DEPARTMENT OF MATHEMATICS
VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

The Department of Mathematics offers various courses in Mathematics and Statistics to undergraduate and postgraduate students of different Engineering Departments. The Department also offers Master and Doctorial programs in Mathematics. Faculty members in the Department are highly qualified and having research collaboration with different National and International Institutions. The Department has a good computing facility. The areas of interests of the staff members include General Relativity, Cosmology, Numerical Analysis, Fluid Mechanics, Operator Theory, Functional Analysis, Ordinary Differential Equations and Partial Differential Equations, Nonlinear Analysis.

The number of credits attached to a subject depends on number of classes in a week. For example a subject with 3–1–0(L–T–P) means it has 3 Lectures, 1 Tutorial and 0 Practical in a week. This subject will have eight credits (3×2+1×2+0×1=8). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz., the Semester Grade Point Average (SGPA) which is the Grade Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\text{SGPA} = \frac{\sum_{\text{Semester}} (\text{Course credits X Grade points}) \text{ for all courses except audit}}{\sum_{\text{Semester}} (\text{Course credits}) \text{ for all courses except audit}}$$

$$\text{CGPA} = \frac{\sum_{\text{All Semester}} (\text{Course credits X Grade points}) \text{ for all courses with pass grade except audit}}{\sum_{\text{All Semester}} (\text{Course credits}) \text{ for all courses except audit}}$$

Students can Audit a few subjects, i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

Courses offered for B.Tech. Branches

Summary of Credits:

Category	Credits
Core Courses	64
Electives	42

Details of credits:

B. Tech. I Semester			
Core			
Code	**Course**	**L-T-P**	**Credits**
MAL 101	Mathematics-I	3-1-0	8
Elective			

B. Tech. II Semester			
Core			
Code	**Course**	**L-T-P**	**Credits**
MAL 102	Mathematics –II	3-1-0	8
Elective			

B. Tech. III Semester			
Core			
Code	**Course**	**L-T-P**	**Credits**
MAL 201	Integral Transforms and Partial Differential Equations	3-0-0	6
MAL 202	Numerical Analysis	3-0-0	6
MAL 203	Special functions and partial differential equations	3-0-0	6
MAL 205	Numerical Methods and probability theory	3-0-0	6
Elective			
MAL 204	Complex variables and Partial Differential Equations	3-0-0	6
MAL 405	Linear Algebra	3-0-0	6
B. Tech. IV Semester			
Core			
Code	**Course**	**L-T-P**	**Credits**
MAL 205	Numerical Methods and Probability theory	3-0-0	6
MAL 206	Linear Algebra and Applications	3-0-0	6
MAL 404	Probability & Statistics	3-0-0	6
Elective			
MAL 401	Mathematical Methods	3-0-0	6
MAL 403	Optimization techniques	3-0-0	6
MAL 406	Finite Element Method	3-0-0	6
MAL 407	Statistics and Optimization Techniques	3-0-0	6
MAL 408	Statistical Analysis and Queuing Theory	3-0-0	6
MAL 409	Operations research in construction	3-0-0	6

Syllabus

MAL101 MATHEMATICS-I 3-1-0-8

Objective: The objective of this subject is to expose student to understand the basic importance of Differential calculus, Integral calculus, Infinite series and matrix theory in science and engineering.

Differential Calculus: Functions of single variable: Limit, continuity and differentiability. Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem, Taylor's theorem with remainders, indeterminate forms,curvature, curve tracing.

Integral Calculus: Fundamental theorem of Integral calculus, mean value theorems, evaluation of definite integrals, Applications in Area, length, volumes and surface of solids of revolutions, Improper integrals: Beta and Gamma functions, differentiation under integral sign.

Infinite series: Sequences, Infinite series of real and complex numbers, Cauchy criterion, tests of convergence, absolute and conditional convergence, improper integrals, improper integrals depending on a parameter, uniform convergence, power series, radius of convergence.

Matrices: Rank of matrix, consistency of a system of equations, linear dependence and independence**,** linear and orthogonal transformations, Eigen values and eigen vectors, Cayley – Hamilton theorem, reduction to diagonal form, Hermitian and skew Hermitian matrices, Quadratic forms.

Text Books

1. Kreyszig, E. ; Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons, 1999.
2. Piskunov, N. : Differential and Integral calculus, Vol. 1, Vol. 2, MIR Publishers, Moscow - CBS Publishers and Distributors (India),1996.

Reference Books:

1. Thomas, G.B. and Finney, R.L.; Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc ; 1998.
2. Michael D. Greenberg: Advanced Engineering Mathematics, Pearson Education Pvt. Ltd 2009 .
3. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers 2005.

MAL102 MATHEMATICS-II 3-1-0-8

Objective: The objective of this subject is to expose student to understand the basic importance of multi variable calculus (Differential calculus & Integral calculus), Vector calculus and ordinary differential equations in engineering.

Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, Tangent plane and normal line. Euler's theorem on homogeneous functions, Total differentiation, chain rules, Jacobian, Taylor's formula, maxima and minima, Lagrange's method of undetermined multipliers.

Multiple Integrals: Double and triple integrals, change of order of integration, change of variables, application to area, volumes, Mass, Centre of gravity.

Vector Calculus: Scalar and vector fields, gradient of scalar point function, directional derivatives, divergence and curl of vector point function, solenoidal and irrotational motion.

Vector integration: line, surface and volume integrals, Green's theorem, Stoke's theorem and Gauss divergence theorem (without proof).

Ordinary Differential Equations:

First order differential equations: Exact equation, Integrating factors, Reducible to exact differential equations, Linear and Bernoulli's form, orthogonal trajectories, Existence and Uniqueness of solutions. Picard's theorem, Picard's iteration method of solution (Statements only).

Solutions of second and higher order linear equation with constant coefficients, Linear independence and dependence, Method of variation of parameters, Solution of Cauchy's equation, simultaneous linear equations.

Text Books

1. Kreyszig, E. ; Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons, 1999.
2. Piskunov, N. : Differential and Integral calculus, Vol.1, Vol.2 MIR Publishers, Moscow - CBS Publishers and Distributors (India),1996.
3. William E. Boyce & Richard C. DiPrima, Elementary Differential Equations, 2009.

Reference Books:

1. Thomas, G.B. and Finney, R.L.; Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc ; 1998.
2. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers; 2003.
3. Michael D. Greenberg: Advanced Engineering Mathematics, Pearson Education Pvt. Ltd, 2009.

MAL201 Integral Transforms & Partial Differential Equations 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of transform techniques to solve real world problems. It also focuses the partial differential equations and its applications in science and engineering.

Laplace Transforms: Definition of Laplace Transforms, Linearity property, condition for existence of Laplace Transform, first and second shifting properties, transforms of derivatives and integrals, evaluation of integrals by Laplace Transform. Inverse

Laplace Transform, convolution theorem, Laplace Transform of periodic functions, unit step function and Dirac delta function. Applications of Laplace Transform to solve ordinary differential equations.

Fourier Series and Fourier Transforms: Fourier series, half range sine and cosine series expansions, exponential form of Fourier series. Fourier integral theorem, Fourier transform, Fourier Sine and cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.

Z-transform: Z - transform, Properties of Z-transforms, Convolution of two sequences, inverse Z-transform, Solution of Difference equations.

Partial differential equations: Formation of first and second order equations, Solution of first order linear equations: Lagrange's equation, particular solution passing through a given curve. Higher order equations with constant coefficients, classification of linear second order PDEs, method of separation of variables, Solution of One dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms), D'Alembert solution of wave equation.

Text Books:

1. Kreyszig, E. ; Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons , 1999.
2. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers, 2005.

Reference Books:

1. Thomas, G.B. and Finney, R.L.; Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc ; 1998.

MAL202 Numerical Analysis 3-0-0-6

Objective: The objective of this subject is to expose student to understand the basic importance of numerical methods to tackle the problems which cannot be solved analytically.

Interpolation : Existence, Uniqueness of interpolating polynomial, error of interpolation - unequally spaced data; Lagrange's formula, Newton's divided difference formula. Equally spaced data : finite difference operators and their properties, Gauss's forward and backward, Sterling's formulae - Inverse interpolation - Hermite interpolation.

Differentiation : Finite difference approximations for first and second order derivatives.

Integration : Newton-cotes closed type methods; particular cases, error terms - Newton cotes open type methods - Romberg integration Gaussian quadrature; Legendre formulae.

Solution of nonlinear and transcendental equations: Regula Falsi method, Newton-Raphson method, Newton Raphson method for system of nonlinear equations.

Solution of linear algebraic system of equations: LU Decomposition, Gauss-Seidal methods; solution of tridiagonal system. Ill conditioned equations.

Eigen values and eigen vectors : Power and Jacobi methods.

Solution of Ordinary differential equations:

Initial value problems: Single step methods; Taylor's, Euler's, Runge-Kutta methods, Implicit Runge Kutta methods

Boundary value problems: Finite difference methods, Shooting method.

Text Books

1. Jain, Iyengar and Jain : Numerical Methods for Engineers and Scientists, Wiley Eastern, 1995.
2. **S. D.** Cante **and** C**.** de Boor, Elementary Numerical Analysis, an algorithmic approach, McGraw-Hill, 2000.

Reference Books

1. Gerald and Wheatley : Applied Numerical Analysis, Addison-Wesley ,1999.
2. Aitkinson : Numerical Analysis, John Wiley and Sons , 1984.

MAL203 Special functions and Partial differential Equations 3-0-0-6

Objective: The objective of this subject is to expose student to understand the necessity of series solutions and special functions. It also focuses the partial differential equations and its applications in science and engineering.

Series solutions, Frobenius method, Legendre equation, Bessel equation, Legendre Polynomials, Bessel function of first kind, Sturm – Liouville Problems.

Fourier Series and Fourier Transforms: Fourier series, half range sine and cosine series expansions, exponential form of Fourier series.

Fourier integral theorem, Fourier transform, Fourier Sine and cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.

Partial differential equations: Formation of first and second order equations, Solution of first order linear equations: Lagrange's equation, particular solution passing through a given curve. Higher order equations with constant coefficients, classification of linear second order PDEs, method of separation of variables, Solution of One dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms), D'Alembert solution of wave equation.

Text Books

1. Kreyszig, E. ; Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons 1999.
2. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers, 2005.

MAL204 Complex Variables & Partial Differential Equations 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of complex variables. It also focuses the partial differential equations and its applications in science and engineering.

Complex variable: Functions of a complex variable - continuity - differentiability - analytic functions - complex integration - Cauchy's integral theorem. Cauchy's integral formula, Taylor's theorem - Laurent's theorem , zeros of an analytic function – singularities, Residue - Cauchy's residue theorem - contour integration - the fundamental theorem of algebra.

Conformal transformation, Bilinear transformation - Transformation by elementary functions.

Fourier Series and Fourier Transforms: Fourier series, half range sine and cosine series expansions, exponential form of Fourier series.

Fourier integral theorem, Fourier transform, Fourier Sine and cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.

Partial differential equations: Formation of first and second order equations, Solution of first order linear equations: Lagrange's equation, particular solution passing through a given curve. Higher order equations with constant coefficients, classification of linear second order PDEs, method of separation of variables, Solution of One dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms), D'Alembert solution of wave equation.

Text Books

1. Kreyszig, E. ; Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons, 1998 .
2. R.V. Churchill and Brown : Complex variables and applications, McGraw Hill, 2001.

Reference Books

1. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers, 2005.
2. Copson, E.T. : Theory of complex variables, Oxford University Press, 1988.

MAL205 Numerical Methods & Probability Theory 3-0-0-6

Objective: The objective of this subject is to expose student to understand the basic importance of numerical methods to tackle the problems which cannot be solved analytically. It also focuses the probability theory and its applications in science and engineering.

Numerical Analysis: Solutions of algebraic and transcendental equations by Iteration method, method of false position, Newton-Raphson method and their convergence.

Solutions of system of linear equations by Gauss elimination method, Gauss Seidal method, LU decomposition method. Newton-Raphson method for system of nonlinear equations.

Eigen values and eigen vectors : Power and Jacobi methods.

Numerical solution of ordinary differential equations: Taylor's series method, Euler's modified method, Runge-Kutta method, Adam's Bashforth and Adam's Moulton, Milne's predictor corrector method.

Boundary value problems: Shooting method, finite difference methods.

Probability theory:

Random variables, discrete and continuous random variable, probability density function; probability distribution function for discrete and continuous random variable joint distributions.

Definition of mathematical expectation, functions of random variables, The variance and standard deviations, moment generating function other measures of central tendency and dispersion, Skewness and Kurtosis.
Binomial, Geometric distribution, Poisson distribution, Relation between Binomial and Poisson's distribution, Normal distribution, Relation between Binomial and Normal distribution.
Random processes, continuous and discrete, determinism, stationarity, ergodicity etc. correlation functions, autocorrelation and cross-correlation, properties and applications of correlation functions.

Text Books:

1. Jain, Iyengar and Jain : Numerical Methods for Engineers and Scientists, Wiley Eastern,1995
2. V.K. Rohatgi and A.K.M. Ehsanes Sateh: An Introduction to Probabability and Statistics, John Wiley & Sons.

Reference Books

1. S. D. **Cante** and **C**. **de Boor**, Elementary Numerical Analysis, an algorithmic approach, McGraw-Hill, 2000.
2. Gerald and Wheatley : Applied Numerical Analysis, Addison-Wesley, 1999.
3. Spiegel, M.R.; Theory and problems of Probability and statistics; McGraw-Hill Book Company; 1980.
4. K.S. Trivedi: Probability Statistics with Reliability, Queuing and Computer Science applications, Prentice Hall of India Pvt. Ltd, 2000.

MAL206 Linear Algebra and Applications 3-0-0-6

Objective: The objective of this subject is to expose student to understand the basic importance of Linear Algebra and its applications its applications to science and engineering.

Matrices: Review of Matrix Algebra; Rank of matrix; Row reduced
Echelon form; Determinants and their properties; Solution of the matrix Equation Ax = b; Gauss elimination method;
Vector Space; Subspaces; Linear Dependence/Independence; Basis; Dimension;
Linear transformation, Range Space and Rank; Null Space and Nullity; Rank nullity theorem; Matrix Representation of a linear transformation; Linear Operators on Rn and their representation as square matrices; Invertible linear operators; Inverse of a non-singular matrix; Eigenvalues and eigenvectors of a linear operator; properties of eigenvalues and eigenvectors of Hermitian, skew-Hermitian, Unitary, and Normal matrices (symmetric, skew-symmetric, and orthogonal matrices); Characteristic Equation; Bounds on eigenvalues; Cayley Hamilton theorem, Diagonalizability of a linear operator; Inner Product Spaces, Norm; Orthonormal Sets, Gram Schmidt orthogonalisation process; projections and least squares approximation.
Optimization: Modeling and formulation of optimization problems; Linear costs and convex domains; Linear programming and Simplex Algorithm (Big M and Two Phase Method), Duality and the primal dual method.

Text books:

1. G. Strang, Linear algebra and its applications (4th Edition), Thomson, 2006.
2. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).

References:

1. Hoffman and Kunje, Linear Algebra, Prentice Hall of India, 2008.
2. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hallof India (2000).
3. P.G. Bhattacharya, S.K. Jain and S.R Nagpaul : First course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 2000.

MAL401 MATHEMATICAL METHODS 3-0-0-6

Objective: The objective of this subject is to expose student to understand the advanced methods to tackle special class of linear and non linear problems which occur frequently in science and engineering.

Approximate Solution of Linear Differential equations:
Classification of singular points of Homogeneous linear equations, Local behavior near ordinary points of homogeneous linear equations, Local series expansions about regular singular points homogeneous linear equations, Local behavior at irregular singular points of homogeneous linear equations, Irregular singular point at infinity, Local analysis of Inhomogeneous Linear equations, Asymptotic Relations, Asymptotic series.
Approximate Solution of Nonlinear Differential equations:

Spontaneous Singularities, Approximate solutions of first order non linear equations, Approximate solutions to Higher order nonlinear differential equations, non linear autonomous systems.

Perturbation Methods

Perturbation theory: elementary introduction, application to polynomial equations and initial value problems for differential equations.

Regular and singular perturbation theory: classification of perturbation problems as regular and singular, introductory examples of boundary – layer, WKB and multiple scale problems.

Asymptotic Matching: Matched asymptotic expansions, application to differential equations.

Boundary Layer theory

Introduction to Boundary – Layer theory: Linear and nonlinear examples.

Mathematical Structure of Boundary Layers: Inner, outer and intermediate limits.

Higher order boundary layer theory: Uniformly valid global approximants to simple boundary value problems.

Distinguished Limits and Boundary layers of thickness $\neq \mathcal{E}$: illustrative examples

Miscellaneous Examples of Linear Boundary Layer problems, Non Linear Boundary Layer problems.

Text Books:

1. Advanced Mathematical methods for Scientists and Engineers by Carl M. Bender & Steven A. Orszag, McGraw Hill Inernational , 1999.
2. Perturbation Methods by Ali Hasan Nayfeh, John Wiley & Sons, New York, 2007.

MAL402 Numerical Solution of Differential Equations 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of finite difference methods for solving ordinary and partial differential equations.

Boundary value problems:

Solution of Ordinary differential equations: Shooting methods, Quasilinearization.

Finite difference methods: finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, Cubic splines and their application for solving two point boundary value problems.

Solution of Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for:

Parabolic equations: Schmidt's two level, multilevel explicit methods, Crank-Nicolson's method.

Hyperbolic Equations : Explicit methods, implicit methods, one space dimension, two space dimensions.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes.

Text Books:

1. G.D. Smith: Numerical solution of Partial Differential equations, Finite Difference methods, Oxford University Press, 1985.
2. M.K. Jain, S.R.K. Iyengar & R.K. Jain: Numerical Methods for Scientific & Engineering Computation, New Age International Publishers, 1996.

Reference Books:

1. DR. Lothar Collatz : The numerical treatment of differential equations, Springer-Verlag, New York 1960.
2. K.W. Morton & D.F. Mayers: Numerical solution of Partial differential equations, Cambridge University press. 2005.
3. M.K. Jain : Numerical solution of Differential equations, Wiley Eastern, New Delhi, 1984.

MAL403 Optimization Techniques 3-0-0-6

Objective: The objective of this subject is to expose student to understand the optimization technique for solving Linear and Non Linear programming problems.

Linear Programming : Formulation of a Linear Programming Problem - Graphical solution - Simplex method (including Big M method and two phase method) - Dual problem - duality theory - dual simplex method - revised simplex method.

Transportation problem - existence of solution - degeneracy - MODI method.
Assignment problem: travelling salesman problem.
Dynamic programming: Multistage decision process-concept of sub optimization-principle of optimality-computational procedure in dynamic programming -Application to problems involving discrete variables, continuous variables and constraints involving equations and inequalities.
Nonlinear programming problem (NLPP): Constrained NLPP, Lagrange's multipliers method -convex NLPP, Kuhn-Tucker conditions.

Text Books:

1. J.C. Pant : Introduction to Optimisation: Operations Research, Jain Brothers, New Delhi, 2004.
2. S.S. Rao: Engineering Optimization : Theory & Practice, New Age International (p) Limited, 1998.

Reference Books :

1. H.M.Wagner : Principles of Operations Research, Prentice Hall of India, New Delhi, 1982.
2. Kambo : Mathematical Progamming Techniques, East-West Publishers, New Delhi, 2008.
3. Kanti Swarup et. al. : Operations Research, Sultan Chand and Co., 1985.

MAL404 Probability & Statistics 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of probability theory and statistical analysis in science and engineering.

Part-I Probability

1. **Random Variable & Probability Distributions:** Random Variables, Density function, distribution function for continuous and discrete R.V.Joint distributions, Distributions of functions of R.V.
2. **Mathematical Expectation:** Mathematical Expectation, The variance and Standard deviation , Moment Generating Function, Characteristic Function.
3. **Special Probability Distributions:** Some special probability distributions like Binomial ,Poisson, Geometric, Normal, Uniform, Exponential Gamma Beta, Chi-Square, Students 't', F-distribution and Weibull Distribution.

Part-II Statistics

4. **Sampling Theory:** Population Parameter, Sample Statistics, Sampling distributions, Sample mean ,Sampling distribution of means, The Sample variance, The sampling distribution of variance.
5. **Estimation Theory:** Point estimate and Interval Estimates, Reliability, Confidence interval estimates of population parameters, confidence intervals for means , proportions and variance .
6. **Tests of Hypothesis and Significance:** Statistical decisions , Tests of hypothesis and significance. Type I and Type II errors. Level of significance , One tailed and two tailed tests. Tests involving small samples and large samples .Fitting theoretical distributions to sample frequency distribution .The chi-square test for goodness of fit.

Text Books:

1. E.Parzen: Modern Probability Theory and Its Applications J. Wiley and Sons Inc., New York 1967
2. Miller and Freund: Probability and Statistics for Engineers Eastern Economy Edition, PHI, 8th Edition, 2011.

Reference Books:

1. M.R.Speigal: Probability and Statistics, McGraw-Hill, 1995.

MAL405 Linear Algebra 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of Linear Algebra.

Systems of linear equations - matrices and elementary row operations-uniqueness of echelon forms - Moore-Penrose Generalised inverse.
Vector spaces - subspaces - bases and dimension - coordinates - linear transformations and its algebra and representation by matrices - algebra of polynomials - determinant functions - permutation and uniqueness of determinants - additional properties -

elementary canonical forms - characteristic values and vectors - Cayley Hamilton's theorem - annihilating polynomial - invariant subspaces. Simultaneous triangularisation - simultaneous diagonalisation - Jordan form - inner product spaces - unitary and normal operators - bilinear forms.

Text Books:

1. Hoffman and Kunze : Linear Algebra, Prentice Hall of India, New Delhi, 1997.

Reference Books :

1. V. Krishnamoorthy et al : An introduction to linear algebra , Affiliated East West Press, New Delhi, 2003 .
2. P.G. Bhattacharya, S.K. Jain and S.R Nagpaul : First course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 2000.
3. K.B.Datta : Matrix and Linear Algebra, Prentice Hall of India, New Delhi, 2000.

MAL406 Finite Element Method 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of finite element methods to tackle the problems of science and engineering.

Introduction to Calculus of Variations.
Finite Element Method: Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.
Global and local finite element models in one dimension - derivation of finite element equation.
Finite element interpolation - polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.
Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation - one dimensional heat and wave equations.

Text Books:

1. J.N.Reddy : An introduction to the Finite Element Method, McGraw Hill, New York, 2006.

Reference Book :

1. T.J. Chung : Finite element analysis in Fluid Dynamics, McGraw Hill Inc, 1978.

MAL 407 Statistics & O.R. Techniques 3–0–0–6

Objective: The objective of this subject is to expose student to understand the importance of statistical analysis. It also focuses the optimization techniques to solve linear and nonlinear programming problems.

Statistics

Sampling Theory : Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance.
Estimation Theory: Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.
Tests of Hypothesis and Significance: Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi-square test for goodness of fit.

O. R. Techniques

Linear Programming: Formulation of linear programming problem, Graphical solution- simplex method (including Big M method and two phase method), dual problem- duality theory, dual simplex method, revised simplex method.
Transportation problem: Existence of solution-degeneracy- MODI method; Assignment problem- traveling salesman problem
Nonlinear programming problem (NLPP): Constrained NLPP, Lagrange's multipliers method – convex NLPP, Kuhn-Tucker conditions.

Text Books:

1. M.R. Speigel: Probability and Statistics, McGraw-Hill, 1995.
2. H.A. Taha : Operation Research Prentice Hall of India Pvt. Ltd, 1998.

Reference Books:

1. J.C. Pant, Introduction to Optimisation : Operations Research Jain Brothers, New Delhi, 2004.
2. Miller and Freund, Probability and Statistics for Engineers, Economy Edition, PHI, 8th Edition, 2011.

MAL408 Statistical Analysis & Queuing Theory 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of statistical analysis. It also focuses on waiting time models.

Testing of Hypotheses: Neyman Pearson theory of testing of Hypotheses: Some fundamental notions of hypotheses testing, Neyman Pearson lemma, unbiased and invariant tests, generalized likelihood ratio tests, Chi – Square test, t – tests, F – tests, Bayes and minimax procedures, methods of finding confidence intervals, unbiased and equivariant confidence intervals.
Stochastic Processes: Introduction, classification of stochastic processes, the Bernoulli process, the Poisson process, Renewal process, availability analysis, random incidence, renewal model of program behavior.
Discrete-Parameter Markov Chains: Introduction, computation of n- step transition probabilities, state classification and limiting distributions, distribution of times between state changes, irreducible finite change with A periodic states, the M/G/1 Queuing system, discrete parameter Birth-Death processes, finite Markov chains with absorbing states.
Continuous – Parameter Markov Chains: Introduction, the Birth and death process, other special cases of Birth –death Model, non Birth-Death processes, Markov chains with absorbing states.
Networks of Queues: Introduction, open queuing networks, closed queuing networks, non exponential service-time distributions and multiple job types, Non – product- Form Networks.
Regression , correlation and Analysis of Variance: Introduction, Least squares curve fitting, the coefficient of determination, confidence intervals in linear regression, correlation analysis, simple non linear regression, higher dimensional least squares fit, analysis of variance.

Text books:

1. Vijay K. Rohatgi & A.K. Md. Ehsanes Saleh: An Introduction to Probability and statistics , John Wiley & Sons Inc., New York, 1976.
2. Kishor S. Trivedi : Probability & Statistics with reliability, Queuing and computer Science applications, PHI private Ltd, 2009.

MAL409 Application of Operational Research Techniques in Construction Management 3-0-0-6

Objective: The objective of this subject is to expose student to understand the importance of operational research to solve problems related to construction management.

Theory: Introduction, concepts in probability and statistics, linear programming, transportation and assignment problems. Dynamic programming waiting line models,
Inventory Management, Sequencing, Decision theory, Game theory, Simulation as applied to construction. Modifications and improvements on CPM/PERT techniques.

Text books:

1. N. D. Vohra : Quantitative Techniques in Management , The Mc. Graw Hill Companies (3rd Edition), 2001.