Statistics for Experimentalists - Video course

COURSE OUTLINE

This course is addressed towards students, researchers and engineers carrying out experiments in their fields of study and work. In depth knowledge of probability and statistics, though helpful, is not a pre-requisite to understand the contents of this course. The first part of the course deals with random variables, typical probability distributions, random sampling, confidence intervals on population parameters and hypothesis testing. These form the basic background of statistical analyses.

In the second part of this course, design of experiments and regression analysis are introduced. The factorial design of experiments involving two or more factors is discussed in detail. Properties of orthogonal designs and other popular design strategies such as the Central Composite Design and Box Behnken design are also discussed. The characteristic features of experimental design strategies are defined and compared.

Linear regression model building concepts are explained using which empirical models may be fitted to experimental data. The methods to assess the quality of the models fitted are discussed.

Identification of optimum performance of the process through experimental investigati*ons* is demonstrated through the response surface methodology approach.

After understanding this course material, the experimentalist will develop the confidence to identify an appropriate design strategy suited for his work. He will also be able to interpret the results of the experiments in a scientific manner and communicate them unambiguously.

COURSE DETAIL

A. **Random Variables**

Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables

B. **Important Statistical Distributions**

Properties and applications of Normal, log-normal and t-distributions, Chi-Square and F distributions

C. **Point and interval estimates of population parameters**

Point Estimation of the population mean, distribution of the sample means, central Limit theorem, confidence Intervals on the population mean, optimal sample size to obtain precision and confidence in interval estimates of mean, maximum likelihood parameter estimation

D. **Hypothesis Testing**

Formulation of null and alternate hypotheses, errors in hypothesis Tests, power of hypothesis tests, hypothesis tests on population means, variances and ratios of variances

E. **Analyze single factor experiments**

Introduction to Analysis of Variance (ANOVA), blocking and randomization

F. **Factorial Design of Experiments**

Need for planned experimentation, factorial design experiments involving two factors, effect of interactions, ANOVA in factorial design, general factorial design, partial factorial designs

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Pre-requisites:

Basic knowledge on Calculus, linear algebra and elementary knowledge on probability

Additional Reading:

1. Montgomery, D. C., *Design and Analysis of Experiments*. 8th ed.New Delhi: Wiley-India, 2011.
2. Myers, R. H., D. C. Montgomery and C. M. Anderson-Cook, *Response Surface Methodology*. 3rd ed. New Jersey: Wiley, 2009.
3. Ogunnaike, B. A., *Random Phenomena*. Florida: CRC Press, 2010.

Coordinators:

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G. **Linear Regression Analysis**

Matrix approach to linear regression, Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis

H. **Comparison of different experimental design strategies**

Properties of orthogonal designs, implications of different factorial design models, importance of center runs, scaled prediction variance, central composite design, Box-Behnken design, moments of experimental designs, rotatable of experimental designs, face centered cuboidal designs, comparison of experimental designs

I. **Response Surface Methodology**

Method of steepest ascent, first and second order models, identification of optimal process conditions

Detailed Course Plan – Part 1

Lecture No.	Topic
1	Introduction and overview
2	Random Variables
3	Discrete Probability Distributions
4	Example Problems
5	Continuous Probability Distributions
6	Normal and Log Normal Probability Distributions
7	t-distribution
8	Chi-Square Distribution
9	F-distribution
10	Example Problems
11	Example Problems
12	Distribution of the random sample mean

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13	Central Limit Theorem and its applications
14	Confidence Intervals
15	Maximum Likelihood Parameter Estimation
16	Example Problems
17	Formulation and Testing of Hypotheses
18	Errors in Hypothesis Testing
19	Hypothesis tests on population means, variances and ratio of variances
20	Example Problems

Detailed Course Plan – Part 2

Lecture No.	**Topic**
21	Design and Analysis of Single Factor Experiments
22	Randomized Block Design
23	Example Problems
24	Factorial Design with Two Factors
25	Factorial Design with Multiple Factors
26	Fractional Factorial Design
27	Example Problems
28	Matrix Approach to Linear Regression Analysis
29	Variance-Covariance Matrix
30	ANOVA in regression Analysis and Confidence Intervals

31	Extra Sum of Squares
32	Lack of Fit Analysis
33	Example Problems
34	Properties of Orthogonal Designs
35	Importance of Center Runs
36	Central Composite Design
37	Box Behnken Design and Face Centered Designs
38	Response Surface Methodology : Method of Steepest Ascent
39	Identification of optimal process conditions
40	Example Problems

References:

Montgomery, D. C., G.C. Runger, *Applied Statistics and Probability for Engineers*. 5th ed.New Delhi: Wiley-India, 2011.