

1. Doughnuts absorb various amounts of fat during cooking. An experiment was conducted to determine if amount of fat absorbed depends on the type of fat used. For each of four fats, six batches of doughnuts were prepared. The amount of fat absorbed in grams was recorded for each batch. The ANOVA table and means for each type of fat are provided below.

Source	D.F.	SS	MS	F	P-Value	Fat type	Mean
Treatment	3	1636.5	545.5	5.41	0.0069	1	72
						2	85
Error	20	2018.0	100.9			3	76
						4	62
Total	23	3654.5					

Suppose fat types 1 and 2 are animal fats while fat types 3 and 4 are vegetable fats.

- Give the coefficients of a contrast for comparing the mean of the animal fat means to the mean of the vegetable fat means.
  - Give the coefficients of a contrast for comparing the animal fat means to each other.
  - Give the coefficients of a contrast for comparing the vegetable fat means to each other.
  - Conduct a  $t$ -test to determine if the mean of the animal fat means is the same as the mean of the vegetable fat means. Write down the null and alternative hypotheses, compute a test statistic and  $p$ -value, and provide a conclusion.
  - Determine a 95% confidence interval for the difference between the animal fat means.
  - Compute the sums of squares for the three contrasts described in parts (a) through (c).
  - Conduct an  $F$ -test for each of the contrasts described in parts (a) through (c). Give the  $F$ -statistic, an approximate  $p$ -value, and a conclusion.
  - How does the  $F$ -test that you computed for the contrast described in part (a) compare to the  $t$ -test that you conducted in part (d)?
  - Show that each pair of contrasts in parts (a) through (c) is orthogonal.
  - Test the null hypothesis that says that all three contrasts are equal to 0 against the alternative that says that at least one of the contrasts is not equal to 0.
  - How does your  $F$ -test compare to the  $F$ -test in the ANOVA table provided at the beginning of the problem?
2. Suppose an experiment was conducted to determine the effect of stocking density on the growth rate of channel catfish raised in plastic-lined ponds. A total of twenty ponds were randomly assigned to five stocking densities (1, 2, 3, 4, or 5 fish per cubic meter) in a completely randomized fashion so that four ponds were selected to be stocked at each density. At the beginning of the study all of the stocked catfish were approximately the same size. At the end of the study, 20 catfish were selected from each pond and weighed. The total weight of the 20 fish was used as a measure of catfish growth during the study period. The data can be read using the SAS program *catfish.sas*. You will most likely need to add SAS code to this program to help you answer some of the following questions.
- What are the experimental units in this experiment?
  - What are the observational units in this experiment?

- (c) Is there evidence that stocking density affects catfish growth? Provide one  $F$ -test to answer this question. Give the test statistic, its degrees of freedom, a  $p$ -value, and a conclusion.
- (d) Partition the sum of squares for the density factor into single-degree-of-freedom orthogonal polynomial contrasts of the density means. For each contrast, give the sum of squares, an  $F$ -statistic, and a  $p$ -value.
- (e) Suppose the mean weight of 20 catfish selected from a pond is a quadratic function of the stocking density. Obtain least-squares estimates of the partial regression coefficients in the quadratic regression function.
- (f) Are any of the partial regression coefficients significantly different from zero? Provide a test statistic,  $p$ -value, and conclusion for each coefficient.
- (g) Does the quadratic regression function adequately fit the data? Conduct one test to answer this question. Provide a test statistic, its degrees of freedom, a  $p$ -value, and a conclusion.