Your Name: _____

Section: _____

36-201 INTRODUCTION TO STATISTICAL REASONING
Computer Lab #12 [there was no lab #11]
Confidence Intervals and Hypothesis Testing

Objectives:

1. To specify the null and alternative hypothesis in several different research settings.
2. To use exploratory methods (i.e., boxplots and numerical summary measures), confidence intervals, and p-values to evaluate the evidence in a data set in support of the null hypothesis.

Getting Started

For today's lab you will need to copy 2 data files using the file server. **The data files are text formated files called** *salary.dat, anorexia.dat.* Copy the files now.

Statistical Background

Definitions: A review

(1) A Hypothesis in statistics refers to a statement about a feature of the population. Specifically, a hypothesis is a statement about the value(s) of a population parameter.

(2) The Null Hypothesis, (H_0), is a statement that the parameter is equal to some specified number. Some examples are:

"$p = 1/2$",

"$\mu_1 - \mu_2 = 0$"

"The mean REM latency μ for depressed patients is *equal to* 50 minutes."

(3) The Alternative Hypothesis, (H_a), is also called the *motivating or research hypothesis.* It is the opposite of the null hypothesis. Some examples are:

"$p \neq 1/2$",

"$\mu_1 - \mu_2 \neq 0$"

"The mean REM latency μ for depressed patients is *not equal to* 50 minutes."

(4) A Significance Test is based on a test statistic that shows whether or not the data provide evidence against the null hypothesis.

(5) The p-value is a number between 0 and 1 that measures the weight of the evidence in the data *against* H_0. Small p-values indicate strong evidence against H_0. If the p-value of a test is smaller than a specific value, such as 0.05, then the data are said to provide statistically significant evidence *against* H_0.

♣ **Question #1 Consider the following situation: "A sociologist is interested in whether a different percentage of female high school students in the U.S. will say that biology is their favorite subject than male high school students. She interviews a random sample of high school students based on a national probability sample."**
(i) What is the population?
(ii) What are the parameters of interest?
(iii) State an appropriate null hypothesis and alternative hypothesis for this study.

Example #1: Statistical Comparison of Faculty Salaries

Use **Open Worksheet** to open the text data file called *salary.dat*. This data file contains the 1973-1974 salaries in dollars for the female (F.SALARY) and male (M.SALARY) faculty members in the department of early and elementary education at the University of Maryland. We are interested in whether there is a difference in the salaries between the female and male faculty.

Question #2 Is this study an experiment? Why or why not?

We are interested in the relationship between SALARY, the response variable, and GENDER, the explanatory variable. However, the data are not presented in this format. What is given to us is the salary for males and the salary for females. To make a boxplot using **Boxplot Y by X** we need to change the format of the data. We already know how to use Minitab to do this. Hint: Use the **Stack** command and create variables called *salary* and *gender*.

Important: You need to surround the variable names in single (') quotes if you want to use them instead of the column numbers, i.e. 'm.salary')

Question #3 Make a boxplot of SALARY by GENDER. Describe and compare the distribution of salaries in the two groups.

Question #4 In the table below, enter the values for the following numerical summary measures. (Use **Stat** $\rightarrow$ **Basic Statistics** $\rightarrow$ **Descriptive Statistics**).

	Female Faculty	Male Faculty
$\bar{x}$		
SD		
Median		
IQR		

Find the difference between the sample mean salary for males and sample mean salary for females.

Question #5 We want to find a 95% confidence interval for the <u>difference</u> between the 2 means. To do this, from the **Stat** menu, select the **Basic Statistics** sub-menu, and choose **2-sample t**. You can use either the stacked column and subscripts with "Samples in one column" or you can use the original two columns with "Samples in different columns". You will get the same results. Write down the interval for the difference between the mean salary for the two groups.

Question #6 Is the value 0 contained in your interval? Why is 0 an important value to consider? Interpret the above interval in the context of the problem.

♣ Question #7 Find a 90% confidence interval for the <u>difference</u> between the 2 means. Write down the interval for the difference between the mean salary for the two groups. Is the value 0 contained in your interval? Interpret the interval in the context of the problem.

Question #8 What feature(s) of the data present in your boxplot will make you cautious about how you interpret your confidence intervals for these data. Why?

Question #9 We next want to do a significance test for these two means. An alternative hypothesis (H_a) of interest is that the population mean salary for female faculty, μ_f, is different from the mean salary for male faculty, μ_m. In words, write-out the *null hypothesis*. (See definition (3)).

From the **Edit** Menu, choose **Edit Last Command Dialog**. Change the Confidence Level back to 95.0. *Click* **OK**.

Question #10 Below is a copy of what you should have in your Session window:

```
Two Sample T-Test and Confidence Interval

Twosample T for m.salary vs. f.salary

           N     Mean     StDev   SE Mean
m.salary  17    17899      3907       948
f.salary  13    15535      2648       734

95% C.I. for mu m.salary - mu f.salary: (-96, 4825)
T-Test mu m.salary = mu f.salary (vs not =): T= 1.97  P=0.059  DF=27
```

(i) Circle and label the *null hypothesis.*
(ii) Circle and label the *alternative hypothesis.*
(iii) What is the difference between the two sample means?

Question #11 Note that the last line in the window which reads **P=0.059** is the p-value. Based on this p-value how would you evaluate the evidence against H_0? (See definition (5).)

♣ Question #12 Based on all of the analyses that you have done (boxplot, confidence intervals and significance test), what conclusions would you make about the differences in the mean salaries between female and male faculty?

Boxplots:

Confidence Intervals:

Significance Test:

Do you reach different conclusions about the relationship between salary and gender using these different methods? Why do you think this is?

We are done with this example. From the **File** menu, choose **Restart Minitab**. Do not save any changes.

Example #2. Statistical Comparison of Two Treatments for Anorexia

In this example you will practice the methods that you learned in Example #1.

A research psychologist is interested in treating anorexia nervosa, an eating disorder that occurs mostly in young women and results in weight loss and the inability to gain weight. Specifically, she is interested in the effect of two different types of counseling, psychodynamic counseling and behavioristic counseling, on weight gain in young women with anorexia. Thirty young women with anorexia are randomly assigned to two different counseling groups. At the beginning of the study their weights are measured. Then after the study their weights are measured again. The outcome variable of interest is the change in weight or weight gain over the course of the study. *The psychologist would like to know whether women who receive behavioristic counseling have a* **different** *weight gain than women who receive psychodynamic counseling.*

Use **Open Worksheet** to open the text data file called *anorexia.dat.* There are 2 variables in the file. B.WT-GAIN is the weight gain (in pounds) for the women who received behavioral counseling; P.WT-GAIN is the weight gain (in pounds) for the women who received psychodynamic counseling.
Question #13 What is the response variable and what is the explanatory variable in this study? Are the response variable and the explanatory variable quantitative and/or categorical variables? Is this study an experiment? Why or why not?

♣ Question #14. In words, state the null hypothesis and state the alternative hypothesis for this experiment. (See definitions (2) and (3).)

To make an appropriate boxplot you need to follow the steps described right before question #3.

Question #15 Make boxplots of the distribution of weight gain for the two counseling groups. From the boxplots what are the approximate median weight gains for each group? Are there any features of the data that make you concerned about using confidence intervals for these data?

Question #16 Based on your boxplots describe the effects of the two types of counseling on weight gain. Do you think these data provide evidence for or against H_0? Explain.

Question #17 Find the following numerical summary measures:

	Behavioral	Psychodynamic
$\bar{x}$		
SD		
Median		
IQR		

What is the difference in the mean weight gain between the two groups?

Question #18 Find a 95% confidence interval for the <u>difference</u> between the 2 means. Write down the interval for the difference between the mean weight gain for the two groups.

Question #19 Based on this interval would you say that there is a differential effect on weight gain due to the type of counseling a woman received? Why or why not?

Question #20 What is the p-value for H_0? (Be sure to choose the correct alternative hypothesis.) Based on this p-value, how would you evaluate the evidence against H_0? Explain.

♣ Question #21. Based on all of the analyses that you have done, (boxplot, confidence interval and significance test), what conclusion would you make about the relative effects of behavioristic counseling versus psychodynamic counseling on weight gain in young women with anorexia nervosa?

Boxplots:

Confidence Interval:

Significance Test:

Summarize:

Remember to **delete** *files and folders that you might have created*