M.Tech and PhD : Courses and Syllabus

School of Mathematics

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

PCL108 Statistical Methods and Algorithms (M.tech CSE, Mech., Civil)

Credits: 4 [3-0-2]

Course Objectives: The course aims to introduce to the students, fundamental principles as well as advanced topics in statistics and sampling techniques. This course underscores the importance of statistical methods to perform scientific and engineering research.

Contents:

Review of basic probability and statistical principles: Axioms of probability, conditional probability, Bayes' rule, introduction to Bernoulli, binomial, Poisson, geometric, normal, exponential, distributions, joint and marginal distributions, uniform, gamma and Weibull distributions.

Hypothesis tests: Sampling distributions (standard Normal, F and t distributions) and their properties, hypothesis tests (difference between one tailed and two tailed tests), level of significance of test and power of test, two sample test for means using t-distribution.

Analysis of variance: One-Way ANOVA, two-way ANOVA with examples.

Time series analysis: Component of time series, method of least squares, autoregressive models: $AR(1)$, $AR(p)$.

Multivariate data analysis and regression: Introduction to linear regression with trends and least squares estimate, definition of covariance matrix and its application in engineering problems using Principal Component Analysis.

Markov Chains: Introduction to discrete Markov chains in finite state space, multi-step state transition probabilities, stationary (limiting distributions), Chapman-Kolmogorov equations.

Laboratory Work: Each laboratory experiment will consist of numerical exercises on each of the above topics. Laboratory experiments will be performed using some statistical software.

Course Learning Outcomes: The student will be able to

1. compute probabilities of composite events along with an understanding of random variables and distributions.
2. make statistical inferences using principles of hypothesis tests and ANOVA.
3. perform analysis of time series data with different time series models and understanding of Markov processes.
4. execute multivariate data analysis using Principal Component Analysis and linear regression.

Text/References:

- S. Ross, Introduction to Probability Models, Elsevier, 12th edition, 2019.
- G. Casella and R.L. Berger, Statistical Inference, Cenage Learning Inc., 2nd edition, 2020.
- R. Hogg, J. McKean, and A. Craig, Introduction to Mathematical Statistics, Pearson, 2013.
- J. Hamilton, Time Series Analysis, Princeton University Press, 2012.
- J. A. Rice, Mathematical Statistics and Data Analysis, Duxbury Advanced Series, 3rd edition, 2007.

Evaluation Scheme:

Mid-Semester Examination	25%
End-Semester Examination	45%
Sessionals (Assignments/Quizzes/Lab Evaluation etc.)	30%

Credits: 3 [2-0-2]

Course Objectives: This course aims to introduce the concepts to formulate the research problem and the various statistical methods such as descriptive statistics, statistical distributions, hypothesis testing, ANOVA, correlation, regression analysis and design of experiments to conduct the research.

Contents:

Introduction: Nature and objectives of research, Study and formulation of research problem, Scope and formulation of hypothesis, Preparation and presentation of research and project proposals, Selection of thrust research.

Introduction to Statistical Analysis: Measures of Central Tendency and Dispersion, Mean, Median, Mode, Range, Mean deviation, Standard Deviation.

Random Variables and Probability Distribution: Definition, Distributions, Cumulative distribution functions, Mathematical Expectation, Binomial, Poisson, Geometric, Negative bionomial, Exponential, Normal and log normal distributions.

Hypothesis Testing: Tests of Significance based on normal, t and chi-square distributions, F-distribution, Analysis of variance techniques.

Linear Regression and Correlation: Linear regression, Least square principle and fitted models, Karl Pearson's correlation coefficient, Rank Correlation, Lines of regression.

Design of Experiments: Completely randomized design, Random block design, Latin square design, Statistical analysis.

Laboratory Work: Each laboratory experiment will consist of numerical exercises on each of the above topics. Laboratory experiments will be performed using some statistical software.

Course Learning Outcomes: The student will be able to

1. formulate research problems and design of research/project proposals.
2. interpret probability and data distribution functions and becoming capable of estimating mathematical expectations.
3. analyze regression and correlation analysis, develop of statistical models, validation and use of models.
4. make statistical inferences using principles of hypothesis tests and ANOVA.
5. acquaint and compare commercially available software packages for the statistical data analysis.

Text/References:

- S. Dowdy, S. Wearden, and D. Chilko, Statistics for Research, Wiley, Second edition, 2004.
- R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, Pearson Education, 7th Edition, 2002.
- C. K. Kothari and G. Garg, Research Methodology: Methods and Techniques, New Age International Publishers, 3rd edition, 2019.

- J. A. Rice, Mathematical Statistics and Data Analysis, Duxbury Advanced Series, 3rd edition, 2007.

Evaluation Scheme:

Mid-Semester Examination	25%
End-Semester Examination	35%
Sessionals (Assignments/Quizzes/Lab Evaluation etc.)	40%

Credits: 4 [3-0-2]

Course Objectives: The aim of this course is to motivate the students an intrinsic interest in statistical thinking and instil the belief that statistics is important for scientific research.

Contents:

Introduction: Nature and objectives of research, study and formulation of research problem, scope and formulation of hypothesis, preparation and presentation of research and project proposals, selection of thrust research.

Introduction to Statistical Analysis: Measures of central tendency and dispersion, mean, median, mode, range, mean deviation, standard deviation, coefficient of variation, Skewness and kurtosis.

Random Variables and Probability Distribution: Definition, distribution functions, mathematical expectation, binomial, Poisson, geometric, negative binomial, exponential, uniform, normal, gamma, and Weibull distributions, two dimensional random variables, joint and marginal distributions.

Markov chains: Basics of Markov chains, finite state space, Markov chains, transition and stationary Markov chains, continuous time Markov process: pure birth, pure death, birth and death process.

Hypothesis Testing: Tests of significance based on normal, analysis of variance technique.

Linear Regression and Correlation: Linear regression, least square principle and fitted models, Karl Pearson's correlation coefficient, rank correlation, lines of regression.

Design of Experiments: Completely randomized design, random block design, Latin square design, statistical analysis.

Time series and forecasting: Components of time series, analysis of time series, measurement of trend, measurement of seasonal variations.

Laboratory Work: Implementation of statistical techniques using statistical software including evaluation of statistical parameters and data interpretation, Regression Analysis, Covariance, Hypothesis testing and analysis of variance.

Course Learning Outcomes: The student will be able to

1. formulate research problems and design of research/project proposals.
2. compute the probabilities of events along with an understanding of the random variables and various statistical distributions.
3. make statistical inferences using principles of hypothesis tests and ANOVA.
4. analyze the correlated data and fit the regression models along with measurement of different components of the time-series.
5. learn the Markov processes with a study of stochastic process an their subsequently applications like gambling problem etc.

Text/References:

- S. Dowdy, S. Wearden, and D. Chilko, Statistics for Research, Wiley, 2nd ed, 2004.
- S. Ross, Introduction to Probability Models, 12th edition, Elsevier, 2019
- G. Casella and R.L. Berger. Statistical Inference, 2nd edition, Cengage Learning Incorporation, 2002
- J.A. Rice. Mathematical Statistics and Data Analysis, 3rd edition, Duxbury Advanced Series, 2007
- J. Medhi, Stochastic Processes, New Age International, 2005.

Evaluation Scheme:

Mid-Semester Examination	25%
End-Semester Examination	40%
Sessionals (Assignments/Quizzes/Lab Evaluation etc.)	35%

DMC013 Research Methodology (BT/CH/CHEM)

Credits: 4 [3-0-2]

Course Objectives: The aim of this course is to motivate the students an intrinsic interest in statistical thinking and instil the belief that statistics is important for scientific research.

Contents:

Introduction: Nature and objectives of research, study and formulation of research problem, scope and formulation of hypothesis, preparation and presentation of research and project proposals, selection of thrust research.

Introduction to Statistical Analysis: Measures of central tendency and dispersion, mean, median, mode, range, mean deviation, standard deviation, coefficient of variation.

Random Variables and Probability Distribution: Definition, distribution functions, mathematical expectation, binomial, Poisson, geometric, uniform, exponential, normal distributions, joint and marginal distributions.

Hypothesis Testing: Tests of significance based on normal, analysis of variance technique.

Linear Regression and Correlation: Linear regression,least square principle and fitted models, Karl Pearson's correlation coefficient, rank correlation, lines of regression.

Time series and Forecasting: Components of time series, analysis of time series, measurement of trend, measurement of seasonal variations.

Laboratory Work: Implementation of statistical techniques using statistical software including evaluation of statistical parameters and data interpretation, Regression Analysis, Covariance, Hypothesis testing and analysis of variance.

Course Learning Outcomes: The student will be able to

1. formulate research problems and design of research/project proposals.
2. compute the probabilities of events along with an understanding of the random variables and various statistical distributions.
3. make statistical inferences based on principles of hypothesis tests and ANOVA.
4. analyze the bivariate correlated data and fit the regression models.
5. perform analysis of time-series data with different time series models.

Text/References:

- C.R. Kothari and G. Garg. Research Methodology: Methods and Techniques. 3rd edition, 2019.
- R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, Dorling Kindersley, 7th ed, 2007.
- S. Ross, Introduction to Probability Models, 12th edition, Elsevier, 2019.
- G. Casella and R.L. Berger. Statistical Inference, 2nd edition, Cengage Learning Incorporation, 2002.

- J. A. Rice. Mathematical Statistics and Data Analysis, 3rd edition, Duxbury Advanced Series, 2007.

Evaluation Scheme:

Mid-Semester Examination	25%
End-Semester Examination	40%
Sessionals (Assignments/Quizzes/Lab Evaluation etc.)	35%

Credits: 3.5 [3-1-0]

Course Objectives: The objective is to develop basic mathematical skills required for biological and chemical studies.

Contents:

Algebra: Linear and quadratic equations; Complex numbers, Argand plane and polar representation of a complex number, Factorial n, Permutations and combinations, Random experiments; outcomes, sample spaces (set representation).

Trigonometry: Review of trigonometric functions, sum and product formulae for trigonometric functions, Identities related to $\sin(2x)$, $\cos(2x)$ and $\tan(2x)$.

Determinants and Matrices: Matrices, Operations on Matrices, Determinants and its properties, singular and non-singular matrices, Adjoint and inverse of a matrix and its properties, Solution of system of linear equations using Cramer's rule.

Differentiation: Review of functions, Limit, Continuity and Differentiability, Differentiation of standard functions (polynomials, trigonometric, exponential and logarithmic), Product rule, Quotient rule.

Applications of derivatives: Rate of change of moving objects, increasing/decreasing functions, maxima and minima.

Integration: Integration as inverse process of differentiation, Integration by substitution, by partial fractions and by parts (polynomials and trigonometric functions only). Evaluation of simple integrals.

Coordinate Geometry: Brief recall of two dimensional geometry from earlier classes, Distance formula, Slope of a line and angle between two lines, Various forms of equations of a line: point-slope form, slope-intercept form.Circles (in standard form).

Course Learning Outcomes: The student will be able to

1. evaluate problems of Algebra and Trigonometry.
2. solve problems on determinants and matrices and subsequently find the solutions of system of linear equations.
3. determine differentiation of standard functions such as polynomial, trigonometric etc.
4. apply different methods of integration such as method of substitution, partial fractions, product rule and quotient rule.
5. find equations of straight line and circle under a given conditions.

Text/References:

- Mathematics, A Text book (Parts I & II), NCERT, New Delhi, 2011.
- G. B. Thomas and R. L. Finney, Calculus and Analytical Geometry, Pearson Education, 9th ed, 2007.
- S. Narayan, Differential and Integral Calculus, S. Chand publications, 2005.

- V. K. Krishnamurthy, V. P. Mainra, and J. L. Arora, An introduction to Linear Algebra, Associated East WestPress, 2007.

Evaluation Scheme:

Mid-Semester Examination	30%
End-Semester Examination	45%
Sessionals (Assignments/Quizzes etc.)	25%