B.TECH SYLLABUS

DEPARTMENT OF MATHEMATICS

Approved in Academic Council held on 29 November 2021

Engineering Mathematics I

COURSE CODE: 18B11MA111

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Basic concepts of calculus and algebra

Course Objectives:

1. Various techniques of Multivariate Calculus and Integral Calculus.
2. The fundamental concepts of Vector Calculus.
3. The fundamentals of Laplace transforms and their applications.
4. To develop the essential tool of Matrices and Linear Algebra in a comprehensive manner.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Evaluate partial derivatives with its physical significance and expand functions of several variables.	Familiarity & Usage
CO-2	Find maxima and minima of functions of several variables with / without constraints.	Assessment
CO-3	Find areas and volumes of solids using multiple integration	Assessment
CO-4	Understand the calculus of vectors and vector valued functions with their physical significance	Familiarity & Usage
CO-5	Use Laplace transforms and inverse Laplace transforms to solve IVP	Usage
CO-6	Solve linear systems of equations and perform diagonalization of matrices	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Differential Calculus:** Limits and continuity of function, Partial Differentiation, Chain rule, Total Derivative; Maxima, Minima and Saddle points; Method of Lagrange's multipliers, Taylor's series for two or more variables	10
2	**Integral Calculus:** Improper integrals; Beta and Gamma functions and their properties; Double integrals, Change of order and Change of variables, Applications to areas and volumes.	10
3	**Vector Calculus:** Equations to a line and a plane, Tangent plane and Normal line, Gradient, Curl and divergence and their physical significance, Directional derivatives, Line and surface integrals.	6
4	**Laplace Transform:** Laplace Transform, Inverse Laplace transform, Convolution, Dirac delta and Unit Step function, Solution of initial value problems.	6
5	**Matrices:** Algebra of matrices, Row Echelon form, Inverse and Rank of a matrix, Symmetric, Skew- symmetric and Orthogonal matrices; Determinants; Solution of systems of linear equations (Gauss's elimination, Rank method), Linear Independence and Dependence of vectors. Eigen values and Eigenvectors; Cayley-Hamilton Theorem, Diagonalization of matrices and Orthogonal transformation.	10
Total lectures		**42**

Suggested Text Book(s):

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, 2002.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. Jain and Iyengar, Advanced Engineering Mathematics, Narosa Publishing House.

Suggested Reference Book(s):

1. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.
2. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Other useful resource(s):

1. Link to NPTEL course contents: https://onlinecourses.nptel.ac.in/noc18_ma05/preview
2. Link to topics related to course:
   i. https://www.whitman.edu/mathematics/calculus_online/chapter14.html
   ii. https://nptel.ac.in/courses/103103037/5
   iii. https://nptel.ac.in/courses/111106051
   iv. https://nptel.ac.in/courses/111107108/25
   v. https://nptel.ac.in/courses/117101056/16

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered upto T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Engineering Mathematics I)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	1	0	1	2	1	0	0	0	2	1	1	1
CO-2	3	2	3	1	2	1	0	0	0	1	2	2	1.5
CO-3	2	1	1	0	1	1	0	0	0	2	1	2	1
CO-4	3	1	1	1	2	2	0	0	0	2	1	2	1.5
CO-5	2	2	1	2	1	2	0	0	0	1	2	3	1.5
CO-6	3	2	1	1	1	2	0	0	0	2	2	3	1.5
Average	2.67	1.5	1.17	1	1.5	1.5	0	0	0	1.67	1.5	2.17	

Basic Mathematics-I

COURSE CODE: 18B11MA112

COURSE CREDITS: 04

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Basic knowledge of Arithmetic and Algebra.

Course Objectives:

1. To learn the basic concepts of Matrices and Determinant used in solving the system of linear equations.
2. To learn the fundamentals of vector, coordinate geometry and Complex number.
3. To learn and use the basic concepts of Differential and Integral Calculus

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand the basic properties of Matrices and Determinant, Solution of system of linear equations	Familiarity& Usages
CO-2	Understand the various concept of vectors and coordinate geometry	Familiarity
CO-3	Understand complex numbers and their properties; geometrical representation, Polar form. DeMoivre's theorem. Roots of complex numbers	Familiarity
CO-4	Work with sets, relations and functions	Usages
CO-5	Understand the basic concept of Differential Calculus; limit and continuity. Derivative. Rules of differentiation. Tangent to a curve. Taylor's series. Maxima and minima.	Familiarity& Assessment
CO-6	Understand the basic concept of Integral Calculus; Integrals of elementary functions. Substitution and partial fractions. Definite integral as a limit of sum. Properties of definite integrals. Application to areas and lengths.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Matrices and Determinants** Algebra of matrices. Determinant of a square matrix. Properties of determinants. Some simple type of matrices. Inverse of a matrix. Solution of equations	8
2	**Vectors and Coordinate Geometry** Vectors and their algebra. Unit vectors. Components of a vector. Position vector. Direction cosines and direction ratios. Dot and cross products. Projection of a vector on another. Distance between two points. Equations of a line, plane and sphere. Intersections. Shortest distance between lines and planes.	9
3	**Complex Numbers** Definition and geometrical representation. Algebra. Complex conjugate. Modulus and amplitude. Polar form. DeMoivre's theorem. Roots of complex numbers. Simple functions.	6
4	**Sets, Relations and function** Sets and their representation. Union, intersection and compliment. Mapping or function. One-one, onto mappings. Inverse and composite mappings.	6
5	**Differential Calculus** Basic concept of limit and continuity. Derivative. Rules of differentiation. Tangent to a curve. Taylor's series. Maxima and minima.	6
6	**Integral Calculus** Fundamental theorem of calculus (statement only).	7

	Integrals of elementary functions. Substitution and partial fractions. Definite integral as a limit of sum. Properties of definite integrals. Application to areas and lengths.	
Total lectures		**42**

Suggested Text Book(s):

1. NCERT. Mathematics Textbook for class XI and XII.
2. R.D. Sharma, Mathematics, Dhanpat Rai Publications, New Delhi.

Suggested Reference Book(s):

1. G. B Thomas, R. L. Finney Calculus and analytical geometry, 9th Ed., Pearson Education Asia (Adisson Wesley), New Delhi, 2000.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/122104018/
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/111106086/2
   ii. https://nptel.ac.in/courses/112104035/14
   iii. https://nptel.ac.in/courses/111103070/
   iv. https://nptel.ac.in/courses/111104085/8
   v. https://nptel.ac.in/courses/111104085/14

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Biostatistics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	2	2	2	3	3	2	1	3	2	3	3	2.4
CO-2	3	1	1	2	2	2	2	1	2	2	1	2	1.8
CO-3	2	1	1	1	1	1	1	1	1	1	1	2	1.2
CO-4	2	1	1	1	1	1	1	1	1	3	1	2	1.3
CO-5	3	2	2	3	2	2	2	1	2	1	3	2	2.1
CO-6	3	3	2	2	2	2	2	1	2	1	2	2	2.0
Average	2.7	1.7	1.5	1.8	1.8	1.8	1.7	1.0	1.8	1.7	1.8	2.2	

Engineering Mathematics II

COURSE CODE: 18B11MA211

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Engineering Mathematics I

Course Objectives:

1. The various methods of solving the second order differential equations with variable coefficients, to study the basic properties of Bessel Functions, Legendre polynomials, Chebyshev polynomials and their Applications.
2. To obtain solutions of Wave, Diffusion and Laplace Equation.
3. To study calculus of complex variables.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Solve problems related to convergence of series	Familiarity & Usage
CO-2	Understand basics of Ordinary Differential equation	Assessment
CO-3	Comprehend series solution with certain special functions e.g. Bessel, Legendre Eqn.	Usage
CO-4	understand partial differential Eqn and Solve Heat, wave & Laplace equation	Usage
CO-5	Understand Functions of a complex variable, Analytic functions, Mobius Transformation	Usage
CO-6	Solve Contour integration and find Taylor's and Laurent's series	Familiarity & Usage
CO-7	Evaluate certain real defnite and improper integrals.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Sequences and Series:** Convergence of sequence and series, tests for convergence; Power series, Fourier series: Half range sine and cosine series, Parseval's theorem.	7
2	**Differential Equations Part I:** Basics of first order Differential Equations, Second and Higher order differential equations with constant coefficients. Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation;	7
3	**Differential Equations Part II:** Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties. Introduction to Partial Differential Equations, Solutions of One dimensional Wave, Heat Equation & Laplace Equation**.**	12
4	**Complex Variable – Differentiation:** Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.	8

5	**Complex Variable – Integration:** Contour integrals, Cauchy Theorem, Cauchy Integral formula, Liouville's theorem and Maximum-Modulus theorem; Taylor's series, zeros of analytic functions, singularities, Laurent's series; **[CO-6]** Residues, Cauchy Residue theorem, Evaluation of definite integral involving sine and cosine, improper integrals.	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006
2. Jain and Iyengar, Advanced Engineering Mathematics, Narosa Publishing House

Suggested Reference Book(s):

1. Simmons, G.F., Differential Equations with Applications, 2nd Ed, McGraw-Hill, 1991.
2. Brown, J.W., Churchill, R.V. , Complex Variables and Applications, 6th Ed., McGrawHill, 1996.
3. Spiegel, Murray R, Theory and Problems of Complex variables Schaum's series.
4. Sneddon I. N., Introduction to Partial Differential Equations, Dover Publications, 2006

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/122101003/2
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/111104031/
   ii. https://nptel.ac.in/courses/111104031/8
   iii. https://nptel.ac.in/courses/122107037/29
   iv. https://nptel.ac.in/courses/111107056/
   v. https://nptel.ac.in/courses/117101055/14

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered upto T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Engineering Mathematics II)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	1	0	1	2	1	0	0	0	2	1	1	1
CO-2	2	2	1	1	1	2	0	0	0	1	2	2	1.5

CO-3	3	2	1	0	2	1	0	0	0	1	1	3	1.5
CO-4	3	1	2	1	2	2	0	0	0	2	1	2	1.5
CO-5	2	2	1	2	1	1	0	0	0	2	2	2	1.5
CO-6	3	2	2	1	2	1	0	0	0	1	2	1	1.5
CO-7	3	1	1	0	2	2	0	0	0	2	1	2	1.5
Average	2.71	1.57	1.14	1	1.71	1.42	0	0	0	1.57	1.42	1.85	

Basic Mathematics II

COURSE CODE: 18B11MA212

COURSE CREDITS: 04

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Basic Mathematics-I (18B11MA112)

Course Objectives:

1. To acquire the basic knowledge of sequence, series and advanced calculus.
2. To study the differential equations and their solutions applicable in Biotechnology and Bioinformatics.
3. To study the fundamentals and applications of Statistics and Numerical Techniques used in Bio sciences.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand the idea of sequence and series and to learn about their convergence	Familiarity
CO-2	learn concepts of calculus of two or more variables	Familiarity
CO-3	learn the fundamentals of differential equations and their types	Familiarity
CO-4	Solve various types of differential equations	Assessment
CO-5	Understand basic statistics and learn to find mean mode, median and standard deviation.	Usage
CO-6	Numerically solve various problems using standard methods	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Sequence and series:** Convergence and divergence. Simple tests for convergence. Absolute convergence.	8
2	**Calculus of two or more variables:** Partial differentiation. Taylor's series. Differentiation of a vector. Tangent to a curve. Gradient of a scalar. Tangent to a surface. Integration of a vector. Line integral. Double integral.	8
3	**Elementary Differential Equations:** Definitions of order, degree, linear, nonlinear, homogeneous and nonhomogeneous Solution of first order equations. Complementary function and particular integral. Initial and boundary value problems. Linear differential equations with constant coefficients. Cauchy-Euler equation	10
4	**Basic Statistics**: Classification of data. Mean, mode, median and standard deviation. Method of least squares	8
5	**Numerical Methods:** Newton-Raphson method. Linear and quadratic interpolation. Simpson's rule	8
Total lectures		**42**

Suggested Text Book(s):

1. G. B Thomas, R. L. Finney Calculus and analytical geometry, 9th Ed., Pearson Education Asia (Adisson Wesley), New Delhi, 2000.

2. NCERT. Mathematics Textbook for class XI and XII.
3. Sharma, R.D. Mathematics, Dhanpat Rai Publications, New Delhi

Suggested Reference Book(s):

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006
2. Dennis G. Zill, Warren S. Wright, Advanced Engineering Mathematics, Jones and Bartlett Publishers, Inc; 4th Revised edition.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111104085/25

2. Link to topics related to course:

i. https://nptel.ac.in/courses/111108081/
ii. https://nptel.ac.in/courses/105103027/module2/lec5/1.html
iii. https://www.khanacademy.org/math/ap-statistics/summarizing-quantitative-data-ap/measuring-center-quantitative/v/statistics-intro-mean-median-and-mode

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2)- 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Parallel and Distributed Algorithms)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	1	1	1	1	1	1	1	2	2	1.3
CO-2	2	2	1	1	2	2	1	1	1	2	1	2	1.5
CO-3	2	3	2	2	1	2	2	1	2	1	2	2	1.8
CO-4	2	3	2	2	1	2	2	1	2	1	2	2	1.8
CO-5	3	2	2	3	3	3	2	1	3	2	3	3	2.5
CO-6	3	1	1	2	3	2	2	1	3	2	3	2	2.1
Average	2.3	2.2	1.5	1.8	1.8	2.0	1.7	1.0	2.0	1.5	2.2	2.2	

Numerical Methods

COURSE CODE: 18B11MA311

COURSE CREDITS:4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: None

Course Objectives:

1. Introduction to numerical errors and various techniques for obtaining roots of the nonlinear equations.
2. Learn to analyze system of linear equations and obtain its solutions.
3. To learn certain interpolation techniques.
4. To comprehend numerical differentiation and integration.
5. Learn to obtain solutions of IVP, BVP and partial differential equations.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand numerical errors and obtain roots of the nonlinear equations & system of nonlinear equations.	Assessment
CO-2	Ability to solve the system of linear equations and finding eigenvalues of the matrices.	Assessment
CO-3	Perform polynomial interpolations using various techniques.	Usage
CO-4	Perform Cubic-spline interpolation and approximations.	Assessment
CO-5	Perform Numerical Differentiation, Numerical Integration.	Assessment
CO-6	Solve IVP, BVP and numerical solutions of parabolic, elliptic and hyperbolic partial differential equations.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to numerical errors and nonlinear equations:** Initial error, round-off error, Truncation error, Absolute error, relative error, percentage error. Root-finding methods: single nonlinear equation - Bisection method, False-Position method, Newton-Raphson method, Secant methods, (Fixed-point) Iteration method; more than one nonlinear equations- Newton's method. Convergence criteria. Iterative methods and the formula for calculation of the approximation.	6
2	**Numerical Linear Algebra:** Direct methods: Gauss-elimination method, LU-Decomposition methods. Iterative methods: Gauss-Siedel method, Successive Over-Relaxation (SOR) methods. Eigenvalue problem: Power method for largest eigenvalue, Jacobi's method for symmetric matrices.	6
3	**Interpolation & Approximation**: (i) Interpolating polynomial. Lagrange formula with error. Formulae for equally-spaced points. Divided differences: Newton's interpolating polynomials. (ii) Hermite interpolation. Cubic-spline interpolation. Pade and rational approximations. Least square approximation. Approximation by splines.	5+5=10
4	**Numerical Differentiation and Quadrature:** Approximation of derivatives,	9

	Newton-cote integration formulae. Gauss-Legendre quadrature formulae. Romberg integration. Double integration.	
5	**Numerical Solutions of ODE and PDE:** Numerical solutions of ODEs using Picard, Euler, modified Euler, Runge-Kutta methods, Predictor corrector methods for IVPs. The Finite difference method and Shooting method for BVPs. Numerical solutions of parabolic, elliptic and hyperbolic partial differential equations.	**11**
Total lectures		**42**

Suggested Text Book(s):

1. C. F. Gerald and P.O Wheatley: Applied Numerical Analysis, 6th Edition, Pearson Education Asia, New Delhi, 2002.
2. Steven C. Chapra, Raymond P. Canale: Numerical Methods for Engineers, 7th Edition, Tata McGraw-Hill.
3. M. K. Jain, S.R.K. Iyengar, R. K. Jain: Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International.

Suggested Reference Book(s):

1. S. Joe D Hoffman: Numerical Methods for Engineers and Scientists, 2nd Edition, Marcel Dekker Inc.
2. Richard L. Burden & J. Douglas Faires: Numerical Analysis, 9th Edition, Cengage Learning.
3. B. S. Grewal: Numerical Methods, 11th Edition, Khanna Publishers.
4. S. S. Sastry: Introductory Methods of Numerical Analysis, 5th Edition, Prentice Hall India Learning Private Limited.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/122102009/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 15 Quizzes (1) - 5 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Numerical Methods)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	2	2	2	1	0	0	1	2	2	2	1.6
CO-2	2	2	1	2	3	3	0	0	1	2	2	2	1.7

CO-3	1	1	2	2	2	2	0	0	2	2	2	2	1.5
CO-4	2	2	2	2	1	2	0	0	2	1	1	2	1.4
CO-5	3	2	2	2	2	2	0	0	2	2	2	2	1.8
CO-6	2	2	1	2	2	2	0	0	2	1	1	1	1.3
Average	2	2	1.7	2	2	2	0	0	1.7	1.7	1.7	1.8	

Probability and Statistical Techniques

COURSE CODE: 18B11MA312

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Working knowledge of basic calculus and combinatorial skills.

Course Objectives: This course introduces students:

1. To the elementary concepts of descriptive and inferential techniques of statistical methodology.
2. To extend and formalize knowledge of the theory of probability and random variables.

Course Outcomes: At the end of the course, the students will be able to apply appropriate statistical concepts, methodologies and technologies in organizing, analyzing and interpreting various real-world situations and in coming up with relevant decisions:

S. No.	Course Outcomes	Level of Attainment
CO-1	Compute and Interpret Measures of Central Tendency and Dispersion of Data; Construct and Analyze Graphical Displays (Histogram, Bar & Pie Charts, Etc.) To Summarize Data.	Familiarity
CO-2	Construct Sample Spaces of Random Experiments; Identify and Specify Events; Apply Discrete/Continuous Probability Distributions to Evaluate Event Probabilities; Use *Central Limit Theorem* to Find Probabilities for Sampling Distributions.	Assessment
CO-3	Conduct Hypotheses Tests & Construct Point & Confidence-Interval Estimates Concerning Population Parameters Based on Sample Data; Perform and Interpret Chi-Square Test of Goodness-of-Fit and Test of Independence.	Usage
CO-4	Compute Correlation Coefficient to Decide The Linear Relationship that May Exist Between Two Variables of Interest; Find The Equation of Regression Line And Predict The Value of One Variable Based on the Value of the Other Variable.	Assessment
CO-5	Identify and Evaluate Common Sampling Techniques Such as F-Test in ANOVA - Evaluating or Approximating the P- Value of the Test Statistic - and Design Simple Experimental.	Applications

Course Contents:

Unit	Contents	Lectures Required
1	**Basics of Statistics:** Population, Sample, Attribute and Variable (Discrete and Continuous). Classification and Tabulation of Data. **Graphical Representation of Data** - Histogram, Frequency Polygon, Stem-and-Leaf Plots, Box Plot, Bar & Pie Charts. **[CO-1]**	5
2	**Descriptive statistics:** Measures of Central Tendency - Mean, Median, Mode. **Dispersion and its Measures** – Range, Quartile Deviation, Mean Deviation, Standard Deviation. Skewness and Kurtosis. **[CO-1]**	6
3	**Probability:** Random Experiment, Sample Space, Event, Types of Events. Three Approaches To Probability, Additive And Multiplicative Laws Of Probability, Conditional Probability, Total Probability Theorem and Bayes' Theorem. **[CO-2]**	5
4	**Random Variables:** Random Variable – Introduction: Probability Mass Function (PMF), Probability Density Function (PDF) and Cumulative Distribution Function (CDF). Moments of Random a Variable - Mean and Variance. Moment	6

	Generating Function of a Random Variable (Definition & Properties). Bernoulli, Binomial, Poisson and Normal Distributions – Problems with Applications. **[CO-2]**	
5	**Statistical Inference:** Introduction to Random Sampling - The Central Limit Theorem, Sampling Distribution. Concept of Estimation and Testing of Hypotheses: Type-I & Type-II Errors, Level of Significance, Confidence Interval, P-Value, Critical Value, Critical Region; Tests for Population Means and Variances for Single and Double Samples (Z-Test, T-Test and F-Test). Chi-Square Test of Goodness of Fit and Independence of Attributes (mxn Contingency). **[CO-3]**	**8**
6	**Correlation And Regression:** Bivariate Data, Scatter Plots. Pearson Product-Moment and Spearman's Rank Correlation Coefficients, Properties of Correlation Coefficient. **Simple Linear Regression** - Regression Equations. **[CO-4]**	**6**
7	**ANOVA and Simple Designs:** One-Way and Two-Way (Without and With Interaction) ANOVA. Concept of Three Basic Principles of Design of Experiments, CRD and RBD. **[CO-5]**	**6**
Total Lectures		**42**

Suggested Text Book(s):

1. Richard A. Johnson Irwin Miller and John E. Freund, ``Probability and Statistics for Engineers", Prentice Hall, New Delhi, 11th Edition, 2011.

Suggested Reference Book(s):

1. Ronald E. Walpole , Raymond H. Myers , Sharon L. Myers and Keying E. Ye, ``Probability and statistics for engineers and scientists'', 9th Edition, Pearson, 2011.
2. Jay L. Devore, ``Probability and statistics for engineering and the sciences", Cengage Learning, 8th Edition, 2011.
3. P. Kousalya, "Probability, statistics and random processes", Pearson Education, 2013.

Other Useful Resource(s):

1. Link to NPTEL Course Contents:
   i. https://nptel.ac.in/courses/111106112/
   ii. https://nptel.ac.in/courses/111105090/
   iii. https://nptel.ac.in/courses/111105041/
   iv. https://nptel.ac.in/courses/102106051/
   v. https://nptel.ac.in/courses/102101056/
2. Link to Topics Related to Course:
   i. https://nptel.ac.in/courses/111106112/1- 5/
   ii. https://nptel.ac.in/courses/111106112/12-17/
   iii. https://nptel.ac.in/courses/111106112/18-21/
   iv. https://nptel.ac.in/courses/111105090/1-32/
   v. https://nptel.ac.in/courses/111105090/49-54/
   vi. https://nptel.ac.in/courses/111105090/61-79/
   vii. https://nptel.ac.in/courses/111105041/3-40/
   viii. https://nptel.ac.in/courses/102106051/32/
   ix. https://nptel.ac.in/courses/102106051/1-24/
   x. https://nptel.ac.in/courses/102101056/1-12/
   xi. https://nptel.ac.in/courses/102101056/15-40/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered upto T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) Contribution to the Programme Outcomes (POs):

Course Outcomes (Probability & Statistics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	1	2	1	1	1	-	-	1	2	1	1.6
CO-2	3	3	1	2	2	1	1	-	-	1	2	2	1.8
CO-3	3	3	2	3	3	3	1	-	-	1	3	3	2.5
CO-4	3	3	3	3	2	3	1	-	-	2	3	3	2.7
CO-5	3	3	3	3	3	3	1	-	-	2	3	3	2.7
Average	3.0	3.0	2.0	2.6	2.4	2.2	1.0	-	-	1.4	2.6	2.4	

Probability and Statistics

COURSE CODE: 18B11MA313

COURSE CREDITS: 4

CORE/ELECTIVE : CORE

L-T-P: 3-1-0

Pre-requisite: Working knowledge of basic calculus from Engineering Mathematics-I (18B11MA111).

Course Objectives:

1. To introduce students, the theoretical knowledge of the probability of random variables.
2. To study the fundamental concepts of descriptive and inferential techniques of statistical methodology.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Construct sample spaces of random experiments; identify and specify events, and perform set operations on events; understand the axiomatic approach of probability theory; compute probabilities by counting; evaluate conditional probability, and apply Bayes' theorem to simple situations.	Familiarity & Assessment
CO-2	Express random variables by using distribution function and density functions; calculate moments related to random variables; understand the concept of inequalities and probabilistic limits; understand the intrinsic need of (functions of) random variables for the analysis of random phenomena.	Familiarity & Assessment
CO-3	Compute probability distributions and correlation measures of bivariate random variables; obtain marginal and conditional distributions of random variables; find probabilities for outcomes of various events related to an uncertain phenomenon using appropriate probability distributions as models.	Assessment & Usage
CO-4	Compute correlation coefficient to decide the linear relationship that may exist between two variables of interest; find the equation of regression line and second degree curve, and to predict the value of one variable based on the value of the other variable.	Familiarity & Assessment
CO-5	Use central limit theorem to find probabilities for sampling distributions; conduct hypotheses tests and construct confidence- interval estimates concerning population parameters based on sample data; perform and interpret chi-square test of goodness-of-fit and test of independence.	Familiarity & Usage

Course Contents:

Unit	Contents	Lectures required
1	**Basic probability:** Random experiments; three basic approaches to probability, combinatorial probability problems; conditional probability, independence; total probability theorem, Bayes' theorem.	4
2	**Random variables:** Concept of random variables – discrete, continuous; probability distributions – probability mass function, density function and cumulative distribution function; expectation, variance and moment generating function of random variables; Chebyshev's inequality;	10

	bivariate distributions - conditional densities, distribution of sums and quotients, covariance (definition and interpretation).	
3	**Probability distributions:** Binomial, multinomial and Poisson approximation to the binomial distribution; exponential, gamma, and normal distributions.	**6**
4	**Descriptive statistics:** Measures of central tendency & dispersion: evaluation of statistical parameters (mean and variance possibly from grouped data) for binomial, Poisson and normal distributions; Measures of skewness and kurtosis; correlation and regression - rank correlation and curve fitting of straight lines, second degree parabolas and more general curves.	**10**
5	**Inferential statistics:** Introduction to sampling distribution - central limit theorem; testing of hypotheses: critical value, critical region, confidence interval, level of significance, p-value; Large and small sample tests (Z-test, t-test and F-test): single proportion, difference of proportions, single mean, difference of means, difference of standard deviations, and tests for ratio of variances and correlation coefficients; Chi-square test of goodness-of-fit and independence of attributes.	**12**
Total Lectures		**42**

Suggested Text Book(s):

1. Richard A. Johnson Irwin Miller and John E. Freund, ``Probability and Statistics for Engineers", Prentice Hall, New Delhi, 11th Edition, 2011.
2. Jay L. Devore, ``Probability and statistics for engineering and the sciences", Cengage Learning, 8th Edition, 2011.

Suggested Reference Book(s):

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, ``Probability and statistics for engineers and scientists'', 9th Edition, Pearson, 2011.
2. Henry Stark and John W. Woods: ``Probability and random processes with applications to signal processing'', Pearson education, 3rd Edition, Asia, 2002.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111106112
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/111105090/
   ii. https://nptel.ac.in/courses/111101004/
   iii. https://nptel.ac.in/courses/111102111/

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1.0 Hour	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2.0 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 05 Quizzes (2) - 15 Attendance - 05

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course Outcomes (Probability & Statistics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	1	2	1	1	1	-	-	1	2	1	1.6
CO-2	3	3	1	2	2	1	1	-	-	1	2	2	1.8
CO-3	3	3	2	3	3	3	1	-	-	1	3	3	2.5
CO-4	3	3	3	3	2	3	1	-	-	2	3	3	2.7
CO-5	3	3	3	3	3	3	1	-	-	2	3	3	2.7
Average	3.0	3.0	2.0	2.6	2.4	2.2	1.0	-	-	1.4	2.6	2.4	

Probability Theory and Random Processes

COURSE CODE: 18B11MA314

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

: 3-1-0

Pre-requisite: Knowledge of Differential & Integral Calculus from Engineering Mathematics-I.

Course Objectives:

1. To provide the students the elementary concepts of descriptive and inferential statistical methods.
2. To extend and familiarize the students with the basic concepts of random process for applications such as Random signals, signal noise, linear systems, etc in communication engineering.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Construct sample spaces of random experiments; identify and specify events, and perform set operations on events; compute probabilities by counting; evaluate conditional probability, and apply Bayes' theorem to simple situations.	Familiarity & Usage
CO-2	Express random variables by using CDFs, PMFs; calculate moments related to random variables; understand the concept of inequalities and probabilistic limits. Understand the axiomatic approach of probability theory and intrinsic need of (functions of) random variables for the analysis of random phenomena.	Familiarity & Assessment
CO-3	Compute probability distributions and correlation measures of bivariate random variables; obtain marginal and conditional distributions of random variables; find probabilities for outcomes of various events related to an uncertain phenomenon using appropriate probability distributions as models.	Assessment & Usage
CO-4	Conduct hypotheses tests concerning population parameters based on sample data; perform and interpret chi-square test of goodness-of-fit and test of independence; find the equation of regression line and second degree curve, and to predict the value of one variable based on the value of the other variable.	Assessment & Usage
CO-5	Identify and classify random processes and determine covariance and spectral density of stationary and ergodic random processes; demonstrate specific applications to Gaussian process.	Familiarity & Usage

Course Contents:

Unit	Contents	Lectures required
1	**Basic probability:** Random experiments; Three basic approaches to probability, combinatorial probability problems; Conditional probability, total probability theorem, Bayes' theorem.	4L
2	**Random variables:** Univariate random variables – discrete, continuous and mixed random variables; probability distributions – probability mass function, density function and cumulative distribution function; Expectation, variance and moment generating function of random variables; Chebyshev's inequality; Bivariate distributions with properties - conditional densities, definition & interpretation of covariance with properties, distributions of sum and quotient of random variables.	10L
3	**Special distributions:** Bernoulli trials – binomial, multinomial and Poisson	6L

	distributions; Exponential, gamma, uniform, and Gaussian distributions.	
4	**Basic statistics:** Measures of central tendency & dispersion: evaluation of statistical parameters (mean and variance possibly from grouped data) for binomial and normal distributions; Measures of skewness and kurtosis; Correlation and regression - rank correlation and curve fitting by the method of least squares regression - fitting of straight lines, second degree parabolas.	**6L**
5	**Applied statistics:** Introduction to sampling distribution; Testing of hypotheses: critical value, critical region, confidence interval, level of significance, p-value; Test for one sample proportion & Tests for mean and variance for single and double samples: Z-test, t-test and F-test; Chi-square test of goodness-of-fit and independence of attributes.	**10L**
6	**Stochastic processes:** Introduction and classification of random processes; Statistical averages – mean and auto-correlation functions; Stationary processes – SSS and WSS processes; Ergodic processes, Gaussian process - covariance matrix; Linear system with random inputs, power spectral density, noise in communication systems, white Gaussian noise.	**6L**
Total Lectures		**42L**

Suggested Text Book(s):

1. Richard A. Johnson Irwin Miller and John E. Freund, ``Probability and Statistics for Engineers", Prentice Hall, New Delhi, 11th Edition, 2011.
2. Oliver C. Ibe, ``Fundamentals of applied probability and random processes", Academic press, 2005.

Suggested Reference Book(s):

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, ``Probability and statistics for engineers and scientists'', 9th Edition, Pearson, 2011.
2. Jay L. Devore, ``Probability and statistics for engineering and the sciences", Cengage Learning, 8th Edition, 2011.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111102111
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/111101004/2
   ii. https://nptel.ac.in/courses/111106112/1
   iii. https://nptel.ac.in/courses/117105085/30
   iv. https://nptel.ac.in/courses/108103112/14

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1.0 Hours	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2.0 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 05 Quizzes (2) - 15 Attendance - 05

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course Outcomes [Probability Theory & Random Processes]	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	1	1	1	1	1	-	-	1	2	1	1.6
CO-2	3	3	1	2	2	1	1	-	-	1	2	2	1.8
CO-3	3	3	2	3	3	3	1	-	-	1	3	3	2.5
CO-4	3	3	3	3	3	3	1	-	-	2	3	3	2.7
CO-5	3	2	2	2	3	3	2	-	-	1	3	3	2.3
Average	3.0	2.8	1.8	2.4	2.4	2.0	1.2	-	-	1.2	2.6	2.4	

Discrete Mathematics

COURSE CODE: 18B11MA413

COURSE CREDITS: 4

CORE / ELECTIVE: CORE L-T-P: 3-1-0

Pre-requisite: None

Course Objectives:

1. To learn various discrete structures (e.g., sets, relations, logic, lattices, graphs, linear transformations, structure of language etc.) that provide the mathematical formalizations for computational problems.
2. Learn Mathematical arguments and proof techniques.
3. Study of certain algebraic structures.
4. To comprehend Languages, grammars, FSA and FSM.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand set operations, various types of relations and their representations, solving recurrence relations.	Familiarity
CO-2	Comprehend the discrete structures of lattices, Propositions with proof of validity of arguments and quantifiers.	Assessment
CO-3	Understand various types of graphs, paths, spanning trees, planarity of graphs and coloring theorems.	Usage
CO-4	Recognize Algebraic structures; Groups, Subgroups, Rings, Fields with extension to concepts of vector spaces, dimensions and linear transformations.	Assessment
CO-5	Comprehend Languages, grammars, finite state automata and finite state machines.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Set, Relations and Functions:** Basic operations on sets, Cartesian products, disjoint union (sum), and power sets. Partitions and Duality. Different types of relations, their compositions and inverses. Different types of functions, Recursively defined functions, Recursive algorithms, generating functions and solutions of recurrence relations, Complexity of algorithms, Big-o notation, Euclidean algorithm for finding GCD, Evaluation of polynomial using Horner's method, Russian Peasant method for multiplication.	8
2	**Lattices and Propositional Logic:** Ordered Sets and Lattices: Partial order relations and Hasse diagram, Supremum and infimum, total ordering, lattices – bounded, distributive, complemented, modular, Product of lattices. Simple and compound statement. logical operators. Implication and double implication, Tautologies and contradictions.Valid arguments and fallacy. Propositional functions and quantifiers.	8
3	**Graph Theory:** Graphs and their basic properties – degree, path, cycle, subgraph, isomorphism, Eulerian and Hamiltonian walk, Matrix representation of Graphs and properties, Planar Graphs, Homeomorphism, Kuratowski's	10

	theorem, Spanning trees, shortest spanning tree, Algorithms for finding shortest spanning tree Graph colorings. Four color problem, Digraphs and related definitions, connectivity in diagraphs.	
4	**Algebraic structures & Vector Space:** Binary operations, Algebraic structures – semigroup, monoid, groups, subgroups, Rings, Integral domain and fields, Vector Space, linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity theorem.	**12**
5	**Introduction to Languages:** Introduction to Languages, finite state automata grammars, finite state machines.	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Kenneth H. Rosen: Discrete Mathematics and Its Applications with combinatorics and Graph Theory, 7th Edition, Tata McGraw-Hill, 2011.

2. Kolman B., Busby R., Ross S.: Discrete Mathematical Structures, 6th Edition, Pearson Education, 2009.

3. Lipschutz S, Lipson M: Linear Algebra, 3rd Edition, Schaum's outlines, Mc Graw-Hill International Edition, 2001.

Suggested Reference Book(s):

1. Liu, C. L.: Elements of Discrete Mathematics, 3rd Edition, Tata McGraw-Hill, 2008.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111107058/

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz - 15 Tutorial Quiz - 5 Attendance - 5

Course Outcomes (COs) contribution to the programme Outcomes (POs):

Course outcomes (Discrete Mathematics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	2	2	2	1	0	0	1	1	1	1	1.3
CO-2	2	2	2	2	2	1	0	0	1	1	1	1	1.2
CO-3	3	2	2	3	1	1	0	0	1	1	1	1	1.3
CO-4	3	2	1	1	1	1	0	0	1	1	1	1	0.8
CO-5	3	2	3	2	3	1	0	0	1	1	1	1	1.1
Average	2.6	2.2	2	2	1.8	1	0	0	1	1	1	1	

Biostatistics

COURSE CODE: 18B11MA411

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Probability and Statistical Techniques.

Course Objectives:

1. To study multiple linear regression and correlation model.
2. To study non-parametric tests, stochastic process and clustering along with their application in Bio-informatics.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Perform correlation and regression analysis and draw conclusions and apply to Bio-informatics models.	Familiarity & Usage
CO-2	Use method of least squares and evaluate least squares estimates.	Assessment
CO-3	Execute non parametric tests and run tests and draw conclusions.	Usage
CO-4	Understand stochastic processes and find ensemble averages, mean function, auto - correlation and auto-covariance functions, SSS and WSS processes.	Usage
CO-5	Understand the Markov chains and apply Markov processes.	Usage
CO-6	Apply clustering algorithms and its applications to large databases and use clustering with categorical attributes.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Regression and Correlation:** Introduction – linear regression and multiple regression (linear & polynomial). Normal regression analysis – estimation of regression coefficients and confidence intervals. Normal correlation analysis - method of maximum likelihood. Multiple linear regression (*method of least squares* and *matrix notation*).	8
2	**Method of Least Squares -** normal equations and least squares estimates**.**	2
3	**Non-Parametric Tests:** Need of non-parametric tests. Sign test for one sample and two samples, signed-rank test, Wilcoxon test (Mann-Whitney test), Run test for randomness. Distribution-free ANOVA: Kruskal- Wallis and Friedman's test**.**	9
4	**Stochastic Processes:** Introduction and classification of stochastic processes. Ensemble averages – mean function, auto-correlation function, auto-covariance function. Stationary processes – strict-sense stationary (SSS) process and wide-sense stationary (WSS) process.	6
5	**Markov Processes** - Markov chains – Markov property, transition probability matrix, state-diagram. Processes with independent increments - Poisson process.	6

	Modeling (applications of Markov chains in Bio-informatics). Brownian motion – simple random walk.	
6	**Clustering:** Definition and meaning, similarity and distance measures, outliers. Clustering algorithms: hierarchical (agglomerative & divisive) and partitioning (k-means & k-medoids). Clustering large databases, clustering with categorical attributes, comparison.	**11**
Total lectures		**42**

Suggested Text Book(s):

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye: ``Probability and statistics for engineers and scientists'', Pearson, Nineth edition, 2011.
2. T. Veerarajan: ``Probability, statistics and random processes", Tata McGraw-Hill, Third edition, 2008.
3. M. H. Dunham: ``Data mining: Introductory and advanced topics", Pearson, 2012.

Suggested Reference Book(s):

1. Wayne W. Daniel: "Biostatistics: A foundation for analysis in the health sciences'', John Wiley & Sons, Nineth edition, 2008.
2. Jay L. Devore: "Probability and statistics for engineering and the sciences", Cengage Learning, Eight edition, 2011.
3. W. J. Ewens and G. R. Grant: "Statistical methods in bioinformatics", Springer 2001.
4. Alan Agresti and Barbara Finlay, "Statistical methods for the social sciences", Pearson prentice hall, Fourth edition, 2009.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/102101056
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/102101056/11
   ii. https://nptel.ac.in/courses/102106051/28
   iii. https://nptel.ac.in/courses/111102014/
   iv. https://nptel.ac.in/courses/106108057/module14/ lecture34.pdf

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered upto T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Biostatistics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	3	2	1	3	0	2	3	2.0
CO-2	2	2	1	2	1	1	2	1	3	0	2	3	1.7
CO-3	3	1	1	2	1	3	1	1	1	0	2	2	1.5
CO-4	2	3	1	1	2	1	1	1	1	0	1	2	1.3
CO-5	2	2	2	1	3	1	1	1	1	0	1	2	1.4
CO-6	3	2	3	2	3	3	2	1	3	2	2	3	2.4
Average	2.3	2.0	1.7	1.7	2.0	2.0	1.5	1.0	2.0	0.3	1.7	2.5	

Biostatistics Lab

COURSE CODE: 18B17MA471

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basic knowledge of Excel and SPSS.

Course Objectives:

1. To develop computer programs for various probability and statistical concepts/procedures.
2. To execute and perform fundamental and specific statistical tests using computer software.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Write and execute the programs to calculate correlation and regression coefficients.	Familiarity and Usage
CO2	Write and execute the programs to calculate least squares estimates.	Assessment
CO3	Write and execute the programs to perform run tests, signed-rank tests, Wilcoxon test, Kruskal-Wallis and Friedman's test.	Usage
CO4	Write and execute the programs to obtain probability distributions for Poisson's process.	Usage
CO5	Write and execute the programs to obtain probability distributions for Markov chains	Assessment
CO6	Write and execute the programs for clustering and applications.	Usage

List of Experiments

S.No	Description	Hours
1	To write a program to calculate correlation and simple linear regression coefficients.	2
2	To write a program to calculate least squares estimates for linear regression using method of least squares/normal equations.	2
3	To write a program to calculate least squares estimates for multivariate linear regression coefficients, using matrix method.	2
4	To write a program to calculate least squares estimates for multivariate polynomial regression coefficients.	2
5	To write a program to perform Run test for randomness for given data.	2
6	To write a program to perform Sign test and Signed-rank for one sample and two samples for given data.	2
7	To write a program to perform and Wilcoxon test (Mann-Whitney test) test for given data.	2
8	To write a program to perform Kruskal-Wallis test and Friedman's test for given data.	2
9	To write a program to obtain probability distribution for Poisson process for given arrival rate and time-interval with a specified detecting probability.	2
10	To write a program to obtain one-step and n-step transition probability distributions for a given homogeneous Markov chain.	2
11	To write a program to obtain steady state probability distribution for a given	2

	homogeneous Markov chain with n states.	
12	To write a program for hierarchical agglomerative (Bottom-up) clustering and display results in the form of a dendrogram.	2
13	To write a program for hierarchical divisive (Top-down) clustering and display results in the form of a dendrogram.	2
14	To write a program to demonstrate partitioning clustering using k-means algorithm.	2
15	To write a program to demonstrate partitioning clustering using k -medoids algorithm.	2
Total Lab hours		30

Suggested/Resources:

1. Andy Field: Discovering Statistics Using IBM SPSS Statistics, 4th Edition, 2013, Sage Publications
2. Norman & Streiner: Biostatistics-The Bare Essentials with SPSS, 4th Edition, People's Medical Publishing House USA Ltd.
3. http://textofvideo.nptel.ac.in/110105060/lec32.pdf
4. https://nptel.ac.in/courses/106108057/module14/lecture34.pdf
5. https://nptel.ac.in/courses/111102014/

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Attendance	15 Marks
4	Lab Assessment	45 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	2	2	2	3	2	1	3	0	2	3	2.0
CO2	2	2	1	2	1	1	2	1	3	0	2	3	1.7
CO3	3	1	1	2	1	3	1	1	1	0	2	2	1.5
CO4	2	3	1	1	2	1	1	1	1	0	1	2	1.3
CO5	2	2	2	1	3	1	1	1	1	0	1	2	1.4
CO6	3	2	3	2	3	3	2	1	3	2	2	3	2.4
Average	2.3	2.0	1.7	1.7	2.0	2.0	1.5	1.0	2.0	0.3	1.7	2.5	

Optimization Techniques

COURSE CODE: 18B1WMA731

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
2. Provide students with the basic mathematical concepts of optimization.
3. Provide students with the modeling skills necessary to describe and formulate optimization problems.
4. Provide students with the skills necessary to solve and interpret optimization problems in engineering.
5. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Solve linear programming problems by different methods.	Familiarity
CO-2	Understand duality and dual simplex method.	Familiarity Assessment
CO-3	Understand assignment problem and method for solving it.	Familiarity
CO-4	Understand transportation model and finding solution of transportation problem.	Familiarity
CO-5	Solve Integer programming problems by different methods.	Usage
CO-6	Solve nonlinear programming problem by Lagrangian multiplier method.	Assessment
CO-7	Learn about KT conditions for solving NLPP.	Familiarity

Course Contents:

Unit	Contents	Lectures required
1	**Linear Programming Problems(LPP):** Definition of LPP, Simplex Method, Artificial Variable Method, Two Phase Method, Charnes' Big-M Method, Sensitivity Analysis, Revised Simplex Method	**10**
	Duality, Dual Simplex Method	**5**
2	**Assignment Problems:** Definition, Hungarian Method for AP	**4**
3	**Transportation Problems:** Introduction to Transportation Model, Matrix Form of TP, Applications of TP Models, Basic Feasible Solution of a TP, Degeneracy in TP, Formation of Loops in TP, Solution Techniques of TP, Different Methods for Obtaining Initial Basic Feasible Solutions viz. Matrix Minima Method, Row Minima Method, Column Minima Methods, Vogel's Approximation Method. Techniques for Obtaining Optimal Basic Feasible Solution	**9**
4	**Integer Linear Programming Problems:** Integer Linear Programming Problems, Mixed Integer Linear Programming Problems, Cutting Plane Method, Branch and Bound Method	**6**

5	**Introduction to NLP :** Definition of NLP, Convex Programming Problems, Quadratic Programming Problems, Wolfe's Method for Quadratic Programming Problem	**4**
	Kuhn-Tucker Conditions, Geometrical Interpretation of KT-Conditions, KT-points etc	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Taha, H.A.: Operations Research- An Introduction, New York, Macmillan, 1992.
2. Harvey M. Wagner: Principles of Operations Research with Applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd 1975.

Suggested Reference Book(s):

1. Hadley, G.: Linear Programming, Massachusetts: Addison- Wesley, 1962.
2. Hiller, F.S.and Lieberman G.J.: Introduction to Operations Research, San Francisco: Holden-Day, 1995.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111107104/
2. Link to topics related to course:
   i. https://nptel.ac.in/courses/111107104/6
   ii. https://nptel.ac.in/courses/111107104/7
   iii. https://nptel.ac.in/courses/111104027/
   iv. https://nptel.ac.in/courses/111102012/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (1) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Optimization Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	0	1	0	1	0	1	0	1	1	1.08
CO-2	3	3	2	0	1	0	0	0	1	0	1	0	0.92
CO-3	3	3	2	0	1	0	0	0	1	0	1	0	0.92
CO-4	3	2	1	1	1	0	1	0	1	0	1	1	1
CO-5	3	2	1	1	1	0	0	0	2	0	1	1	1
CO-6	3	3	2	0	1	0	0	0	0	0	1	0	0.83
CO-7	3	3	2	0	1	0	0	0	0	0	1	0	0.83
Average	3	2.71	1.714	0.28	1	0	0.28	0	0.85	0	1	0.42	

Linear Programming and Applications

COURSE CODE: 18B1WMA831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. Provide students with the basic mathematical concepts of linear programming problems.
2. Provide student to formulate the LPP and conceptualize the feasible region.
3. Solve the LPP with two variables using graphical and simplex method.
4. Provide students to analyze the sensitivity of a decision variable.
5. Understand the concept of an objective function, a feasible region, and a solution set of an optimization problem.
6. Write down the dual linear programming problem.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand basic terms and Solve linear programming problems by graphical method.	Familiarity
CO-2	Solve linear programming problems by simplex, big M and Two phase methods.	Assessment
CO-3	Understand duality and dual simplex method.	Familiarity
CO-4	Understand assignment problem and method for solving it.	Familiarity
CO-5	Understand transportation model and finding solution of transportation problem.	Familiarity
CO-6	Solve Integer programming problems by different methods.	Usage
CO-7	Solving sequencing problems.	Usage
CO-8	Understand game theory, CPM and PERT.	Familiarity

Course Contents:

Unit	Contents	Lectures required
1	**Linear Programming Problems (LPP):** Definition of LPP, Mathematical formulations of LP Models, Graphical Solutions of Linear Programming Problems (LPP)	4
	Simplex Method, Artificial Variable Method, Two Phase Method, Charnes' Big-M Method	5
	Sensitivity Analysis, Revised Simplex Method, Duality, Dual Simplex Method	5
2	**Assignment Problems :** Definition, Hungarian Method for AP	4
3	**Transportation Problems :** Introduction to Transportation Model, Matrix Form of TP, Applications of TP Models, Basic Feasible Solution of a TP, Degeneracy in TP, Formation of Loops in TP, Solution Techniques of TP, Different Methods for Obtaining Initial Basic Feasible Solutions viz. Matrix Minima Method, Row Minima Method, Column Minima Methods, Vogel's Approximation Method. Techniques for Obtaining Optimal Basic Feasible	12

	Solution	
4	**Integer Linear Programming Problems :** Integer Linear Programming Problems, Mixed Integer Linear Programming Problems, Cutting Plane Method, Branch and Bound Method	**5**
5	**Sequencing Problem**: Johnsons Algorithm for n Jobs and Two machines, n Jobs and Three Machines, 2 Jobs and m machines problems	**3**
6	**Game Theory**: Concept of game; Two-person zero-sum game; Pure and Mixed Strategy Games; Saddle point,Odds Method; Dominance Method and Graphical Method for solving Mixed Strategy Game. CPM and PERT- network diagram-Events and activities- project planning reducing critical events and activities-critical path calculations	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Taha,H.A.: Operations Research- An Introduction, Macmillan, New York 1992.
2. Sharma S.D.: Operations Research, Kedar Nath Ram Nath, 2003.

Suggested Reference Book(s):

1. Hadley, G.: Linear Programming, Massachusetts, Addison-Wesley, 1962.
2. Hiller, F.S. and Lieberman, G.J.: Introduction to Operations Research, Holden-Day, San Francisco 1995.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111102012/
2. Link to topics related to course:
   - i. https://nptel.ac.in/courses/111104027/
   - ii. https://nptel.ac.in/courses/109103021/
   - iii. https://nptel.ac.in/courses/111102012/29
   - iv. https://nptel.ac.in/courses/111102012/27

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (1) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Linear Programming and Applications)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average

CO-1	3	3	2	0	1	0	1	0	1	0	1	1	1.08
CO-2	3	3	2	0	1	0	0	0	1	0	1	0	0.92
CO-3	3	3	2	0	1	0	0	0	1	0	1	0	0.92
CO-4	3	2	1	1	1	0	1	0	1	0	1	1	1
CO-5	3	2	1	1	1	0	0	0	2	0	1	1	1
CO-6	3	3	2	0	1	0	0	0	0	0	1	0	0.83
CO-7	3	3	2	0	1	0	0	0	0	0	1	0	0.83
CO-8	3	3	2	0	1	0	0	0	0	0	1	1	0.92
Average	3	2.75	1.75	0.25	1	0	0.25	0	0.75	0	1	0.5	

Linear Algebra for Data Science and Machine Learning

COURSE CODE: 22B1WMA731

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Course Objectives: This course gives a foundation on applied linear algebra concepts, and emphasizes their usage in data science and machine learning. On successful completion of this course a student will be able

1. To learn orthogonality and obtain orthonormal bases using Gram-Schmidt process.
2. To learn eigenvalues, eigenvectors and understand the idea behind diagonalization process.
3. To describe vector projections and implement the least-squares solution to Ax=b.
4. To describe and interpret singular value decomposition and principal component analysis
5. To learn and describe how to find minimum value of cost function with gradient descent.
6. To gain understanding of theoretical results in linear algebra with implementation with coding.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the roll of matrices and their properties in data science; Understand linear transformation and find the matrix representation of a linear transformation given bases of the relevant vector spaces.	Familiarity
CO-2	Find orthogonalization, eigenvalues, eigenvectors of matrices and perform diagonalization.	Assessment
CO-3	Make use of the matrix algebra techniques to solve computational problems such as finding principal components and reducing dimensionality for datasets.	Assessment & Usage
CO-4	Appraise the matrix algebra techniques for implementing the machine learning algorithms. Identify minimum values of cost function and calculate the gradient descent.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Fundamental concepts:** Notion of vectors and matrices in data science: basics of matrix algebra, vector space; linear combination of input variables from data; role of basis vectors in reducing data storage; definition and meaning of eigenvalues and eigenvectors in the rotation of a image; orthogonal and identity matrices in Machine learning; probability fundamentals.	10
2	**Matrices and Machine learning:** Data representation by system of linear equations Ax = b; linear transformations, range and null spaces; orthogonal complement of the column space of A, orthogonal projections; finding the best fit line for the data points with regression - minimizing the	12

	residual sum of squares to find the scalar weights from the data set.	
3	**Matrix operations & approximations:** Fundamental theorem of linear algebra: rank-nullity theorem; eigendecomposition, spectral decomposition, singular value decomposition (SVD) - Moore-Penrose matrix pseudoinverse and data compression; principal component analysis (PCA) and dimensionality reduction; low-rank approximations; Python implementation of SVD, PCA.	**12**
4	**Applications:** Computing singular values and reduction of image size; optimizing cost/loss function: gradient of function, gradient descent and stochastic gradient descent, back propagation algorithm.	**8**
Total Lectures		**42**

Suggested Text Book(s):

1. Jason Brownlee, ``Basics of Linear Algebra for Machine Learning,'' Machine Learning Mastery, 2018.

Reference Book(s):

1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, ``Mathematics for Machine Learning,'' Cambridge University Press, 2020.
2. Gilbert Strang, ``Linear Algebra and Learning from Data,'' Wellesley-Cambridge Press, 2019.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Linear Algebra for Data Science and Machine Learning)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	2	2	2	2	**1.75**
CO-2	2	3	3	3	3	1	1	1	2	2	1	2	**2**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.75**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2.0**
Average	**2**	**2.5**	**2.5**	**2.5**	**2.5**	**1**	**1**	**1**	**2**	**2.25**	**1.5**	**2**	

Soft Computing & Optimization Algorithms

COURSE CODE: 21B1WMA831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Course Objectives: On successful completion of this course a student will be able

1. To describe various types of soft computing techniques, and applications of soft computing.
2. To describe the fuzzy sets and fuzzy logic
3. To describe the fuzzy controller and fuzzy rule base and approximate reasoning.
4. To describe the evolutionary computing.
5. To understand the concepts of genetic algorithm.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basic tools of soft computing.	Familiarity
CO-2	Understand the fuzzy sets and crisp sets, fuzzy set theory and operations.	Assessment
CO-3	Understand the fuzzy controller and fuzzy rule base and approximate reasoning.	Assessment
CO-4	Understand the basic evolutionary processes.	Familiarity
CO-5	Understand the working principle and procedures of genetic algorithm.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Introduction, soft computing vs. hard computing, various types of soft computing techniques, and applications of soft computing. Basic tools of soft computing - Fuzzy logic, neural network, evolutionary computing. Introduction: Neural networks, application scope of neural networks, fuzzy logic, genetic algorithm, and hybrid systems.	08
2	**Fuzzy Sets and Logic:** Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion. Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzifications and Defuzzifications.	08
3	**Fuzzy Systems:** Fuzzy Controller, Fuzzy rule base and approximate	10

	reasoning: truth values and tables in fuzzy logic, fuzzy propositions formation of rules, decomposition of compound rules, aggregation of fuzzy rules, fuzzy reasoning, fuzzy inference system, fuzzy expert systems.	
4	**Evolutionary Computing:** Basic Evolutionary Processes: A Simple Evolutionary System, Evolutionary Systems as Problem Solvers, A Historical Perspective, Canonical Evolutionary Algorithms - Evolutionary Programming, Evolution Strategies, A Unified View of Simple EAs- A Common Framework, Population Size.	**06**
5	**Genetic Algorithm:** Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, Traditional algorithm vs genetic algorithm, simple GA, general genetic algorithm, schema theorem, Classification of genetic algorithm, Holland classifier systems, genetic programming, applications of genetic algorithm, Convergence of GA. Applications and advances in GA, Differences and similarities between GA and other traditional method, applications.	**10**
Total Lectures		**42**

Suggested Text Book(s):

1. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2004, Pearson Education 2004.
2. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill, International Editions, Electrical Engineering Series, Singapore, 1997.
3. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.

Suggested Reference Book(s):

2. Stamatios V. Kartalopoulos "Understanding Neural Networks and Fuzzy Logic Basic concepts & Applications", IEEE Press, PHI, New Delhi, 2004
3. Vojislav Kecman, "Learning & Soft Computing Support Vector Machines, Neural Networks, and Fuzzy Logic Models", Pearson Education, New Delhi,2006.
4. S. Rajasekaran & GA Vijayalakshmi Pai "Neural Networks, Fuzzy Logic, and Genetic Algorithms synthesis and application", PH

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Approved in Academic Council held on 29 November 2021