

STATISTICS QUALIFYING EXAM – TAKE HOME

Due 11:30 a.m. Friday, Jan. 13, 1995, Math. and Stat. Dept. Office

Directions: Answer both questions. The answers should be typed (or typeset), double spaced, and the answer to each question should be no more than 3 pages long. An Appendix is allowed but will be examined only at the discretion of the graders. (The better constructed the Appendix, the more likely it is to get examined.)

1. On the following page are 30 observations from a process with 4 input variables and a corresponding yield. The input variables are:

X_1 = mix %, the range is 25-50

$3X_2$ = mixing temperature in degrees F, the range for X_2 is 40-60

X_3 = mixing time in minutes, the range is 10-20

X_4 = drying time in hours at 100°F, the range is 2-10.

a. Find a reasonable model with the purpose in mind of finding the maximum yield. Make the model economical with respect to the number of variables kept in the model and give reasons for dropping variables that are not kept in the model.

b. Is the selected model adequate for prediction? Are there other variables that might be considered?

c. If you had another chance to run an experiment with these same variables, design an experiment that would help in the determination of maximum yield. Give specific values of each variable in the chosen experimental design and the number of tests at each.

d. Give your best estimate of the levels of the selected variables that give maximum yield and how you obtained them.

e. Get a 95% prediction interval for the maximum yield (i.e. the yield at the levels of the variables in part d.)

To people practicing for qualifiers:

There is a problem with these parts because there was no max. in region specified.

Decide how you would go about this problem but note the difficulty with carrying the procedures through in this case.

| X_1 | X_2 | X_3 | X_4 | Yield |
|-------|-------|-------|-------|---------|
| 30 | 45 | 13 | 4 | 2913.34 |
| 35 | 50 | 15 | 6 | 2887.20 |
| 30 | 55 | 17 | 8 | 1059.95 |
| 40 | 45 | 13 | 4 | 3247.42 |
| 35 | 50 | 15 | 6 | 2916.06 |
| 40 | 45 | 17 | 4 | 3033.94 |
| 35 | 60 | 15 | 6 | 1795.71 |
| 30 | 45 | 13 | 8 | 2902.84 |
| 40 | 55 | 17 | 8 | 2821.21 |
| 35 | 50 | 15 | 6 | 2894.93 |
| 40 | 45 | 13 | 8 | 3343.60 |
| 35 | 50 | 10 | 6 | 3267.54 |
| 30 | 45 | 17 | 8 | 2258.31 |
| 35 | 50 | 15 | 6 | 2902.37 |
| 30 | 55 | 17 | 4 | 990.16 |
| 25 | 50 | 15 | 6 | 773.63 |
| 35 | 50 | 15 | 6 | 2906.19 |
| 30 | 45 | 17 | 4 | 2387.86 |
| 40 | 55 | 17 | 4 | 2987.95 |
| 35 | 50 | 20 | 6 | 2236.43 |
| 30 | 55 | 13 | 4 | 1631.80 |
| 40 | 55 | 13 | 8 | 3283.46 |
| 35 | 50 | 15 | 2 | 2893.35 |
| 50 | 50 | 15 | 6 | 2492.51 |
| 30 | 55 | 13 | 8 | 1315.51 |
| 35 | 50 | 15 | 6 | 2890.00 |
| 40 | 55 | 13 | 4 | 3038.26 |
| 40 | 45 | 17 | 8 | 2901.32 |
| 35 | 40 | 15 | 6 | 3023.14 |
| 35 | 50 | 15 | 10 | 2849.96 |

2. To reduce the amount of a certain pollutant, a waste stream of a small plastic molding factory has to be treated before it is discharged. State laws stipulate that the daily average of this pollutant cannot exceed 10 pounds. The following 11 experiments were performed to determine the best way to treat this waste stream.

| order in which experiments were performed | chemical brand | temperature (° F) | stirring | pollutant (lb/day) |
|---|-------------------|----------------------|--------------|-----------------------|
| 5 | A | 72 | none | 5 |
| 6 | B | 72 | none | 30 |
| 1 | A | 100 | none | 6 |
| 9 | B | 100 | none | 33 |
| 11 | A | 72 | fast | 4 |
| 4 | B | 72 | fast | 3 |
| 2 | A | 100 | fast | 5 |
| 7 | B | 100 | fast | 4 |
| 3 | AB* | 86 | intermediate | 7 |
| 8 | AB | 86 | intermediate | 4 |
| 10 | AB | 86 | intermediate | 3 |

*AB denotes a 50-50 mixture of both brands.

- Describe this experiment as completely as you can, using the terminology of experimental design.
- Write a linear model for this design, using only terms you could actually estimate. Explain why each term is in the model.
- Discuss *confounding* in the context of this design.
- Analyze these data.
- Write your conclusions from part d in a report suitable for presentation to the company's management.