# Factorial Designs using R

1. An article in *Quality Progress* (May 2011, pp. 42–48) describes the use of factorial experiments to improve a silver powder production process. This product is used in conductive pastes to manufacture a wide variety of products ranging from silicon wafers to elastic membrane switches. We consider powder density (g/cm2)(g/cm2) as the response variable and critical characteristics of this product. The data is shown below.

| **Ammonium (%)** | **Stir Rate (RPM)** | **Temperature (°C)** | **Density** |
| --- | --- | --- | --- |
| 2 | 100 | 8 | 14.68 |
| 2 | 100 | 8 | 15.18 |
| 30 | 100 | 8 | 15.12 |
| 30 | 100 | 8 | 17.48 |
| 2 | 150 | 8 | 7.54 |
| 2 | 150 | 8 | 6.66 |
| 30 | 150 | 8 | 12.46 |
| 30 | 150 | 8 | 12.62 |
| 2 | 100 | 40 | 10.95 |
| 2 | 100 | 40 | 17.68 |
| 30 | 100 | 40 | 12.65 |
| 30 | 100 | 40 | 15.96 |
| 2 | 150 | 40 | 8.03 |
| 2 | 150 | 40 | 8.84 |
| 30 | 150 | 40 | 14.96 |
| 30 | 150 | 40 | 14.96 |

The data may be downloaded from here: <https://raw.githubusercontent.com/tmatis12/datafiles/main/PowderProduction.csv>

Assume Ammonium, Stir Rate, and Temperature are factors with fixed effects, each with two levels, and the design is replicated twice.

1. Write the model equation for a full factorial model
2. What factors are deemed significant, using α=.05 as a guide. Report final p-values of significant factors (and interaction plots if necessary).
3. A full factorial experiment was conducted to determine whether either firing temperature or furnace position affects the baked density of a carbon anode.

|  | **Temperature (°C)** | | | |
| --- | --- | --- | --- | --- |
| **Position** | **800** | **825** | **850** |  |
| 1 | 570 | 1063 | 565 |  |
| 565 | 1080 | 510 |  |
| 583 | 1043 | 590 |  |
| 2 | 528 | 988 | 526 |  |
| 547 | 1026 | 538 |  |
| 521 | 1004 | 532 |  |

1. Assume that both Temperature and Position are fixed effects. Report p-values
2. Assume that both Temperature and Position are random effects. Report p-values
3. Assume the Position effect is fixed and the Temperature effect is random. Report p-values
4. Comment on similarities and/or differences between the p-values in parts a,b,c.