APPENDIX A

CURRICULAR OF THE MATHEMATICS COURSES OFFERED FOR THE GENERAL/SPECIAL DEGREE PROGRAMME IN SCIENCE

100 LEVEL COURSES

Course Number	Course Title	No. of credits	Prerequisites	Compulsory for		
				General Degree		Special Degree
				*	* *	
MT101	Vector Methods	2			√	√
MT102	Introduction to Probability Theory	3			√	√
MT103	Differential Equations	2			√	√
MT104	Abstract Algebra I	3		√	√	√
MT105	Real Analysis I	3		√	√	√
MT106	Classical Mechanics I	3	MT 101		√	√
	Total	**16**				

* Mathematics as a single subject
** Mathematics as two subjects

MT 100 Mathematics for Biological Sciences (2 credits)

Sets and inequalities, Linear equations, Quadratic equations, Functions and graphs, Trigonometric Functions,

Limits, Derivatives, Curve sketching, Maximum-minimum problems, Exponential and logarithmic functions

Techniques of integration, Areas and volumes, partial derivatives,

Introduction to vectors, Matrices and determinants.

Recommended text:

Mathematics for Biological Sciences, J.C. Arya and R.W. Lardner

MT 101 Vector Methods (2 credits)

Vector algebra: Introduction to vectors, Linear combinations, Linear dependence and independence. Bases and dimension, Scalar product. Vector product. Triple scalar product. Triple vector product. Solutions of vector equations involving products.

Vector Geometry: Collinear Vectors, Coplanar vectors, Vectors equation of a line, Vector equation of a plane, Tetrahedron, Parallelepiped, pyramid and the prism, Coplanar and skew lines, Intersecting and parallel planes, Cylindrical polar coordinates, Spherical polar

coordinates, Simple surfaces: Sphere- Cone, Cylinder, Cosine and Sine formula in Spherical Trigonometry.

Vector Functions of a Single Scalar Variable: Differentiation, Integration, Space curves, Tangent and normals.

Recommended texts:

1. *Elementary Vector Analysis,* C.E. Weatherbum
2. *Vector Analysis,* M.D. Raisinghania

MT 102 Introduction to Probability Theory (3 credits)

Counting Techniques: Combinations, Permutations, Set partitions, Elements of Probability: Experiments, Events, Sample space, Laws of Probability, Bayes' Theorem, Independence of events. Random variables: Discrete and continuous r.v.'s, Probability mass function, Probability density function, Cumulative distribution function, Functions of a random variable, Expectation, Moments, Mean and variance, Moment Generating function. Probability inequalities: Chebyshev's and Markov's etc.

Distributions: Discrete: Uniform, Bernoulli & Binomial, Poisson, Geometric, Negative Binomial, Hypergeometic, Multinomial, Continuous: Uniform, Normal, Gamma, Exponential, Properties and applications of distributions, Probability Generating functions. Approximation to Binomial using Poisson, Binomial using Normal, and Poisson using Normal.

Recommended Texts:

1. A*pplied Probability and Statistical Methods*, G.C.Canovos .
2. *Basic Course in Statistics*, G.M.Clarke and D. Cooke
3. *A Course in Probability & Statistics,* C.J. Stone

MT 103 Differential Equations (2 credits)

Fist Order Ordinary Differentials Equations: Review of fist order equations, Exact equations, Clairaut's equation, Ricarti’s equation.

Higher Order Ordinary Differential Equations: Linear equations with constant coefficients, Wronskian, Differential operators, Undetermined coefficients. Variationof parameters.

Recommended texts:

1. *A First Course in Differential Equations,* D.G. Zill
2. *Differential Equations,* H.T.H. Piaggio

MT 104 Abstract Algebra I (3 credits)

Number Theory: Euclid's Algorithm, Greatest common divisor and least common multiple, and their Relationship, Solution of Linear Diophantine equations in two variables, Linear congruences, Systems of linear Congruences having he same modulus, Chinese Remainder Theorem.

Relations, Functions and Binary Operations: Equivalence relation. Partitions, Orbits and transversals functions a subset of a relations, bijective functions, inverse of a function.

Permutations: Theorems on the product of disjoin cycles, Transpositions and the uses, parity and signature of a permutation.

Group Theory: Group Tables, Subgroups, Elementary properties of Cyclic groups, Dihedral group of order 2n and its properties, Symmetric and Alternating group: Direct product of two groups, Identification of non-isomorphic groups of order up to 10.

Recommended texts:

1. *A First course in Abstract Algebra,* J.B. Fraleigh
2. *Elementary Number Theory,* D.M. Burton

MT 105 Real Analysis I (3 credits)

Real number system as a complete ordered field, Complex number system, Topology of the real line, Neighborhoods, Sequences and limits, Limit theorems, Monotonic Sequences, Limit Concept of a Real-Valued Function, Algebra of limits, Continuity, Monotonic functions, Differentiability, Role's Theorem, Mean-Value Theorems, L'Hospital's Rule, Riemann Integral and the basic properties. Fundamental theorem of Calculus, Improper integrals.

Recommended texts:

1. *Elementary Real Analysis,* H.G. Eggleston
2. *Analysis*, S.R. Lay

MT 106 Classical Mechanics I (3 credits)

(Prerequisite: MT 105)

Motion of a particle in a plane: Velocity and acceleration components in Cartesian and polar coordinates, Newton's second law: Inertial fame, Use of poplar coordinates, Impulse-Momentum Integral Work-Energy Integral.

Constrained motion: Motion in a space curve. Use of intrinsic coordinates, Varying mass: Mass increasing or decreasing at a constant race.

Dynamics of a system particles: Linear momentum and equation of the center of mass. Angular Momentum, Kinetic energy, Equations for impulsive motion, Rotation of a rigid body abut a fixed axis: Kinetic Energy of rotation and energy Conservation equation, Forces exerted on the axis of revolution, Angular Momentum and impulse, conservation of angular momentum about a fixed axis.

Plane motion of a rigid body: Instantaneous center of a lamina, Motion of the center of mass, motion relative to the center of mass, Equations of motion and their use, Kinetic energy and energy conservation equation, Angular momentum about any axis, conservation of linear momentum/angular momentum.

Recommended texts:

1. *Textbook a/Dynamics,* F.Chorlton
2. *New Tertiary Mathematics,* C.Plumpton

NOTE: MT 104 and MT 105 are compulsory for students who offer Mathematics as a principal subject.

200 LEVEL COURSES

Course Number	Course Title	No. of Credits	Prerequisites	Compulsory for		
				General Degree		Special Degree
				*	**	
MT 201	Groups, Rings and Fields	3	MT 104	√	√	√
MT 202	Real Analysis II	3	MT 105	√	√	√
MT 203	Ordinary Differential Equations	3	MT 103			
MT 204	Mathematical Methods	3	MT 101		√	√
MT 205	Classical Mechanics II	2	MT 106			
MT 206	Mathematical Modelling	3			√	√
MT 207	Numerical Analysis I	2			√	√
MT 208	Set Theory	1				
MT 209	Graph Theory	2				
	Total	**22**				

Courses MT 201 and MT 202 shall be compulsory for students offering Mathematics as a single subject.

Courses MT 201, MT 202, MT 204, MT 206 and MT 207 shall be compulsory for students offering Mathematics as two subjects.

MT 201 Groups, Rings and Fields (3 credits)

(Prerequisite: MT 104)

Groups: Cosets, Normal Subgroups and Factor Groups, Direct Product and Semi-direct Products, omomorphisms, Isomorphisms, Isomorphism Theorems, Permutation Groups, Cayley's Theorem, Isomorphism between Dihedral and Symmetric Groups, Conjugacy and the Class Equation.

Rings: Commutative rings, Rings with unity, Integral Domains and Fields, Subrings, Ring Homomorphisms, Ideals and Factor Rings, Principal Ideal Domains, Euclidean Domains and Unique Factorisation Domains, Quotient Fields.

Polynomials: Polynomials with Integer Coefficients, Solution of Cubic and Quartic Polynomials, General Polynomial over a field, Roots of a Polynomial, Existence of Roots, Factorisation, Irreducible polynomials, Gauss's Lemma, Eisenstein's Irreducibility Criterion.

Fields: Properties of a Field, Properties of a multiplicative group of a Field, Field Extensions, Finite Fields.

Recommended Texts:

1. J. B. Fraleigh (1999), *A First Course in Abstract Algebra*, Addison-Wesley Publishing Company
2. M. Artin, *Algebra* (1994), Prentice-Hall
3. I.N. Herstein (1964), *Topics in Algebra*, Blaisdell

MT 202 Real Analysis II (3 credits)

(Prerequisite: MT 105)

Cauchy sequences, Convergence tests, Absolute and conditional convergence, Power series, Integration and differentiation of power series, Taylor series, Uniform continuity, Upper and lower Riemann integrals, Characterization of Riemann integrable functions, Functions of several variables, Limits and continuity, Partial derivatives, Differentials, Chain rule, Extrema of functions of several variables, Lagrange Multipliers.

Recommended Texts:

1. S. R. Lay (1986), *Analysis An Introduction to Proof*, Prentice-Hall
2. T. M. Apostol (1974), *Mathematical Analysis*, Addison-Wesley

MT 203 Ordinary Differential Equations (3 credits)

(Prerequisite: MT 103)

Series solutions, Picard iterates, Existence and uniqueness of solutions, eigenvector method for linear systems, Fundamental matrix solutions, Non-linear autonomous systems, Phase plane, Phase portraits of linear systems, stability, Liapunov functions, Periodic solutions, Poincare-Bendixson theorem, Introduction to bifurcation theory.

Recommended Text:

M. Braun (1992), *Differential Equations and Their Applications*, Springer-Verlag

MT 204 Mathematical Methods (3 credits)

(Prerequisite: MT 101)

Differentiation of Vectors: Scalar and vector point functions and their partial derivatives with respect to coordinate variables, Gradient of a scalar point function; Directional derivative, Divergence and curl of a vector point function**. Integration of Vectors:** Line integrals and their evaluation using parametric representation, Surface integrals, Green's theorem in the plane Stokes theorem, Circulation and flux of a vector point function, Volume integrals, Divergence theorem, Irrotational and Solenoidal vector fields, Orthogonal Curvilinear Coordinates, Grad, Div, Curl in OCC, Cylindrical polar and spherical coordinate systems, Use of these coordinate systems in evaluation of surface and volume integrals. **Special Solution of Laplaces Equation:** Solutions in two-dimensions, Axi-symmetric solutions. **Integral Transforms:**

Laplace transforms; Elementary Properties, Inverse Laplace transform and its properties, Convolution theorem and its use in evaluation of integrals, Uses of Special functions connected with Laplace transform, Evaluation of integrals using LT, Applications in ODE and integro-differential equations, Applications in PDE, Fourier Transforms; Infinite-Fourier sine/cosine transforms and their inverse formulae, Finite-Fourier sine/cosine transforms, Derivation of inverse formulae, Use of Fourier series, Boundary value problems-Use of Fourier transforms.

Recommended Texts:

1. M.R. Spiegel (1968), *Vector Analysis*, McGraw-Hill
2. M.D. Raisinghania (1997), *Vector Analysis*, S. Chand & Comp. Ltd.
3. M.D. Raisinghania (1995), *Integral Transforms*, S. Chand & Comp. Ltd.

MT 205 Classical Mechanics II (2 credits)

(Prerequisite: MT 106)

Statics

Catenary: Equation of catenary; Standard relations, Tension at a point, Examples on equilibrium of heavy strings, Tightly stretched catenary. **Strings on plane curves:** Heavy string on smooth space, Heavy string on rough space.**Thin rigid beams:** Shear force and SF diagram, Bending Moment and BM diagram, Relationship between SF, BM and Loading (continuous/ concentrated). **Deflection of beams:** Equilibrium of slightly elastic beams, Bending of slightly elastic beams, Equation of three moments.

Dynamics

Central Orbits: Particle motion under a central force, Use of polar and reciprocal polar coordinates, Use of pedal coordinates, Elliptic, Parabolic and Hyperbolic Orbits, Kepler's Laws of planetary motion, Distributed central orbits. **Small Oscillations:** Expressions for Kinetic/Potential Energies, Equation of motion and their solutions, Normal modes of oscillation, Normal coordinates and their determination.

Recommended Texts:

1. S.L. Green (1962), *General Degree Applied Mathematics*, University Tutorial Press Ltd
2. F. Chorlton (1985), *Dynamics*, CBS publishers

MT 206 Mathematical Modelling (3 credits)

Dimensions and Units, Scaling, Approximation and reasonableness of answers, Linear and quadratic models, Polynomial and rational models, Traffic flow models, Exponential models, Catastrophe theory, usage of differential equations and Bifurcation

Economic Functions: supply; Demand; *TC*; *TR*; *AC*; *AR*; *MC* and *MR*. Elasticity, Cosumer's Surplus, Producer's Surplus, Income determination model, Cobweb model, Harod model, Equilibrium in Economic Resources, Economies, Attainable states, Private ownership, Fixed point theory, Continuous-time systems, Controllability, Liner feed back, Discrete-time systems, Stability theory, Optimal controls.

Recommended Text:

R. Haberman (1998), *Mathematical Models*, SIAM

MT 207 Numerical Analysis I (2 credits)

Difference equations, Solutions of equations in one variable: Bisection method, Fixed-point iteration, Newton-Raphson method, Error analysis for iterative methods.

Interpolation and Polynomial Approximation: Taylor polynomials, Interpolation and Lagrange polynomial, Iterated interpolation, Divided differences, Hermite interpolation, Cubic spline interpolation.

Numerical Differentiation and Integration: Numerical differentiation, Richardson's extrapolation, Elements of numerical integration.

Recommended Text:

K. E. Atkinson (1998), *An Introduction to Numerical Analysis*, John Wiley

MT 208 Set Theory (1 credits)

Axiom schema of comprehension, Formulas, classes, ZFC-model; Algebra of sets, Principle of Duality, Indexing, Countability, Cardinal Arithmetic, Cantor's Theorem; Continuum Hypothesis, Partial ordering and Zone's Lemma, Ordinal numbers and Transfinite Induction, Well-ordering Principle.

Recommended Text:

K.J. Delvin (1993), *The Joy of Sets : Fundamentals of Contemporary Set Theory* (*Undergraduate Texts in Mathematics*), Springer-Verlag

MT 209 Graph Theory (2 credits)

Isomorphism of Graphs, Paths, Circuits, Eulerian graphs, Hamiltonian graphs, Shortest path problem, Chinese postman problem, Directed graphs, Graph Colouring, Four colour problem, Proof of five colour theorem, Planar graphs, **Trees and Searching:** Properties of trees, Travelling salesman problem, Tree Analysis of sorting algorithms, Hall's Theorem, Transversal theory, Applications to game theory.

Recommended Texts:

1. F. Harary (1988), *Graph Theory*, Narosa Publishing House
2. R. J. Wilson (1996), *Introduction to Graph Theory*, Addison-Wesley Longman

300 LEVEL COURSES

Course Number	Course Title	No. of Credits	Prerequisites	Compulsory for		
				General Degree		Special Degree
				*	**	
MT 301	Linear Algebra	3	MT 201	√	√	√
MT 302	Real Analysis III	3	MT 202	√	√	√
MT 303	Differential Geometry	2				
MT 304	Partial Differential Equations	2	MT 103			
MT 305	Group Theory	3	MT 201			√
MT 306	Topology I	3	MT 105			√
MT 307	Complex Analysis I	2	MT 202			√
MT 308	Combinatorics	2	MT 209			
MT 309	Number Theory	3	MT 201			√
MT 310	Fluid Mechanics I	3	MT 202,MT 204		√	√
MT 311	Linear Programming	3				
MT 312	Numerical Analysis II	3	MT 207		√	√
	Total	**32**				

Courses MT 301 and MT 302 shall be compulsory for students offering Mathematics as a single subject.

Courses MT 301, MT 302, MT 310 and MT 312 shall be compulsory for students offering Mathematics as two subjects.

Courses MT 301, MT 302, MT 305, MT 306, MT 307, MT 309, MT 310 and MT 312 shall be compulsory for students following Special Degree Course in Mathematics.

MT 301 Linear Algebra (3 credits)

(Prerequisite: MT 201)

Vector Spaces: The abstract definition using the definition of vectors in $\Re^3, \Re^n, \mathbf{C}^n$. Subspaces, Dimension Theorem, Isomorphism Theorems. **Linear Transformations and Matrices**: Null Space and Range, Linear Operators, Rank-Nullity Theorem, Matrix Representation of a Linear Transformation, Composition of Linear Transformations, Change of Coordinate Matrix, Similar Matrices, Matrix of Change of Bases. **Symmetric, Hermitian and Unitary Matrices:** Properties of these Matrices, Shur's Theorem, The Reyleigh-Ritz Theorem. **Elementary Matrices:** Block Matrices, Elementary Matrix Operations and Elementary Matrices. **Systems of Linear Equations:** Augmented Matrix, Theoretical Treatment of Systems of Linear Equations. **Determinants:** Determinants of Order n, Properties of Determinants, Properties of the Adjoint. **Diagonalisation of Matrices:**

Eigenvalues and Eigenvectors, Diagonalisability, Invariant Subspaces, Matrix Polynomials and Cayley-Hamiltion Theorem, Minimum Polynomial.

Inner Product Spaces: Abstract Inner Products and Norms, Distance and angle between two vectors, Cauchy -Schwarz Theorem, The Gram-Schmidt orthogonalisation Process, Linear Operator in Inner Product Spaces, Positive definite linear operators.

Recommended Texts:

1. S. Lipschistz (1989), *Linear Algebra -Shaum Solved Problem Series*, McGraw-Hill
2. K. Hoffman and R. Kunze (1997), *Linear Algebra*, Prentice-Hall
3. G. L. Bradley (1975), *A Primer of Linear Algebra*, Prentice-Hall

MT 302 Real Analysis III (3 credits)

(Prerequisites: MT 202)

Jacobian, Inverse and Implicit Functions Theorem, Multiple integrals, change of variables (transformations) in multiple integrals, Function of Bounded Variation, Total variations, Rectifiable curves, Uniform convergence of infinite series, Infinite products, Special Functions (Gamma, Beta, Bessel, Legendre etc), Riemann Stieltjes Integral.

Recommended Texts:

1. W. Rudin (1976), *Principles of Mathematical Analysis*, McGraw-Hill
2. T. M. Apostol (1974), *Mathematical Analysis*, Addison-Wesley Longman

MT 303 Differential Geometry (2 credits)

Curves in space: Serret-Frenet formulae, Osculating plane, Osculating circle and osculating sphere, Involutes and evolutes, Helices.

Surfaces: Envelopes, Developable surfaces, Fundamental forms, Lines of curvature and Asymptotic curves, Ruled surfaces, Geodesics.

Recommended Texts:

1. T. J. Willmore (1959), *An Introduction to Differential Geometry*, Oxford University Press
2. CE. Weatherburn (1927), *Differential Geometry*, Cambridge University Press,

MT 304 Partial Differential Equations (2 credits)

(Prerequisite: MT 103)

First order partial differential equations: Linear equations, Non-linear equations, Characteristics.

Second order partial differential equations: Equations with constant coefficients, Equations with variable coefficients, Laplace equation, Wave equation, Diffusion equation, Boundary value problems,

Use of Fourier series.

Numerical methods of solving partial differential equations.

Recommended Texts:

1. R. V. Churchill & J.W. Brown (1987), *Fourier Series and Boundary Value Problems*, McGraw-Hill
2. E.T. Copson (1975) *Partial Differential Equations*, Cambridge University Press

MT 305 Group Theory (3 credits)

(Prerequisite: MT 201)

Classes of groups, Radicals and Residuals, Group Action on a set, Orbits and Stabiliser, Sylow's Theorems, Simple groups, Applications of Sylow's Theorems, Subnormal and Normal Series, Jordan-Holders Theorem, p-groups, Soluble and Nilpotent groups, Non-solubility of S_n (n>4) and Simplicity of A_n (n>4), Action of groups on groups.

Recommended Texts:

1. J. B. Fraleigh (1999), *A First Course in Abstract Algebra*, Addison-Wesley Publishing Company
2. R. Scott (1964), *Group Theory*, Prentice-Hall
3. J. S. Rose (1978), *A Course in Group Theory*, Cambridge University Press

MT 306 Topology I (3 credits)

(Prerequisite: MT 105)

Metric spaces, open and closed sets, continuous and Bi-continuous functions, complete metric spaces and Banach's Fixed Point Theorem, Topology on $\Re^n$, General topological spaces, Neighborhood Axioms, Bases and Local Bases Homeomorphisms, Subspaces, Finite Products and Quotients, Separation Axioms, Convergence, Compactness, Connectedness, Homotopy of paths.

Recommended Texts:

1. E. T. Copson (1978), *Metric Spaces*, Cambridge University Press
2. J. R. Munkres (1975), *Topology: A First Course*, Prentice-Hall

MT 307 Complex Analysis I (2 credits)

(Prerequisite: MT 202)

The complex field, Riemann sphere, Topology of the complex plane, Analytic functions, Cauchy- Riemann equations, Elementary functions, Cauchy's Theorem (Proof based on Green's theorem), Cauchy's integral formulae, Taylor series, Laurent series, Classification of singularities, Residue Theorem, Evaluation of real-valued integrals by means of residues, Conformal mappings.

Recommended Texts:

R. V. Churchill & J. W. Brown (1984), *Complex Variables and Applications,* McGraw-Hill

MT 308 Combinatorics (2 credits)

(Prerequisite: MT 209)

Recurrence relations and generating functions: Computing solutions to recurrence relations, The principle of Inclusion and Exclusion, Latin squares, System of distinct representatives, Extremal set theory.

Steiner triple systems: Direct construction, Recurrence construction, Tournaments and Kirkman's school girls problem, Further Graph Theory, Networks, Matroids, Designs, Hadamard matrices.

Error-Correcting codes : Linear Codes and Hadamard codes.

Recommended Texts:

1. P. J. Cameron (1994), *Combinatorics: Topics, Techniques, Algorithms*, Cambridge University Press

MT 309 Number Theory (3 credits)

(Prerequisite: MT 201)

Continued fractions, Linear congruences in two or more variables, System of congruences, Congruences of higher order, Euler ϕ-function and related theorems, Properties of the group $\phi(n)$, Euler's theorem, Wilson's theorem, Primitive roots, Quadratic residues, Gauss Quadratic Reciprocity law and its applications, Fermat numbers and Pepin's test.

Recommended Texts:

1. K. H. Rosen (1992), *Elementary Number Theory And Its Applications,* Addison-Wesley Publishing Company
2. I. Niven and H.S. Zuckerman (1980), *An Introduction to the Theory of Numbers*, John Wiely

MT 310 Fluid Mechanics I (3 credits)

(Prerequisites: MT 202, MT 204)

Kinematics of Fluid Motion: Real and Perfect Fluids, Velocity of a fluid at a point, Streamlines and their differential equations, Steady and Unsteady motions, Vorticity and Circulation; Stokes's theorem, Irrotational flow and the velocity potential, Local, convectional and material rates of change of flow quantities, Acceleration as a material derivative, Equation of Continuity, Compressible and Incompressible fluids Conditions satisfied by a perfect fluid at a rigid boundary.

Euler's Equation of Motion: Pressure at a point in a fluid (moving or at rest), Euler's Equation in vector form, Motion under conservative body force; Steady Rotation about a fixed vertical axis, Bernoulli's Equation in irrotational motion; Radial flow, Theorems on velocity potential,Kinetic Energy; Kelvin's theorems.

Three-dimensional flow fields: Source, Sink and Doublet, Flow past a fixed sphere; Moving sphere in a fluid, Motion generated by impulses on boundaries of fluid, Concentric Spherical boundaries of fluid.

Two-dimensional flow fields: Velocity and Vorticity in terms of the Stream Function in incompressible fluid, The Complex Potential and the Complex Velocity, in irrotational motion, Source, Sink, Doublet and Vortex, Image Systems for straight and circular boundaries Circle Theorem of Milne-Thomson, Flow past a fixed circular cylinder with singularities in the field outside.

Recommended Texts:

1. F. Chorlton (1990), Fluid Dynamics, Oxford University Press

MT 311 Linear Programming (3 credits)

Convex Analysis: Convex combinations, Convex sets, Extreme points of a convex set, Convex polyhedron, Hyperplanes, Half-spaces and polytopes, Convex functions.

Linear Programming (LP): Mathematical formulation of the LP problem, LP in two-dimensional space, Graphical solution methods, General LP problem.

The Simplex Method: Simplex algorithm, Two-phase simplex algorithm, Revised simplex algorithm, LP problems with unrestricted variables, LP problems with bounded variables.

Duality in LP: Duality in LP problems, Duality theorems, Applications of duality, Dual simplex algorithm.

Special Types of LP Problems: Transportation problem, Assignment problem.

Recommended Texts:

1. G. B. Dantzig & M. N. Thapa (1997), *Linear Programming*: *Introduction*, Springer-Verlag New York
2. K. Kapoor (1998), *Operations Research*, Sultan Chand & Sons

MT 312 Numerical Analysis II (3 credits)

(Prerequisite: MT 207)

Initial-value Problems For Ordinary Differential Equations: Euler's method, Higher-order Taylor methods, Runge-Kutta method.

Direct Methods for Solving Linear Systems: Linear systems of equations, Gaussian elimination and backward substitution.

Numerical Solutions of Non-Linear Systems of Equations: Fixed points for functions of several variables, Newton's method, Quasi-Newton methods, Steepest descent techniques.

Boundary-Value Problems for Ordinary Differential Equations: The linear shooting method, The shooting method for non-linear problems, Finite-difference methods for linear problems, Finite-difference methods for non-linear problems.

Recommended Texts:

1. K. E. Atkinson (1998), *An Introduction to Numerical Analysis*, John Wiley
2. P.A. Stark (1970), *Introduction to Numerical Analysis*, The Macmillan Company

400 LEVEL COURSES

Course Number	Course Title	No. of Credits	Prerequisites	Compulsory for Special Degree
MT 401	Galois Theory	3	MT 301,MT 305	√
MT 402	Measure Theory	3	MT 302	√
MT 403	Topology II	3	MT 306	√
MT 404	Complex Analysis II	3	MT 306,MT 307	√
MT 405	Functional Analysis	3	MT 301,MT 306,MT 402	√
MT 406	Fluid Mechanics II	3	MT 310	√
MT 407	Optimization Theory	3	MT 311	√
MT 408	Independent Study /Project Work	3		√
	Total	**24**		

All of the following courses shall be compulsory for students following Special Degree Course in Mathematics.

MT 401 Galois Theory (3 credit)

(Prerequisites: MT 301, MT 305)

Field extensions, Ruler and Compass Constructions, Three classical Problems, Galois groups of field extensions, Automorphisms of a field, Theorem of the Primitive Element, Splitting Fields, Automorphisms of a field extension over a fixed field, Galois Groups, Separable and Inseparable Extensions, Normal Extensions and Galois Extensions, Subgroups of the Galois group and intermediate fields of the extension, Fundamental Theorem of Galois Theory, Solubility of polynomials, Galois group of a polynomial, Radical Extensions, Solubility by radicals, Proof that a polynomial is irreducible if and only if its Galois group acts transitively on its roots, Proof of the Fundamental Theorem of Algebra.

Recommended Texts:

1. M. Artin (1994), *Algebra*, Prentice-Hall
2. I. Kaplansky (1972), *Rings and Fields*, University of Chicago Press
3. I.N. Stewart (1973), *Galois Theory*, Chapman and Hall

MT 402 Measure Theory (3 credit)

(Prerequisite: MT 302)

Lebesgue Measure on the real line, σ-algebras, Measurable functions, Measure spaces, Lebesgue integral, Fatou's Lemma, Monotone Convergence Theorem, Dominated Convergence Theorems, L^p spaces, Modes of Convergence, Product measures, Fubini's Theorem.

Recommended Texts:

1. G. De Barra (1974), *Introduction to Measure Theory*, Van Nostrand Reinhold Company
2. H.L. Royden (1988), *Real Analysis*, Macmillan

MT 403 Topology II (3 credits)

(Prerequisite: MT 306)

Box Topology and Tychonoff Topology, Inadequacy of sequences, Nets and Filters ;

Tychonoff spaces and Normal spaces, Uryshon's Lemma and Tietze's Extension theorem ;

Paracompactness and BNS- Metrization Theorem ; G_δ - Sets and Baire Spaces ;

Totally disconnected spaces, The Cantor set , Homotopy relations, Fundamental group;

Triangulating spaces, Infinite Complexes , Euler Characteristics and Surgery, Knots and covering spaces

Recommended Texts:

1. J. R. Munkres (1975), *Topology: A First Course*, Prentice-Hall
2. R. Brown (1968), *Elements of Morden Topology*, McGraw-Hill

MT 404 Complex Analysis II (3 credits)

(Prerequisites: MT 306, MT 307)

Homotopy of paths and Cauchy's theorem, Winding numbers and Cauchy's integral formulae, Power series and uniform convergence, Miscellaneous contour integrals, Maximum modulus principle, Schwarz's lemma, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem, Argument principle, Rouche's theorem, Open mapping theorem, Reflection principle, Normal families, Riemann mapping theorem.

Recommended Texts:

1. L. V. Ahlfors (1979), *Complex Analysis*, McGraw-Hill
2. J. B. Conway (1980), *Functions of One Complex Variable*, Narosa Publishing House

MT 405 Functional Analysis (3 credits)

(Prerequisites: MT 301, MT 306, MT 402)

Normed Linear Spaces , Banach Spaces, Riesz-Fischer Theorem, Linear maps and functionals or normal linear spaces, Dual Spaces; Geometry of Banach Spaces , Hanch Banach Theorems (Separation Form, Extension Form); Uniform Boundedness Principle, Open Mapping Theorem, Banach's Isomophism Theorem, Closed Graph Theorem; Second Dual Space, Projections and direct sums in Banach Spaces , Schauder Basis, Hilbert Spaces; Banach Algebras, Topoligical Vector Spaces.

Recommended Text:

E. Kreyszig (1978), *Introductory Functional Analysis With Applications*, John Wiley

MT 406 Fluid Mechanics II (3 credits)

(Prerequisite: MT 310)

Perfect Fluid Theory

Two-dimensional flow:Complex potential, Blasius Theorem, Conformal Transformation; Joukowski and Schwartz Christoffel. Discontinuous Motion, Vortex Motion.

Three-dimensional flow: Stokes' stream function in axi-symmetric flows, Image systems in 3-D.

Viscous Flow

Navier-Stokes equation of motion; its exact solutions, Steady slow motion past a fixed sphere, Reynold's Number, Prandtl's Boundary Layer.

Recommended Texts:

1. L.M. Mline-Thomson (1968), *Theoretical Hydrodynamics*, McMillan
2. D.H. Wilson (1959), *Hydrodynamics*, Edward Arnold
3. F. Chorlton (1990), *Fluid Dynamics*, Oxford University Press

MT 407 Optimization Theory (3 credits)

(Prerequisite: MT 311)

Advanced Linear Programming: Dantzig-Wolf decomposition algorithm, Goal programming.

Integer Programming: Cutting plane algorithms, Branch and bound algorithms.

Non-Linear Programming: Kuhn-Tucker conditions, Quadratic programming, Separable programming.

Recommended Text:

D. A. Pierre (1998), *Optimization Theory with Applications*, Dover Publications Inc

MT 408 Independent Study/Project Work (3 credits)

Supervised independent study on a project approved by an academic staff member of the department.

Candidates are required to present their work at a seminar and submit the work in a report/dissertation form.

CURRICULAR OF THE MATHEMATICS COURSES OFFERED FOR THE STATISTICS & OPERATIONS RESEARCH DEGREE PROGRAMME

100 LEVEL COURSES

Semester I	**Semester II**
ST 101 Introduction to Statistics (3 credits)*	ST 102 Introduction to Probability Theory (3 credits)*
ST 103 Statistics Applications I (1 credit) #*	ST 104 Statistics Applications II (1 credit)#*
CS 101 Introduction to Computer Science (3 credits)*	CS 102 Programming Techniques (3 credits)*
CS 103 Programming Laboratory I (1 credit)	CS 103 Programming Laboratory I (1 credit)
MT 107 Mathematics for Operations Research (3 credits)*	MT105 Real Analysis I (3 credits)*
MT 108 Operations Research I (2 credits)*	MT 109 Linear Programming (3 credits) # *

* : Compulsory courses # : Courses including practical

MT: Courses offered by the Department of Mathematics

100 LEVEL COURSES

MT 105 Real Analysis I (3 credits)

Real number system as a complete ordered field, Complex number system, Topology of the real line, Neighborhoods, Sequences and limits, Limit theorems, Monotonic Sequences, Limit Concept of a Real-Valued Function, Algebra of limits, Continuity, Monotonic functions, Differentiability, Role's Theorem, Mean-Value Theorems, L'Hospital's Rule, Riemann Integral and the basic properties. Fundamental theorem of Calculus, Improper integrals.

Recommended texts:

1. *Elementary Real Analysis,* H.G. Eggleston
2. *Analysis,* S.R. Lay

MT 107 Mathematics for Operations Research (3 credits)

Vector methods: Introduction to vectors, Linear combinations, Linear dependence and independence, Bases and dimension, Scalar product, Vector product

Differential equations: First order ordinary differential equations, Exact equations, Higher order linear ordinary differential equations with constant coefficients

Linear Algebra: Preliminaries, Determinants, Simultaneous linear equations, Eiganvalues and eiganvectors, Matrix calculations, Special matrices, Range and null space, Decomposition of matrices, Quadratic forms. Differentiation of scalar functions of matrices.

Recommended Texts:

1. *Elementary Vector Analysis,* C.E. Weatherburn,(1982)
2. *A First Course in Differencial Equations,* D.G. Zill, (1998)
3. *Linear Algebra,* K. Hoffman and R. Kunze, (1999)

MT 108 Operations Research I (2 credits)

Introduction to Operations Research, Operations Research methods: Probabilistic and Deterministic.

Recommended Text:

Operations Research, Kanti Swarup.(1987)

MT 109 Linear Programming (3 credits)

(Prerequisites: MT 107, MT 108)

Introduction, Convex sets and functions, The Simplex method, Big-M method, Revised simplex method, Dual simplex method, Sensitivity analysis, Introduction to LINGO.

Some practical assignments will be given for this course.

Recommended Texts:

1. *Linear and Nonlinear Programming*, David G. Luenberger,(1997)
2. *Operations Research*, Kanti Swarup.(1987)

200 LEVEL COURSE

Semester I	**Semester II**
ST 201 Probability Theory (3 credits)*	ST 203 Theory of Statistics (3 credits) #*
ST 205 Statistical Simulation (2 credits) #*	ST 204 Sampling Techniques (2 credits) #*
CS 207 Statistical Information Processing (3 credits)*	ST 206 Introduction to Data Mining (2 credits)
CS 208 Programming in Statistical Information Processing (1 credit)	CS 208 Programming in Statistical Information Processing (1 credit)
MT 202 Real Analysis II (3 credits)	MT211 Integer Programming (3 credits) #*
MT 204 Mathematical Methods (3 credits)	MT 212 Operations Research II (2 credits)*
MT 209 Graph Theory (2 credits)	
MT 210 Advanced Linear Programming (3 credits) # *	

* : Compulsory courses # : Courses including practical

MT: Courses offered by the Department of Mathematics

MT 202 Real Analysis II (3 credits)

(Prerequisite: MT 105)

Cauchy sequences, Convergence tests, Absolute and conditional convergence, Power series, Integration and differentiation of power series, Taylor series, Uniform continuity, Upper and lower Riemann integrals, Characterization of Riemann integrable functions, Functions of several variables, Limits and continuity, Partial derivatives, Differentials, Chain rule, Extrema of functions of several variables, Lagrange Multipliers.

Recommended Texts:

1. S. R. Lay (1986), *Analysis An Introduction to Proof*, Prentice-Hall
2. T. M. Apostol (1974), *Mathematical Analysis*, Addison-Wesley

MT 204 Mathematical Methods (3 credits)

(Prerequisite: MT 101)

Differentiation of Vectors: Scalar and vector point functions and their partial derivatives with respect to coordinate variables, Gradient of a scalar point function; Directional derivative, Divergence and curl of a vector point function**. Integration of Vectors:** Line integrals and their evaluation using parametric representation, Surface integrals, Green's theorem in the plane Stokes theorem, Circulation and flux of a vector point function, Volume integrals, Divergence theorem, Irrotational and Solenoidal vector fields, Orthogonal Curvilinear Coordinates, Grad, Div, Curl in OCC, Cylindrical polar and spherical coordinate systems, Use of these coordinate systems in evaluation of surface and volume integrals. **Special Solution of Laplaces Equation:** Solutions in two-dimensions, Axi-symmetric solutions. **Integral Transforms:**

Laplace transforms; Elementary Properties, Inverse Laplace transform and its properties, Convolution theorem and its use in evaluation of integrals, Uses of Special functions connected with Laplace transform, Evaluation of integrals using LT, Applications in ODE and integro-differential equations, Applications in PDE, Fourier Transforms; Infinite-Fourier sine/cosine transforms and their inverse formulae, Finite-Fourier sine/cosine transforms, Derivation of inverse formulae, Use of Fourier series, Boundary value problems-Use of Fourier transforms.

Recommended Texts:

1. M.R. Spiegel (1968), *Vector Analysis*, McGraw-Hill
2. M.D. Raisinghania (1997), *Vector Analysis*, S. Chand & Comp. Ltd.
3. M.D. Raisinghania (1995), *Integral Transforms*, S. Chand & Comp. Ltd.

MT 209 Graph Theory (2 credits)

Isomorphism of Graphs, Paths, Circuits, Eulerian graphs, Hamiltonian graphs, Shortest path problem, Chinese postman problem, Directed graphs, Graph Colouring, Four colour problem, Proof of five colour theorem, Planar graphs, **Trees and Searching:** Properties of trees, Travelling salesman problem, Tree Analysis of sorting algorithms, Hall's Theorem, Transversal theory, Applications to game theory.

Recommended Texts:

1. F. Harary (1988), *Graph Theory*, Narosa Publishing House
2. R. J. Wilson (1996), *Introduction to Graph Theory*, Addison-Wesley Longman

MT 210 Advanced Linear Programming (3 credits)

(Prerequisite: MT 109)

Transportation problem, Assignment problem, Goal programming, Dantzig-Wolf Decomposition algorithm, Interior point algorithms, Bounded variable Simplex algorithm.

Some practical assignments will be given for this course.

Recommended Text:

Linear programming and Network Flows, Mokhtar S. Bazaraa, Operations Research, Kanti Swarup, (1997)

MT 211 Integer Programming (3 credits)

(Prerequisite: MT 210)

Introduction to Integer Programming, Modeling and applications, Dual of Primal Cutting Plane algorithms, Branch and Bound Enumerations, Search Enumerations, Partitioning in Mixed Integer Programming, Group Theory in Integer programming.

Some practical assignments will be given for this course.

Recommended Text:

Integer programming, Applications and Computations, Hamdy A. Taha., (1998)

MT 212 Operations Research II (2 credits)

(Prerequisite: MT 109)

Theory of games, Queuing theory, Inventory management.

Recommended Text:

Operations Research, Kanti Swarup., (1987)

300 LEVEL COURSES

Semester I	**Semester II**
ST 301 Regression Analysis (3 credits) #*	ST 303 Design and Analysis of Experiments (3 credits)#*
ST 302 Statistical Quality Control (2 credits) #*	ST 304 Non Parametrics & Categorical Data Analysis (2 credits) #*
ST 305 Multivariate Methods I (2 credits) #*	ST 307 Time Series Analysis (2 credits) #
ST 308 Bayesian Statistics I (2 credits)	ST 325 /MT325 Seminar (1 credit) #*
ST 306 Data Analysis & Preparation of Reports (1 credit) #*	
CS 302 Design and Analysis of Algorithms credit)#	MT 304 Partial Differential Equations (2 credits)
MT 313 Convex Analysis (2 credits)	MT 315 Operations Research III (2 credits)*
MT 314 Network Optimization Theory (3 credits) *	MT 316 Non-Linear Programming (3 credits) *

* : Compulsory courses # : Courses including practical

MT: Courses offered by the Department of Mathematics

MT 304 Partial Differential Equations (2 credits)

(Prerequisite: MT 103)

First order partial differential equations: Linear equations, Non-linear equations, Characteristics.

Second order partial differential equations: Equations with constant coefficients, Equations with variable coefficients, Laplace equation, Wave equation, Diffusion equation, Boundary value problems,

Use of Fourier series.

Numerical methods of solving partial differential equations.

Recommended Texts:

1. R. V. Churchill & J.W. Brown (1987), *Fourier Series and Boundary Value Problems*, McGraw-Hill
2. E.T. Copson (1975) *Partial Differential Equations*, Cambridge University Press

MT 313 Convex Analysis (2 credits)

(Prerequisite: MT 202)

Convex sets, Convex functions, Continuity and Differentiability of convex functions, Minimum and maximum of a Convex function over a Convex set, Lagrange multipliers, Minimax theorems and duality, Saddle-functions

Recommended Text:

Convex Analysis, R. Tyrell Rockafellar.(1987)

MT 314 Network Optimization Theory (3 credits)

(Prerequisite: MT 210)

Introduction, Paths, Trees and Cycles, Shortest Paths, Maximum flows, The Traveling Salesman problem.

Recommended Text:

Linear programming and Network Flows, Mokhtar S. Bazaraa. (1997)

MT 315 Operations Research III (2 credits)

(Prerequisites: MT 109, MT 314)

Simulation, Network Scheduling, Information Theory.

Recommended Text:

Operations Research, Kanti Swarup. (1982)

MT 316 Non-Linear Programming (3 credits)

(Prerequisite: MT 210)

Quadratic programming, Dynamic programming, Geometric programming, Probabilistic programming, Fractional programming, Gradient Search methods.

Recommended Text:

Linear and Nonlinear Programming, David G. Luenberger, Operations Research, Kanti Swarup, (1997).

MT 325 Seminar (1 credit)

(Prerequisies: ST 306, ST 307)

A student is expected to carry out an extensive literature survey on a topic assigned to him/her by a senior staff member. At the completion of the course the student is expected to write a report of not less than ten pages, and make a presentation.

400 LEVEL COURSES

Semester I	Semester II
ST 401 Actuarial Statistics (2 credits)	ST 404 Stochastic Processes (2 credits)
ST 402 Statistical Data Mining (3 credits) #*	ST 405 Multivariate Methods II (2 credits) #*
ST 403 Statistics for Bioinformatics (2 credits)	ST 406 Bayesian Statistics II (2 credits)
CS 403 Artificial Neural Networks (3 credits)	CS 405 Fuzzy Logic and Modeling (3 credits) #
MT 411 Optimization Modeling (2 credits)*	MT 412 Financial Mathematics (3 credits) *
MT 409 Selected Topics in Applied Operations Research (2 credits)	MT 410 Optimization for Engineering Design *(3 credits)
ST 425/MT 425 Project work /Industrial training (3 credits) #*	

* : Compulsory courses # : Courses including practical

MT: Courses offered by the Department of Mathematics

MT 409 Selected Topics in Applied Operations Research (2 credits)

(Prerequisites: MT 315, MT 316)

Topics will be selected from significant areas in Operations Research. Topics may vary each year.

MT 410 Optimization of Engineering Design (3 credits)

(Prerequisites: MT 315, MT 316)

Introduction, Single-variable optimization algorithms, Multivariable optimization algorithms, Constrained optimization algorithms, Specialized algorithms, Nontraditional optimization algorithms.

Recommended Text:

Optimization for Engineering Design (*Algorithms and Examples*), Kalyanmoy Deb, (1999)

MT 411 Optimization Modeling (2 credits)

(Prerequisites: MT 315, MT 316)

Optimization models in Linear programming, Nonlinear programming and Integer programming. Students are expected to develop reasonable modeling skills allowing them to cast appropriate real world problems as optimization problems and solve them with available software.

Recommended Text:

Spreadsheet Modelling & Decision Analysis, *A practical Introduction to Management Science*, Cliff T. Ragsdale

MT 412 Financial Mathematics (3 credits)

An introduction to options and markets, Interest and present value analysis, Geometric Brownian Motion, Pricing contract via arbitrage, Arbitrage theorem, Black-Scholes option pricing formula, The binomial option pricing model, More results on options, Valuing by expected utility, Exotic options.

Recommended Texts:

1. *An Elementary Introduction to Mathematical Finance. Options and other Topics,* S.M. Ross, (1987)
2. *The Mathematics of Financial Derivatives, A student Introduction,* P. Wilmott, S. Howisan, J. Dewynne,(2000)
3. *Options, Futures and other Derivatives,* J. Hull, Prentice Hall,(1998)

MT 425 Project Work/Industrial Training (3 credits)

Students are expected to carry out an independent research project on a topic assigned to him/her under the supervision of a senior staff member or spent 6 weeks in industry working in a relevant project. At the completion of the project students are expected to write a report and make a presentation.

CURRICULAR OF THE MATHEMATICS COURSES OFFERED FOR THE COMPUTATION & MANAGEMENT DEGREE PROGRAMME

100 LEVEL COURSES

Semester I	**Semester II**
CS 101 Introduction to Computer Science (3 credits) ECN 101 Introductory Microeconomics I (3 credits) MGT 101 Principles of Management (3 credits)	CS 102 Programming Techniques (3 credits) ECN 102 Introductory Macroeconomics II (3 credits)
CS 103 Programming Laboratory (2 credits – 1 credit per semester)	
Arts and Biological Science Stream: MGT 103 Introduction to Business Accounting (3 credits) MT 121 Mathematics for Arts/Commerce I (3 credits); **Commerce Stream:** MT 121 Mathematics for Arts/Commerce I (3 credits) and PSC 101 Introduction to State & Government (3 credits) or SE 101 Science and Society (3 credits) **Physical Science Stream**: MGT 103 Introduction to Business Accounting (3 credits) and PSC 101 Introduction to State & Government (3 credits) or SE 101 Science and Society (3 credits)	**Arts, Biological Science and Commerce Stream**: MT 122 Mathematics for Arts/Commerce students II (3 credits) **Physical Science Stream**: FNA102 Introduction to Art History and Aesthetics (3 credits)

MT: Courses offered by the Department of Mathematics

MT 120 Foundation Course in Mathematics (2 credits)

Different types of numbers, Variables, Parameters, Computer arithmetic, Linear and Quadratic equations, Functions and graphs, Logarithmic and Exponential functions, Trigonometric functions, Cartesian coordinate system, Coordinate geometry of straight line and circle, Evaluation of limits,

Derivatives: Derivatives of standard functions , Algebra of derivatives, Chain rule, Derivatives of functions in parametric forms, Anti-derivatives and Techniques of integration. First order Difference Equations and Discrete models.

MT 121 Mathematics for Arts/Commerce I (3 credits)

Algebraic inequalities, Basic set theory, Permutations and Combinations, Mathematical Induction, Binomial Theorem, Vectors, Systems of Linear equations, Continuity and Differentiability, Applications of derivative, Curve sketching, Applications of definite integral, Convergence of sequences and Summation of series.

MT 122 Mathematics for Arts/Commerce II (3 credits)

Probability: Tree diagrams, Sample space and events, Axioms of probability and basic laws, Probability in discrete sample space, Conditional probability and multiplicative law, Baye's theorem,

Independent events.

Descriptive Statistics: Graphical representation of statistical data, Mean, Median, Mode. Quartiles, Deciles, Inter quartile range, Standard deviation. Shapes of distributions

Linear and non-linear market models, Marginal functions in economics.

200 LEVEL COURSES

Semester I	**Semester II**
CS 201 Data structures (2 credits) CS 202 Data Structures Practical (1 credits) ECN 201 Intermediate Microeconomics I (3 credits) MGT 206 Human Resource Management (3 credits) MGT 211 Business Accounting for Decision Making (3 credits) MT 221 Mathematics for Management Studies I (3 credits)	CS 203 Database Management Systems (2 credits) CS 204 Programming using DMS Packages (1 credit) ECN 205 Intermediate Macroeconomics II (3 credits) MGT 207 Operations Management (3 credits) MGT 208 Business Statistics (3 credits) MGT 209 Project Management (3 credits)

MT: Courses offered by the Department of Mathematics

MT 221 Mathematics for Management Studies I (3 credits)

Algebra and Advanced Calculus: Matrices, Determinants, Eigenvalues and Eigenvectors, Quadratic forms, Functions of several variables, Partial derivatives, Vector-calculus, Multi-variable Optimization.

Statistical Quality Control: SQC tools, Shewhart charts (Attributes and variables), Regression analysis.

Network Analysis: Graph theory, Minimum cost problem, Maximum flow problem, Critical path analysis.

Queuing Theory: Characteristics of queues, Simple queues, Queuing costs, Multiple-server queues.

300 LEVEL COURSES

Semester I	**Semester II**
CS 301 Software Design and Development (3 credits) CS 302 Design and Analysis of Algorithms (1 credit) CS 303 Operating Systems Concept (3 credits) MGT 301 Marketing (3 credits) MGT 305 Cost and Management Accounting (3 credits) MT 321 Mathematics for Management Studies II (3 credits)	CS 305 Computer Networks (2 credits) CS 309 Object Oriented Analysis and Design (3 credits) ECN 304 Econometrics I (3 credits) MGT 304 Entrepreunership (3 credits) MGT 307 Business Law (3 credits)

MT: Courses offered by the Department of Mathematics

MT 321 Mathematics for Management Studies II (3 credits)

Game theory: Pure strategies, Mixed strategies, Zero-sum games, Dominance, $2\times n$ game, Graphical solutions, $m\times n$ game, Games with optimal pure strategies, Games with optimal mixed strategies.

Linear Programming: LP in two dimensional space, Graphical solution methods, General LP models, Primal simplex method, Big-M method, Two-phase simplex method, revised simplex method, Applications of duality, Dual simplex method.

Transportation model, Assignment model.

Quadratic Programming: QP algorithms, Applications of QP.

400 LEVEL COURSES

Semester I	**Semester II**
MGT 424 Strategic Management (3 credits) MGT 438 Management Information Systems (3 credits)	MGT 421 Project involving Internship (6 credits) MGT 423 Seminar (1 credit)
3 more credits from CS 4xx and 2 from MGT 4xx	9 credits chosen from CS4xx or MGT 4xx of which at least 3 must be from CS4xx and 3 from MGT4xx

No Mathematics courses are offered in the 400 Level.