DOE Course Content

Section 1. Statistical Methods - “A Review”

1.1. Statistical Thinking

1.2 Descriptive Statistics

1.2.1. Statistics that Measure Center or ‘Location’ of the Data Set
1.2.2. Statistics that Measure the ‘Dispersion’ or Variability of the Data Set

Section 2. Probability Density Functions

2.1. Discrete Density Functions

2.1.1. Binomial Distribution
2.1.2. Poisson Distribution
2.1.3. Some Discrete Density Functions

2.2. Continuous Density Functions

2.2.1. Normal Distribution
2.2.2. Standard Normal Distribution
2.2.3. Lognormal Distribution
2.2.4. Weibull Distribution
2.2.5. t Distribution or “Student’s T Distribution”
2.2.6. Chi-Square Distribution
2.2.7. F Distribution* ‘Important for Design of Experiments’
2.2.8. Some Continuous Density Functions

Section 3. Quantiles

3.1. Percentiles

3.2. Quantile and Q-Q Plots

3.2.1 Percentiles

3.3. Box Plots

3.4. Categorical Data (Nominal or Ordinal)

3.5. Enumerative and Analytical Statistical Studies

3.6. Select References

Section 4. ‘Data Quality’
4.1. Exploring Outliers
   4.1.1 For JMP Users
   4.1.2. For Minitab Users

Section 5. Hypothesis Testing, Type I Error, and p-values
   5.1. Hypothesis Testing
   5.2. Level of Significance
   5.3. Confidence Intervals
      5.3.1. Confidence Interval for $\mu$ when $\sigma^2$ is known
      5.3.2. Confidence Interval on $\mu$ when $\sigma^2$ is unknown
   5.4. Significance Tests on the Mean when $\sigma^2$ is unknown
      5.4.1. Hypothesis Test Example
      5.4.2. Hypothesis Test Exercise
   5.5. Post-hoc Analysis Comparison Tests
      5.5.1. One-Sample t-test.
      5.5.2. Independent Sample t-test
      5.5.3. Paired Sample t-test.
      5.5.4 One and Two-Tailed t-tests
   5.6. F test -“Important for ANOVA”

Section 6. Design of Experiments ('DOE')
   6.1. Scientific Inference
   6.2. Introduction to Modern Design
   6.3. Key Design Principles
   6.4. Example: Experiments with a Single Factor
   6.5. Analysis of Variance (ANOVA)
   6.6. General Linear Model (GLM)
   6.7. Example: General Linear Model (GLM) - ANOVA
   6.8. Assumptions of ANOVA
      6.8.1. Tests for Non-Homogeneous Variance
   6.9. Sums of Squares
6.10. One-Way ANOVA Computational Approach
   6.10.1. Cochran’s Theorem
   6.10.2. Example: Single Factor One-Way ANOVA (Random Run Order)
   6.10.3. Example: Single Factor One-Way ANOVA
   6.10.4. Minitab Example: Single Factor Experiment
   6.10.5. Additional Exercises

6.11. Example: Helicopter Experiment

6.12. Full Factorial Designs Two-Way ANOVA
   6.12.1. Two-Factor “Full Factorial Design”
   6.12.2. Example: “Two-Factor, Fixed Effects Model”
   6.12.3. JMP Example: Two-Factor, Fixed Effects Model
   6.12.4. Minitab Two Factor Fixed Effects Example – Battery Life
   6.12.5. Exercise: Helicopter Experiment Two Factors

6.13. ‘Three Factor Fixed-Effects’ Model

6.14. ANCOVA - Designing Experiments with ‘Covariates’
   6.14.1. JMP Example: Designing Experiments with Covariates
   6.14.2. Minitab Example: Designing Factorials with Covariates

6.15. The 2k Design “Screening Designs”
   6.15.1. ‘Yates Notation’ for 2³ Design
   6.15.2. JMP 2³ and 2³ Factorial Examples
   6.15.3. Minitab Screening Design Practice Example

Section 7. Assumptions of ANOVA
   7.1 Key assumptions in industrial experimentation often overlooked

Section 8. Sample Size Determination
   8.1. The Use of Operating Characteristic (OC) Curves
   8.2. Sample Size Determination using Minitab
   8.3. Sample Size Determination using in JMP

Section 9. Philosophy of ‘Blocking’ in Experimentation
   9.1. Randomized Complete Block Design (RCBD)
9.2. Example: RCBD for Single Factor using JMP and Minitab

9.3. Example: RCBD for Two-Factor using JMP and Minitab

9.4. Exercise: Helicopter Experiment with “Blocking”

9.5. Latin Squares
   
   Exercise 9.5.1. Latin Squares in JMP
   
   Exercise 9.5.2. Latin Squares in Minitab

Section 10. Split-Plot Design

10.1 ‘2-Level’ Split-Plot in Minitab

10.2 ‘2-Level’ Split Plot in JMP

10.3 ‘3-Level’ Split-Plot Design (Box et al. 2005)

10.4. Box et al. (2005) example in JMP

10.5 Split-Plot Design “Industrial Engineered Panel Application”
   
   Exercise 10.5.1. Analyze ‘3-level’ split plot in JMP
   
   Exercise 10.5.2. Analyze ‘2-level’ split plot in Minitab

10.6. JMP Help - Split-Plot Design Illustration

10.7 Minitab Help – Split Plot Design Illustration

Section 11. Nested Designs

11.1. Two-Stage Nested Design
   
   Exercise 11.1.1. Two-Stage Nested Design in JMP
   
   Exercise 11.1.2. Two-Stage Nested in Minitab

11.2. Nested General “m-Stage Design”
   
   Exercise 11.2.1. Three-Stage Nested Design
   
   Exercise 11.2.2. Helicopter Experiment

Section 12. Taguchi Philosophy - “Robust Product Design”

12.1. “Signal-to-Noise” (S/N) Ratio”

12.2. Orthogonal Arrays (OA)

12.3. Example: Taguchi Philosophy

12.4. Limitations of the Taguchi Method

12.5. Advantages of the Taguchi Method
12.6. JMP Example: Taguchi Philosophy
12.7. Minitab Example. Taguchi Analysis
12.8. Exercise: Helicopter Experiment with “Induce Noise”

Section 13. Two-Level Fractional Factorial Designs
13.1. One-Half Fraction of the $2^k$ Design
13.2. One-Half Fraction of the $2^k$ Design “Design Resolution”
   Exercise 13.2.1. Fractional Factorial in JMP
   Exercise 13.2.2. Fractional Factorial in Minitab
13.3. General $2^{k-p}$ Fractional Factorial Design
13.4. Example: Two-Level Fractional Factorial Designs using JMP or Minitab

Section 14. Blocking and Confounding in the 2k Factorial Design
14.1. Example: $2^{3-1}$ Fractional Factorial Design in Four Blocks
   Exercise 14.1.1. $2^{3-1}$ Fractional Factorial Design in Four Blocks in JMP
   Exercise 14.1.2. $2^{3-1}$ Fractional Factorial Design in Four Blocks in Minitab

Section 15. Response Surface Designs
15.1. Center Points in Response Surface Designs
15.2. The Central Composite Design or CCD
   15.2.1 Axial Points in Central Composite Designs
   Exercise 15.2.2. Central Composite Design in JMP
   Exercise 15.2.3. Central Composite Design in Minitab
15.3. Box-Behnken Design
   Exercise 15.3.1. Box-Behnken Design in JMP
   Exercise 15.3.2. Box-Behnken in Minitab
15.4. ‘Plackett-Burman’ Experimental Design

Section 16. Mixtures Designs
16.1. Mathematical Proof – Important for Response Surface
16.2. Simplex and Centroid Designs - 3 Component Mixture Designs
16.3. Extreme Vertices Designs – Constrained Mixture Designs
16.4. Mixture Designs in JMP
16.5. Mixture Designs in Minitab

16.5.1. Minitab – ‘Fondue’ Example

Section 17. DOE Flow Chart Guide (Fixed Effects)

Section 18. Final Helicopter Experiment

Section 19. Case Studies