Portland State University
Mechanical and Materials Engineering Department
ME 488: Design of Experiments

Class Project Due Dec 11, 2014 @ 4PM

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1 Project Objective

You are expected to work as a member of groups of 5-6 students to design, conduct, analyze, and conclude an experimental study.

2 Scenario

Conduct a set of experiments to study the effect of the 6 variables below on either the flight accuracy (the closer the ground touching point to the projected dropping point on the ground, the better) or flight time (the longer the flight time, the better) of a paper helicopter (instructions are given in the end of this project statement). All helicopters are to be released from same height (7 feet or more).

2.1 The Factors

1. Blade length (length of blade cut)
2. Blade angle (angle of folding)
3. Body width (The remaining width of the lower part after folding)
4. Paper weight (must be copy paper not magazine or newspaper)
5. Blade holes
6. Blade end (i.e. blade tip) form (1/4 inch or less)

3 R&D

You can do a few 'getting-to-know' the system experiments but do not use the data collected in the main experiment. After you develop a feel for the system, set factor variables at suitable levels. There is no cost associated with this portion of the experiment.

4 Data Integrity

If your helicopters tumble (fall without spinning), change the factor levels so that they do not. During experimentation if a helicopter tumbles, redo the experiment. In other words the population of interest does not include tumbling helicopters and they completely mess up the results. However, you are expected to still present that data [mark it with a star], but there is no cost to that run (see below)

5 Costs

While the majority of your grade is based on your write-up (see Deliverable section), a portion of your grade is based on the overall resource expenditure, which you have a large control over. You are expected to keep accurate track of your costs. There should be about 20 teams total in the class. I will give an extra 1% to the project grade for every position above the most expensive experiment (e.g. the most cost effective team will get 20% extra added to project grade, if 20 teams total). The costs of various activities are as follows:

5.1 Experimental Run

Each data collection event after R&D phase, that is not marked with a star, costs $2,000

5.2 Level Change Over

Each change of levels between data collection costs the following:

- Blade length or Blade End: $200
- Blade angle or Body width: $100
- Paper weight $1,000
- Blade holes $500

5.3 Analysis Costs

- Each coefficient in initial regression model (based on Experimental Design): $10,000
- Each interaction or factor dropped as insignificant after initial model: $500

5.4 Accuracy Bonus

- Your final model ${R_{adj}}^2$: $\$500,000({R_{adj}}^2)$ is deducted from your over all costs
- The difference in runs required from a 2^6 Balanced Full Factorial Experiment with the same df_{error}: $1,000 each

5.5 Fatal Errors: These penalty costs will be calculated by the instructor

- Accepting a useless Final model [i.e. p-value on F is greater than 0.01]: $2,000,000
- Accepting a model with no df_{error}: $3,000,000
- Poor Randomization Artifact: Distinctive pattern in run order plots: $20,000 per variable

6 Deliverable

A written report is expected from each group. The report should be no more than 10 pages long including figures. (12 font, 1.5 line spacing, one side of paper, stapled). Appendices can be as long as you wish. The report should include:

1. Objective
2. Executive Summary
3. Experimental Design and explanation of what that means
4. Narrative on why that Experimental Design was chosen
5. Method of Data Collection and Randomization
6. Collected Data
7. Post Analysis [Any assumptions that were validated]: Include Run Order Plots!
8. Analysis of the Experiment [include confidence intervals on coefficients]
    - Initial Regression Model Output based on Experimental Design
    - Final Regression Model Output [you can put interim ones in Appendices]
    - Narrative of interaction removal justification [Engineering or Factor Principle used]
9. Conclusions
    - Best Design Factor Level Settings
    - Total Costs
    - Things you would have done differently if you had to do it again
    - Challenges/Insights
10. Appendix A: Design/Planning/Model Matrices
11. Appendix B: Cost Accounting
12. Appendix C: R Code used
13. Appendix D: Interim Regression Runs
14. Appendix E: Other Analysis/Tables/Figures
15. Attachments:
    - A picture of experimenter running experiment, including data collection
    - Handwritten copy of data collection sheet including time/date/signature
    - Your 'best' helicopter design prototype

7 The Basic 'Copter

1. Start with a regular copier paper and cut a 6" by 2" piece.
2. Make a length-wise cut.
3. Make two cross cuts
4. Fold the side cuts into a thin strip.
5. Fold the blades to create a paper helicopter.
6. Apply the same procedure and create other models
7. The end form size is up to you - I suggest less than 1/4 inch
8. Make each helicopter individually - do not cut then all at the same time (that would not be a genuine experiment).
9. A piece of tape can be used to keep the body together.