

Statistics 5303 — Final Exam
December 20, 2010
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This exam is open book, open notes; you may use a calculator. **Do your own work!** Use the back if more space is needed. There are nine questions, each worth 10 points.

For questions 1–2, describe the experimental design that you would choose for each situation. Tell me about units, treatments, blocks, etc.

1. Every year at Christmas I make “thumbprint” cookies. I want to perfect them, and I need to find the right time and temperature for baking them. It should be about 375 degrees for about 11 minutes, but it may not be that exactly. I’m going to make 12 trays of these cookies this week, and from those trays I want to be able to estimate the best time and temperature for baking. Note, all the cookies on a tray are baked for the same time/temperature combination. The response is how good the cookies taste to me.

2. The cookbook *Joy of Cooking* has a dynamite recipe for egg nog (and repeats an adage attributed to Mark Twain about how too much of anything is bad, except for whisky, for which too much is just right). We want to design an experiment that will compare the use of light rum, dark rum, and bourbon in this recipe; we make a batch using each liquor. A rater should drink at least four ounces of one of the egg nogs before giving his or her rating, and we expect substantial rater to rater variability. Furthermore, this recipe contains a lot of alcohol, and, to put it gently, ratings after the second cup are not reliable. We have twelve people at our party willing to dedicate a few moments to science and participate in the experiment.

The recipe is great, but it uses raw eggs. If you decide to try it, please use eggs certified as salmonella free. Egg substitutes (e.g., Egg Beaters) will work, but they're not as good as fresh eggs.

For each of questions 3–5, describe the design and give a skeleton anova.

3. Decades ago there was a sequence of TV commercials for luggage boasting about how tough the luggage was. In the commercials, the airport luggage handlers were a bunch of gorillas literally going ape and flinging the luggage around, jumping on it and so on. Well, did you ever wonder what happened to your package after you hand it to UPS or the Postal Service? Are they also employing simians to handle your fragile cargo?

Our experiment will be done at UPS and will vary class (overnight, two-day, or ground), and size/weight of packages. There are four size/weight combinations obtained by crossing light and heavy with large and small. Each package contains only a recording accelerometer to measure the forces on the package and ballast to obtain the desired weight. On nine separate days, our colleague will bring four packages to the UPS store, one of each of the size/weight combinations. The packages will be presented at the counter in random order. On three randomly chosen days, the packages will be sent via overnight delivery; similarly, three randomly chosen days will be two-day delivery, and three days will be ground delivery. All packages are sent from Minneapolis to the same address in Connecticut. The recipient in Connecticut will open the package and send us the peak acceleration experienced by each package.

4. Our dog's feet get cold and packed with ice when they go for walks in the winter. We can buy little dog booties, but they always come off. What we would like to do is find the brand of booties that stay on the longest. We have purchased booties of six different brands. As our dog only has four feet, we can only test four of them at one time. There are 15 different sets of four brands that can be taken from the six brands. We randomly assign the 15 sets to 15 consecutive days. On each day, we randomly assign the four brands from that day's set to the four feet on the dog. When we go on the walk, we time how long it takes until each bootie comes off, and that is the response.

5. The Vikings are playing a football game tonight at TCF Bank Stadium, and traffic is going to be a nightmare around the university. Out of morbid curiosity, a group of twelve students decide to run an experiment to determine the fastest way to get from Minneapolis campus to St. Paul campus leaving around 5:30 PM. They break into three sets of four. One group of four will be randomly assigned to get in a car at the 4th Street parking ramp and take Como Avenue to St. Paul. One group of four will get in a car at the Washington Avenue parking ramp and take University and Raymond to St. Paul. The third group will pick up the Campus Connector at Coffman Union. All students leave from Morrill Hall at the same time, and the response is travel time to the St. Paul Student Center.

6. An opened bottle of wine will deteriorate and become undrinkable. Various products purport to help preserve opened bottles. In this experiment, we use three different varieties (Merlot, Cabernet, and Shiraz) from each of five randomly chosen vinyards (just labeled A through E). We obtain six bottles of each variety from each vinyard. These six are randomly assigned to three different wine preservation products, two bottles to each of the three products. The bottles are opened, one half of the wine is poured out, and then the bottles are closed with their assigned product. Four days later, a professional wine judge tastes wine from each of the bottles (fully blinded) and gives a rating on a 1–100 scale for the wine.

Below are two different Hasse diagrams. Tell me which one is correct and why the other is not correct.

7. We have run a 2_{III}^{6-3} fractional factorial with generators ABCD, ACE, and BCF.

(a) List all of the aliases of I.

(b) In the Daniel plot, the main effects of B, D, and E looked large. What can you conclude?

(c) Your colleague claims that the following factor/level combinations were run in the experiment: ace, cd, bcf, abcdef, be, def, af, abd. Is he correct? Explain why or why not.

8. Consider the following Type II analysis of variance table. Which terms would you include in your model for the data? (You may indicate them on the ANOVA table if you wish.)

```
> Anova(fit,type=2)
Anova Table (Type II tests)

Response: y
      Sum Sq Df F value    Pr(>F)
a      0.768  2  0.4329    0.65357
b     23.812  1 26.8318 2.637e-05 ***
c      2.148  1  2.4202    0.13287
d     58.236  1 65.6208 2.528e-08 ***
a:b      0.724  2  0.4079    0.66955
a:c      2.459  2  1.3856    0.26948
b:c      0.176  1  0.1982    0.66018
a:d      7.103  2  4.0021    0.03163 *
b:d     77.767  1 87.6290 1.756e-09 ***
c:d      0.064  1  0.0721    0.79057
a:b:c     7.980  2  4.4958    0.02196 *
a:b:d     3.782  2  2.1305    0.14069
a:c:d     3.225  2  1.8171    0.18415
b:c:d     3.261  1  3.6749    0.06722 .
a:b:c:d   2.732  2  1.5395    0.23494
Residuals 21.299 24
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
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9. A laboratory is trying to find compounds that will increase the “grip” of tires in the winter. The real test is to make tires containing the compound, but that is expensive, and the lab can only afford to do that when there is some indication that the compound might actually work. Before making actual tires, the lab screens a large number of compounds using a cheaper, but less precise, process. For each compound screened, the output of the cheaper process is a p-value for the null hypothesis that the compound does not affect winter grip. Because the lab is testing a lot of compounds, there could be a lot of false positives if they take all compounds with a p-value below 5%. The lab doesn't mind have a small fraction of false positives that go on to the expensive test, but they don't want the fraction of false positives to be larger than 10%.

Choose an error rate that gives the lab the control that they want while still selecting as many active compounds as possible. Defend your choice.