**Chapter 19.   Inference on Two Means**

1.  Why are the problems in this chapter the most interesting questions in statistics classes?

2.  How do I identify when I need to use "paired t" methods (Ch. 18)  and when I need to use "2-sample" methods (Ch. 19)?

3.  What are the conditions needed to do a 2-sample t-procedures?   (And how are they "easier to meet" than even the conditions for the 1-sample t-procedures?)

4.  When I use 2-sample methods, what is the test statistic, its degrees of freedom, and how do I find the p-value?  (And how are they similar and different to the 1-sample methods?)

5.  Can we finally quit drawing a picture of the sampling distribution of the sample mean for every hypothesis test?  Why?

6.  What do I need to know about "Details of the t Approximation"?

7.  What do I need to know about "Avoid the **Pooled** 2-sample t procedures"?

8.  What do I need to know about "Avoid Inference about Standard Deviations"?

9.  Is there anything special to know about using software for two-sample t procedures?

10. How can I begin to see the overall pattern of these four chapters?

11. Additional practice in class, as we have time:  19.38, 19.33, 19.32

**Discussion:**

1.  Why are the problems in this chapter the most interesting questions in statistics classes?

    Answer:  Look at Exercise 19.35.   We've been talking about this study in several chapters so far – asking questions about one sample or another from it.  But do you see that the question here is the really interesting one – if you were a waitress?    When we learned about producing data (Chs 8 and 9) we were often interested in comparing two groups.   We compare two groups using techniques in Ch. 18 (and Ch. 21, about comparing two proportions.) I think that two-group comparisons are the most interesting and useful techniques of Elementary Statistics.

2.  How do I identify when I need to use "paired t" methods (Ch. 18)  and when I need to use "2-sample" methods (Ch. 19)?

    Answer:   This can be simple or tricky.  You must focus on how the sample was chosen or the experiment was set up.   Were the subjects chosen individually or in pairs?  If they were chosen in pairs, then they don't meet the condition of "independent samples" needed for 2-sample methods.   Practice with exercises 19.1 – 19.4 in the first section of Chapter 19.

3.  What are the conditions needed to do a 2-sample t-procedures?   (And how are they "easier to meet" than even the conditions for the 1-sample t-procedures?)

**Randomization**.  The data must be collected with suitable randomization techniques.  For a survey, two independent separate SRS's from two separate pop'ns.  For an experiment, an appropriate randomized design.

**Shape of the pop'n distributions**.

    a. It's best to have equal or approximately equal samples from the two populations.  If so, then if the two dist'ns have the similar shapes, it is acceptable to use *t*-procedures even for sample sizes as small as _____.

    b. In any case, it is acceptable to _____ and then use the criteria for *t*-procedures of one mean on the _____.

4. When I use 2-sample methods, what is the test statistic, its degrees of freedom, and how do I find the p-value?  (And how are they similar and different to the 1-sample methods?)

   Answer:  It's a t-statistic, so we use t-methods.  Various things are more complicated, since we have two population means, two sample means, etc.  Here is the comparison for hypothesis tests.

$$H_O : \mu = \mu_o \qquad\qquad\qquad\qquad H_O : \mu_1 = \mu_2$$

$$t = \frac{\bar{x} - \mu_o}{\frac{s}{\sqrt{n}}} \qquad\qquad\qquad\qquad t = \frac{(\bar{x}_1 - \bar{x}_2) - 0}{\sqrt{\frac{s_1^{\,2}}{n_1} + \frac{s_2^{\,2}}{n_2}}}$$

   We also have two options (page 470 in "Two-sample t procedures) for the degrees of freedom, depending on whether we are doing the problem by hand or software.   Software gives a more accurate df, but NO ONE would compute that df by hand!!

   See the computations Examples 19.2, 19.3, and 19.4  (Section "Two Sample t procedures), Practice with Exercise 19.9 (Section "Robustness Again.")

5. Can we finally quit drawing a picture of the sampling distribution of the sample mean for every hypothesis test?  Why?

   Yes.  It seems more complicated to deal with the statistic now and so the picture is not as "intuitive" as it was before.   I prefer that you continue to focus on what you knew from the one-sample pictures.

6. What do I need to know about "Details of the t Approximation"?

   Answer:  Only that you should NOT do this by hand.   But it is useful to know how software is getting their answer.   (This more accurate df formula gives a number between the smaller of the two sample sizes minus one and the sum of the two sample sizes minus 2.)

7. What do I need to know about "Avoid the **Pooled** 2-sample t procedures"?

Answer:  Only that, when software offers you the option to do pooled 2-sample t-procedures, DO NOT choose that.

8. What do I need to know about "Avoid Inference about Standard Deviations"?

    Answer:  We avoid these inferences here because the usual methods are VERY non-robust against deviations from normal distributions for the populations.  Since our whole way of thinking about these chapters is based on using robust procedures, then the procedures for standard deviation don't fit well here.

9. Is there anything special to know about using software for two-sample t procedures?

    • Both Minitab and Crunch-It will let you use any of these three forms for the data:  in separate columns, "summarized", and "grouped."

    • Both will give you the means and standard deviations of both samples, as well as the value of the t-statistic, etc.  Both will use the more accurate df.   They may differ in their answers to that, because they round differently.   Either will be counted correct.

    • Both will give you an opportunity to use "Pooled" procedures, which we DO NOT DO. Crunch-It calls that "Pooled" and Minitab calls it "Assume equal variances".

    • Minitab gives you the option of including graphs to compare the two groups graphically. Crunch-It does not.  (However, you can use Graph>Boxplots in CrunchIt to do comparative boxplots for grouped data.)

10. How can I begin to see the overall pattern of these four chapters?

    Answer:   I will give you two handouts – one on the formulas and one on the conditions.  Both of those will be attached to your Test 4 when you take it.   Those are now posted in the "Detailed Course Calendar" on our web page under the "Summary for Test 4."   Since they cover 4 chapters,  I am not handing them out until after we get well into Chapter 19, which is our second chapter, because I think they might be too intimidating before then.

**Quiz 11**:  Due at the beginning of class Wed. April 10.

19.40, 20.2, 20.28, 20.34, 20.38
As you do your homework, be sure to do enough "by hand" to make sure that you can find t-scores and use the t-table appropriately on Test 4.  Then you can do the rest using software.