## STA 4211 – Spring 2002 – Exam 2

**Print Name:** **SSN:**

1) A shoe company executive is interested in comparing her company's (NIKE) top of the line shoe with those for her 2 biggest competitors (ADIDAS, REEBOK). The response she's interested in is the vertical leap (distance off the ground, in inches) for basketball players. Because she knows that there is a large amount of variation in players, she treats them as blocks, having each player wear each brand (in random order).

a) Write out the statistical model for the randomized complete block design, very briefly defining all terms.

b) She obtains the following sample data. Give least squares estimates for all model parameters (except $\sigma^2$).

| Player | Nike | Adidas | Reebok |
|---|---|---|---|
| Pat | 37 | 31 | 34 |
| Terry | 23 | 21 | 19 |
| Kim | 28 | 20 | 24 |
| Mel | 16 | 15 | 14 |
| Chris | 26 | 23 | 29 |

c) Give the Analysis of Variance ($\sum_{i=1}^{n}\sum_{j=1}^{r}(Y_{ij}-\overline{Y}_{..})^2 = 660$).

d) Test whether the true mean vertical leaps differ among the brands of shoes by completing the following parts (use $\alpha = 0.05$).

i) $H_0$ : $H_A$ :

ii) Test Statistic:

iii) Rejection Region:

iv) Conclusion:

e) Give the estimated standard error for the difference between any two brand means.

2) While lost in the woods, you find the following partial ANOVA table. The response being measured was the bird's height. The researcher has written "Unbalanced 2-factor ANOVA" (which is barely legible next to the sabre-tooth bite marks on the tattered output).

| Source | df | SS |
|---|---|---|
| Species | | 150.0 |
| Gender | 1 | 20.0 |
| Interaction | 5 | |
| Error | | 25.0 |
| Total | 35 | 200.0 |

a) How many birds were there in the sample?

b) How many species were there in the sample?

c) What was the number of replicates per species/gender combination?

d) $MS$(Species)= $MS$(Gender)= $MS$(Interaction)= $MSE$=

3) Rank the following datasets by their interaction sum of squares from smallest to largest (assume number of replicates per treatment group are all equal). The cell means are given in each table.

| Factor A | Factor B 1 | 2 | 3 |
|---|---|---|---|
| 1 | 50 | 75 | 100 |
| 2 | 50 | 25 | 0 |

| Factor A | Factor B 1 | 2 | 3 |
|---|---|---|---|
| 1 | 25 | 50 | 75 |
| 2 | 50 | 50 | 50 |

| Factor A | Factor B 1 | 2 | 3 |
|---|---|---|---|
| 1 | 0 | 25 | 50 |
| 2 | 50 | 75 | 100 |

4) Adhesive force on gummed material was determined under three humidity (factor A) and three temperature (factor B) conditions. Four readings were made under each set of conditions. The experiment was completely randomized and some of the results are given below.

$$\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}(\overline{y}_{ijk}-\overline{y}_{...})^2 = 52.30 \qquad \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}(\overline{y}_{ijk}-\overline{y}_{ij.})^2 = 28.50$$

Of the among cell variation, 38.1% is attributable to humidity level effects, 36.4% is attributable to temperature level effects, and 25.5% is attributale to humidity/temperature interaction effects.

a) Give the ANOVA table, clearly stating: sources of variation, degrees of freedom, sums of squares, and mean squares.

b) Does the effect of temperature depend on the level of humidity (and vice versa)? Test at $\alpha = 0.05$ significance level. Clearly state all elements of the test.

5) A quality engineer for a clothing manufacturer is interested in the combination of yarn types (Filament, Spun) and and weaving method (plain, till, satin) on durability of fabric (as measured by the number of wash cycles until the article of clothing has visuals signs of wear). He obtains 5 shirts made from each combination of yarn type and weaving method. Means (standard deviations) are given in the following table. He fits the cell means model, as he is only concerned in choosing the most durable shirts.

| Yarn | Weaving Method | | | |
|---|---|---|---|---|
| Type | Plain | Till | Satin | Mean |
| Filament | 15.0 (3.0) | 20.0 (2.0) | 10.0 (1.0) | 15.0 |
| Spun | 19.0 (3.0) | 20.0 (5.0) | 15.0 (2.0) | 18.0 |
| Mean | 17.0 | 20.0 | 12.5 | 17.5 |

a) Compute the between treatment sum of squares and its degree of freedom.

b) Compute the within treatment (error) sum of squares and its degree of freedom.

c) Test whether the 6 population variances are equal ($\alpha = 0.05$) based on Hartley's test. Clearly state the test statistic, rejection region, and conclusion.

d) Give the critical value based on Tukey's HSD to determine whether two population means are significantly different. That is:

Conclude $\mu_{ij} \neq \mu_{i'j'}$ if $|\overline{Y}_{ij} - \overline{Y}_{i'j'}| >$???

6) When a Randomized Block Design has been conducted, for the block sum of squares in the ANOVA to be 0, which of the following conditions would have to occur?

a) $Y_{ij} = Y_{ij'} \quad \forall \quad i = 1, \ldots, n \quad j, j'$
b) $Y_{ij} = Y_{i'j'} \quad \forall \quad i, i' \quad j, j'$
c) $\overline{Y}_{.j} = \overline{Y}_{.j'} \quad \forall \quad j, j'$
d) $\overline{Y}_{i.} = \overline{Y}_{i'.} \quad \forall \quad i, i'$