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: Classical and empirical probability, axioms of probability, conditional probability, Bayes' rule, law of total probability and law of total expectation, introduction to Bernoulli, binomial, Poisson, geometric, normal, exponential, distributions, joint and marginal distributions, central limit theorem, probability distribution of functions of random variables.

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: $AR(1)$, $AR(p)$, moving average models: $MA(1)$, $MA(q)$, autoregressive moving average models: ARMA(p, q).

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, hitting probabilities, return and exit time distributions for discrete Markov chains, classification of states, detailed balance.

Laboratory Work: Each laboratory experiment will consist of numerical exercises on one of the above topics. Laboratory experiments will be performed using Matlab/SPSS.

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.
4. perform multivariate data analysis using Principal Component Analysis and linear regression.
5. obtain foundational understanding of discrete Markov processes.

Text/References:

- J. Medhi, Stochastic Processes, New Age International, 2005.
- Paul L. Meyer, Introductory probability and statistical applications, Addison-Wesley Publishing Company, 1970

- R. Durrett, Essentials of Stochastic Processes, Springer, 2016.
- S. Ross, Stochastic Processes, John Wiley and Sons, 1996.
- R. Hogg, J. McKean, and A. Craig, Introduction to Mathematical Statistics, Pearson, 2013.
- J. Hamilton, Time Series Analysis, Princeton University Press, 2012.

Evaluation Scheme:

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

PMA102 Research Methodology

Credits: 3 [2-0-2]

Course Objectives: Ability to elaborate the concept of distribution functionability to distinguish between a discrete and continuous random variable and discuss transformation of one-dimensional, two-dimensional variables; develop potential towards problem solving using analysis of variance techniques; able to compute and interpret Karl Pearsons correlation coefficient and Spearman's rank correlation coefficient. Able to constitute random block design, Latin square design, and derive their probability distributions.

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, 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, 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 and variance of estimates, Analysis of variance.

Laboratory Work: Implementation of statistical techniques using statistical packages viz., SPSS, ORIGIN PRO & MATLAB, R Programming, Mathematica 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. acquire skills for formulating research problems and hypotheses to be tested, and for the preparation and presentation of research/project proposals.
2. interpret probability and data distribution functions and becoming capable of estimating mathematical expectations.
3. analyze regression and correlation analysis, development of statistical models, and calibration, validation and use of models.
4. design of experiments for investigations and hypotheses testing relating to research problems and projects.
5. acquaint with the 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.

Evaluation Scheme:

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

DMC007 Research Methodology

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, distributions, functions, mathematical expectation, binomial, Poisson, geometric, negative binomial, exponential, normal distributions, two dimensional random variables, 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 packages viz. SPSS, R 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. learn how to analyze the data using different descriptive measures and present graphically.
2. compute the probabilities of events along with an understanding of the random variables, expectation, variance and distributions.
3. make statistical inferences using principles of hypothesis tests.
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.
- R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, Dorling Kindersley, 7th ed, 2007.
- R. A. Jhonson, C. B. Gupta, Miller and Freund's Probability and Statistics for Engineers, Dorling Kindersley, 7th ed, 2007.
- P. L. Meyer, Introductory Probability and Statistical Applications, Addison Wesley, 1970.
- 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, distributions, functions, mathematical expectation, binomial, Poisson, geometric, 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 packages viz. SPSS, R 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. learn how to analyze the data using different descriptive measures and present them graphically.
2. compute the probabilities of events along with an understanding of the random variables, expectation and various probability distributions.
3. understand the estimation of Normal distribution parameters and their one-sample and multisample hypothesis tests along with applications to real world problems.
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:

- S. Dowdy, S. Wearden, and D. Chilko, Statistics for Research, Wiley, 2nd ed, 2004.
- R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, Dorling Kindersley, 7th ed, 2007.
- R. A. Jhonson, C. B. Gupta, Miller and Freund's Probability and Statistics for Engineers, Dorling Kindersley, 7th ed, 2007.

- P. L. Meyer, Introductory Probability and Statistical Applications, Addison Wesley, 1970.
- 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%

PIM101 Basic Mathematics

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). Events; occurrence of events, exhaustive events, mutually exclusive events, Probability of an event: simple mathematical problems involving shuffling of cards, tossing of coin and rolling of a die.

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, inverse trigonometric, exponential and logarithmic), Product rule, Quotient rule.

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

Integration: Integration as inverse process of differentiation, Integration by substitution, by partial fractions and by parts (polynomials, trigonometric functions only), Evaluation of simple integrals of the following types and problems based on them:

$$\int \frac{dx}{x^2 \pm a^2}, \int \frac{dx}{\sqrt{x^2 \pm a^2}}, \int \frac{dx}{\sqrt{a^2 - x^2}}, \int \sqrt{a^2 \pm x^2}dx, \int \sqrt{x^2 - a^2}dx$$

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. solve various problems on Algebra and Trigonometry.
2. solve problems on determinants and matrices and subsequently the solutions of system of linear equations.
3. evaluate differentiation of standard functions various problems.
4. apply different methods of integration such as method of substitution, by partial fractions and by parts.
5. find equations of straight line and circle under 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.
- Shanti Narayan, Differential and Integral Calculus, S. Chand, 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%