DEPARTMENT OF MATHEMATICS

Course Book for
B. Tech, B. Arch and M. Tech. in All Branches

Visvesvaraya National Institute of Technology, Nagpur

October 2015

Brief about B.Tech Programs:

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, Fixed point theory, Ordinary Differential Equations and Partial Differential Equations, Nonlinear Analysis, Non-linear dynamics.

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 four credits ($3\times1+1\times1+0\times1=4$). 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:

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

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

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.

Details about Faculty members of Mathematics Department

S.No.	Name of faculty Member	Designation	Qualification	Area of Specialization
1	Dr. G. P. Singh	Professor and Head	Ph.D.	Relativity and Cosmology, Mathematical Modelling
2	Dr. P. P. Chakravarthy	Associate Professor	Ph.D.	Numerical Analysis, Numerical Analysis of Singular Perturbation problem
3	Dr. Pallavi Mahale	Assistant Professor	Ph.D.	Functional Analysis and Operator equations
4	Dr. R. P. Pant	Assistant Professor	Ph.D.	Functional Analysis, General Topology, Fixed point theory
5	Dr. G. Naga Raju	Assistant Professor	Ph.D.	Partial Differential Equations, Spectral Element Methods, Parallel Computing.
6	Dr. M. Devakar	Assistant Professor	Ph.D.	Fluid Dynamics
7	Dr. V. V. Awasthi	Assistant Professor	Ph.D.	Algebraic Topology and its Application
8	Dr. Pradip Roul	Assistant Professor	Ph.D.	Numerical Analysis, ODE, Fractional Calculus
9	Dr. Deepesh Kumar Patel	Assistant Professor	Ph.D.	Fixed Point Theory
10	Dr. Jyoti Singh	Assistant Professor	Ph.D.	Commutative Algebra
11	Dr. A. Satish Kumar	Assistant Professor	Ph.D.	Approximation Theory

Scheme of Instruction for B. Tech

I Semester				**II Semester**			
Code	Course	L-T-P	Cr	Code	Course	L-T-P	Cr
MAL 101	Mathematics - I	3-1-0	4	MAL 102	Mathematics - II	3-1-0	4
MAL 103	Mathematics (for B.Arch)	3-1-0	4				
III Semester				**IV Semester**			
MAL 201	Integral Transforms and Partial Differential Equations	3-1-0	4	MAL 203	Numerical Methods and Computation	3-1-0	4
MAL 203	Numerical Methods and Computation	3-1-0	4	MAL 204	Linear Algebra and Applications	3-1-0	4
MAL 207	Complex variables and Partial Differential equations	3-1-0	4	MAL 206	Discrete Mathematics and Graph Theory	3-1-0	4
MAL 208	Probability Theory and Statistical Methods	3-1-0	4	MAL 208	Probability Theory and Statistical Methods	3-1-0	4
V/ VII Semesters				**VI/VIII Semesters**			
MAL 301	Introduction to Operations Research	3-0-0	3	MAL304	Financial Mathematics	3-0-0	3
MAL 302	Fractional Calculus	3-0-0	3	MAL 305	Wavelet Analysis	3-0-0	3
MAL 303	Calculus of variations and Integral equations	3-0-0	3	MAL403	Numerical Linear Algebra	3-0-0	3
MAL 401	Finite Difference methods for Differential Equations	3-0-0	3	MAL 405	Application of Operational Research Techniques in Construction Management	3-0-0	3
MAL 408	Statistical Analysis and Queuing Theory	3-0-0	3	MAL407	Statistics & Optimization Techniques	3-0-0	3
MAL406	Perturbation Methods	3-0-0	3	MAL 409	Introduction to Finite Element Method	3-0-0	3
MAL407	Statistics & Optimization Techniques	3-0-0	3				

Scheme of Instruction only for M. Tech.

I Semester				**II Semester**			
Code	Course	L-T-P	Cr	Code	Course	L-T-P	Cr
MAL 504	Applied Linear Algebra	3-0-0	3	MAL 503	Optimization Techniques	3-0-0	3
MAL 505	Mathematical elements for Engineers	3-0-0	3				
MAL 506	Statistical methods for Urban Planning	3-0-0	3				

Syllabus

Note: For all text books/reference books, the latest editions are requested to use.

MAL101 - MATHEMATICS-I [(3-1-0); Credit: 4]

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: Review of limit, continuity and differentiability. Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem, Taylor's theorem with Lagrange's form of remainder, 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.
2. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; NarosaPublishers .
3. Thomas, G.B. and Finney, R.L.; Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc.

Reference Books:

1. Michael D. Greenberg: Advanced Engineering Mathematics, Pearson Education Pvt. Ltd.
2. Piskunov, N. : Differential and Integral calculus, Vol. 1, Vol. 2, MIR Publishers, Moscow - CBS Publishers and Distributors (India).

MAL102 - MATHEMATICS-II **[(3-1-0); Credit: 4]**

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.
2. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers.
3. Thomas, G.B. and Finney, R.L.; Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc.

Reference Books:

1. Piskunov, N. : Differential and Integral calculus, Vol.1, Vol.2 MIR Publishers, Moscow - CBS Publishers and Distributors (India).
2. Michael D. Greenberg: Advanced Engineering Mathematics, Pearson Education Pvt. Ltd.

MAL 103 – Mathematics (for B. Arch) [3-1-0; Credits 4]

Objective: The objective of this subject is to expose student to understand the basic concepts of differential and integral calculus, ordinary differential equations, matrix theory, three dimensional geometry and basic statistics.

Calculus:
Tangent and Normal, Maxima and minima of functions of one variable, Curvature (Cartesian and Parametric form), Curve tracing, Taylor's and Maclaurin's expansion for one variable, Indeterminate forms, partial differentiation, Maxima and minima of functions of two variables.

Double integrals, Calculation of areas using double integrals (Cartesian and Polar), Applications of double integrals for Centre of gravity and Moment of inertia.

Ordinary Differential Equations:
First order ODEs: Method of solution, orthogonal trajectories, Newton's law of cooling.
Second and higher order linear ODEs: Solution of homogeneous and non-homogeneous linear equations with constant coefficients, Applications

Matrices:
Review of inverse of a square matrix using Adjoint matrix. Rank of a matrix, consistency and inconsistency of system of linear equations, solution of LPP using graphical method.

Three Dimensional Geometry:
Directional Cosines and ratio's, angle between two lines, equations of straight line, coplanar lines, equation of plane, shortest distance between lines and planes, tangent plane and normal line,sphere.

Statistics:
Arithmetic mean, median, mode, standard deviation and variance, regression and correlation;
Curve fitting, method of least squares (Straight line and parabola).

Reference Books:

1. Kreyszig, E., Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, New York 2008.
2. Thomas G.B., Calculus and Analytical Geometry, Addison Wesley, London, 1998.
3. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 2011.
4. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers 2005.
5. Piskunov, N. : Differential and Integral calculus, Vol. 1, Vol. 2, MIR Publishers, Moscow - CBS Publishers and Distributors (India),1996.
6. James Stewart, Calculus -Early Transcendental, Thomson Brooks/Cole, 2008.

MAL201: Integral Transforms and Partial Differential Equations [(3-1-0); Credit: 4]

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.

Partial differential equations: 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.

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

Text Books:

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

Reference Books:

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

MAL203 - Numerical Methods and Computation [(3-0-1); Credit: 4]

Objective: The objective of this subject is to make the students aware of the numerical methods for the solution of scientific problems which cannot be solved analytically.

Interpolation : Existence, Uniqueness of interpolating polynomial, error of interpolation - unequally spaced data; Lagrange'sformula, 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: RegulaFalsi 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 eigenvectors : Power and Jacobi methods.

Solution of Ordinary differential equations:
Initial value problems: Single step methods; Taylor's, Euler's, Runge-Kutta methods, Implicit RungeKutta methods Boundary value problems: Finite difference methods, Shooting method.

Text Books:

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

Reference Books:

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

MAL204 - Linear Algebra and Applications [(3-1-0); Credit: 4]

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 eliminationmethod.

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 R^n and theirrepresentation as square matrices, invertible linear operators, inverse of a non-singular matrix, eigenvalues and eigenvectors of a linear operator, properties of eigenvalues and eigenvectorsof Hermitian, skew-Hermitian, unitary, and normal matrices (symmetric, skew-symmetric,and orthogonal matrices), characteristic equation, bounds on eigenvalues,Cayley-Hamiltontheorem, diagonalizability of a linear operator, invariant sub spaces, annihilators, minimal polynomials.
Inner product spaces, norm; orthonormal sets, Gram-Schmidt orthogonalisation process;projections and least squares approximation, Ad-joint operator, normal, unitary and self-adjoint operator. Spectral theorem for normal operator, applications of linear algebra in engineering.

Text books:
(1) G. Strang, Linear algebra and its applications , Thomson Publications.
(2) E. Kreyszig, Advanced engineering mathematics, John Wiley publications .

References:
(1) Hoffman and Kunje, Linear Algebra, Prentice Hall of India.
(2) S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India.
(3) Nagpaul, First course in Linear Algebra, Wiley Eastern Ltd, New Delhi.

MAL206 –Discrete Mathematics and Graph Theory [(3-1-0); Credit: 4]

Objective: The objective of this subject is to make the students aware of sets, relations, functions, Boolean algebra and graph theory and its applications in science and engineering.

Sets and propositions: Combinations of sets, Finite and Infinite sets, uncountably infinite sets, principle of inclusion and exclusion, mathematical induction. Propositions, fundamentals of logic, first order logic, ordered sets.

Permutations, combinations, numeric functions, generating functions.

Recurrence relations and recursive algorithms : recurrence relations, linear recurrence relations with constant coefficients, homogeneous solutions, particular solutions, total solutions, solution by the method of generating functions, sorting algorithm.

Relations and functions : properties of binary relations, equivalence relations and partitions, partial and total ordering relations, Transitive closure and Warshal's algorithm.

Boolean algebra : Chains, Lattices and algebraic systems, principle of duality, basic properties of algebraic systems, distributive and complemented lattices, boolean lattices and algebras, uniqueness of finite boolean algebras, boolean expressions and functions.

Graphs and planar graphs : Basic terminology, multigraphs and weighted graphs, paths and circuits, shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Colourable graphs, Chromatic numbers, Five colour theorem and Four colour problem. Trees and cut-sets : trees, rooted trees, path lengths in rooted trees, spanning trees and BFS & DFS algorithms, minimum spanning trees and Prims &Kruskal's algorithms.

Text Books:

1. Mott, Kandel and Baker, Discrete Mathematics for Computer Scientists, PHI.
2. C.L.LIU, Elements of Discrete Mathematics, McGraw Hill.
3. Tremblay and Manohar, Discrete Mathematical Structures with applications to Computer Science, McGraw Hill Book Co.

MAL207 - Complex Variables and Partial Differential Equations [(3-1-0); Credit: 4]

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.

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.

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.

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: 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.

MAL 208 - Probability Theory and Statistical Methods [(3-1-0); Credit: 4]

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

Probability

Random Variable & Probability Distributions: Random Variables, Density function, distribution function for continuous and discrete random variables, Joint distributions.
Mathematical Expectation: Mathematical Expectation, The variance and Standard deviation , Moment Generating Function, Characteristic Function.
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.

Statistics

Moments, correlation, covariance and regression.
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 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. Paul L. Meyer, Introductory Probability and Statistical Applications,Addison Wesley.
2. Miller and Freund: Probability and Statistics for Engineers Eastern Economy Edition, PHI.
3. E.Parzen: Modern Probability Theory and Its Applications J. Wiley and Sons Inc., New York.

Reference Books:

1. M.R.Speigal: Probability and Statistics, McGraw-Hill, 1995.
2. V.K. Rohatgi and A.K.M. EhsanesSateh: An Introduction to Probabability and Statistics, John Wiley & Sons.

MAL301– Introduction to Operations Research [(3-0-0); Credit: 3]

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.
2. KantiSwarupet. al. : Operations Research, Sultan Chand and Co.
3. H.A.Taha: Operations Research, An Introduction , PHI.

Reference Books :

1. S.S. Rao: Engineering Optimization : Theory & Practice, New Age International (p) Limited, 1998.
2. H.M.Wagner : Principles of Operations Research, Prentice Hall of India, New Delhi, 1982.
3. Kambo : Mathematical Progamming Techniques, East-West Publishers, New Delhi, 2008.

MAL302–Fractional Calculus **[(3-0-0); Credit: 3]**

Objective:
The main objective of this course is to introduce the fractional-order calculus and its applications in science and engineering.

Functions used in Fractional Calculus.
Gamma Function, Beta Function, Mittag-Leffler Function, Wright Function, Hyper geometric Functions.

Fractional Derivatives and Integrals.
Grünwald-Letnikov Fractional Derivatives, Riemann- Liouville Fractional Derivative, Riemann-Liouville Fractional Integral, Caputo's Fractional Derivative, Fractional Integral Equations (First and Second kind), Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives and Fractional Integrals. Fourier Transforms of Fractional Derivatives and Fractional Integrals.

Linear Fractional Differential Equations.
Fractional Differential Equation of a General Form, Existence and Uniqueness Theorem as a Method of Solution, Dependence of a Solution on Initial Conditions.

Methods for the Solution of Fractional-order Equations.
The Laplace Transform Method, The Mellin Transform Method, Power Series Method. Babenko's Symbolic Calculus Method, Fractional Green's function.

Text Books:

1. I. Podlubny, Fractional Differential Equations, Academic Press, San Diego, 1999.
2. S. Das, Functional Fractional Calculus, Springer Berlin, 2011.

Reference Books:

1. Miller KS & Ross B. An introduction to the fractional calculus. New York: John Wiley.
2. Oldham KB &Spanier J. The fractional calculus. New York: Academic Press.
3. A.A Kilbas, H.M. Srivastava, and J.J. Trujillo, J.J. Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam.

MAL303- Calculus of Variations and Integral equations [(3-0-0); Credit: 3]

Objective: The objective of this subject is to expose student to understand the basic importance of special functions, calculus of variations and integral equations.

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

Calculus of Variations: Variation and its properties, Euler's equation, Functional dependent on higher order derivatives, functional dependent of the functions of several independent variables, variational problems in parametric form, applications, variational problems with moving boundaries, variational problems involving a conditional extremum, Direct methods – Ritz method, Kantorovich's method.

Integral Equations: Volterra Integral Equations: Basic concepts, Relationship between linear differential equations and Volterra integral equations,Resolvent Kernel of Volterra Integral equation, Solution of integral equations by Resolvent Kernel, Method of successive approximations, Convolution type equations, Solution of integral differential equations with the aid of Laplace transformation.

Fredholm Integral equations: Fredholm equations of the second kind, Fundamentals - Iterated Kernels, Constructing the resolvent Kernel with the aid of iterated Kernels, Integral equations with degenerate kernels, Characteristic numbers and eigenfunctions, Solution of homogeneous integral equations with degenerate kernel, Non-homogeneous symmetric equations,Fredholm alternative.

Text Books:

1. I.Sneddon, The Use of Integral Transforms (Tata McGraw Hill), 1974.
2. Hildebrand, Methods of Applied Mathematics, Dover Publications; 2nd edition, 1992.
3. L. Elsgolts, Differential equations and calculus of variations, MIR publisher, Moscow.

Reference Books:

1. Krasnov, Problems and Exercises in Integral Equations (Mir Publ.), 1971.
2. Ram P Kanwal, Linear Integral Equations (Academic Press), 1971.
3. F.G.Tricomi, Integral Equations, Dover Publications, (1985).
4. R. V. Churchill and J. W. Brown, Fourier series and boundary value problems (7th Edition), McGraw-Hill (2006).
5. Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers, 2005.
6. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).

MAL304–Financial Mathematics [(3-0-0); Credit: 3]

Prerequisite: Probability and Statistics for Engineering (MAL 205) and Operations Research (MAL 301).

Objective:

The main objective of this course is to introduce the financial mathematics and is applications to marketing.

Some Basic definitions and terminology.

Basic Theory of Option Pricing: Single and Multi-Period Binomial Pricing Models, Cox-Ross-Rubinstein (CRR) Model, Black-Scholes Formula for Option Pricing as a Limit of CRR Model.

Brownian and Geometric Brownian Motion, Theory of Martingales. Stochastic Calculus, Stochastic Differential Equations, Ito's Formula to Solve SDE's.Applications of Stochastic Calculus in Option Pricing.

Mean-Variance Portfolio Theory: Markowitz Model of Portfolio Optimization and Capital Asset Pricing Model (CAPM). Limitations of Markowitz Model and New Measures of Risk.

Interest Rates and Interest Rate Derivatives: Binomial Lattice Model, Vasicek, Hull and White Models for Bond Pricing.

Text books:

1. D. G. Luenberger: Investment Science, Oxford University Press.
2. M. Capińsky and T. Zastawniak: Mathematics for Finance: An Introduction to Financial Engineering, Springer.
3. Thomas Mikosch: Elementary Stochastic Calculus with Finance in view, World Scientific.
4. Suresh Chandra, S. Dharmaraja, AparnaMehra, R. Khemchandani: Financial Mathematics: An Introduction, Narosa Publishing House.

Reference Books:

1. S. E. Shreve: Stochastic Calculus for Finance, Vol. I & Vol. II, Springer.
2. Sean Dineen: Probability Theory in Finance: A Mathematical Guide to the Black-Scholes Formula, American Mathematical Society, Indian edition.

MAL305–Wavelet Analysis [(3-0-0); Credit: 3]

Objective: The main objective of this course is to introduce the wavelet Analysis.

Heuristic treatment of the wavelet transform – wavelet transform – Haar wavelet expansion :Haar functions and Haar series, Haar sums and Dyadic projections, completeness of the Haar functions, Haar series in C_0 and L_p spaces, pointwise convergence of Haar series, construction of standard Brownian motion, Haar function representation of Brownian motion – Multiresolution analysis : Orthogonal systems, scaling functuions, from scaling function to MRA, Meyer wavelets, from scaling function to orthonormal wavelet – Wavelets with compact support : from scaling filter to scaling function, explicit representation of compact wavelets, Daubechies recipe, Hernandez-Weiss recipe, smoothness of wavelets - convergence properties of wavelet expansions: wavelet series in L^p spaces, large scale analysis, almost everywhere convergence, convergence at a preassigned point – Wavelets in several variables: tensor product of wavelets, general formulation of MRA and wavelets in R^d, Examples of wavelets in R^d.

Text Books:

1. Mark A. Pinsky : Introduction to fourier analysis and wavelets, Cenage Learning India Pvt. Ltd, 2002.
2. M.V.Altaisky :Wavewlets Theory, Applications Implementation, University Press, 2009

MAL401–Finite Difference methods for Differential equations [(3-0-0); Credit: 3]

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.

Finite difference methods: finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, Quasilinearization, 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.

Computation using MATLAB.

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. LotharCollatz : 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.

MAL 403 – Numerical Linear Algebra **[(3-0-0); Credit: 3]**

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

Special Matrices, Vector and Matrix Norms, SVD. Floating Point Numbers and Errors. Stability, Conditioning and Accuracy. Gauss Elimination and Linear Systems, LU Factorization using Gaussian Elimination, Stability of Gaussian Elimination, Basic Results on Existence and Uniqueness, Some Applications Giving Rise to Linear Systems of Problems, LU Factorization Methods, Conditioning and Pivoting, Inverses and Determinants. Iterative Methods for Large and Sparse Problems: Gauss Seidal, SOR, Chebyshev Acceleration, Conjugate Gradient Method, Preconditioning. QR Factorization, SVD, and Least Squares Solutions. Numerical Eigenvalue Problems, Generalized Eigenvalue Problem.

Text Books:

1. G. H. Golub and C. F. van Loan: Matrix Computations, Johns Hopkins University Press, 1984.
2. L. N. Trefethen and D. Bau, III: Numerical Linear Algebra, SIAM, 1997.
3. G. Allaire and S. M. Kaber: Numerical Linear Algebra, Springer, 2007.
4. B. N. Datta: Numerical Linear Algebra and Applications, Springer, 2008.

MAL405 - Application of Operational Research Techniques in Construction Management

[(3-0-0);Credit: 3]

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

Introduction to 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 applications to construction management.

Text books:

1. N. D. Vohra : Quantitative Techniques in Management , The Mc. Graw Hill Companies.
2. J.C. Pant, Introduction to Optimization : Operations Research Jain Brothers, New Delhi.
3. H.M.Wagner : Principles of Operations Research, Prentice Hall of India, New Delhi.
4. Kambo : Mathematical Progamming Techniques, East-West Publishers, New Delhi.

MAL406–Perturbation Methods [(3-0-0); Credit: 3]

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 $\neq \varepsilon$: 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 HasanNayfeh, John Wiley & Sons, New York, 2007.

MAL 407 - Statistics & Optimization Techniques [(3-0-0); Credit: 3]

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 Optimization: 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); Credit: 3]

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. EhsanesSaleh: 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.

MAL 409 - Introduction to Finite Element Method [(3-0-0); Credit: 3]

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 503 - Optimization Techniques [(3-0-0); Credit: 3]

Motivation. mathematical review , matrix factorizations, sets and sequences, convex sets and functions, linear programming and simplex method, Weierstrass' theorem, Karush Kuhn Tucker optimality conditions, algorithms, convergence, unconstrained optimization, Line search methods, method of multidimensional search, steepest descent methods, Newton's method, modifications to Newton's method , trust region methods, conjugate gradient methods, quasi-Newton's methods. constrained optimization, penalty and barrier function methods, augmented Lagrangian methods, polynomial time algorithm for linear programming, successive linear programming, successive quadratic programming.

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:

3. H.M.Wagner : Principles of Operations Research, Prentice Hall of India, New Delhi, 1982.
4. David Luenberger and Yinyu Ye, Linear and Nonlinear Programming, 3rd Edition,Springer, 2008.
5. Fletcher R., Practical Methods of Optimization, John Wiley, 2000.
6. Venkataraman P., Applied Optimization with MATLAB Programming, Wiley, 2001

MAL 504 - Applied Linear Algebra **[(3-0-0); Credit: 3]**

Vector spaces, linear independence, bases and dimension, linear maps and matrices, eigenvalues, invariant subspaces, inner products, norms, orthonormal bases, spectral theorem, isometries, Linear Transformations, The Null Space and the Range Space of a Linear Transformation, , The Rank-Nullity-Dimension Theorem. Isomorphisms between Vector Spaces, polar and singular value decomposition, operators on real and complex vector spaces, characteristic polynomial, minimal polynomial.

Text books:

1. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India).
2. M. Artin: Algebra, Prentice Hall of India.

Reference Books:

1. I. N Herstein: Topics in Algebra, 2 nd Edition, John-Wiley.
2. S. Lang: Linear Algebra, Springer Undergraduate Texts in Mathematics.
3. S. Kumeresan: Linear Algebra: A Geometric Approach, Prentice Hall of India

MAL 505 - Mathematical Elements for Engineers [(3-0-0); Credit: 3]

Objective: The objective of this subject is to expose student to understand the basic importance of Linear Algebra and numerical techniques to solve scientific problems.

Linear Algebra & Matrices: Linear Vector Spaces, Linear dependence, basis and dimensions, Four fundamental subspaces, Linear transformations, Transformation from one linear space to another, Inner product space and applications, Eigen values and Eigen vectors, diagonalization, complex matrices, similarity transformations, matrix norms & condition number, iterative methods for solving $AX = b$.

Numerical Techniques: Review of the topics in elementary numerical analysis, Basic Principles, Construction of approximate integration formulae using method of undetermined weights & nodes, Gauss-Legendre formula, Gauss Chebyshiv formula, Gauss-Hermite formula, Errors in numerical integration.

Finite Difference Methods : Approximation of derivatives (Ordinary & Partial) in terms of pivotal values: Application to solve

1. Boundary value problems in ordinary differential equations
2. Boundary value problems in partial differential equations: Laplace equation, one dimensional heat equation and one dimensional wave equation.

Introduction to Mathematical Modeling: Study of cases of modeling through Linear equations and differential equations.

Text Books:

1. G.D. Smith: Numerical solution of Partial Differential equations, Finite Difference methods, Oxford University Press, 1985.
2. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House, 2008.
3. ErwynKreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
4. M.K.Jain, S.R.K.Iyengar and R.K.Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.
5. G. Strang, Linear algebra and its applications , Thomson Publications (2006).

MAL 506 - Statistical Methods for Urban Planning [(3-0-0); Credit: 3]

Objective: The objective of this subject is to expose student to understand the importance of statistical methods for urban planning.

Introduction, scope and methods of statistics, frequency distribution, measures of location, dispersion and skewness.
Correlation & regression analysis, least square method – curve fitting
Theory of probability: random variables, some probability distributions – Binomial, Poisson, Normal.
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.

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics,Khanna Publishers, New Delhi, 1989.
2. M.R. Speigel: Probability and Statistics, McGraw-Hill, 1995.
3. Vijay K. Rohatgi& A.K. Md. EhsanesSaleh: An Introduction to Probability and statistics , John Wiley & Sons Inc., New York, 1976.
4. Kishor S. Trivedi : Probability & Statistics with reliability, Queuing and computer Science applications, PHI private Ltd, 2009.