
# Master of Science in Mathematics

(Two Year Full Time Master Degree Program)

SYLLABUS

(M. Sc.)

## School of Mathematics

## Shri Mata Vaishno Devi University Katra

**(May 2018)**

| | **ABBREVIATIONS / CODES / NOMENCLATURE** |
|---|---|
| | |
| | |
| **Course Code Convention** | |
| SCT – LSAY<br><br>Example<br>MTL 9101<br>MTP 9101<br>MTD 9102<br>MTE 9110 | Course Code for various Courses / Subjects<br>SC: School Code<br>T: Course Type Code (Lecture/Practical/Project etc.)<br>L: Course Level (1, 2, 3, 4 & 5 for First, Second years …)<br>SA: Study Area / Sub Area<br>Y: Course Number |
| MT | School Code (SoM) |
| L | Lecture |
| P | Practical |
| E | Elective |
| D | Project based/Dissertation |
| N | Non Credit |
| V | Special Lecture Topic |
| **Teaching Scheme Convention** | |
| L | Lecture |
| T | Tutorial |
| P | Practical |
| C | Course Credit |
| **Evaluation Scheme Convention** | |
| Minor | (Mid Term Exams / Tests) I & II |
| Major | End Semester Examination (ESE) |
| CBCS | Choice Based Credit System |

# VISION

Grow as Center of Excellence to Nurture Talented Human Resource by Providing High Quality Education in Mathematical Sciences to address Problems in Science, Engineering and Management Encompassing Human & Social Values.

# MISSION

School of Mathematics strives to provide quality education that builds a rigorous and comprehensive foundation of Mathematical Education and Research in Compliance with Established International Standards.

School of Mathematics
Program Structure of M.Sc. (Mathematics) Two Year Full Time Degree
(Entry Batch 2018 Onwards)

1st Semester

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MTL6051 | Abstract Algebra | 4 | 0 | 0 | 4 |
| 2 | MTL6052 | Real Analysis | 4 | 0 | 0 | 4 |
| 3 | MTL6061 | Discrete Mathematics | 4 | 0 | 0 | 4 |
| 4 | MTL6062 | Computer Programming and MATLAB | 4 | 0 | 2 | 5 |
| 5 | MTL 6063 | Advanced Calculus and Special Functions | 4 | 0 | 0 | 4 |
| Total Credits | | | | | | 21 |

2nd Semester

| Sl. No | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MTL 6053 | Linear Algebra | 4 | 0 | 0 | 4 |
| 2 | MTL 6054 | Complex Analysis | 4 | 0 | 0 | 4 |
| 3 | MTL 6065 | Differential and Integral Equations | 4 | 0 | 0 | 4 |
| 4 | MTL 6071 | Probability & Statistics | 4 | 0 | 0 | 4 |
| 5 | MTL 6066 | Numerical Methods | 3 | 1 | 2 | 5 |
| Total Credits | | | | | | 21 |

3rd Semester

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MTL 7081 | Optimization Techniques | 3 | 1 | 0 | 4 |
| 2 | MTL 7051 | Topology | 4 | 0 | 0 | 4 |
| 3 | MTL 7061 | Calculus of Variations and Mechanics | 4 | 0 | 0 | 4 |
| 4 | MTE 70XX | Elective -I | 4 | 1 | 0 | 5 |
| 5 | | Open Elective-I | 3 | 0 | 0 | 3 |
| 6 | | Open Elective-II | 3 | 0 | 0 | 3 |
| Total Credits | | | | | | 23 |

4th Semester

| Sl. No | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | MTL 7062 | Differential Geometry | 4 | 0 | 0 | 4 |
| 2 | MTL 7063 | Modern Applied Algebra | 4 | 0 | 0 | 4 |
| 3 | MTL 7052 | Functional Analysis | 4 | 0 | 0 | 4 |
| 4 | MTD 7091 | Minor Project / Survey Article / Book Review | | | | 8 |
| 5 | MTE 70XX | Elective –II | 4 | 1 | 0 | 5 |
| | | | | | | |
| Total Credits | | | | | | 25 |

Total Credits to be earned in order to become eligible for award of M.Sc. (Mathematics) (Two Year Full Time) Degree: **90**

| LIST OF ELECTIVES | | | | | | |
|---|---|---|---|---|---|---|
| S. No. | Course Code | Course Title | L | T | P | C |
| 1 | MTE 7012 | Partial Differential Equations | 4 | 1 | 0 | 5 |
| 2 | MTE 7013 | Measure Theory | 4 | 1 | 0 | 5 |
| 3 | MTE 7014 | Non Linear Analysis | 4 | 1 | 0 | 5 |
| 4 | MTE 7015 | Advanced Topics in Algebra | 4 | 1 | 0 | 5 |
| 5 | MTE 7011 | Algebra-IV | 4 | 1 | 0 | 5 |
| 6 | MTE 7021 | Information Theory | 4 | 1 | 0 | 5 |
| 7 | MTE 7022 | Digital Signal Processing | 4 | 0 | 2 | 5 |
| 8 | MTE 7023 | Real Time Systems | 4 | 0 | 2 | 5 |
| 9 | MTE 7024 | Parallel Processing | 4 | 0 | 2 | 5 |
| 10 | MTE 7025 | Distributed Computing | 4 | 0 | 2 | 5 |
| 11 | MTE 7026 | Coding Theory | 4 | 1 | 0 | 5 |
| 12 | MTE 7027 | Graph Theory | 4 | 1 | 0 | 5 |
| 13 | MTE 7028 | Galois Theory | 4 | 1 | 0 | 5 |
| 14 | MTE 7029 | Biomathematics | 4 | 0 | 2 | 5 |
| 15 | MTE 7031 | Time Series and Stochastic Process | 4 | 1 | 0 | 5 |
| 16 | MTE 7032 | Decision Theory | 4 | 1 | 0 | 5 |
| 17 | MTE 7033 | Econometrics | 4 | 1 | 0 | 5 |
| 18 | MTE 7041 | Queuing Theory | 4 | 1 | 0 | 5 |
| 19 | MTE 7042 | Theory of Reliability | 4 | 1 | 0 | 5 |
| 20 | MTE 7043 | Inventory Theory | 4 | 1 | 0 | 5 |
| 21 | MTE 7044 | Modeling and Simulation | 4 | 0 | 2 | 5 |
| 22 | MTE7045 | Theory of Games | 4 | 1 | 0 | 5 |
| 23 | MTE 7231 | Financial Mathematics | 4 | 1 | 0 | 5 |

| LIST OF OPEN ELECTIVES | | | | | | |
|---|---|---|---|---|---|---|
| S. No. | Course Code | Course Title | L | T | P | C |
| 1 | MTE 7141 | Complex dynamics | 3 | 0 | 0 | 3 |
| 2 | MTE 7151 | Techniques in numerical analysis | 3 | 0 | 0 | 3 |
| 3 | MTE 7152 | Tensor Calculus | 3 | 0 | 0 | 3 |
| 4 | MTE 7153 | Mathematical Modeling | 3 | 0 | 0 | 3 |
| 5 | MTE 7161 | Statistical techniques | 3 | 0 | 0 | 3 |
| 6 | MTE 7171 | Introductory Operation research | 3 | 0 | 0 | 3 |

## PEO's and PO's of School of Mathematics, Shri Mata Vaishno Devi University.

### Program Education Objectives (PEOs)

The Graduates will be able to:

**PEO1.** acquire a strong and diversified background in mathematical sciences which includes courses from Mathematics, Computer Science, Management, Operations Research, Statistics and Professional Ethics.

**PEO2.** choose a successful career in the diversified sectors such as teaching, research, banking, planning and higher education.

**PEO3.** exhibit professionalism, ethics, communication skills, team work in their profession and adapt to current scenario by engaging in lifelong learning for the service of the society.

### Program Outcomes (POs)

On successful completion, graduates will be able to:

**PO1**. solve problems through analytical thinking.

**PO2**. apply knowledge of mathematics to solve various real life problems.

**PO3**. formulate mathematical models to interpret and analyze data for interdisciplinary research and development.

**PO4**. solve various mathematical problems by using relevant mathematical and statistical software.

**PO5**. communicate effectively both orally and in writing.

**PO6**. exhibit strong ethical and professional responsibility.

| **MTL 6051** | | | **Abstract Algebra** | | | | Pre Requisites | | **None** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 4 | 1.5 Hour | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Learn the basic terminology and results concerning abstract algebra.
2. Understand, construct, and write proofs.
3. Build foundation to model the problems in coding, cryptography and switching circuits.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Review of basic Group Theory and Ring Theory, Symmetric and alternating groups, Simplicity of Alternating group An for n>5, Commutators, Conjugates, Centralizer, series of subgroups, Jordan Holder theorem, solvable groups..

**Unit-II:** (16 Contact Periods)

Integral Domains, Fields, Ideals, Residue class Rings, Theorems on Homomorphisms, Division Rings, Prime and Maximal Ideals, Polynomial Rings, Divisibility, Eulclidean and Principal Ideal Domains, Unique Factorization Domains, Gauss Theorem..

**Unit-III:** (16 Contact Periods)

Prime fields, Field Extensions, Algebraic element, Algebraic Extensions, Separable Extensions, Perfect Fields and Splitting Field.

## SUGGESTED BOOKS

1. I.N. Herstein,Topics in Algebra, Wiley, 2004.
2.N. Jacobson, Basic Algebra-I, 2 ed, Courier Corporation, 2012.
3. J.B. Fraleight, A First Course in Abstract Algebra, 7th ed., Pearson, 2002.
4. Bhattacharya, Jain &Nagpal, Abstract Algebra, Cambridge University Press, 2 ed, 1994.
5. Rajendra Kumar Sharma, SudeshKumari Shah and Asha Gauri Shankar, Alegebra I: A Basic Course in Algebra, Pearson Education, 2011

| **MTL 6052** | | | **Real Analysis** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 0 | 1.5Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
2. Demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration.
3. Understand the concept of Bolzano-Weierstrass theorem, Rolle's theorem, extreme value theorem and the Mean Value theorem.
4. Evaluate Riemann integrable and Riemann sums.
5. Prove some results on Riemann sums and Riemann integrals and their relations.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Metric spaces: Basic notions, Examples of Metric spaces, Continuity, Completeness, Compactness, Euclidean spaces, Cantor's Theorem, Bolzano Weierstrass theorem, Lindeloff covering theorem, Heine Borel theorem, Pointwise and Uniform convergences, Baire Category theorem.

**Unit-II:** (16 Contact Periods)

The Riemann-Stieltjes integral: partitions, definition of Riemann-Stieltjes integral, refinement, existence of the integral, properties of the integral, fundamental theorems of integral calculus, mean value theorems, integration by parts. Functions of bounded variation, total variation, bounded variation functions as difference of monotone functions, continuous functions of bounded variations.

**Unit-III:** (16 Contact Periods)

$\sigma$-algebra of sets, limits of sequences of sets, Borel$\sigma$-algebra, G and F-sets, Measurable space and measure space, Outer measures, regular outer measures, metric outer measures, construction of outer measures. Construction & properties of Lebesgue measure, Integration of simple functions, Lebesgue integral of non-negative and measurable functions, Properties of Lebesgue integrals.

## SUGGESTED BOOKS

1. Rudin Walter: Real and Complex analysis, McGraw-Hill, 1976.
2. T. M. Apostol: Mathematical analysis, 2nd Edition, Addison Wesley, 1974.
3. J.Yeh Lectures on Real Analysis, World Scientific 2000.
4. M.E. Munroe, Measure and Integration, 2nd edition Addison Wesley, 1971.
5. G.DeBarra, Measure theory and Integration, Wiley Eastern Ltd.,1987.
6. H.L.Royden, Real Analysis,3rd edition, Macmillan, New York, 1988.

| **MTL 6061** | **Discrete Mathematics** | Pre Requisites | **None** |
|---|---|---|---|

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 4 | 1 Hour | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand the basic principles of sets, functions and relations and their applications
2. Understand the concept of lattice and Boolean Algebra with their applications relating to circuits and Networks.
3. Understand the basic terminology of graphs and trees and their applications
4. Understand the concept of recurrence relations and generating functions and their applications in problems of combinatorics.

## COURSE CONTENT

**Unit-I:** (16 Contact Periods)

Unary and Binary operations, partial order relation, chains and anti chains, Structure theorem, Lattices, Boolean algebra, order relation in Boolean algebra, Boolean polynomials, Block diagrams for gating network, Connections with logic. Boolean subalgebra, Disjunctive Normal form, Direct products and Boolean morphisms.

**Unit-II:** (16 Contact Periods)

Basic concepts of graph theory: vertices, edges, degree, paths, circuits, cycles, complete graphs and trees. Multi-graphs, weighted graphs and directed graphs, Adjacency matrix of a graph, Connected and disconnected graphs, K-connected and K-edge connected graphs. Shortest path in weighted graphs, Eulerian path and circuits, Hamiltonian path and circuits, Planar graphs, chromatic number, edge colouring of graphs, Vizing's theorem. Trees and cut sets: Trees, spanning tree and cut set, minimum spanning tree.

**Unit-III:** (16 Contact Periods)

Pigeon hole Principle, Inclusion - Exclusion principle, Generating functions and Discrete numeric functions, manipulation of numeric functions, Asymptotic behaviour of numeric function, Recurrence relations, Linear recurrence relation with constant coefficients and their solutions, Homogeneous solution, particular solution & total solutions. Solution by the method of generating functions.

## SUGGESTED BOOKS

1. C.L. Liu, Elements of Discrete Mathematics, Mc Graw Hill International editions, 2006.

2. J.P Tremblay & R. Manohar, Discrete Mathematical Structures with applications to Computer Science, Tata Mc Graw Hill Book Co. 1988

3. N. Iyengar, Discrete Mathematics, Vikas Publishing House Pvt Ltd, 2003.

4. Richard Johnson Baugh, Discrete Mathematics, 7th ed., pearsons, 2009.

5. NarsinghDeo, Graph Theory, Prentice Hall of India, 2004.

6. K.D. Joshi, Foundations of Discrete Mathematics, Wiely Eastern Ltd., 1989

| **MTL 6062** | | | **Computer Programming and MATLAB** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 2 | 5 | 1.5 Hours | 3.0 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand basic concepts of computer and computer programming.
2. Develop the ability to design algorithmic solution to problems.
3. Convert algorithms to C programs.
4. Understand basics of MATLAB.
5. Solve mathematical problems using MATLAB.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Review of basics of computer, Further Computer programming: Control statements -sequencing, conditional and unconditional branching and looping. Single and multi-dimensional arrays. Searching (linear, binary), sorting (exchange, bubble, selection and insertion) and merging. User defined data types.

**Unit-II:** (16 Contact Periods)

Stepwise refinement. Subroutines: Functions and Procedures. Parameter passing, call by value & call by reference. Functions and procedures as parameters, recursion. Further data structures: Records (simple, hierarchical and variant), sets, files (text and binary files).

**Unit-III:** (16 Contact Periods)

Basic introduction to matlab , writing basic scripts/functions, matrix computations , data fitting techniques (interpolation and least squares) , optimization problems, solving linear systems, quadrature, initial valueproblems , computational efficiency, and visualization.

## SUGGESTED BOOKS

1. YashwantKanetkar, Programming in C, BPB Publications, New Delhi.
2. Introduction to Computer Science, ITL/ESL.
3. D.E.Knuth, Fundamental Algorithms
4. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, A Guide to MATLAB for Beginners andExperienced Users, Cambridge University Press, 1st Edition.

| **MTL 6063** | | | | **Advanced Calculus & Special Functions** | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 0 | 1.5Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand the concepts of Differentiability in several variables, the chain rule, the mean value theorem, higher order partial derivatives, Taylor's theorem, critical points, extreme value problems,Frechet derivatives.
2. Study the applications of Schwarz theorem and Young's Theorem.
3. Evaluate the Bessel's equations, Bessel's functions, Bessel's integrals and Fourier-Bessel expansion and by using these expansions solve some mathematical problems.

## COURSE CONTENT

**Unit-I:** (16 Contact Periods)

Limit of function of two variable, continuity, partial differentiation. Partial derivatives of higher order, Schwarz theorem, Young's Theorem, Homogeneous functions of three variables.

**Unit-II:** (16 Contact Periods)

Maxima and Minima, Restricted maxima and minima, Lagranges multipliers, Jacobian, Legendre polynomials $P_n(x)$, $Q_n(x)$; Rodrigues formulae, Orthogonality of Legendre Polynomials, Recurrance formulae.

**Unit-III:** (16 Contact Periods)

Bessels equations, Bessels functions, Recurrance relations, Orthogonality, generating function, integral expressions, Trigonometric expansion involving Bessel's function, Bessel's integrals, Fourier-Bessel expansion.

## SUGGESTED BOOKS

1. F. Watson, Advanced Calculus:An Introduction to Analysis, Wiley, 3 edition, 2016
2. E. Kreyszig, Advanced Engineering Mathematics , John Wiley & Sons, Inc.,9th edition, 2011.
3. W. Rudin, Mathematical Analysis , Mc Graw-Hill, Inc., 3rd edition, 1976.
4. R. Goldberg, Methods of Real Analysis, John Wiley & Sons, Inc., 2nd edition, 1976.

| **MTL 6053** | | | **Linear Algebra** | | | | Pre Requisites | | **None** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 4 | 1.5 Hour | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Prove basic results in linear algebra using appropriate proof-writing techniques such as linear independence of vectors; properties of subspaces, etc.
2. Compute linear transformations, kernel and range, and inverse linear transformations, and find matrices of general linear transformations.
3. Create orthogonal and orthonormal bases, Gram-Schmidt process and use bases and orthonormal bases to solve application problems.
4. Understand various operators and their relationships understand the concept of invariant subspaces and their connections with nilpotent canonical forms.
5. Understand the concept of companion matrix, Jordan canonical form and Jordan blocks.

## COURSE CONTENT

**Unit-I:** (16 Contact Periods)

Review of basics of linear Algebra, Linear functionals and the dual space, Dual basis, Second dual space, Annihilators, Inner product spaces, Cauchy-Schwarz inequality, orthogonality, orthonormal sets, Gram-Schmidt orthogonalization process(Section 4.3 to 4.4 of Topics in Algebra by I.N. Herstein). Minimal polynomial, Characteristic and minimum polynomials of linear operators(Section 6.1 to 6.2 of Topics in Algebra by I.N. Herstein).

**Unit-II:** (16 Contact Periods)

Hermitian, Unitary and Normal Transformations(Section 6.10 of Topics in Algebra by I.N. Herstein). Similar linear transformations, Invariant subspaces of vector spaces. Reduction of a linear transformation to triangular form. Nilpotent transformations. Index of nilpotency of a nilpotent transformation. Cyclic subspace with respect to a nilpotent transformation. Uniqueness of the invariants of a nilpotent transformation. (Sections 6.4 to 6.5 of the book. Topics in Algebra by I.N. Herstein).

**Unit-III:** (16 Contact Periods)

Primary decomposition theorem. Jordan blocks and Jordan canonical forms. rational canonical forms, Cyclic module relative to a linear transformation. Companion matrix of a polynomial f(x). Rational Canonicals form of a linear transformation and its elementary divisior. Uniqueness of the elementary divisior. Trace and transpose. (Sections 6.6 to 6.8 of the book. Topics in Algebra by I.N. Herstein).

## SUGGESTED BOOKS

1. I. N. Herstein, Topics in Algebra,Wiley Eastern Limited, 2nd edition, 1992.
2. S. Lang, Linear Algebra, Springer New York, 1997
2. Hoffman &Kunze, Linear Algebra, Prentice Hall PTR,3rd revised ed., 1999.
5. Seymour Lipschutz, Theory and Problems of Linear Algebra, McGraw-Hill, 1989.

| **MTL 6054** | | | **Complex Analysis** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 0 | 1.5Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand the concepts of the theories for functions of a complex variable. They also understand the exploration of the algebraic, geometric and topological structures of the complex number field.
2. Define continuity of a function using limits. Determine where a function is continuous/discontinuous.
3. Define differentiability of a function using limits. Determine where a function is differentiable/non-differentiable.
4. Define analyticity of a function. Determine whether a function is analytic/not analytic or entire/not entire.
5. Evaluate a contour integral with an integrand which have singularities lying inside or outside the simple closed contour.
6. Find the residues of a function at given points or singularities. Use the residue theorem to evaluate a contour integral.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Analytic (Holomorphic) functions, Cauchy-Riemann equations, Polar form of Cauchy-Rieman equations, Harmonic functions, Exponential and Trigonometric functions, conformal transformation, Bilinear transformation.

**Unit-II:** (16 Contact Periods)

Integral along a path, Cauchy's Theorem, Cauchy Integral Formula, Taylor's and Laurent's expansions, Cauchy inequalities, Liouville's Theorem' Fundamental Theorem of Algebra, Morera's Theorem, Maximum modulus and minimum modulus Theorems, Argument Principle, Rouche's Theorem, Schwarz Lemma.

**Unit-III:** (16 Contact Periods)

Singularities, Different Types of singularities, Residue at a singularity, Cauchy's Residue theorem.Residue and Contour integration, Analytic continuation, Uniqueness of analytic continuation.

## SUGGESTED BOOKS

1. John H. Mathews and Russell W. Howell, Complex analysis, Narosa Publication, 2006.
2. S. Lang, Complex Analysis Springer; 4th ed. 1999.
3. J.B. Conway, Functions of one Complex Variable, Springer; 2nd ed. 1978. Corr. 7th printing 1995 4. Ahlfors, Complex Analysis McGraw Hill Education India Private Limited; Third edition, 2013
5. J.C. Chaturvedi& S.S. Seth, Functions of a Complex Variable McGraw-Hill, 1987
6. Walter Rudin , Real and Complex Analysis, McGraw-Hill, 1976.

| **MTL 6065** | | | | **Differential and Integral Equations** | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assignment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 0 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. understand and solve problems based on simultaneous linear differential equations
2. solve the second order differential equations using various methods
3. solve various problems based on Riccati's equation, exact differential equation, and homogeneous equations
4. understand the concept of integral equations and their use in solving initial and boundary value problems

**Unit-I** (16 Contact Periods)

Simultaneous differential equations- Methods of solving simultaneous differential equation, Simultaneous equations of the first order, Linear differential equations of second order, Complete solution of the differential equations when one integral of the complementary function is known, Reduction to normal form, Solution by change of the independent variable, Solution by means of operational factors, Method of variation of parameters, Methods of undetermined coefficient.

**Unit-II** (16 Contact Periods)

Exact linear differential equations of nth order, Condition of exactness for a linear equation of order n, Integrating factors, Non-linear differential equation of particular forms, Exact non-linear differential equations, Riccati's Equation, Homogeneous equations. Introduction and basic examples of Integral Equations

**Unit-III** (16 Contact Periods)

Classification, Conversion of Volterra Equation to ODE, Conversion of IVP and BVP to Integral Equation, Successive approximation, Successive substitution methods for Fredholm Integral Equations, series solution, successive approximation, successive substitution method for Volterra Integral Equations, Volterra Integral Equation of first kind, Integral Equations with separable Kernel, Fredholm's first, second and third theorem(statements only), Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem.

## SUGGESTED BOOKS

1. E.L. Ince, Ordinary Differential Equations, Dover Publication Inc. 1956.
2. E.A. Coddington, An Introduction to ordinary differential equations, PHI,1990.
3. M. D. Raisinghania, Ordinary and Partial differential equations, S. Chand & Co., 2016.
4. C., Cordumeanu, Integral Equations and Applications, Cambridge University Press, 1991.
5. M. D. Raisinghanis, Integral Equations & Boundary Value Problems, S. Chand & Co., 2010.

| **MTL6071** | | | **Probability & Statistics** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 3 | 1 | 0 | 4 | 1.5 Hours | 3.0 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand Probability and Distribution functions.
2. Gather knowledge of Correlation, Regression and their applications
3. Understand and apply Hypothesis testing, Analysis of Variance, sample survey in real life. situations.

## COURSE CONTENT

Unit-I (16 Contact periods)

Review of probability- Random variable and Distribution function, Marginal and joint probability distribution Mathematical expectation of sum and product of random variables. Moments, Cumulates and their interrelationship, Moment generating function and cumulate generating function, Binomial, Normal and Poisson with their properties.

Unit-II (16 Contact periods)

Correlation and Regression, Karl Pearson and Spearman's rank correlation coefficient, Regression coefficient and lines of regression. Partial and multiple correlation, Sampling distribution, Standard error, Simple random sampling and stratified random sampling with their role.

Unit-III (16 Contact periods)

Test of significance for mean, variance, proportion and correlation coefficient, Test of goodness of fit and Independence of attributes, Analysis of variance for one way and two way classified data, Concept of estimation, Definition of unbiasedness, Consistency and efficiency, Statistical decision making: Risk function, Loss function. Baye's rule and Baye's approach.

## SUGGESTED BOOKS

1. A.M. Goon, M.K. Gupta and B. Das Gupta, Fundamental of Statistics, Vol. I & Vol. II, World Press, 1988.
2. A.M. Goon, M.K. Gupta, B.Das Gupta, A Dublin of Statistical Theory-Vol. I & II, World Press, 1983.
3. S.C. Gupta , V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2005.
4. An Introduction to probability theory and mathematical statistics: V.K. Rohatgi (Wiley Eastern Publisher Ltd., New Delhi), 1988.
5. S.P.Gupta, Statistical Methods, Sultan Chand and Sons, 2012.

| **MTL 6066** | | | **Numerical Methods** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 3 | 1 | 2 | 5 | 1.5 Hours | 3.0 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1 find roots of algebraic/transcendental equations.
2 find polynomials which best fits a tabulated data.
3 solve linear system of equations.
4 differentiate and integrate a function which best fits a given data.
5 apply differentiation and integration to practical problems.
6 solve ordinary differential equations.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Differences: Error in interpolation, Detection of error by use of difference tables, Differences of a Polynomial, Newton's formula for Forward and Backward interpolation, Gauss Central difference Interpolation formula, Striling's formula, Bessel's formula, Interpolation with unequal intervals; Lagrange's formula, Divided differences and their properties, Newton's general Interpolation formula, Inverse interpolation.

**Unit-II:** (16 Contact Periods)

Errors in Numerical Calculations, Number and their accuracy, Errors and their analysis errors in a series approximation, Numerical solutions of algebraic and transcedental equations: BiSection Method, Iterative Method, Method of false-position, Newton-Raphson method, Secant method, curve fitting and approximation; fitting of a straight line. Approximation of functions, Chebyshev polynomials. Taylor's series approximation. Solution of linear systems of equations: Direct method, Elimination method, Gauss-seidel method, Jacobi method.

**Unit-III:** (16 Contact Periods)

Numerical Differentiation: Maximum and minimum value of a tabulted function, Numerical Integration: Trapezoidal Rule. Simpon's 1/3 and 3/8 Rule. Newton-cotes integration formula. Gaussian quardrature formula. Numerical evaluation of singular integrals. Numerical solution of ordinary differential equations: Solution by Taylor's series. Euler's method, Picard's method. RungeKutta method. Predictor Corrector Method: Miline's method and Adams-Moulton's method.

## SUGGESTED BOOKS

1. V. Rajaraman, Computer Oriented Numerical Methods, PHI; 3 edition, 1993.
2. Foroberg, Introduction of Numerical Analysis, Addison Wesley Publishing Company, 2nd Edition, 1969.
3. S.S. Shastri, Introductory methods of Numerical Analysis, 5th Edition, PHI, 2012
4. M.K. Jain et. al., Numerical Methods. New Age International P (Ltd), 4th Edition, 2004.
5. Steven C. Chapra, Applied Numerical Methods with MATLAB, Tata McGraw-Hill, 2nd Edition, 2007.

| **MTL 7081** | **Optimization Techniques** | Pre Requisites | |
|---|---|---|---|

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assignment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 3 | 1 | 0 | 0 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. formulate and solve various industrial and managerial problems as linear programming problems
2. formulate and solve various transportation and assignment problems
3. apply the principles of game theory and network scheduling methods to solve problems that arise in business and industry
4. develop queuing models for solving congestion problems

**Unit-I** (16 Contact Periods)

Introduction to Operations Research. Linear Programming: Principles of simplex Method, Simplex method in tabular form, Duality and Dual simplex Method, Degeneracy and cycling. Transportation and Assignment problems.

**Unit-II** (16 Contact Periods)

Matrix games, Fundamental theorem of matrix games, Games with mixed strategies. Matrix game and its relation with linear programming. Network Scheduling: Networks and basic components, Rules for Network Construction, CPM and PERT.

**Unit-III** (16 Contact Periods)

Queuing theory: Objectives, Different characteristics of a queuing system, Measures of Performance, Poisson process, Birth-death process, Steady-state behavior of Markovian and Erlangian queuing models (MM/1, MM/c, and $M/E_K/1$).

## SUGGESTED BOOKS

1. V.K. Kapoor, Operations Research, Sultan Chand and Sons, 9th Edition, 2014.
2. H. A. Taha, Operations Research, Pearson India, 9th Edition, 2014.
3. KantiSwaroop, Operations Research, Sultan Chand , 2014.
4. S.D. Sharma, Operations Research, KedarNath Ram Nath and Co., 2013.
5. B.E. Gillet, Introduction of Operations research, Tata Mc-Graw Hill, 32nd Edition, 2008.
6. G.K. Murthy, Linear Programming, John Wiley & Sons Ltd. 1st Edition, 1983.
7. D. Gross and C.M. Harris, Fundamentals of Queuing Theory, Wiley India Private Limited; 4th Edition, 2012.

| **MTL 7051** | **Topology** | Pre Requisites | |
|---|---|---|---|

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 4 | 1.5 Hours | 3.0 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. work with sets and functions, images and preimages, and you can distinguish between finite, countable, and uncountable sets.
2. generate topology from basis and subbasis.
3. know how the topology on a space is determined by the collection of open sets/closed sets.
4. check connectedness or compactness of a topological space.
5. understand the concept of separation axioms and their characterizations.
6. Know the notions of compactification and metrization.

## COURSE CONTENT

**Unit-I:** (16 Contact Periods)

Infinite sets, Countable & Uncountable sets, Statements of axiom of choice, Well ordering principle, Zorn's Lemma, Principle of transfinite induction, Housdorff's maximal principle, Topological spaces, open sets, closed sets, neighbourhoods, Bases for a Topology, order Topology, Product Topology, Subspace Topology, limit points, closures, interiors, closed sets, Continuous function. Homeomorphism. Metric Topology, quotient Topology (Introduction only).

**Unit-II:** (16 Contact Periods)

Connectedness and Compactness: Connectedness, Local Connectedness, path connectedness, Compact spaces, locally compact spaces and Limit point Compact spaces.

**Unit-III:** (16 Contact Periods)

Separation Axioms: Hausdorff spaces, Regularity, Normality, Urysohn's lemma, Tietze extension Theorem, Urysohn'sMetrization Theorem. Tychnoff Theorem, Completely regular spaces, One-point Compactification and Stone-Cech compactification (Statement only).

## SUGGESTED BOOKS

1. J. R. Munkers, Topology- A First Course: Prentice Hall of India, 2 ed, 2002.
2. K. D. Joshi, General Topology, New age international, 2014.
3. M. G. Murdeshwar, General Topology, New Age International Pvt Ltd Publishers, 2008.
4. G. F. Simmons, Introduction to Topology & Modern Analysis, Tata McGraw-Hill Education, 2004.
5. J. L. Kelley, General Topology, Springer-Verlag, Berlin-Heidelberg-New York, 1975.
6. S. Willard, General Topology, Addison-Wesley Publishing company, Dover, 2012.

| **MTL 7061** | **Calculus of Variations and Mechanics** | Pre Requisites | **None** |
|---|---|---|---|

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 0 | 0 | 4 | 1.5 Hour | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Handle optimization problems where the variables, instead of being finite dimensional as in ordinary calculus, are functions.
2. Students will be able to formulatevariational problems and analyze them.
3. Understand the foundations of motion of a mechanical system.
4. Use Lagrange-Hamilton formalism to obtain the equations of chaotic motion for a variety of problems with the help of generalized coordinates.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Introduction, problem of brachistochrone, problem of geodesics, isoperimetric problem, Variation and its properties, functions and functionals, Comparison between the notion of extrema of a function and a functional. Variational problems with the fixed boundaries, Euler's equation, the fundamental lemma of the calculus of variations, examples.

**Unit-II:** (16 Contact Periods)

Functionals involving more than one dependent variables and their first derivatives, the system of Euler's equations. Functionals depending on the higher derivatives of the dependent variables, Euler- Poisson equation, examples, Functionals containing several independent variables, Ostrogradsky equation, examples, Variational problems in parametric form, applications to differential equations, examples, Variational problems with moving boundaries, Transversality condition, examples.

**Unit-III:** (16 Contact Periods)

Generalized coordinates, Lagrange's equations, Applications of Lagrange Equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis.

## SUGGESTED BOOKS

1. L.E.Elsgolc, Calculus of Variations, Courier Corporation, 2012.
2. L.A. Pars, An Introduction to the Calculus of Variations, Courier Corporation, 2013.
3. I. M. Gelfand and S. V. Fomin, Calculus of Variations, PHI
4. M.G. Calkin, Lagrangian and Hamiltonian Mechanics, World Scientific Publishers, 1996.
5. Sankara Rao, Classical Mechanics, Prentice Hall India, 2005.

| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 0 | 4 | 1.5 Hour | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. understand fundamental concepts of geometry like parametric curves, surfaces, manifold etc.
2. Based on above concepts they are able to understand fundanetal theorems like Frenet-Serret theorem, Fundamental form of Surfaces, Weingartem theorem etc.
3. they are able to understand the Intrinisic and Extrinsic properties of surfaces
4. they are able to solve numerical analysis poblem and applications based on above structures.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Parametrized differential curve, regular curve, arc length, plane curves, Euler's theorem, curvature, fundamental theorem for plane curves, involutes and evolutes, Frenet-Serret theorem, torsion, helix, Fundamental theorem for curves in R3 .

**Unit-II:** (16 Contact Periods)

Regular surfaces. Inverse function theorem, Implicit function theorem, Change of Co-ordinates, tangent plane, Orientable surface, Tangential maps, First fundamental of a surface, Metric on a regular surface, Curvature for Surfaces,Euler's theorem, Gauss map, Meusnier theorem

**Unit-III:** (16 Contact Periods)

Metric equivalence of surfaces, local isometry, Intrinisic and Extrinsic properties of surfaces, Christoffel Symbols of the first Kind and second kind, Gauss theorem, Fundamental theorem for regular surfaces in R3, Geodesic curves.

## SUGGESTED BOOKS

1. T.J. Will More, Introduction to differential Geometry, Oxford University press, 2012
2. John Mccleary, Geometry from a differential view point, Cambridge University press, 2013
3. Barrett O'Neill, Elementary Differential Geometry, Academic press, 2006
4. W. Klingenberg, A course in differential geometry, springer- Verlag, 1978
5. E. Weatherburn, Differential geometry of three dimensions, Cambridge University press.

| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 0 | 4 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Explain the fundamentals of Modern Algebra (Group, Rings and Fields)
2. Apply these techniques notions in coding by using matrix technique and polynomial technique.
3. Compare the process of coding and decoding by above mentioned techniques.
4. Explain some useful codes like Hamming codes and BCH-codes and their applications.

## COURSE CONTENTS

**Unit-I:** (16 Contact Periods)

Binary Group Codes, Communication system and its problems, Binary Symmetric Channel, Encoding and Decoding, Error detecting and correcting codes, Block codes, Distance between words, Matrix Encoding Technique, Groups codes, Construction of Decoding Table, Hamming codes.

**Unit-II:** (16 Contact Periods)

Polynomial Rings, Polynomial Rings over field,Polynimal codes, Shift Register and its use in polynomial multiplication, Unique Factorization Theorem for polynomials,Complex Roots of unity, Formal Derivatives.

**Unit-III:** (16 Contact Periods)

Extension of fields, Simple Extensions, Computation in R[x]/[m(x)], Existence Theorem, Finite fields, Computation in GF (2n). Root fields of Polynomials, BCH Codes.

## SUGGESTED BOOKS

1. G.Birkhoff., Barte, Thomas C., Modern Applied Algebra, CBS Publication
2. I.N. Herstein, Topics in Algebra, John Wiley & sons publisher, 2nd edition (1975)
3.Gill,Arthar, Applied Algebra for computer science, Prentice Hall of India.
4.Dornhoff, Larry L., Applied Modern Algebra , MacMillan & Co. & Franz E.
5. V. K. Bhat, Modern Algebra and its Applications, Narosa,

| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 0 | 0 | 1.5Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand the foundations of functional analysis in the context of normed linear spaces The Big Theorems (Hahn-Banach, Baire Category, Uniform Boundedness, Open Mapping and Closed Graph) and several applications. They can understand the important notion of duality in Banach and Hilbert spaces.
2. Define continuity of linear operators. Determine whether an operator is continuous/ discontinuous.
3. Apply his or her knowledge of functional analysis to solve mathematical problems.

## COURSE CONTENT

**Unit-I:** (16 Contact Periods)

Normed spaces, Banach spaces, Further properties of Normed spaces, Subspaces, Linear operators, Linear functionals, Bounded and continuous linear operators, Normed spaces of operators, Dual spaces.

**Unit-II:** (16 Contact Periods)

Hahn-Banach theorem (Extension of linear functionals) for nomed spaces, Application to bounded linear functionals on C[a,b], Adjoint operator, reflexive spaces, uniform boundedness theorem, Convergence of sequence of operators and functionals, Open mapping theorem, Closed linear operator, Closed graph theorem.

**Unit-III:** (16 Contact Periods)

Inner product spaces, Hilbert spaces, Further properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, Total orthonormal sets and sequences, Representation of functionals on Hilbert spaces, Hilbert adjoint operators, Self adjoint, Unitary and normal operators.

## SUGGESTED BOOKS

1. A. Mukherjea and K. Pothoven, Real and Functional Analysis, Springer-Verlag New York Inc.
2. E. Kreyszig , Introductory functional Analysis with application, John Willey and Sons, 1978.
3. Bachman and Naricel, Functional Analysis, Dover Publication, 2nd edition, 2003.
4. G.F. Simmons, Introduction to Topology and Modern Analysis ,TMH, 2003.
5 P.K. Jain, O.P. Ahuja and Khalil Ahmed, Functional Analysis.

| **MTE 7015** | **Advanced Topics in Algebra** | Pre Requisites | **None** |
|---|---|---|---|
| Version R-01 | | Co-requisites | |

| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 0 | 5 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand application of modules over rings as an analogue of vector spaces over fields.
2. Understand the notion of lengths of chains of prime ideals in commutative Noetherian rings and its analogue in non-commutative set up.
3. Study the radicals i.e. Prime ideals, Jacobson radical and Nil radical and brief introduction to their possible application

## COURSE CONTENT

**Unit-I:** (20 Contact Periods)

Rings, Matrix rings, Polynomial rings, Skew Polynomial rings, Laurant rings, Boolean rings. Opposite ring, Characteristic of a ring. Direct Products.
Ideals, Homomorphism of rings, Endomorphism rings, Field of fractions, Prime fields, PIDS and UFDS.

**Unit-II:** (20 Contact Periods)

Modules Direct product, Direct sum of modules, Free modules, Homomorphism of modules, Maximal submodule, Minimal Submodule, Simple modules, Schurs lemma, Annihilator of a Subset of a module, Modules over PID's, Torsion modules, torsion free modules.

**Unit-III:** (20 Contact Periods)

Chain conditions, Artinian modules, Northerian modules, Composition series, Modules of finite length, Jordan Holder Theorem.
Artinian rings, Noetherian rings, Hilbert Basis Theorem, I.S.Cohen's Theorem, Introduction of Nil radical and Jacobson radical.

## SUGGESTED BOOKS

1.C. Musili, Introduction to rings and modules, Narosa, 2003.
2. K.R. Gooderal and R.B. Warfield, Introduction to Non-commutative rings, Cambridge University Press.
3. N. McCoy, Ring Theory, Chelsea Pub Co., 1973

| **MTE 7033** | **Econometrics** | Pre Requisites | |
|---|---|---|---|
| Version R-01 | | Co-requisites | |

| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assign ment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 0 | 0 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. To understand advanced Econometrics Techniques.
2. To apply advanced Econometrics concept to real life situations with help of Mathematical tools.
3. To built complex Mathematical model with the help of Econometrics Techniques.

**Unit-I** (20 Contact Periods)

Two-variable linear model: Linear model and underlying assumptions, ordinary least squares estimators, linear hypothesis, Testing a single coefficient, Testing the significance of the complete regression, Testing the significance of a subset of coefficients confidence estimation, R2 and adjusted R2, Use of extraneous information in terms of exact and stochastic linear restrictions, restricted restrictions, Prediction in the least squares model, point and interval predictors.

**Unit-II** (20 Contact Periods)

Tests for structural change, use of dummy variables, problem of multicollinearity and its remedies, estimation of parameters by generalised least squares in models with non spherical disturbances, heterosceldasticity of disturbances, estimation under autocorrelated disturbances.

**Unit-III** (20 Contact Periods)

Bayesian analysis of linear models, Simultaneous equation model, concept of structural and reduced forms, problem of identification, rank and order conditions of identifiability, indirect least squares, Two stage least square and limited information maximum, likelihood estimation.

## SUGGESTED BOOKS

1. J. Johnston, Econometric methods
2. Judge, Griffiths, Hill, Hitkepohl, The theory and practice of econometrics.
3. D.N. Gujrati, Basic Econometrics (McGraw-Hill).

| **MTE 7041** | | | **Queuing Theory** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (Assign ment) | | | | |
| 4 | 1 | 0 | 0 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. understand the concept and applications of Markov chains
2. develop and solve the Markovian as well as non-Markovian queuing models, and apply them
3. derive the transient solutions of Markovian queuing systems
4. develop and apply bulk queuing models, and queuing network models
5. apply simulation procedures for solving queuing problems

**Unit-I** (20 Contact Periods)

Concept of Stochastic Process, Markov Chains with discrete and continuous time parameter. Objectives and different characteristics of a queuing system. Performance measures, Steady-state solution of queuing models: M/M/1, M/M/c, M/$E_k$/1 and $E_k$/M/1.

**Unit-II** (20 Contact Periods)

Transient solution of M/M/1, M/M/c and M/M/$\infty$ queuing models including busy period distribution. Bulk Queues: Steady-state analysis of $M^{[X]}$/M/1 and M/$M^{[Y]}$/1 queuing models.

**Unit-III** (20 Contact Periods)

Imbedded Markov chain technique and its use to the Queuing models: M/G/1, GI/M/1. Design and control of queuing systems. Queuing Networks: Open and Closed Queuing Networks, Jackson network, Jackson Theorem, Tandem queuing networks. Applications of Queuing networks.

Simulation procedures: Data generation and Book- keeping aspects.

## SUGGESTED BOOKS

1. Cooper, R.B., Introduction to Queuing Theory, George Washington Univ. Dept. of, 3rd Edition, 1990.
2. D.R. Cox and W. L. Smith, Queues, Springer, 1971.
3. D. Gross and C.M. Harris, Fundamentals of Queuing Theory, Wiley India Private Limited; 4th Edition, 2012.
4. L. Kleinrock, Queuing Systems (Vol. I), Wiley India Pvt. Ltd., 2013.
5. J. Medhi, Stochastic Model in Queuing theory, Academic Press, 2nd Edition, 2002.
6. T.L. Satty, Elements of Queuing Theory with Applications, Dover Publications Inc., New Edition, 1984.

| **MTE 7231** | | | **Financial Mathematics** | | | | Pre Requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Version R-01 | | | | | | | Co-requisites | | | |
| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (Assign ment) | | | | |
| 4 | 1 | 0 | 5 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. demonstrate a systematic and analytical knowledge of the mathematical methods suitable for resolving mathematical problems in banks and other financial institutions

2. demonstrate a comprehensive understanding of the most common applications of mathematics in finance and recent extensions thereof;

3. demonstrate skills in applying cross-disciplinary techniques of analysis (for example, to the domain of finance from pure and applied mathematics and other disciplines)

**Unit-I** (20 Contact Periods)

Role of Financial Management. Financial Analysis and planning. Working Capital Management. Cost of Capital, Capital Structure and Dividend Policies, Short term and Long term Financial Planning.

**Unit-II** (20 Contact Periods)

Analytical Approach to Finance. Technique of Goal Programming and its Application to Profit Planning and Financial Budgeting. Capital Expenditure Decision under Risk.

**Unit-III** (20 Contact Periods)

Financing Decision: Problem of determining optimal capital structure, Leasing, Debt Management, Analysis of commitment of funds and risk of cash insolvency; Receivables and Inventory Management Approaches, Simulation Approach to Working Capital Management.

## SUGGESTED BOOKS

1. Van Horne J.C., Fundamentals of Financial Management, Prentice Hall
2. Brigham E.F., Gapenski L.C., Financial Management: Theory and Practice, The Dryden Press, 9th edi., 1998.
3. Khan M.Y. and Jain P.K., Financial Management, Tata McGraw Hill Pub. Co.,
4. Clark J.J. Hendland T.J. and Pritchard R.E, Capital Budgeting Planning and Control of Capital Expenditures, Prentice Hall, Englewood Cliffs, NJ, 1986.
5. Donaldson G. and Bertrand F., Corporate Debt Capacity: A Study of Corporate Debt Policy and the Determination of Corporate Debt Capacity, Beard Books, 2000.
6. Fogler, R.H. and Ganpathy, S., Financial Econometrics, Prentice Hall,
7. Levy H. and Sarnat M., Capital Investment and Financial Decisions, Prentice Hall, Englewood Cliffs, NJ, 1982.
8. Mao J.C.T., Quantitative Decision of Financial Decisions, Macmillan, NY,

| | | | |
|---|---|---|---|
| **MTE 7012** | **Partial Differential Equations** | Pre Requisites | |

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assignment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 1 | 0 | 5 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

**COURSE OUTCOMES**

After successful completion of this course, students shall be able to;

1. Understand fundamental concepts of partial differential equations of first order, second order etc.
2. Learn various methods to solve linear and non linear partial differential equations.
3. Understand to solve various real life problems by formulating them into a partial differential equations.

**Unit-I** (20 Contact Periods)

Partial Differential equation of the first order-formulation and Classification of partial differential equations, Lagrange's linear equation, particular forms of non-linear partial differential equations, Charpit's method. Linear partial differential equations with constant coefficients. Homogeneous equations, Non homogeneous equation.

**Unit-II** (20 Contact Periods)

Partial differential equation of $2^{nd}$ and higher order, classification examples of partial differential equations, partial differential equations relevant to industrial problems, solution of elliptic, hyperbolic and parabolic equations.

**Unit-III** (20 Contact Periods)

Partial Differential equations of second order with variable coefficients, Monge's Methods, Separation of variables, Canonical forms, Cauchy's problem, Legendre polynomials- Solution of Legendre's Equation, Generation function, Rodrigue's formula, orthogonal Properties. Integrals involving Legnedrepolynmials, Fourier-Legendre expansion, Recurrence relations, Legendre's function of second kind $Q_n(x)$, Christoffel's summation formula.

**SUGGESTED BOOKS**

1. F. John, Partial Differential equations, Narosa Publication
2. I. N. Sneddon, Elements of Partial Differential Equations, Mc-Graw Hill
3. H.F. Weinberger, A First Course in Partial Differential equations, John Willey & Sons,
4. W.E. William, Partial Differential equations, Clarendan Press, Oxford.
5. T. Amarnath, PDE, PHI.

| **MTE 7013** | **Measure Theory** | Pre Requisites | |
|---|---|---|---|
| Version R-01 | | Co-requisites | |

| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assign ment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 0 | 5 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. understand the basic concepts of measure and integration theory.
2. learn some standard inequalities useful solve various boundness problems in science and engineering.
3. understand signed measure and Radon Nikodyn derivatives which is useful for theoretical foundation of some applicable measures.
4. understand the concept of product measure and Fubini Theorem with their applications.

**Unit-I** (20 Contact Periods)

Lebsegue integration & its properties.Fatou's Lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, $L^p$ Spaces: Cauchy-Schwartz inequality, Holder inequality, Minkowski inequality, Jensen inequality,

**Unit-II** (20 Contact Periods)

Signed Measures,Signed Measure Spaces,Integration on a Signed Measure Space,Absolute Continuity of a Measure, The Radon-Nikodym Derivative, Absolute Continuity of a Signed Measure Relative to a Positive Measure, Properties of the Radon-Nikodym Derivative

**Unit-III** (20 Contact Periods)

Product Measure Spaces,Existence and Uniqueness of Product Measure Spaces, Integration on Product Measure Space, Fubini's Theorem, Completion of Product Measure Space, Convolution of Functions, Some related Theorems.

## SUGGESTED BOOKS

1. J.Yeh Lectures on Real Analysis, World Scientific 2000.
2. M.E. Munroe, Measure and Integration, 2nd edition Addison Wesley, 1971.
3. G.DeBarra, Measure theory and Integration, Wiley Eastern Ltd.,1987.
4. H.L.Royden, Real Analysis,3rd edition, Macmillan, New York, 1988.

| **MTE 7031** | **Time Series And Stochastic Process** | Pre Requisites | |
|---|---|---|---|

| Version R-01 | | | | | | | Co-requisites | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Minor Duration | Major Duration | Internal Marks (Assignment) | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
| 4 | 1 | 0 | 5 | 1.5 Hours | 3 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students shall be able to;

1. Understand Time Series, Stochastic processes and their analysis.
2. Understand the variant difference method, AR, MA, ARMA process, tests for stationary stochastic process.
3. Gather knowledge of Markov chain and stationary probability.
4. Understand and apply Poisson process, random walk, Renewal theory and their applications.

**Unit-I** (20 Contact Periods)

Time series as a stationary or non stationary stochastic process, time domain analysis based on correllogram, sample autocovariance function and autocorrelation function at log K, log correlation.Measurement of cyclic fluctuations: Periodogram and its relation with acvf, Harmonic analysis. Measurement of irregular component: Variant difference method. AR(p) process, MA(q) process, mited ARMA(p,q) process, Stationarity and inevitability conditions, ARIMA (p,d,q) model, estimation of parameters, tests for stationarity Stochastic – Process.

**Unit-II** (20 Contact Periods)

Markov Chain having two states, n-step transition probabilities, Classification of states, recurrent and transient states, Chapman-Kolmogorov equations, Stationary probability theorems and limit theorem for ergodic chains, martingales.

**Unit-III** (20 Contact Periods)

Poisson process, birth and death process, Random walk and Gambler's Ruin problem, Wiener process, Renewal theory and its application, Branching chains: Discrete Process (Galton-Watson), Continuous process (Markov Branching), Fundamental theorem of Extinction.

## SUGGESTED BOOKS

1. P.G.Hoel, S.C. Port, C.J. Stone, Introduction to stochastic processes, Universal Book Store, New Delhi.
2. S.K. Srinivasan, K.M. Mehata, Stochastic Processes, Tata McGraw-Hill Publishing Company limited, New Delhi.
3. J. Medhi, Stochastic Processes.
4. G.E.P. Box and G.M. Jenkins, Time series Analysis: Forecasting and control.
5. C. Chatfield, The Analysis of Time Series: Theory and Practice

| **BUL 8223** | **Research Methodology** | Pre Requisites | |
|---|---|---|---|
| Version R-01 | | Co-requisites | |

| L | T | P | C | Minor Duration | Major Duration | Internal Marks | Minor-I Marks | Minor-II Marks | Major Marks | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 0 | 4 | 1.5 Hours | 3.0 Hours | 10 | 20 | 20 | 50 | 100 |

## COURSE OUTCOMES

After successful completion of this course, students will be able to;

1. Introduce the basic concept of research, sampling methods.
2. Enable the students to understand the measures of Central tendency and dispersion, Probability Distributions
3. Understand the different methods of Testing of Hypothesis, Correlation, regression and Analysis of Variance.
4. Understand the different methods of Correlation, regression and Analysis of Variance.

## COURSE CONTENTS

**Unit-I** (16 Contact periods)

Meaning and Objectives of Research, Criteria of good research, Significance of research, Types of research, Research methods: Historical method, case study method, survey method, and experimental method. Research process, Identification and formulation of a research problem, Relevance of literature review. Hypothesis: types and characteristics. Research Design: need, features and characteristics of a good research design. Different research designs: descriptive, exploratory and experimental. Design of Sample surveys: concept of census and sample survey, Sampling and non-sampling errors, Probabilistic and non-probabilistic sampling designs and their types.

**Unit-II** (16 Contact periods)

Measurement and Scaling Techniques: Scales of measurement for qualitative and quantitative data, Scaling techniques: comparative and no-comparative, Multi-dimensional scaling. Collection of data: Method of collection of primary and secondary data, Questionnaire design. Data preparation process: editing, coding, classification, tabulation and graphical representation. Descriptive Statistics: Measures of central tendency, Measures of dispersion, and Measures of relationship. Association of Attributes. Concept of probability distribution, Normal, Binomial and Poisson distributions.

**Unit-III** (16 Contact periods)

Elementary knowledge of matrices, vectors and differential calculus. Inferential Statistics: Point and Interval estimation, determination of sample size. Sampling distribution. Type-I and Type-II errors. Hypothesis testing procedure, t-test, z-test, chi square test, F-test, ANOVA. Regression Analysis: Simple linear regression, multiple linear regression, Logistic regression. Problem of multicollinearity. Factor Analysis: Centroid and Principal Components Method.
Writing Scientific Report, Writing a research project proposal, Academic ethics and Plagiarism, Intellectual Property Rights and Patent Law.

## SUGGESTED BOOKS

1. S.C. Gupta , V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2005.
2. S.P.Gupta, Statistical Methods, Sultan Chand and Sons, 2012.
3. C.R. Kothari, Research Methodology, New Age International Publishers, 2004.
4. Deepak Chawla, NeenaSondhi, Research Methodology, Vikas Publishing House 2016.
5. P. Sivaramakrishna Das, C. Vijayakumari, Engineering Mathematics, Pearson 2017.

| | | PO1 | PO2 | PO 3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|---|
| 1 | MTL6051 | 3 | 3 | 1 | 2 | 2 | 2 |
| 2 | MTL6052 | 3 | 3 | 1 | 2 | 2 | 2 |
| 3 | MTL6061 | 3 | 3 | 2 | 2 | 2 | 2 |
| 4 | MTL6062 | 2 | 3 | 2 | 3 | 2 | 2 |
| 5 | MTL 6063 | 3 | 3 | 1 | 2 | 2 | 2 |
| 6 | MTL 6053 | 3 | 3 | 1 | 3 | 2 | 2 |
| 7 | MTL 6054 | 3 | 3 | 1 | 1 | 2 | 2 |
| 8 | MTL 6065 | 3 | 3 | 1 | 2 | 2 | 2 |
| 9 | MTL 6071 | 3 | 3 | 3 | 3 | 2 | 2 |
| 10 | MTL 6066 | 3 | 3 | 1 | 3 | 2 | 2 |
| 11 | MTL 7081 | 3 | 3 | 3 | 2 | 2 | 2 |
| 12 | MTL 7051 | 3 | 3 | 1 | 1 | 2 | 2 |
| 13 | MTL 7061 | 3 | 3 | 1 | 1 | 2 | 2 |
| 14 | MTL 7062 | 3 | 3 | 1 | 1 | 2 | 2 |
| 15 | MTL 7063 | 3 | 3 | 1 | 2 | 2 | 2 |
| 16 | MTL 7052 | 3 | 3 | 1 | 1 | 2 | 2 |
| 17 | MTD 7091 | 3 | 3 | 3 | 3 | 3 | 3 |
| 18 | MTE 7012 | 3 | 3 | 1 | 2 | 2 | 2 |
| 19 | MTE 7013 | 3 | 3 | 0 | 0 | 2 | 2 |
| 20 | MTE 7015 | 3 | 3 | 1 | 0 | 2 | 2 |
| 21 | MTE 7033 | 3 | 3 | 2 | 2 | 2 | 2 |
| 22 | MTE 7041 | 3 | 3 | 1 | 2 | 2 | 2 |
| 23 | MTE 7231 | 2 | 3 | 3 | 1 | 2 | 2 |

Course Outcomes of every course in M.Sc. (Mathematics) Program are mapped to POs considering following;

0 Value = Addressing to Zero Degree
1 Value = Addressing to Low Degree
2 Value = Addressing to Medium Degree
3 Value = Addressing to High Degree

**Note: In this outcome based education syllabus only those elective courses are included which has been offered by School of Mathematics during the last five years.**