K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle) |
UGC honoured "College of Excellence"
Dept. of Biotechnology, Ministry of Science & Technology honoured
"Star College" | DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी - 'ए' (सी.जी.पी.ए. : ३.१५ - तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स'
भारत सरकारच्या विज्ञान, तंत्रज्ञान, जैवतंत्रज्ञान विभागातर्फे
घोषित 'स्टार कॉलेज'। डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 29/06/2019

NOTIFICATION

Sub :- CBCS Syllabi of B. Sc./M. Sc. in Mathematics (Sem I & II)

Ref. :- Decision of the Academic Council at its meeting held on 28/06/2019.

The Syllabi of B. Sc./M. Sc. in Mathematics (First and Second Semesters) as per CBCS-UG/PG Regulations, 2016 and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2019-20.

Copy of the Syllabi shall be downloaded from the College Website (www.kcesmjcollege.in)

Chairman
Board of Studies

MOOLJI JAITHA COLLEGE, JALGAON • AUTONOMOUS • NAAC GRADE 'A' CGPA-3.15 (3rd CYCLE) ESTD. 1945

Principal,
M. J. College, Jalgaon

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The Director, School of Mathematical Sciences, M. J. College, Jalgaon.
3) The office of the COE, M. J. College, Jalgaon.
4) The office of the Registrar, M. J. College, Jalgaon.
5) Office File.

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College" Affiliated to

KBC North Maharashtra University, Jalgaon

KNOWLEDGE IS POWER

ESTD. 1945

SYLLABUS STRUCTURE OF

M. Sc. Mathematics

Under Choice Based Credit System (CBCS)

[w. e. f. Academic Year: 2019-20]

M. Sc. I Mathematics Course Structure

Term / Semester	Course Module	Subject Code	Title of Paper	Credit	Hours per Week
I	DSC	MT-101	Measure Theory	4	4
	DSC	MT -102	Advanced Metric Spaces	4	4
	DSC	MT -103	Algebra	4	4
	DSC	MT -104	Differential Equations	4	4
	SEC	MT -105(A) OR MT-105(B)	Programming in C++ OR Numerical Methods	4	4
	DSE	MT -106(A) OR MT-106(B)	Problem course based on MT-101 and 102 OR Problem course based on MT-103 and 104	4	4
II	DSC	MT-201	Complex Analysis	4	4
	DSC	MT -202	Topology	4	4
	DSC	MT -203	Linear Algebra	4	4
	DSC	MT -204	Number Theory	4	4
	GE	MT -205(A) OR MT 205(B)	Mathematical Methods OR Calculus of Variations	4	4
	DSE	MT -206(A) OR MT 206(B)	Problem course based on MT-201 and 202 OR Problem course based on MT-203 and 204	4	4

M. Sc. II Mathematics Course Structure

Term / Semester	Course Module	Subject Code	Title of Paper	Credit	Hours per Week
III	DSC	MT -301	Functional Analysis	4	4
	DSC	MT -302	Graph Theory	4	4
	DSC	MT -303	Field Theory	4	4
	DSC	MT -304	Lattice Theory	4	4
	SEC	MT -305(A) OR MT-305(B)	Fluid Dynamics OR Solid Mechanics	4	4
	DSE	MT -306(A) OR MT 306(B)	Problem course based on MT-301 and 302 OR Problem course based on MT-303 and 304	4	4
IV	DSC	MT -401	Advanced Mathematical Methods	4	4
	DSC	MT -402	Operations Research	4	4
	DSC	MT -403	Commutative Algebra	4	4
	DSC	MT -404	Advanced Abstract Algebra	4	4
	GE	MT -405	Algebraic Topology OR Integral Equations	4	4
	DSE	MT-406(A) OR MT-406(B)	Problem course based on MT-401 and 402 OR Problem course based on MT-403 and 404	4	4

Examination Pattern for the all Courses (60: 40)

Nature	Marks
External Marks	60
Internal Marks	40
Total Marks	100

M. Sc. Mathematics Syllabus (First Year)

MT-101: Measure Theory

Course Description: This course provides fundamental knowledge of Countable and Uncountable sets, measure on real line, integration and differentiation of functions on real variables.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Measure Theory. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Measure Theory to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on Countable sets
b) understand the concepts of Measure theory
c) know the important theorems and their applications.
d) know the integration and differentiation of real functions

==========

1. Countable and uncountable sets, Infinite sets and the axioms of choice, Cardinal numbers and their arithmetic, Schroeder- Bernstein theorem, Cantors theorem and the continuum Hypothesis, Zorn's lemma, Well Ordering principle, Cantor set, Cantor like sets, The Lebesgue functions. **(9 Hours)**
2. Measure on the real line: Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel sets and Lebesgue measurability. **(16 Hours)**
3. Integration of functions of a real variable: Integration of nonnegative function, The general integral, Integration of series, Riemann and Lebesgue integrals**. (16 Hours)**
4. Differentiation: The four derivatives. Functions of bounded variation. Lebesgue differentiation theorem, Differentiation and Integration**. (9 Hours)**
5. Differentiation of monotone function: Vitali covering theorem (lemma), Fundamental theorem for integral calculus for Lebesgue integral, Absolutely continuous functions. **(10 Hours)**

Recommended Books:

1. G. de Barra, *Measure Theory and Integration*. New Age International (p) Limited, New Delhi, 2000. (Chapter 1- Art 1.5,1.7, Chapter 2- Art 2.1, 2.5, Chapter 3- Art 3.1 to 3.4 Chapter 4- Art 4.1, 4.3 to 4.5 Chapter 9- Art 9.3)
2. Royden H. L., *Real analysis*, Prentice-Hall of India (P) Limited, New Delhi, 4th Edition, 2009.(Chapter Art-1)

Reference Books:

1. Halmos P. R.: *Measure Theory*, Springer international student Edition. Narosa Publishing House, New Delhi.
2. Walter Rudin: *Real and Complex Analysis* (1986), Tata McGraw- Hill New York.

MT-102: Advanced Metric Spaces

Course Description: This course provides fundamental knowledge of sets and distance functions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of metric spaces. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of metric spaces to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on Metric spaces.
b) understand the concepts of Sequences and their convergence
c) know the important theorems and their applications of Topology.
d) know the Compact and Connected spaces.

==========

1. Partially ordered sets, well ordered sets, Axiom of choice, Zorn's lemma, Well ordering principle. **(8 Hours)**
2. Metric spaces, open sphere, open sets. **(7 Hours)**
3. Sequences of metric spaces, Cauchy sequences, convergence. **(8 Hours)**
4. Completeness, Bair's Theorem, Completion of metric spaces. **(7 Hours)**
5. Continuity, Homeomorphism, Isometry. **(8 Hours)**
6. Compactness, totally bounded sets, Arzela Ascoli Theorem. **(7 Hours)**
7. Contraction principle, Existence theorem for differential equations. **(8 Hours)**
8. Connectedness, finite product of connected spaces. **(7 Hours)**

Reference Books:

1. G. F. Simmon: *Introduction to Topology and Modern Analysis*, Tata Mc Graw Hill. (Chapter -1: Art.-5, 8; Chapter -2: Art.- 9 to 14; Chapter -4: Art.-21, 24, 25; Chapter -6: Art.-31; Appendice-1)
2. J. R. Munkers: *Topology: A First Course*, Prentice Hall of India Ltd., 1992.

MT-103: Algebra

Course Description: This course provides fundamental knowledge of product of subgroups, various types of integral domains and Noetherian rings.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Algebra. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Algebra to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on Sub groups
b) understand the concepts of factorization
c) know the important theorems and their applications.
d) know the Noetherian rings.

==========

1. Direct product of subgroups, Class equation, Cauchy's Theorem, Solvable groups, Sylow's Theorem, Jordan - Holder Theorem. **(27 Hours)**
2. Factorization, Euclidean domains, principal ideal domains, Unique Factorization domains, Polynomial rings, Roots of polynomials, factorization of polynomials. **(27 Hours)**
3. Noetherian rings, Hilbert basis Theorem. **(6 Hours)**

Recommended Books:

1. N.S. Gopalkrishnan: *University Algebra*, Wiley – Eastern, 1988. (Sec. 1.10, 1.12, 1.13, 1.14, Sec. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16)
2. N.S. Gopalkrishnan: *Commutative Algebra*, Oxonian press pvt. Ltd., New Delhi, 1988. (Sec. 3.1)

Reference Books:

1. I.N. Herstein: *Topics in Algebra*, Wiley – Eastern, 1988.
2. N. Jacobson: *Basic Algebra*, Vol. I-2009
3. J.B. Freleigh: *Abstract Algebra.*
4. Jain and Bhattacharya: *Basic Abstract Algebra.1994 Cambridge Press*

MT-104: Differential Equations

Course Description: This course provides fundamental knowledge of Second order linear Differential equations, Power series solution, Lengendre Polynomials and second order partial differential equations.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Differential equations. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Differential equations to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on ordinary Differential equations
b) understand the concepts of partial differential equations
c) know the important theorems and their applications.
d) know the Legendre polynomials .

==========

1. **Second Order L.D.E. with constant Coefficients**: Basic theory of linear differential equations (L.D.E.), the homogenous L.D.E. with constant coeffecients, the method of undetermined coefficients, Variation of Parameters, The Cauchy-Eulerequation, theorems on second order homogenous L.D.E. **(15 Hours)**
2. **Power series solutions and special functions** : Introduction – a review of power series. Series solutions of first order equations. Second order Linear equations, ordinary points, existence of unique solution at ordinary points. Regular singular points, Frobeniusmethod of series solutions. Indicial equations. **(15 Hours)**
3. **Legendre Polynomials**: Series solition, orthogonality and normalization, Rodruguez formula, Generating function, recursion relations. **(15 Hours)**
4. **Partial differential equations of the second order**: Origin, applications in Physics, Linear P.D.E.with constant coefficients. Linear P.D.E. with variable coefficients. Classification of P.D.E of second order, Characteristics curves. Characteristic curves of second order equations. Characteristics of Equations in three variables. The solution of Linear Hyperbolic Equations. Riemann – Green's functions. **(15 Hours)**

Recommended Books:

1. Shepley L. Ross, *Differential Equations*, John Wiley and sons, New York. (Ch. 4.1-4.6)
2. G.F. Simmons : *Differential Equation* (Ch. 5 : Articles - 25, 26, 27, 28, and 29; Ch. 6 : Articles - 32, 33, 34, 35)
3. Ian Sneddon : *Elements of Partial Differential Equations*. (Ch.3: Articles – 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10)

Reference Books:

1. Arfken: *Mathematical Methods for Physics*
2. Churchill and Brown: *Fourier Series and Boundary Value Problems*.

MT-105 (A): Programming in C++

Course Description: This course provides fundamental knowledge of writing programs in C++ language

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of programming in C++ language. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of programming in C++ to develop mathematical skills to write efficient programs.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts of C++ language
b) understand the concepts of programming
c) know the important functions in C++ and their applications.

==========

1. Elementary Concepts: Introduction, output operator, characters, literals, variables and declaration, program token, initializing variables and constants, input operator and output operator, simple programs. **(10 Hours)**
2. Fundamental Types: Numeric, Boolean, enumeration, character, integer, arithmetic, increment, decrement, and composite assignment operators. Floating point, type conversion, numeric outflow, round-off error, and thee-format. **(10 Hours)**
3. Conditional statements: If and If-Else statements, statement blocks, compound conditions, short-circuiting, Boolean expressions, nested selection, else-if, switch statements and conditional expression operators. **(10 Hours)**
4. Iteration: The while statement, terminating a loop, do-while, for statements, break, continue and go-to Statements. **(10 Hours)**
5. Functions: Standard library functions, user defined functions, test drivers, functional declarations, local variables and functions, void functions, Boolean functions, Input-Output functions, passing by reference, passing by constant reference, inline function, slope, overloading, main function, default arguments. **(10 Hours)**
6. Arrays: Processing and initialization of arrays, array index, passing an array to a function, linear search, bubble sort, binary search algorithms, arrays with enumerations types, type definitions, multi-dimensional arrays. **(10 Hours)**

Recommended Books:

1. John R. Hubbard: *Programming with C++*, Schaum's outline series, 2002.
2. V.N.Vedamurthy and N.Ch.S.N.Iyengar: *Numerical methods*, Vikas Publishing House, 2008.

Reference Books:

1. Deital H.M. and Deital P.J: *C++How to program*, Prentice Hall of India, 1998.
2. Capper, D.M.: *Introducing C++ for Scientists*, Engineers and Mathematicians, Springer-Verlag, 1994.

MT-105 (B): Numerical Methods

Course Description: This course provides fundamental knowledge and concepts of solving system of linear equations, eigen values, eigen vectors, numerical solution of Initial and boundary value problems.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Numierical methods. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Numerical analysis to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on system of linear equations
b) understand the concepts of finding eigen values and eigen vectors
c) know the important theorems and their applications.
d) solve the initial and boundary value problems.

==========

1. **System of linear equations :** Introduction, various types of matrices, norm of a matrix; Direct methods like Gauss elimination, Gauss-Jordan; Triangularisation methods like Crout's method, Do-Little method and Cholesky's method. Error analysis for direct methods. **(15 Hours)**
2. **Eigen values and Eigen vectors:** Eigen values and Eigen vectors; Bounds on eigen values; Jacobi's method, Given's method and Householder's method for symmetric matrices. Power method and inverse power method, Inverse power method. **(15 Hours)**
3. **Numerical Solution of ODE(IVP):** Initial value problems, Numerical Solution of O.D.E using Picard, Taylor series, Modified Euler and Runge-Kutta fourth order methods. **(15 Hours)**
4. **Boundary value problems (ODE):** Introduction, Initial value problem method, Finite difference methods and finite element methods. **(15 Hours)**

Recommended Book:

1. M.K.Jain, S.R.K. Iyengar and R.K. Jain : Numerical methods for Scientific and Engineering computation (Sixth Edition), New Age International Publishers, New Delhi. (Unit I : Ch. 3.1-3.4 Unit II: 3.5-3.9, 3.11-3.12 Unit III: 6.6-6.9 Unit IV : 7.1-7.3)

Reference Books:

1. V.N. Vedamurthy and N.Ch. S. N. Iyengar: *Numerical methods*, Vikash Publishing House
2. C. Gerald and O.Wheatley: *Applied Numerical Analysis*, Addison Publishing company.
3. E. Balagurswamy: *Numerical Methods*,Tata McGraw-Hill.
4. S. S. Shastry: *Introductory methods of Numerical Analysis*, Prentice Hall of India.

MT-106(A): Problem course based on MT-101 and 102

Course Description: This course provides basic training to prepare for various competitive exams by explaining various MCQ type questions.
Prerequisite Course(s): T.Y. B.Sc. (Mathematics)
General Objective: The basic aim of this course is to prepare the students for the competitive examinations which are based on multiple choice questions on various topics of mathematics.
Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts of Measure theory
b) understand the concepts of Metric spaces
c) solve the MCQ type of questions

MT-106(B): Problem course based on MT-103 and 104

Course Description: This course provides basic training to prepare for various competitive exams by explaining various MCQ type questions.
Prerequisite Course(s): T.Y. B.Sc. (Mathematics)
General Objective: The basic aim of this course is to prepare the students for the competitive examinations which are based on multiple choice questions on various topics of mathematics.
Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand the concepts of Algebra
b) understand the concepts of Differential equations
c) solve the MCQ type of questions

MT-201: Complex Analysis

Course Description: This course provides fundamental knowledge and concepts of analytic functions, R-S integrals, closed curves, singularities and convex functions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Complex analysis. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Complex analysis to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on analytic functions
b) understand the concepts of singularities and residues.
c) know the important theorems and their applications.
d) solve important types of integrals.

==========

1. Power series, Analytic functions, Branch of a logarithm, Mobius(Bilinear) Transformation s and Conformal Mappings. **(9 Hours)**
2. Riemann-Stieltjes Integrals, Power Series representation of analytic functions, Taylor's Theorem, Cauchy's Estimate, Zeros of an analytic function, Louville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Theorem. **(16 Hours)**
3. Index of a closed curve, Cauchy's Theorem, Cauchy's Integral Formula, Higher Order derivatives, Morera's Theorem, The Homotopic version of Cauchy's Theorem and simple connectivity, Counting of Zeros, The Open mapping Theorem, Goursat,s theorem. **(9 Hours)**
4. Singularities, Classification of Singularities, Laurent's Series, Casorati-Weierstrass Theorem, Residues, Cauchy's Residue Theorem, Evaluation of Integrals, Meromorphic functions, The Arument Principle, Rouche's Theorem, Schwartz Lemma. **(16 Hours)**
5. Convex Functions and Hadamard's three Circles Theorem, The Space of continuous Functions, Spaces of Analytic Functions, The Riemann mapping Theorem. **(10 Hours)**

Recommended Book:

1. J. B. Conwey: *Functions of One Complex variable*, 2nd edition, Springer International Student Edition.

Reference Books:

1. S. Ponnusammy and Herb Silverman: *Complex Variables with Applications*, Birkhauser.
2. S. Ponnusammy: *Foundations of Complex Analysis*, 2nd edition, Narosa Publishing House.

MT-202: Topology

Course Description: This course provides fundamental knowledge of connected and compact topological spaces, product topology and regular spaces.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Topology. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Topology to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on topological spaces.
b) understand the concepts of connectedness and compact spaces.
c) know the important theorems and their applications of Topology.
d) know the product topology and regular spaces.

==========

1. Topological spaces and continuous functions: Topological spaces, Basis for topology. The order topology, subspace topology, closed sets and limit points, continuous functions, The product topology, Continuous functions, Metric topology, The quotient topology **(20 Hours)**
2. Connectedness and compactness: Connected spaces, connected sets in the real line, components and path components, local connectedness compact spaces, Limit point compactness. **(15 Hours)**
3. Countability and separation axioms: The countability axioms, The separation axioms, The Urysohn Lemma, Urysohn Metrization theorem. **(15 Hours)**
4. The Tychonoff Theorem, Completely regular spaces **(10 Hours)**

Reference Books:

1. J. R. Munkers: *Topology: A First Course*, Prentice Hall of India Ltd., 1992. (Chapter-2: sec 2.1 – 2.9 and 2.11; Chapter-3: sec 3.1-3.8; Chapter-4: sec 4.1-4.4 and Chapter-5: sec 5.1-5.2).
2. K.D. Joshi: *Introduction to general topology*, Wiley Eastern India Ltd, Reprint 2004.

MT-203: Linear Algebra

Course Description: This course provides fundamental knowledge and concepts of modules, sub modules, diagonalization of operators, Noetherian modules and decomposition of modules.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of modules and sub modules. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of liner algebra to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts of modules and sub modules.
b) understand the concepts of diagonalisation
c) know the important theorems and their applications.
d) know the basics of decomposition of modules.

==========

1. Modules, Submodules, R-homomorphism, Isomorphism, Direct sum of modules, free modules, Rank, Structure theorem for finitely generated modules over PID, Application to group Theorem. **(36 Hours)**
2. Diagonalization and Triangularization of operators, Jordan & Rational Canonical forms.(**18 hours**)
3. Noetherian Modules, primary decomposition for modules. (**6 Hours**)

Recommended Books:

1. N.S. Gopalkrishnan: *University Algebra*, Wiley – Eastern, 1988.(Sec. 3.6, 3.7, 5.10)
2. C.S. Musli: *Introduction to Rings & Modules*.(Sec.2.1, 2.2, 2.3, 3.2)
3. Vivek Sahai and Vikas Bist: *Linear Algebra*, Narosa Publication.

Reference Books:

1. I.N. Herstein: *Topics in Algebra*, Wiley – Eastern, 1988.

MT-204: Number Theory

Course Description: This course provides fundamental knowledge and concepts of arithmetic functions, congruences, quadratic residues and primitive roots.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Number theory. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Number theory to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on arithmetic functions
b) understand the fundamentals of congruences.
c) know the important theorems and their applications.
d) solve problems using quadratic residues and primitive roots.

==========

1. **Arithmetic functions:** The Mobius function $\mu(n)$, The Euler totient function $\phi(n)$, Dirichlet product of arithmetic functions, Dirichlet inverses and the Mobius inversion formula. The Mangolt function $\Lambda(n)$, Multiplicative functions, Dirichlet multiplication, The inverse of a completely, multiplicative function, Liouvilles function $\lambda(n)$, The divisor function $\sigma(n)$, Generalized convolutions. Formal power series, Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, The Selberg identity. **(20 Hours)**
2. **Congruences:** Residue classes, Complete and reduced residue systems and Euler-Fermat's theorem, Polynomial congruences $mod\ p$. Lagranges theorem and its applications, Polynomial congruences with prime power moduli. The principle of cross classification. **(10 Hours)**
3. **Quadratic residues and Quadratic Reciprocity law:** Quadratic residues, Legenre's symbol and its properties, Evaluation of $(-1|\ p)$ and $(2\ |\ p)$, Gauss lemma, The Quadratic Reciprocity law and its applications, The Jacobi Symbol. Applications to Diophantine equations. **(15 Hours)**
4. **Primitive roots:** The exponent of a number modulo m, Primitive roots, Primitive roots and reduced residue systems, The non-existence of primitive roots $mod\ p^n$ and $2p^n$ for odd primes p and $n \geq 1$. The non-existence of primitive roots in the remaining cases. The number of primitive roots $mod\ m$. the primitive roots and quadratic residues. The index calculus. **(15 Hours)**

Recommended Book:

1. T. M. Apostol: *Introduction to Analytic Number Theory*, 1972 Springer International student Edition. (Sec. 2.1 - 2.19, Sec. 5.2, 5.4, 5.5, 5.6, 5.9, 5.10, Sec. 9.1 to 9.8, Sec. 10.1 to 10.10)

Reference Book:

1. D. M. Burton: *Elementary Number Theory*, 1980 Universal Book Stall.

MT-205(A): Mathematical Methods

Course Description: This course provides fundamental knowledge and concepts of solving linear pde by separation of variables, boundary value problems, heat equation, wave equation, Laplace equation, generalized Fourier series and Bessel functions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of mathematical methods. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of mathematical methods to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts of solving linear pde
b) understand the concepts of linear boundary value problems
c) know the important theorems and their applications.
d) solve heat, wave and Laplace equations.

==========

1. **Linear boundary value problems:** Introduction, derivation of wave equation, heat equation and Laplace's equation in Cartesian, cylindrical and spherical co-ordinates. Principle of superposition, series solutions, separation of variables, types of initial value problems and general solution of partial differential equation. **(15 Hours)**
2. **Orthogonality:** Orthogonality of sets of functions in the space of piecewise continuous functions on (a, b), generalized Fourier Series, approximation in the mean, closed and complete orthonormal sets. Fourier series and half range Fourier series, Sturm-Liouville problems, orthogonality of the eigen functions and their uniqueness. **(15 Hours)**
3. **Boundary value problems:** Boundary value problems involving the wave equation, heat equation and Dirichlet's problems. Solution by the method of separation of variables, temperature in along Cylinder, heat transfer at the surface of the cylinder and vibrations of the circular membrane. **(15 Hours)**
4. **Bessel's functions:** Bessel's differential equation and its solution, Bessel function of first kind, second kind, Bessel functions of order zero and one, recurrence relations, generating function, orthogonality of Bessel functions, Fourier Bessel Series. **(15 Hours)**

Recommended Books:

1. R.V. Churchill and J.W. Brown: *Fourier series and Boundary value problems*, McGraw-Hill International, 2011.
2. J. P.Chauhan : *Differntial and difference equations*, Garg Publishing House.
3. Raysinghania : *Advanced Differential Equations*, S. Chand Pub., 1988.

Reference Book:

1. Mary, L Boas: *Methods of Mathematical Physics*.
2. N. N. Lebedev : *Special functions and their applications*, Prentice Hall.

MT-205(B): Calculus of Variations

Course Description: This course provides fundamental knowledge and concepts of functionals, variational principle, extrema and problems of various types of motions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic need of this course is to understand the concepts and applications of Calculus of variations. Also, this course will improve problem solving and logical thinking abilities of the students. By learning this course students can use the concepts of Calculus of variations to develop mathematical skills.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts on functionals
b) understand the concepts of variational principles
c) know the important theorems and their applications.
d) solve various types of problems of extrema and constrained motion.

==========

1. Functionals, Euler's Equations, Another form and cases of Euler's Equation, Necessary and sufficient conditions for extremums, Functionals dependent on Higher order derivatives, Extension of the variational cases, Isoperimetric Problems, Geodesic, Rayleigh-Ritz Method, Lagrange's Equation, Invariance of Euler Equation. **(24 Hours)**
2. Transversality Condition, Variational Problem with Moving Boundary in Implicit form, Basic Problem with variable end, Generalized Boundary and Transversality condition for the variable end points, One sided variation, Extremals with corners. **(24 Hours)**
3. Jacobi Condition, Wierstrass Function, Sufficient condition for extremum: Legendre condition, Application of Calculus of Variation. **(12 Hours)**

Recommended Book:

1. S. K. Pundir and R. Pundir: *Calculus of Variation*, Pragati Prakashan (Chapter 1- Art 1.1 to 1.13, Chapter 2- Art 2.1 to 2.5, Chapter 3- Art 3.1 to 3.5)

Reference Book:

1. I.M. Gelfand and S.V. Fomin, *Calculus of Variation*, Prentice Hall.

MT-206(A): Problem course based on MT-201 and 202

Course Description: This course provides basic training to prepare for various competitive exams by explaining various MCQ type questions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic aim of this course is to prepare the students for the competitive exams which are based on multiple choice questions on various topics of mathematics.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand basic concepts of Complex analysis

b) understand the concepts of Topology

c) solve the MCQ type of questions

MT-206(B): Problem course based on MT-203 and 204

Course Description: This course provides basic training to prepare for various competitive exams by explaining various MCQ type questions.

Prerequisite Course(s): T.Y. B.Sc. (Mathematics)

General Objective: The basic aim of this course is to prepare the students for the competitive exams which are based on multiple choice questions on various topics of mathematics.

Learning Outcomes: Upon successful completion of this course the student will be able to:

a) understand the concepts of Linear Algebra

b) understand the concepts of Number Theory

c) solve the MCQ type of questions