

ST 411/511, D. Schafer, **FINAL EXAM**, Winter 1999, Open-book. 1 hr. 50 min.

**NAME:** \_\_\_\_\_ **STUDENT ID NO.** \_\_\_\_\_

**A. (24 points)** Write the letter corresponding to the term from the list at the bottom of the page that best matches each of the following descriptions.

1. \_\_\_\_\_ In regression, the variable whose mean is to be described as a function of the explanatory variable.
2. \_\_\_\_\_ The type of confidence level to control if data snooping is used.
3. \_\_\_\_\_ A way to test whether the mean of  $y$  is zero when  $x$  is zero (in simple linear regression).
4. \_\_\_\_\_ The set of all hypothesized values of a parameter that, when tested, have two-sided  $p$ -values greater than .05.
5. \_\_\_\_\_ A way to organize the calculations associated with an extra-sum-of-squares  $F$ -test.
6. \_\_\_\_\_ An observation that is thought to be far from its estimated mean.
7. \_\_\_\_\_ A robust and resistant alternative to the two-sample  $t$ -test.
8. \_\_\_\_\_ A method for estimating parameters so that the sum of squared residuals is minimized.
9. \_\_\_\_\_ The distribution of a test statistic over all possible ways the random assignment could have turned out.
10. \_\_\_\_\_ The kind of study with which statistical statements of causation can be made.
11. \_\_\_\_\_ A term for the mean of a response variable as a function of an explanatory variable.
12. \_\_\_\_\_ An observation minus its estimated mean.

- |                                   |                               |                                 |
|-----------------------------------|-------------------------------|---------------------------------|
| A. analysis-of-variance $F$ -test | B. analysis of variance table | C. confounding variable         |
| D. explanatory variable           | E. family-wise                | F. least squares                |
| G. observational study            | H. outlier                    | I. $p$ -value                   |
| J. pair-wise                      | K. randomization distribution | L. randomized experiment        |
| M. rank-sum test                  | N. regression                 | O. residual                     |
| P. resistance                     | Q. response variable          | R. sampling distribution        |
| S. signed-rank test               | T. $t$ -test for equal means  | U. $t$ -test for zero intercept |
| V. $t$ -test for zero slope       | W. 95% confidence interval    | X. 95% prediction interval      |

**B. (20 points)** For each data problem in 13-17 below, write a letter from the list at the bottom of the page corresponding to the most appropriate tool for answering the specified question of interest.

13.  $x$  = amount of newspaper coverage devoted to a publicized suicide (in square inches),  $y$  = number of suicides in the week after the newspaper coverage. Is the mean of  $y$  associated with  $x$  (from 15 observed  $x, y$  pairs)?

**Tool for answering question:** \_\_\_\_\_

14. Each of 30 cats was randomly assigned to receive one of 5 diet treatments. The weight gain was measured for each cat after completion of the diet. Are the mean weight gains the same for all 5 diets?

**Tool for answering question:** \_\_\_\_\_

15. (Continuation of problem 14). Which diets differ from which others (with respect to mean weight gain)?

**Tool for answering question:** \_\_\_\_\_

16. Students were randomly assigned to receive one of four teaching methods: a standard method with homework, a standard method without homework, a new method with homework, and a new method without homework. Their improvement in test scores was recorded. Is there evidence that the methods with homework lead to greater improvement than the methods without homework?

**Tool for answering question:** \_\_\_\_\_

17. At a bolt manufacturing plant 20 bolts were selected at each of days 0, 5, 10, 15, and 20 after machine maintenance, and their diameters were measured. It is believed that the mean diameter decreases linearly with day. What can we expect a diameter to be for any particular bolt made on day 12 after machine maintenance?

**Tool for answering question:** \_\_\_\_\_

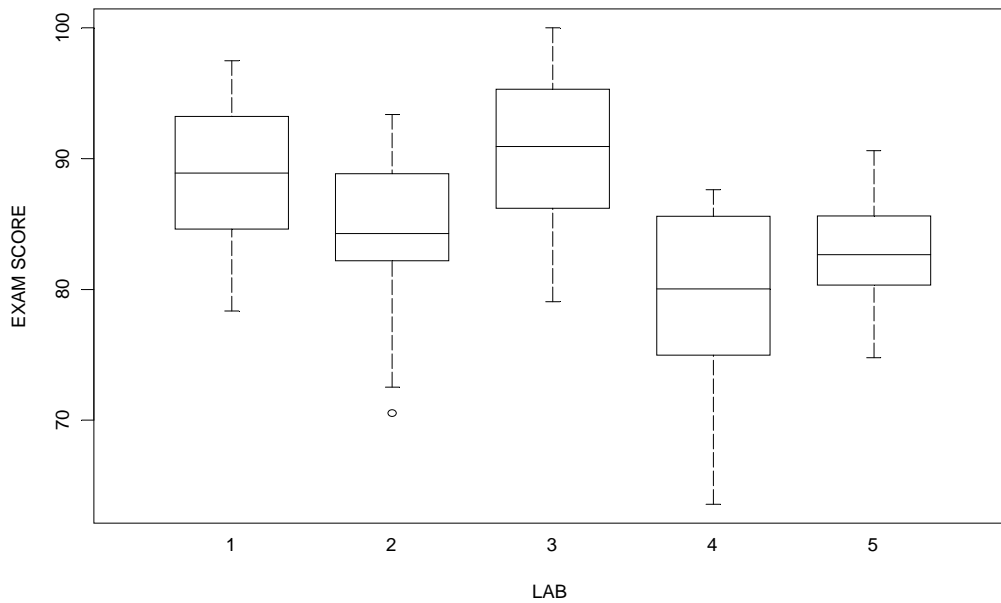
- A. One-way analysis of variance F-test.
- B. Unadjusted (LSD) t-test for comparing 2 of several means.
- C. Bonferroni-adjusted t-tests for comparing several means.
- D. Tukey-Kramer-adjusted t-tests for comparing each mean with each other mean.
- E. A t-test for some specific linear combination of several means.
- F. A confidence interval for a specific linear combination of means
- G. A t-test for the hypothesis that the intercept in a simple regression model is zero.
- H. A confidence interval for the intercept in a simple regression model
- I. A t-test for the hypothesis that the slope in a simple regression model is zero.
- J. A confidence interval for the slope in a simple regression model.
- K. A confidence interval for the mean of a response at some value of the explanatory variable.
- L. A prediction interval for values of the response at some value of the explanatory variable.

**C. Questions 18-20 pertain to the following data problem.** The summary statistics, analysis of variance table, and box plots below are of average homework scores, grouped by lab section (1,2,3,4, or 5) for a particular class. Notice that labs 1 and 2 were taught by Deb, 3 by Tom, and 4 and 5 were taught by Jim.

| <u>Lab</u> | <u>TA</u> | <u>n</u> | <u>Average score</u> |
|------------|-----------|----------|----------------------|
| 1          | Deb       | 16       | 89.1                 |
| 2          | Deb       | 13       | 83.6                 |
| 3          | Tom       | 15       | 90.2                 |
| 4          | Jim       | 12       | 78.7                 |
| 5          | Jim       | 13       | 83.1                 |

| ANALYSIS OF VARIANCE TABLE |                       |             |                    |                |                |
|----------------------------|-----------------------|-------------|--------------------|----------------|----------------|
| <u>Source of variation</u> | <u>Sum of Squares</u> | <u>d.f.</u> | <u>Mean Square</u> | <u>F-stat.</u> | <u>p-value</u> |
| Between groups             | 1206.3                | 4           | 301.6              | 7.64           | .00004         |
| <u>Within groups</u>       | <u>2526.7</u>         | <u>64</u>   | <u>39.5</u>        |                |                |
| Total                      | 3733.0                | 68          |                    |                |                |

BOX PLOTS OF HOMEWORK SCORES  
GROUPED BY LAB



18. (12 points) Answer these questions from the output above:

- a) What is the 75th percentile of homework scores for lab 1? (within 1 is OK) \_\_\_\_\_
- b) What is the median homework score for lab 5? (within 1 is OK) \_\_\_\_\_
- c) What is the estimated *standard deviation* of scores about the lab mean? \_\_\_\_\_
- d) How many degrees of freedom are associated with the pooled estimate of variance? \_\_\_\_\_
- e) What are the numerator and denominator degrees of freedom associated with the one-way analysis of variance F-test?  
numerator d.f.: \_\_\_\_\_ denominator d.f.: \_\_\_\_\_
- f) Which of the following best describes the evidence that there is a difference in mean scores for different labs? (circle one letter)
  - a) Convincing
  - b) Moderate
  - c) Slight but suggestive
  - d) No evidence of a difference

19. (4 points) What is an estimate of the linear combination of means for testing whether scores tend to be higher for labs with female TAs than for labs with male TAs (Tom and Jim are males; Deb is female)? [SHOW WORK. CIRCLE ANSWER.]

20. (4 points) Consider the hypothesis that the mean scores for Jim tend to be lower than the mean scores for Deb and Tom. This can be investigated through the linear combination,  $\gamma = \frac{1}{3}(\mu_1 + \mu_2 + \mu_3) - \frac{1}{2}(\mu_4 + \mu_5)$ . What is the standard error of the estimate of this? (It is not necessary to complete the arithmetic, but use numerical values, rather than symbols, in your expression.) [SHOW WORK.]

**D. Questions 21 - 27 pertain to the following data problem.**

Diameters (in mm) of 5 bolts were measured on each of days 1-8 after maintenance of a machine that makes the bolts. It was desired to see if bolt diameter decreases with increasing time after maintenance.

21. (12 points) The following is an incomplete analysis of variance table for analyzing the 40 bolt diameters using one-way analysis of variance. Complete the table by finding (a)-(f).

| Source of variation | df       | Sum of Squares | Mean Square | F-stat   |
|---------------------|----------|----------------|-------------|----------|
| Between groups      | (a)_____ | (c)_____       | (d)_____    | (f)_____ |
| Within groups       | (b)_____ | 852            | (e)_____    |          |
| Total               | 39       | 1684           |             |          |

22. (3 points) Which of the following is the best reason why Tukey-Kramer comparisons of all 8 means with each other is not appropriate?

- a) The Tukey-Kramer confidence intervals will tend to be too wide; Bonferroni is more appropriate.
- b) The question of interest implies a particular planned comparison.
- c) It is the pair-wise confidence levels, and not the family-wise that is of interest for this problem.
- d) Using the Tukey-Kramer in this problem would be a form of data-snooping.
- e) The question of interest only requires a comparison of two of the means; not each mean with each other.

23. (4 points) Suppose that the sum of squared residuals to the fit of the simple linear regression of diameter on day is 1186. What is the estimate of the variance about the regression line? [SHOW WORK. CIRCLE ANSWER.]

24. (6 points) What are the units of measurement (i.e. mm, day, day/mm, mm/day, liters/lightyear) for...

- a) the intercept of the regression line (for the regression of diameter on day)? \_\_\_\_\_
- b) the slope of the regression line (for the regression of diameter on day)? \_\_\_\_\_
- c) the standard deviation about the regression line (for regression of diameter on day)\_\_\_\_\_

25. (4 points). Suppose the least squares fit for the regression of diameter on day is  $93.1 - .48 \cdot \text{DAY}$ . That is, the estimated intercept is 93.1 (with a standard error of 1.7) and the estimated slope is  $-.48$  (with a standard error of  $.13$ ). What is a t-statistic for testing the hypothesis that the mean does not depend on day if the alternative is that it is decreasing with day. [t-statistic only. SHOW WORK. CIRCLE ANSWER.]

26. (4 points) The manager is also concerned that the mean diameters do not meet specification even at day zero. The mean diameter is supposed to be 90 at day 0. What is a t-statistic for the hypothesis that the mean is 90 on day 0? [t-statistic only. Note: there IS enough information to answer this. SHOW WORK.]

27. (3 points) Which of the following actions would permit a more precise estimate of the slope in the regression of diameter on day (assuming the straight line regression model is correct)? (CIRCLE LETTERS CORRESPONDING TO **ALL** CORRECT ANSWERS.)

- a) Refine the manufacturing machinery so that the standard deviation of bolt diameters is smaller.
- b) Select 4 bolts on each of days 1 through 10 (rather than 5 bolts on each of days 1-8).
- c) Select 6 bolts on each of days 1 through 8 (rather than 5 bolts on each of days 1-8).
- d) Select 5 bolts on each of days 1,3,5,7,9,11,13,15 (rather than 5 bolts on each of days 1-8).
- e) Call the psychic hotline and ask a psychic for the answer; average that with what you get from regression.