## APPENDIX A

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

### 100 LEVEL COURSES

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>No. of credits</th>
<th>Prerequisites</th>
<th>Compulsory for General Degree</th>
<th>Compulsory for Special Degree</th>
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<tbody>
<tr>
<td>MT101</td>
<td>Vector Methods</td>
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<tr>
<td>MT102</td>
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<td>MT106</td>
<td>Classical Mechanics I</td>
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<td>MT 101</td>
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<td><strong>16</strong></td>
<td></td>
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</tbody>
</table>

* 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 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

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**MT 102 Introduction to Probability Theory (3 credits)**


Recommended Texts:
2. *Basic Course in Statistics*, G.M.Clarke and D. Cooke

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**MT 103 Differential Equations (2 credits)**

**First 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
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 the 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

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 frame, Use of polar 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 rate.
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 about 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

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

### 200 LEVEL COURSES

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>No. of Credits</th>
<th>Prerequisites</th>
<th>Compulsory for General Degree</th>
<th>Compulsory for Special Degree</th>
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<tbody>
<tr>
<td>MT 201</td>
<td>Groups, Rings and Fields</td>
<td>3</td>
<td>MT 104</td>
<td>✓</td>
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<tr>
<td>MT 202</td>
<td>Real Analysis II</td>
<td>3</td>
<td>MT 105</td>
<td>✓</td>
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<tr>
<td>MT 203</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
<td>MT 103</td>
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<tr>
<td>MT 204</td>
<td>Mathematical Methods</td>
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<td>MT 101</td>
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<tr>
<td>MT 205</td>
<td>Classical Mechanics II</td>
<td>2</td>
<td>MT 106</td>
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<tr>
<td>MT 206</td>
<td>Mathematical Modelling</td>
<td>3</td>
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<tr>
<td>MT 207</td>
<td>Numerical Analysis I</td>
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<tr>
<td>MT 209</td>
<td>Graph Theory</td>
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</table>

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, homomorphisms, 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:**
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:**
MT 203 Ordinary Differential Equations (3 credits)
(Prerequisite: MT 103)
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 Laplace’s 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:
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


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)
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:

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:

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:
### 300 LEVEL COURSES

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>No. of Credits</th>
<th>Prerequisites</th>
<th>Compulsory for General Degree</th>
<th>Compulsory for Special Degree</th>
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<tbody>
<tr>
<td>MT 301</td>
<td>Linear Algebra</td>
<td>3</td>
<td>MT 201</td>
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<td>MT 302</td>
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<td>MT 202</td>
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<tr>
<td>MT 303</td>
<td>Differential Geometry</td>
<td>2</td>
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<td>MT 304</td>
<td>Partial Differential Equations</td>
<td>2</td>
<td>MT 103</td>
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<td>MT 305</td>
<td>Group Theory</td>
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<td>MT 201</td>
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<tr>
<td>MT 306</td>
<td>Topology I</td>
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<td>MT 105</td>
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<td>MT 307</td>
<td>Complex Analysis I</td>
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<td>MT 310</td>
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<td>MT 311</td>
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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 \( \mathbb{R}^3, \mathbb{R}^n, \mathbb{C}^n \). 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-Hamilton 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:

**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:

**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:
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.


**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:


**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 $\mathbb{R}^n$, 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:

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:

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:

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 φ(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:
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:


**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.


Recommended Texts:


### 400 LEVEL COURSES

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>No. of Credits</th>
<th>Prerequisites</th>
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<tbody>
<tr>
<td>MT 401</td>
<td>Galois Theory</td>
<td>3</td>
<td>MT 301,MT 305</td>
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<tr>
<td>MT 402</td>
<td>Measure Theory</td>
<td>3</td>
<td>MT 302</td>
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<tr>
<td>MT 403</td>
<td>Topology II</td>
<td>3</td>
<td>MT 306</td>
<td>✓</td>
</tr>
<tr>
<td>MT 404</td>
<td>Complex Analysis II</td>
<td>3</td>
<td>MT 306,MT 307</td>
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<tr>
<td>MT 405</td>
<td>Functional Analysis</td>
<td>3</td>
<td>MT 301,MT 306,MT 402</td>
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<td>MT 406</td>
<td>Fluid Mechanics II</td>
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<td>MT 310</td>
<td>✓</td>
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<td>MT 407</td>
<td>Optimization Theory</td>
<td>3</td>
<td>MT 311</td>
<td>✓</td>
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<tr>
<td>MT 408</td>
<td>Independent Study/Project Work</td>
<td>3</td>
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**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:
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, \( \sigma \)-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:
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; \( G_\delta \) - 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:


**MT 404 Complex Analysis II (3 credits)**
(Prerequisites: MT 306, MT 307)


Recommended Texts:


**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 Isomorphism Theorem, Closed Graph Theorem; Second Dual Space, Projections and direct sums in Banach Spaces, Schauder Basis, Hilbert Spaces; Banach Algebras, Topological Vector Spaces.

Recommended Text:


**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
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:


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.
100 LEVEL COURSES

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

* : 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

Recommended Texts:

**MT 108 Operations Research I (2 credits)**

Recommended Text:

**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:

### 200 LEVEL COURSE

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Semester II</th>
</tr>
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</table>
| 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)            | MT 211 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:


**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 Laplace's 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:


**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:


**MT 210 Advanced Linear Programming (3 credits)**

(Prerequisite: MT 109)

Transportation problem, Assignment problem, Goal programming, Dantzig-Wolfe Decomposition algorithm, Interior point algorithms, Bounded variable Simplex algorithm. Some practical assignments will be given for this course.

Recommended Text:


**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:

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

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

*: 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:

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)
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:

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:

MT 325 Seminar (1 credit)
(Prerequisites: 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

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

* : 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:


**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:


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:


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

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<tr>
<td>CS 101 Introduction to Computer Science (3 credits)</td>
<td>CS 102 Programming Techniques (3 credits)</td>
</tr>
<tr>
<td>ECN 101 Introductory Microeconomics I (3 credits)</td>
<td>ECN 102 Introductory Macroeconomics II (3 credits)</td>
</tr>
<tr>
<td>MGT 101 Principles of Management (3 credits)</td>
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<tr>
<td>CS 103 Programming Laboratory (2 credits – 1 credit per semester)</td>
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</tr>
</tbody>
</table>

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,
**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

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

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

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

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

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<thead>
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<tbody>
<tr>
<td>MGT 424 Strategic Management (3 credits)</td>
<td>MGT 421 Project involving Internship (6 credits)</td>
</tr>
<tr>
<td>MGT 438 Management Information Systems (3 credits)</td>
<td>MGT 423 Seminar (1 credit)</td>
</tr>
<tr>
<td>3 more credits from CS 4xx and 2 from MGT 4xx</td>
<td>9 credits chosen from CS4xx or MGT 4xx of which at least 3 must be from CS4xx and 3 from MGT4xx</td>
</tr>
</tbody>
</table>

No Mathematics courses are offered in the 400 Level.