Statistics 514: Problem Set No. 7

Due Thursday, December 6, Session 30

Work the following Exercises on pages 523-524: 13-24 13-25 13-32
Work the following Exercise on page 554: 14-2

1. An experiment was conducted to study the effects of irrigation, crop variety, and aerially sprayed pesticide on grain yield. There were two replicates. Within each replicate, three fields were chosen and randomly assigned to be sprayed with one of the pesticides. Each field was then divided into two east-west strips; one of these strips was chosen at random to be irrigated, and the other was left unirrigated. Each east-west strip was split into north-south plots, and the two varieties were randomly assigned to plots.

Rep 1			Rep 2				
P1	P2	P3	P1	P2	P3	Irrig	Var
53.4	54.3	55.9	46.5	57.2	57.4	yes	1
53.8	56.3	58.6	51.1	56.9	60.2	yes	2
58.2	60.4	62.4	49.2	61.6	57.2	no	1
59.5	64.5	64.5	51.3	66.8	62.7	no	2

   What is the design of this experiment? Analyze the data and report your conclusions. What is the standard error of the estimated difference in average yield between pesticide 1 and pesticide 2? Irrigation and no irrigation? Variety 1 and variety 2?

2. A consumer testing agency wishes to test the ability of laundry detergents, bleaches, and prewash treatment to remove soils and stains from fabric. Three detergents are selected (a liquid, an all-temperature powder, and a hot-water powder). The two bleach treatments are no bleach or chlorine bleach. The three prewash treatments are none, brand A, and brand B. The three stain treatments are mud, grass, and gravy. There are thus 54 factor-level combinations.

   Each of 108 white-cotton handkerchiefs is numbered with a random code. Nine are selected at random, and these nine are assigned at random to the nine factor-level combinations of stain and prewash. These nine handkerchiefs along with four single sheets make a "tub" of wash. This is repeated twelve times to get twelve tubs. Each tub of wash is assigned at random to one of the six factor-level combinations of detergent and bleach. After washing and drying, the handkerchiefs are graded (in random order) for whiteness by a single evaluator using a 1 to 100 scale, with 1 being whitest (cleanest).

   Analyze these data and report your findings.

			Stain 1			Stain 2			Stain 3		
Tub	Det.	Bl.	P1	P2	P3	P1	P2	P3	P1	P2	P3
1	1	1	1	3	3	3	3	5	10	3	2
2	1	2	5	3	3	3	5	3	7	3	2
3	2	1	3	2	2	4	6	1	5	1	2
4	2	2	3	1	2	2	4	3	8	1	2
5	3	1	34	29	35	35	34	41	49	25	26
6	3	2	7	5	6	6	6	7	10	5	4
7	1	1	4	4	4	5	7	10	11	5	4
8	1	2	4	6	3	4	7	6	9	7	5
9	2	1	6	8	7	5	6	7	11	6	4
10	2	2	6	6	8	8	7	9	12	5	5
11	3	1	26	28	31	38	30	34	41	27	27
12	3	2	2	4	2	2	5	3	8	3	2

Paper helicopter experiment

This experiment involves making a paper helicopter. To the best of my knowledge, it is due to Soren Bisgaard and/or George Box and/or Conrad Fung. The goal is to make a paper helicopter that takes as long as possible to fall, and to learn which variables most affect the time to fall. There are four variables to consider: the wing length, wing width, base length, and base width.

You may do this experiment in small teams of 1 to 3 members. The team members can either write it up individually, or jointly.

Materials

1. 20 pages, $8\frac{1}{2}$ by 11 inches in size. (Printer/copier paper recommended.)
2. Stopwatch.

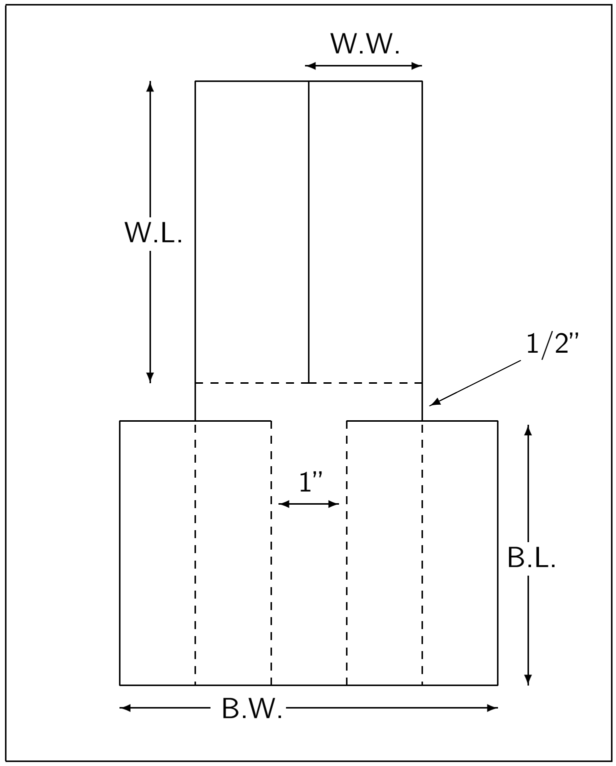
Variables

The four variables to consider are listed below with their minimum and maximum sizes.

Variable	Min	Max
Wing Length	3.0	5.0
Wing Width	0.5	2.0
Base Length	3.0	5.0
Base Width	3.0	8.0

Construction

The variables are illustrated in the following figure. The solid lines on the figure indicate where the paper is to be cut. The dashed lines indicate folds. The helicopter is constructed by first cutting it out, then folding the based around the "stem", then folding the wings back at 90 degrees (one in each direction!). The stem, with the base folded around it, becomes the handle. The figure shows four folds on the stem; the actual number needed depends on the base width. The stem is to be 1 inch in width. The wings are separated by 1/2 inch from the stem.



Experimentation

Your budget is 20 helicopters: each to be dropped just once, and three experimental "episodes". Each episode has two stages: make a number of helicopters, and time them as they fall. After one episode, you can plan the next. You have to commit to all the runs in one episode before you can gather data on any of the runs in that episode.

You episodes might be

1. Prototype
2. Experiment
3. Follow-up

The prototype stage, which you might skip, is to practice making and folding a helicopter. You might also use it to help decide on the range over which to vary an input factor.

The experimental stage is the main part of the experiment. A factorial design, such as a 2^4 experiment is expected, though you can do something else if you give a good explanation of it.

The follow-up stage, which you might skip, is there in case you need to verify conclusions or to allow some partial salvaging. Perhaps one of the helicopters failed to "open", or came up an outlier for some other reason.

Naive Questions

Using your experimental data, answer the naive questions below. The questions are naive because, for example, asking whether the response increases with a variable might not make sense if that variable interacts strongly with another. It is also possible that the differences being asked about are not statistically significant. If you can give a straight answer, do so. If not, explain why not.

1. For each variable, does "hang time" increase with increasing values of that variable?
2. Which variable(s) most strongly affect the "hang time" of the helicopter?
3. Which interactions appear the strongest?
4. What settings of the variables do you recommend in order to maximize the response? [A straight answer is required for this one.]

Presentation

In addition to answering the questions above, write up your experiment including the following:

1. Say who your team members were if you had any.
2. Say where you dropped the helicopters. You might use the balcony in PMU. (Watch out for people walking below. Say what steps you took to reduce the likelihood of outliers.)
3. The reasoning you used before each stage, including how you decided what range to explore.
4. Include your run-sheets, with the raw data entered as an appendix.
5. A plot or two that best shows what you learned.
6. An anova table, or other appropriate analysis.

Warning: The more you think your experiment is truly ingenious, the more you might risk getting stuck with something you can't analyze. Be especially cautious doing intricate and complex experiments.