Suppose we tossed a coin 100 times and we have obtained 38 Heads and 62 Tails. Is the coin biased****?*
The argument: If the coin is fair than P(tails)=0.50.
We got 62 tails out of 100 tosses.
P(at least 62 tails)=1-Binomialcdf(100,0.5,61)=0.01.
There is a 1% chance to observe 62 or more tails if the coin were fair.
Conclusion: the coin is biased. (but there is still a 1% chance that it is fair)

A hypothesis test (or test of significance) is a standard procedure for testing a claim about a property of a population.

A hypothesis: a Math statement about the numerical value of a parameter

Testing Hypotheses:

1. Null hypothesis H_O: established fact, status quo, no change of parameters; scientist wants to test it.
2. Alternative hypothesis H_A: new claim contradicting Ho, a statement that needs strong support to be accepted

Example: ***Back to the coin problem (biased or fair?)***
H_O: coin is fair, p = 0.5
H_A: coin is biased, p > 0.5, or p<0.5, or just p≠0.5 (choose one)
Where p is the probability that the coin turns "tails"

Example: testing a hypothesis about μ *= average GPA for all Stat students*
H_O: GPA did not change, $\mu = \mu_0$
H_A: GPA improved, $\mu > \mu_0$

- Null hypothesis is a statement about the value of a population parameter. It must contain a condition of equality $=, \leq, or\ \geq$
  It is often called a ***status-quo*** hypothesis

- Alternative hypothesis (denoted by H_1 or H_A) is the statement that the parameter has a value that somehow differs from the null hypothesis. Must contain ≠, <, >
  It is often called a ***research*** hypothesis

Class Exercise: # 7.14 page 366
The interest rate at which London banks lend money to one another is called the *London interbank offered rate, or Libor. The British Bankers Association regularly surveys international banks for the Libor rate. One recent report (Bankrate.com, Aug. 23, 2006) had the average Libor rate at 1.10% for 1-year loans-a value considered high by many Western banks. Set up the null and alternative hypotheses for testing the reported value.*

Attitude: We assume that the null hypothesis H_0 is true, and uphold it unless data strongly speak against it (unless we gather enough evidence to reject it).

- Conclusions.
  1. Reject the null hypothesis H_0 (= support H_a); data provide strong evidence that H_a is true
  2. Fail to reject H_0 (= uphold H_0); data do not provide strong enough evidence that H_a is true

CAUTION (page 360) *Avoid the phrase "accept H_0"*. *Failing to reject null hypothesis H_0 does not mean that data support it. It only means that the **sample evidence is insufficient** to support the alternative hypothesis H_a.*

Test mechanics: From data we compute the value of a proper **test statistic**. If the difference between what we have observed and what is expected under the null hypothesis (H_O) assumption is statistically significant (= large enough) then we reject H_O in favor of H_A.

Test statistic (standardized test statistic**)** is a standardized sample statistic (z-score or t-score) computed from the data. The value of the test statistic is used in determining whether or not we may reject the null hypothesis.

$z = \dfrac{\bar{x} - \mu}{\sigma / \sqrt{n}}$ or $t = \dfrac{\bar{x} - \mu}{s / \sqrt{n}}$

The rejection region – a set of values of the test statistic for which the researcher will reject the null hypothesis H_0 in favor of H_a.

Errors

Type I error = the error of rejecting the null hypothesis H_0 when, in fact, H_0 is true. In other words it is the error of accepting H_a when, in fact, H_a is not true.

Type II error = the error of not rejecting the null hypothesis H_0 when, in fact, H_0 is false. In other words the error of not accepting H_a when, in fact, H_a is true.

Type I errors are denoted by letter α: type II errors by β

Examples:

1. H_O : *not guilty.*

Type I error - finding guilty, if a person actually is not
Type II error - finding not guilty, while a person actually is guilty

2. H_O : *new medicine is not better than the existing.*

Type I error – promoting a new drug, while it is not better than existing on the market

Type II error - not introducing the new, better drug.

Table 7-1 Type I and Type II Errors

		True State of Nature	
		The null hypothesis is true.	The null hypothesis is false.
Decision	We decide to reject the null hypothesis.	**Type I error** (rejecting a true null hypothesis) α	Correct decision
	We fail to reject the null hypothesis.	Correct decision	**Type II error** (failing to reject a false null hypothesis) β

Type I error is often <u>very serious</u> and in our decision we want to limit the probability of the type I error to a small number α, called the **significance level** or alpha level

The significance level α is the upper limit of type I error (set up before performing the test)

Interpretation of *α*:
If we perform a test at a significance level $\alpha = 0.05$, then P(type I error) ≤ .05

#7.16 p.366
One of the most pressing problems in high-technology industries is computer security. Computer security is typically achieved by using a *password-a* collection of symbols (usually letters and numbers) that must be supplied by the user before the computer permits access to the account. The problem is that persistent hackers can create programs that enter millions of combinations of symbols into a target system until the correct password is found. The newest systems solve this problem by requiring authorized users to identify themselves by unique body characteristics. For example, a system developed by Palmguard, Inc. tests the hypothesis H_0: The proposed user is authorized H_A The proposed user is unauthorized by checking characteristics of the proposed user's palm against those stored in the authorized users' data bank *(Omni,* 1984).

a. Define a Type I error and Type II error for this test.
Which is the more serious error? Why?

b. Palmguard reports that the Type I error rate for its system is less than 1%, whereas the Type n error rate is .00025%. Interpret these error rates.

Chapter 7.2 More about the hypothesis testing:

A **one-tailed test** of hypothesis is one in which the alternative hypothesis includes the symbol “ < ” or “ >.”

A **two-tailed test** of hypothesis is one in which the alternative hypothesis is written with the symbol “ ≠.”

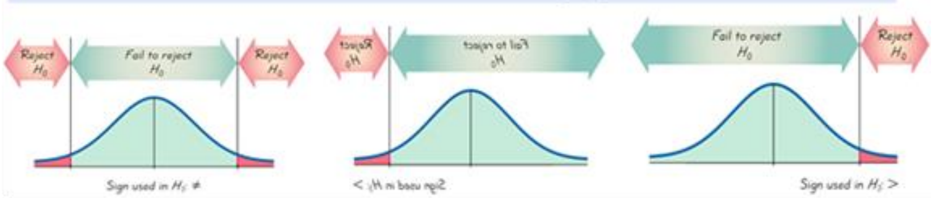
The rejection region is the region under the density function with the area equal *α*

For one-tail test the rejection region is in the tail of the size = alpha under standard normal distribution.
For two-tails-test the rejection region consists of two tails, each of the size = alpha/2 (total size of both tails = alpha)

If the test statistic z falls in the rejection region you should reject null hypothesis (in favor of alternative hypothesis)

Two-Tailed	Left-Tailed	Right-Tailed
$H_0: \mu = \mu_0$	$H_0: \mu = \mu_0$	$H_0: \mu = \mu_0$
$H_1: \mu \neq \mu_0$	$H_1: \mu < \mu_0$	$H_1: \mu > \mu_0$

Note: μ_0 is the assumed value of the population mean.



Example:
Suppose that the significance level of a one-tail test to be α = 0.05.
Question: *What should be the rejection region?*
Answer: *It should be* $z > z_{0.05}$, *because then P(type I error) =* $P(z > z_{0.05}) = 0.05$

The rejection region at significance level α = 0.05 *is* $z > 1.645$

Exercise 7.8
7.8 For each of the following rejection regions, sketch the sampling distribution for *z* and indicate the location of the rejection region.

a. z > 1.96
b. z > 1.645
c. z > 2.576
d. z < − 1.282
e. z < − 1.645 or z > 1.645
f. z < − 2.576 or z > 2.576
g. For each of the rejection regions specified in parts **a–f,** what is the probability that a Type I error will be made?

Example: 7.10 p. 366 Play Golf America program. The Professional Golf Association (PGA) and *Golf Digest* have developed the Play Golf America program, in which teaching professionals at participating golf clubs provide a free 10-minute lesson to new customers. According to *Golf Digest* (July 2008), golf facilities that participate in the program gain, on average, $2,400 in greens, fees, lessons, or equipment expenditures. A teaching professional at a golf club believes that the average gain in greens fees, lessons, or equipment expenditures for participating golf facilities exceeds $2,400.

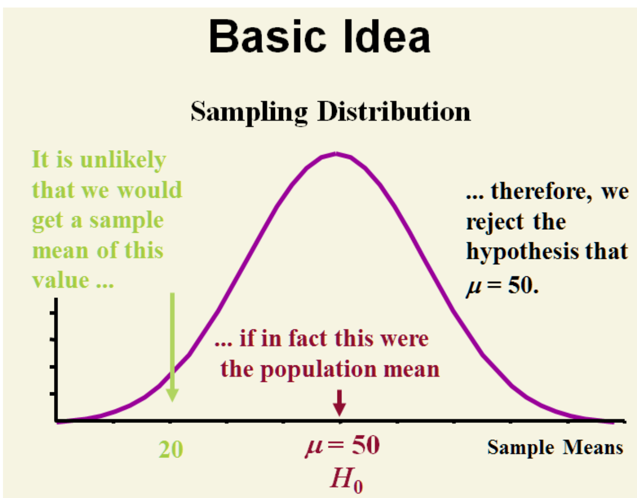
a. In order to support the claim made by the teaching professional, what null and alternative hypotheses should you test?

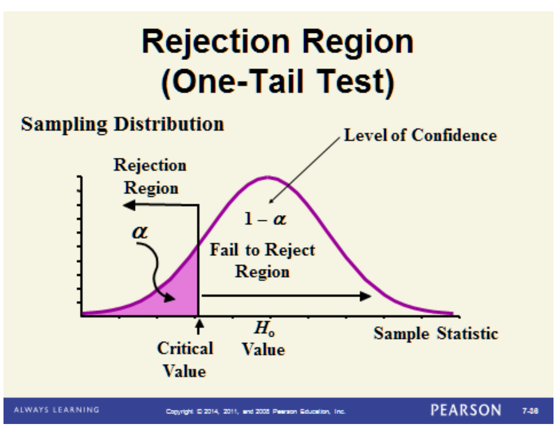
H_O: ***H_A:***

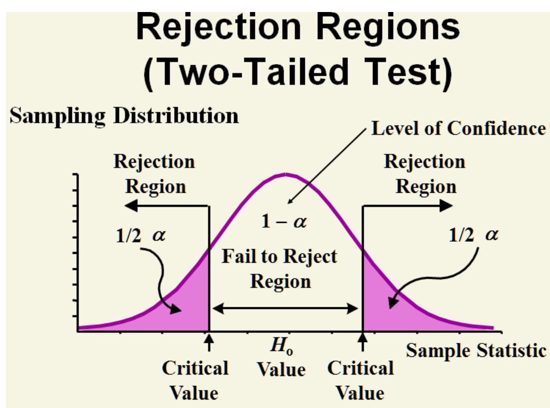
b. Suppose you select α = .05 . Interpret this value in the words of the problem.

c. For α = .05 , specify the rejection region of a large-sample test.

Summary 7.1-7.2 few additional illustrations







7.3 Observed Significance Level: P-value

Because of an extensive use of computer software**, the modern method of testing is to simply find the smallest significance level α at which H_0 can be still rejected** (called **p-value**)

p-value, for a specific statistical test is the probability that, assuming that H_0 is true, the test statistic takes the observed or even more extreme value.

P-value is also called "observed significance level", because it is the smallest value of *alpha* for which H_0 can be rejected.

Finding P-value

1. One tail test:

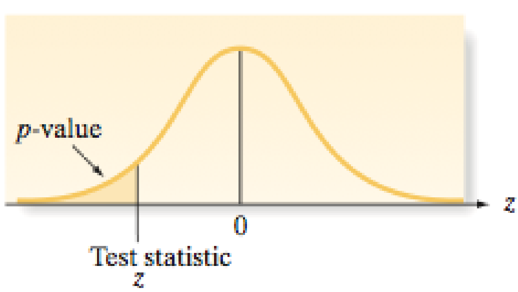
- If Ha: parameter < a (left, or lower tail test) find test statistic and then find the area under the graph to the left of the statistic:

  On TI-83/84: P-value=normalcdf(-10^9, test statistic)
- If Ha: parameter > a (right, or upper tail test) find test statistic and then find the area under the graph to the right of the statistic:

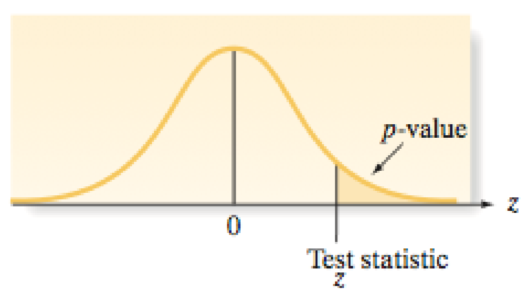
  On TI-83/84: P-value=normalcdf(test statistic, 10^9)

2. Two-tails test:

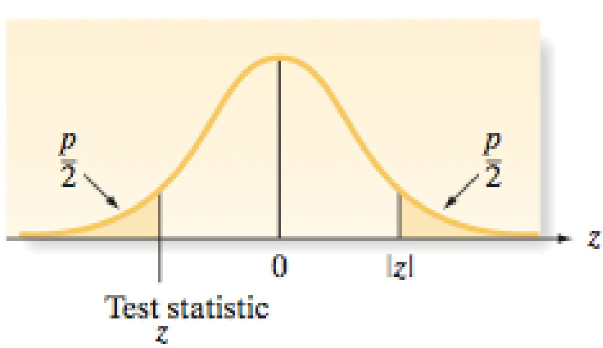
If Ha: parameter ≠ a find test statistic, then find the area under the graph on a tail marked by the test statistic and MULTIPLY BY 2:



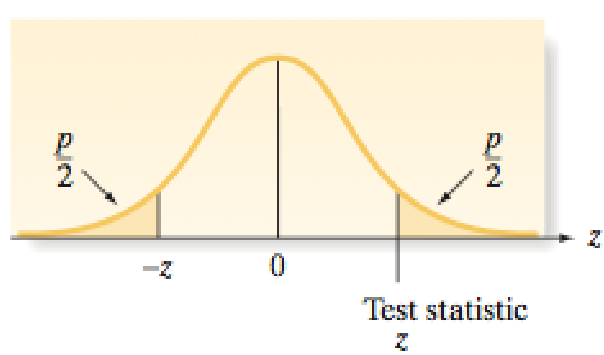
a. Lower-tailed test, H_a: $\mu < \mu_0$



b. Upper-tailed test, H_a: $\mu > \mu_0$



a. Test statistic z negative



b. Test statistic z positive

Making a decision while basing on P-value

If P-value < α then reject null hypothesis (and support alternative)
If P-value > α then fail to reject null hypothesis (not enough evidence to support alternative)

Exercises:
Learning the Mechanics
7.19 Consider the test of $H_0: \mu = 7$. For each of the following, find the *p*-value of the test:

a. $H_a: \mu > 7$, $z = 1.20$

b. $H_a: \mu < 7$, $z = -1.20$

c. $H_a: \mu \neq 7$, $z = 1.20$

7.21 For each α and observed significance level (*p*-value) pair, indicate whether the null hypothesis would be rejected.

a. $\alpha = .05$, p-value $= .10$

b. $\alpha = .10$, p-value $= .05$

7.24 In a test of the hypothesis $H_0: \mu = 10$ versus $H_a: \mu \neq 10$, a sample of $n = 50$ observations possessed mean $\bar{x} = 10.7$ and standard deviation $s = 3.1$. Find and interpret the *p*-value for this test.

7.26 In a test of $H_0: \mu = 75$ performed using the computer, SPSS reports a two-tailed *p*-value of .1032. Make the appropriate conclusion for each of the following situations:
c. $H_a: \mu > 75$, $z = 1.63$, $\alpha = .10$
d. $H_a: \mu \neq 75$, $z = -1.63$, $\alpha = .01$

Exercise: In a test of the hypothesis H_O: μ= 10 versus Ha: μ< 10 a sample of n = 50 observations possessed mean 9.2 and standard deviation s = 3.1.

a. Find the observed value of the test statistics ……………………………………

b. Find, draw, and interpret the p-value for this test.

P-value = ……………

Interpretation ………………………………………

c. What is your conclusion at significance level α = 0.01 ……………………

d. What is your conclusion at significance level α = 0.025……………………

e. What is your conclusion at significance level α = 0.05 ……………………

f. What is your conclusion at significance level α = 0.10 ……………………

7.4 Test of Hypothesis about a Population Mean μ: Normal (z) Statistic

When testing a hypothesis about a population mean μ, the test statistic we use will depend on whether the sample size n is large (say, $n \geq 30$) or small, and whether or not we know the value of the population standard deviation σ,

This section treats the large-sample case.

Large-Sample Test of Hypothesis about a Population Mean μ

1. Assumptions:

- Random sample
- Large sample size n ($n \geq 30$)
- The population standard deviation σ known
- No assumptions about the population distribution

2. Hypotheses:

- Null hypothesis H_O: use "="
- Alternative hypothesis Ha: use either ">", "<" or "≠"

3. Test statistic: $z = \dfrac{\bar{x} - \mu}{\sigma / \sqrt{n}}$

4. Distribution of the test statistic under H_0: z-distribution

5. Testing methods:
The <u>Rejection Region</u>: defined by significance level alpha
Or
The <u>P-value</u>: depends on the test statistic and the operator used in Ha

6. Decision:

- If the test statistic is in the rejection region reject H_0 **at the α level of significance.** Otherwise fail to reject H_0.
- If P-value is less than the significance level alpha reject H_0 **at the α level of significance.** Otherwise fail to reject H_0.

Example: One-Tailed *z*-Test
State University uses thousands of fluorescent light bulbs each year. The brand of bulb it currently uses has a mean life of 800 hours. A competitor claims that its bulbs, which cost the same as the brand the university currently uses, have a mean life of more than 800 hours. The university has decided to purchase the new brand if, when tested, the evidence supports the manufacturer's claim at the .05 significance level. Suppose 121 bulbs were tested with the following results: sample mean was 830 hours, and sample standard deviation = 110 hours. Conduct the test using α=5%.

Steps:
a. State the parameter of interest and check if the assumptions are met.

…………………………………………………………………………………………..
b. Give the null and alternative hypotheses

H_0: ………………….. Ha: …..…………….. The form of the test (left/right/two tails).

c. Collect and label the information

x-bar=……………… s = ………………n=…………...

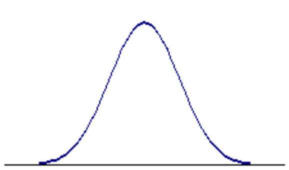
d. Write the formula for the test statistic and find the observed value of the test statistic

Test statistic – the formula: ……………………

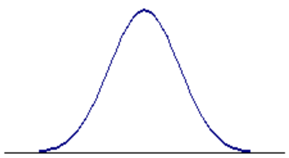
The observed value of the test statistic………….

e. Give the rejection region using α = .05. ………………………

f. Draw the rejection region and mark the value of the test statistics on the graph



g. Find P-value, place it on the graph;



compare with the significance level alpha: ………………………………..

h. State the appropriate conclusion for the hypothesis test

- Reject / Fail to reject Ho at significance level ……………..
- Conclude that ………………………………………………………

Exercise:
7.28 Consider the test $H_0 : \mu = 70$ versus $H_a : \mu > 70$ using a large sample of size n = 400 . Assume $\sigma = 20$.

a. Describe the sampling distribution of $\bar{x}$.
b. Find the value of the test statistic if $\bar{x} = 72.5$.
c. Refer to part **b.** Find the *P*-value of the test.
d. Find the rejection region of the test for $\alpha = .01$.
e. Use the *P*-value approach to make the appropriate conclusion.
f. Repeat part **e**, but use the rejection region approach.
g. Do the conclusions, parts **e** and **f**, agree?

Exercise: <u>Two-Tailed *z*-Test</u> (Handout!)
Does an average box of cereal contain **368** grams of cereal? A random sample of 4**0** boxes had $\bar{x}$ **= 372.5**. The company has specified ***s*** to be **25** grams. Test at the **.05** level of significance

Exercise: <u>One-Tailed *z*-Test</u>
Does an average box of cereal contain **more than 368** grams of cereal? A random sample of **40** boxes showed $\bar{x}$ = **372.5**. The company has specified **s** to be **25** grams. Test at the **.05** level of significance.

<u>7.5 Test of Hypothesis about a Population Mean μ: Student's t-Statistic</u>

This section deals with the case when the sample size is small and σ is not known. We must assume that the population is normal.

Small-Sample Test of Hypothesis about a Population Mean μ
1. Assumptions:

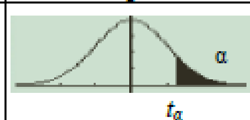
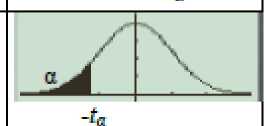
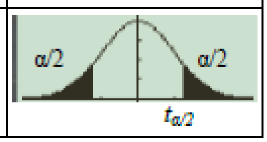
- Random sample
- Small sample size
- Population distribution is normal
- Population standard deviation σ is not known

2. Hypotheses:
- Null hypothesis H_O: μ= c
- Alternative hypothesis Ha: μ> c or Ha: μ< c or Ha: μ≠ c

3. Test statistic: $t = \dfrac{\overline{x} - \mu}{s/\sqrt{n}}$

4. Distribution of the test statistic under H_0: t-distribution with *df = n-1*

5. <u>Rejection region</u> - depends on the form of an alternative hypothesis and the significance level α:

H_a	Rejection Region	Graph
H_a: $\mu > \mu_0$	$t > t_\alpha$, where $P(t > t_\alpha) = \alpha$	
H_a: $\mu < \mu_0$	$t < -t_\alpha$, where $P(t < -t_\alpha) = \alpha$	
H_a: $\mu \neq \mu_0$	$\lvert t \rvert > t_{\alpha/2}$, where $P(t > t_{\alpha/2}) = \alpha/2$	

6. Conclusions: If the observed value of the test statistic falls in the rejection region, reject H_0 **at the α level of significance.**

If the observed value of the test statistic does not fall in the rejection region, do not reject H_0. The data do not provide sufficient evidence to reject H_0 **at the α level of significance.**

In both cases, refer to the claim

7. P-value – computation depends on the form of an alternative hypothesis. If we denote the observed value of the test statistic by $t_{observed}$, then

Ha: μ> 0	p-value = $P(t > t_{obs})$
Ha: μ< 0	p-value = $P(t < t_{obs})$
Ha:μ ≠ 0	p-value = $P(\lvert t \rvert > \lvert t_{obs} \rvert)$

(Make a sketch for each situation above)

REMARKS:

1. If σ is known and the population is normal, then use the z-test statistic (which under H_0 has the standard normal distribution). The rejection region and the p-value are computed from z-distribution

2. If the sample size *n* is small, and the population distribution is NOT normal, then the methods developed in this chapter **cannot** be used.

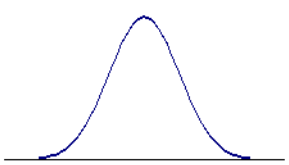
Exercise (Two tails case)
Does an average box of cereal contain **368** grams of cereal? A random sample of **25** boxes had a mean of **372.5** and a standard deviation of **12** grams. Test at the **.05** level of significance

a. State the parameter of interest. ………………
.
b. Give the null and alternative hypotheses H0: ………. Ha: ……………..

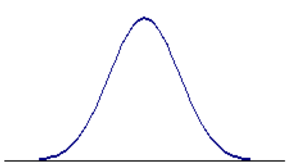
c. Find sample mean and sample standard deviation x-bar= ……… s = ……..

d. Find the observed value of the proper test statistic ……………………………..

e. Give and graph the rejection region at α= .01 ………………………………



f. Compute and graph the p-value for this test. *P-value* = ……………….



g. State the conclusion for the hypothesis test

h. Repeat the test using TI-83 [STAT → TEST → 2:T-Test]

Exercise [7.50, p.384]
A sample of five measurements was taken from a normally distributed population. Sample statistics are x-bar=4.8 and s=1.3

a. Test the null hypothesis that the mean of the population is 6 against the alternative hypothesis, μ < 6, at a significance level α = .05. Use the *rejection region method* . Answer all parts

observed value of the test statistics …………………… t=(4.8-6)/(1.3/sqrt(6))=-2.26
rejection region …$t<t_0$; t_0=-2.02……
conclusion at α = .05 ……Reject Ho at alpha 5%; conclude that the mean measurement is less than 6.

b. Test the null hypothesis that the mean of the population is 6 against the alternative hypothesis, μ ≠6. at a significance level α = .05. Use the *rejection region method.* Answer all parts

observed value of the test statistics …as above……………………..
rejection region … $t<-t_0$ or $t>t_0$; t_0=2.571……….
conclusion at α = .05 Fail to reject Ho at alpha 5%; not enough evidence to conclude that the mean measurement is less than 6.

c. Find the observed significance level (p-value) for each test. Use a calculator or software. Then repeat parts a. and b. using the *p-value method*.

Test a: p-value P(t<-2.26)=tcdf(10^9,-2.26,5)=0.0366, conclusion Reject Ho at alpha 5%; conclude that the mean measurement is less than 6.
Test b: p-value P(|t|>2.26)=2*tcdf(10^9,-2.26,5)=0.0733
conclusion …… Fail to reject Ho at alpha 5%; not enough evidence to conclude that the mean measurement is less than 6.

7.6 Large-Sample Test of Hypothesis about a Population Proportion *p*

> Recall that for large n (i.e. when $np \geq 15$ and $nq \geq 15$, where $q = 1\text{-}p$) the sampling distribution of the sample proportion $\hat{p}$ is approximately normal with the mean
> $\mu_{\hat{p}} = p$ and the standard deviation $\sigma_{\hat{p}} = \sqrt{\frac{pq}{n}}$

NOTE: This implies that for large *n,* a binomial distribution with parameters *n* and *p (i.e. the distribution of the number of successes x* = in the sample) is approximately normal with mean and standard deviation as above.

Test of Hypothesis about a Population Proportion *p*
1. Assumptions:

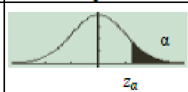
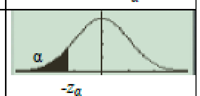
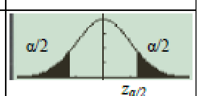
a. Random sample
b. Large sample size, both $np_0 \geq 15$ and $nq_0 \geq 15$, where $q_0 = 1-p_0$

2. Hypotheses:
a. Null hypothesis H_O: $p = p_0$
b. Alternative hypothesis Ha: $p > p_0$ or Ha: $p < p_0$ or Ha: $p \neq p_0$

3. Test statistic: $z = \frac{\hat{p}-p_0}{\sqrt{\frac{p_0 q_0}{n}}}$ where $q_0 = 1 - p_0$

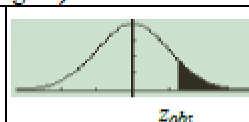
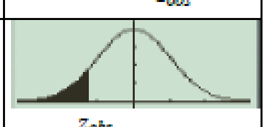
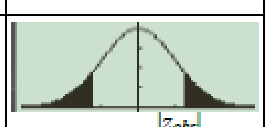
4. Distribution of the test statistic under H_0: standard normal (z-distribution)

5. Rejection region - depends on the form of an alternative hypothesis and the significance level α:

H_a	Rejection Region	Graph
H_a: $p > p_0$	$z > z_\alpha$, where $P(z > z_\alpha) = \alpha$	
H_a: $p < p_0$	$z < -z_\alpha$, where $P(z < -z_\alpha) = \alpha$	
H_a: $p \neq p_0$	$\lvert z\rvert > z_{\alpha/2}$, where $P(z > z_{\alpha/2}) = \alpha/2$	
H_a	Rejection Region	Graph

6. Conclusions:
a. If the calculated test statistic falls in the rejection region, reject H_0 and support Ha.
b. If the test statistic does not fall in the rejection region, uphold H_0. State that the sampling experiment does not provide sufficient evidence to reject H_0 at the α level of significance.

7. P-value – computation depends on the form of an alternative hypothesis. If we denote the observed value of the test statistic by z_{obs}, then

H_a	p-Value (= area of shaded region)	
H_a: $p > p_0$	p-value $= P(z > z_{obs})$	
H_a: $p < p_0$	p-value $= P(z < z_{obs})$	
H_a: $p \neq p_0$	p-value $= P(\lvert z\rvert > \lvert z_{obs}\rvert)$	

8. Decision Rule based on the p-value**.** Given a significance level α
if p-value < α, then reject H_O at the significance level α
if p-value ≥ α, then don't reject H_O at the level α
(Finally, refer to the stated claim and either support or don't support it).

Exercise [7.64, page 391]
Suppose a random sample of 100 observations from a binomial population (= population with unknown proportion *p* of items of some type) gives a value of p-hat = .63 and you wish to test the null hypothesis that the population parameter *p* is equal to .70 against the alternative hypothesis that *p* is less than .70. Use large sample z-test
a. Write the null and alternative hypotheses, H_0: ………. Ha: ……………..

b. Give and graph the rejection region at α= .05. ………………

c. Find the observed value of the test statistic ………………

d. State the conclusion for the hypothesis test ………………

e. Find and interpret the observed significance level (p-value) of the test you conducted.

Ans. p-value = ……………..
f. Repeat part e using TI-83 [STAT → TEST → 5:1-PropZTest]

Exercise: You're an accounting manager. A year-end audit showed 4% of transactions had errors. You implement new procedures. A random sample of 500 transactions had 25 errors. Has the proportion of incorrect transactions changed at the .05 level of significance?

a. Calculate a point estimate for p. ………………

b. Set up the null and alternative hypotheses to test this claim

H0: ………. Ha: ……………..

c. Calculate the test statistic for the test. *Ans*. ……………….

d. Find the rejection region for the test if α= .05. *Ans*. ………………

e. Make the appropriate conclusion. *Ans*. ………………

Use TI-83 to find the p-value and repeat part e. *Ans. p-value* = ……………..

Additional Exercises – use TI-83/84 to solve problems

Ch. 6-7 Summary: Which option to use on TI-83?

Parameter	Sample Size	Population	σ	Conf. Int.	Test
Mean μ	Large	Any	Known or unknown	Z-Interval	Z-Test
	Small	Normal	Known	Z-Interval	Z-Test
	Small	Normal	Unknown	T-Interval	T-Test
Proportion *p*	Large	N/A	N/A	1-PropZInt	1-PropZTest

Exercises: Solve the following problems using TI-83/84. State any assumptions that you need to make and interpret the results.

1. Of 346 items tested, 16 are found to be defective. Construct a 98% confidence interval for the percentage of all such items that are defective.

2. Is the mean lifetime of particular type of car engine different than 220,000 miles? To test this claim, a sample of 23 engines is measured, yielding an average of 226,450 miles and a standard deviation of 11,500 miles. Use a significance level of 0.01.

3. A sociologist develops a test to measure attitudes about public transportation, and 55 randomly selected subjects are given the test. Their mean score is 76.2 and their standard deviation is 21.4. Construct the 95% confidence interval for the mean score of all such subjects.

4. The U.S. Department of Labor and Statistics released the current unemployment rate of 15.3% for the month in the U.S. and claims the unemployment has not changed in the last two months. However, the states statistics reveal that there is a decrease in the U.S. unemployment rate. A test on unemployment was done on a random sample size of 1000 and found unemployment at 13.8%. Test an appropriate hypothesis and state your conclusion. Use a significance level of 0.05.

5. A state university wants to increase its retention rate of 4% for graduating students from the previous year. After implementing several new programs during the last two years, the university reevaluated its retention rate using a random sample of 360 students and found the retention rate at 5%. Test an appropriate hypothesis and state your conclusion. Use a significance level of 0.02.

6. The principal randomly selected six students to take an aptitude test. Their scores were: 83.9 73.7 82.1 88.5 87.2 83.3

Determine a 90% confidence interval for the mean score for all students in the school

7. Solve the previous problem assuming that the standard deviation of this aptitude test is known to be $\sigma = 4.8$

"To do" list for Hypotheses Testing

a. **What is being tested?** The population mean, or population proportion? _______

b. **Hypotheses.** H_0: ___________ vs. H_1: ________________.
(Hint: circle the claim)

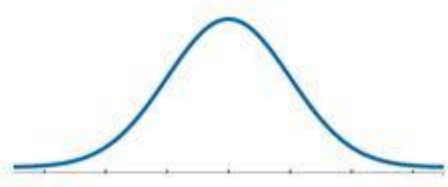
c. **Type of the test :** Right/Left Tail or Two-Tail Test? __________

Significance level: α=…….. (if not given, 5%)

d. Calculate test statistic:

e. Choose the method or use both

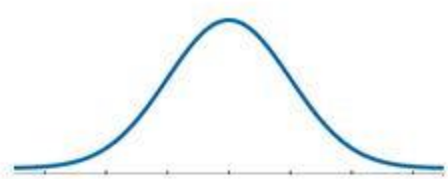
I Rejection region: Find the critical value and mark clearly the rejection region and critical value on the graph.



If α = ____ then z_α =__________,

Test statistic **is / is not** in the rejection region.

II: P-value method:



P-value=____________________ (Mark clearly P-value and the test statistic)

Compare with α: **P-value< α or P-value > α?**

f. The conclusion (Two statements):

a) Reject/fail to reject H_0

b) Support / do not support the claim that