Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

SYLLABUS

for

Master of Science (M. Sc.)
[Mathematics]

Choice Based Credit System
(Outcome Based Curriculum)

2021 - 2022

Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. (Mathematics)

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Core	**16**	**16**	**16**	**12**
02	Skill based	**04**	**04**	**-**	**-**
03	Elective	**-**	**-**	**04**	**08**
04	Project	**-**	**-**	**-**	**-**
05	Audit	**02**	**02**	**02**	**02**
06	Total Credits	**22**	**22**	**22**	**22**

Subject Type	Core	Skill based	School Elective	Project	Audit	Total
Credits	**60**	**08**	**12**	**00**	**08**	**88**

Total Credits = 88

Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon

M. Sc. (Mathematics)

Choice Based Credit System (Outcome Based Curriculum) with effect from 2021 -2022

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course (No weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	4	16	**16**	1	4 + 0	4	1	2	2	**22**
II	4	16	**16**	1	4 + 0	4	1	2	2	**22**
III	4	16	**16**	1	4 + 0	4	1	2	2	**22**
IV	4	12	**12**	2	8 + 0	8	1	2	2	**22**
Total Credits	**60**			**20**			**8**			**88**

(T, Theory; P, Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
	Prerequisite and Core Courses									
(A)	Theory	4	4	4	4	4	4	4	3	60
	Practical	0	0	0	0	0	0	0	0	00
(B)	**Skill Based / Subject Elective Courses**									
1	Theory /Practical	4	1	4	1	4	1	4	2	20
(C)	**Audit Course (No weightage in CGPA calculations)**									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			
4	Professional and Social + Value Added Course							2	1	2
	Total Credit/ Courses	22	6	22	6	22	6	22	6	88

***List of Audit Courses** (Select any ONE course of Choice from Semester II; Semester III and Semester IV)*							
Semester I (Compulsory)		**Semester II** (Choose One)		**Semester III** (Choose One)		**Semester IV**(Choose One)	
		Personality and Cultural Development		**Technology + Value Added Course**		**Professional and Social + Value Added Course**	
Course Code	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**
AC-101	Practicing Cleanliness	AC-201A	Soft Skills	AC-301A	Computer Skills	AC-401A	Human Rights
		AC-201B	Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Yoga	AC-301C	Project work on typesetting in Latex	AC-401C	Review +Seminar of Research Papers in Mathematics
		AC-201D	Music	AC-301D	Project work on Recent topics in Mathematics	AC-401D	Vedic Mathematics

Semester-wise Course Structure of M.Sc. Mathematics

Semester I

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MT-101	Core	Advanced Real Analysis	4	--	4	40	--	60	--	4
MT -102	Core	Topology	4	--	4	40	--	60	--	4
MT -103	Core	Abstract Algebra	4	--	4	40	--	60	--	4
MT -104	Core	Partial Differential Equations	4	--	4	40	--	60	--	4
MT -105	Skill Based	Programming in C++	4	--	4	40	--	60	--	4
AC -101	Audit Course	Practicing Cleanliness	--	2	2	--	100	--	--	2
Total Credit for Semester I: 22 (T = Theory: 16; P = Practical:00; Skill Based:04; Audit Course:02)										

Semester II

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
MT -201	Core	Number Theory	4	--	4	40	--	60	--	4
MT -202	Core	Complex Analysis	4	--	4	40	--	60	--	4
MT -203	Core	Linear Algebra	4	--	4	40	--	60	--	4
MT -204	Core	Classical Mechanics	4	--	4	40	--	60	--	4
MT -205	Skill Based	Python Programming	4	--	4	40	--	60	--	4
AC-201 A/B/C/D	Audit Course	Choose one out of Four (AC-201A/ AC-201B/AC-201C/AC-201D) from Personality and Cultural Development	--	2	2	--	100	--	--	2
Total Credit for Semester II: 22 (T = Theory Course: 16; P = Practical:00; Skill Based course:04; Audit course:02)										

Semester III

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
						Internal		External		
			T	P	Total	T	P	T	P	
MT-301	Core	Topics in Functional Analysis	4	--	4	40	--	60	--	4
MT -302	Core	Numerical Analysis	4	--	4	40	--	60	--	4
MT -303	Core	Topics in Field Theory	4	--	4	40	--	60	--	4
MT -304	Core	Fluid Dynamics	4	--	4	40	--	60	--	4
MT -305	Elective (Select any **one**)	Statistical Techniques	4	--	4	40	--	60	--	4
MT -306		Lattice Theory								
AC-301 A/B/C/D	Audit Course	Choose one out of Four (AC-301A/ AC-301B/AC-301C/AC-301D) from Technology + Value Added Courses	--	2	2	--	100	--	--	2
Total Credit for Semester III: 22 (T = Theory Course: 16; P = Practical:00; Elective Course:4; Audit Course:02)										

Semester IV

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
						Internal		External		
			T	P	Total	T	P	T	P	
MT-401	Core	Linear Integral Equations	4	--	4	40	--	60	--	4
MT -402	Core	Operations Research	4	--	4	40	--	60	--	4
MT -403	Core	Commutative Algebra	4	--	4	40	--	60	--	4
MT -404	Elective (Select any **two**)	Advanced Abstract Algebra	8	--	8	40	--	60	--	8
MT -405		Algebraic Topology								
MT -406		Theory of Special Functions								
MT -407		Cryptography								
AC-401 A/B/C/D	Audit Course	Choose one out of Four (AC-401A/ AC-401B/ AC-401C/ AC-401D) from Professional and Social + Value Added Courses	--	2	2	--	100	--	--	2
Total Credit for Semester IV: 22 (T = Theory Course: 12; P = Practical:00; Elective Course:08; Audit Course:02)										

Program at a Glance

Name of the program (Degree)	: M. Sc. (Name of the Subject)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60 : 40 (60 marks University exam and 40 marks continuous internal assessment)
Passing standards	: 40% in each exam separately (separate head of passing)
Evaluation mode	: CGPA
Total Credits of the program	: 88 (60 core credits, 08 Skill enhancement credits, 12 Elective credits and 08 audit credits)

Program Objectives for M.Sc. Mathematics Program:

- To prepare skilled manpower with scientific knowledge of Mathematics for solving real life and industrial based problems
- To inculcate critical thinking to carry out scientific investigations in Mathematics.
- To equip the student with mathematical, software based and social thinking based skills to analyze problems, formulate hypothesis, evaluate or validate results, and draw reasonable conclusions thereof.
- Prepare students to purse research or careers in mathematical sciences and allied fields
- Imbibe effective scientific and technical communication in both oral and writing.

Program Outcomes (PO) for M.Sc. Mathematics Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	Cognitive level
PO1	Understand the fundamental axioms in mathematics and equipped with the capabilities of developing ideas based on them	**2**
PO2	Develop themselves as a professionals in mathematics	**6**
PO3	Carry our scientific research in mathematics and related fields.	**5**
PO4	Apply mathematical methods/tools/skills in other scientific, engineering and industrial domains	**3**
PO5	Nurture problem solving skills, social thinking, creativity through skill and audit based courses.	**4**
PO6	Prepare themselves for competitive examinations	**3**

Program Specific Objectives for M.Sc. Mathematics program:

- To provide quality education through effective teaching learning processes by introducing Choice based credit systems and latest software skills.
- Enable students to enhance mathematical skills and understand the fundamental concepts of pure and applied mathematics.
- To provide an opportunity through up to date curriculum to develop scientific temper among the students results into skilled manpower.
- To inculcate innovative skills, team work, ethical practices among students so as to meet societal expectations through audit courses.
- To inculcate the inquisitiveness for mathematics and motivate the students for research in mathematics. .

Program Specific Outcomes (PSOs) for M.Sc. Mathematics program:

Students who graduate with a Master of Science in **Mathematics** will:

PSO No.	PSO	Cognitive level
PSO1	Understand the technicalities of mathematics and software's to explore the acquire knowledge for further developments.	2
PSO2	Employ confidently the techniques of mathematics for solving problems and scientific investigations.	4
PSO3	Apply the knowledge of mathematical concepts in interdisciplinary fields.	3
PSO4	Continue to acquire mathematical knowledge and skills appropriate for their professional activities and demonstrate highest standard and ethics.	6
PSO5	Pursue research in advanced areas of pure and applied mathematics.	5
PSO6	Qualify national level tests like NET/SET/GATE etc.	4

Distribution of Course papers for M. Sc. Part I (Mathematics)

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I					
Semester I : Theory Courses					
MT-101	Advanced Real Analysis	Core course	04	100	03
MT -102	Topology	Core course	04	100	03
MT -103	Abstract Algebra	Core course	04	100	03
MT -104	Partial Differential Equations	Core course	04	100	03
MT -105	Programming in C++	Skill based	04	100	03
Semester I : Audit Courses					
AC-101		Audit Course	02	100	--
Semester II : Theory Courses					
MT -201	Number Theory	Core course	04	100	03
MT -202	Complex Analysis	Core course	04	100	03
MT -203	Linear Algebra	Core course	04	100	03
MT -204	Classical Mechanics	Core course	04	100	03
Semester II : Practical Courses					
MT -205	Python Programming	Skill based	04	100	03
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	02	100	--

	MT-101: Advanced Real Analysis	Lecture
	Course Objectives: The aim of this course is • To understand basic elements of measure theory such as measurable sets, functions. • To solve Lebesgue integration and differentiation. • To understand the concepts of abstract measure theory with the help of classical Banach spaces.	
Unit 1	Countable and uncountable sets, Infinite sets and the axioms of choice, Cardinal numbers and their arithmetic, Schroeder- Bernstein theorem, Cantor's theorem and the continuum Hypothesis, Zorn's lemma, Well Ordering principle, Cantor set, Cantor like sets, The Lebesgue functions.	**08 L**
Unit 2	Measure on the real line: Lebesgue Outer measure, Measurable sets, Regularity, Measurable functions, Borel sets and Lebesgue measurability.	**17 L**
Unit 3	Integration of functions of a real variable, Integration of nonnegative function, The general integral, Integration of series, Riemann and Lebesgue integrals.	**15 L**
Unit 4	Differentiation: The four derivatives, Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and Integration.	**10 L**
Unit 5	Differentiation of monotone function: Vitali covering theorem (lemma), Fundamental theorem for integral calculus for Lebesgue integral, Absolutely continuous functions.	**10 L**
Suggested readings: 1. G. de Barra, (2000) **Measure Theory and Integration**, New Age International (p) Limited, New Delhi. **(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. H. L.Royden,(2009) **Real analysis**, Prentice-Hall of India (P) Limited, New Delhi, 4th Edition **(Chapter Art-1)**		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C101.1	Acquire fundamentals of Countability, Continuum hypothesis and Zorn's lemma	**2**
C101.2	Understand and analyze Lebesgue measure, measurable functions and their properties	**4**
C101.3	Solve integrations of functions not necessarily defined on closed sets and verify their properties.	**3**

	MT-102: Topology	
	Course Objectives: • Students will learn the concept of topology, topology generated by basis. • Students will learn, subspaces, closed sets, limit points of a set. • Students will learn continuous functions on topological spaces, product topology, metric topology. • Students will learn connectedness of a set, compactness and separation axioms	
Unit 1	Topological Spaces, Basis for a Topology, The Order Topology, The Product Topology on $X \times Y$, The Subspace Topology, Closed Sets and Limit Points,	**12L**
Unit 2	Continuous Functions, The Product Topology, The Metric Topology, The Quotient Topology	**12L**
Unit 3	Connected Spaces, Connected Subspaces of the Real Line, Components and Local Connectedness	**12L**
Unit 4	Compact Spaces, Compact Subspaces of the Real Line, Limit Point Compactness, Local Compactness	**12L**
Unit 5	The Countability Axioms, The Separation Axioms, Normal Spaces, The Urysohn Lemma, The Tietze Extension Theorem(Sec 30-33, 35 [1])	**12L**

Suggested readings:

1. J. R. Munkres, (1992) **Topology (A first course)**, Prentice Hall of India Ltd. (Sections 12-17, 18-20, 22-33)
2. K. D. Joshi: **Introduction to general topology**, New Age International Private Limited)
3. C. Wayne Patty , **Foundations of Topology**, Jones and Bartlett Publishers, Inc; 2nd edition

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C102.1	understand the definition of topology, examples, basis, order topology.	**2**
C102.2	understand the subspaces, closed sets, limit points of a set.	**2**
C102.3	understand continuous functions on topological spaces, product topology, metric topology.	**2**
C102.4	understand connectedness of a set, compact ness and separation axioms.	**2**

	MT - 103: Abstract Algebra	Lecture
	Course Objectives: 1. To know the concept and applications of Finite groups. 2. To study well known theorems for finite groups: Cauchy's Theorem, Sylow's Theorem, Jordan - Holder Theorem. 3. To know concepts of particular types of integral domains: ED, PID, UFD.	
Unit 1	**Finite groups:** Direct products, External direct product of groups, Conjugate classes, Class equation, Cauchy's Theorem.	**12 L**
Unit 2	**Sylow theorems and solvable groups:** Sylow p-subgroups, Sylow theorems, Solvable group, Normal series, Composition series, Jordan-Holder Theorem.	**15 L**
Unit 3	**Integral domains:** Greatest common divisor, prime element, irreducible element, Euclidean domain, principal ideal domain, Factorization domain, Unique Factorization domain.	**15 L**
Unit 4	**Polynomial rings:** Polynomial rings, Roots of polynomials, Eisenstein's criterion, primitive polynomial, Gauss lemma, Gaus theorem, factorization of polynomials.	**12 L**
Unit 5	**Noetherian rings:** Finitely generated ideals, Chain conditions, Noetherian rings, Hilbert basis theorem.	**06 L**

Suggested readings:

1. Gopalakrishnan N. S. (2018), **University Algebra**, Wiley Eastern Limited, New Delhi. (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. Gopalakrishnan N. S. (2016), **Commutative Algebra**, Universities Press (India) Pvt. Ltd. (Sec. 3.1).
3. Herstein I. N. (1975), **Topics in Algebra**, John Wiley and Sons, New Delhi.
4. Jacobson N. (2012), **Basic Algebra-I**, Second Edition, Hindustan Publishing Corporation.
5. Fraleigh J. B. (2003), **A first Course in Abstract Algebra**, Pearson.
6. Bhattacharya P.B., Jain S.K. and Nagpaul S.R. (1994), **Basic Abstract Algebra**, Cambridge Press.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C103.1	Understand class equation for finite groups and its applications.	2
C103.2	Explain Sylow theory and solvable groups.	3
C103.3	Learn Euclidean domains, Principal ideal domains, unique factorization domains, Noetherian rings and the Hilbert Basis Theorem.	4

	MT - 104: Partial Differential Equations	Lecture
	Course Objectives: • To understand the concepts and applications of Differential equations. • To improve problem solving and logical thinking abilities of students. • To use the concepts of Differential equations to develop mathematical skills.	
Unit 1	**Partial Differential Equations of First Order:** First order PDE, classification of integrals, Linear equations of first order, Pfaffian differential equations, compatible systems, Cauchy Problem, Integral surfaces through a given curve for partial differential equations, Charpit's method, Jacobi's method.	15 L
Unit 2	**Partial Differential Equations of Second Order:** Origin of second order partial differential equation, Linear equations with constant coefficients, Equations with variable coefficients, Method of separation of variables, Nonlinear equations of the second order.	15 L
Unit 3	**Laplace Equation:** The occurrence of Laplace's equation in physics, Elementary solution of Laplace's equation, Families of equipotential surfaces, Boundary value problems, Method of separation of variables	10L
Unit 4	**The Wave Equation:** The occurrence of wave equation in physics, Elementary solutions of the one-dimensional wave equation, Riemann-Volterra solution of the one-dimensional wave equation, Method of separation of variables.	10 L
Unit 5	**The Diffusion Equation:** The occurrence of the diffusion equation in physics, Elementary solutions of the diffusion equation, Separation of variables.	10 L

Suggested readings:

1. Sneddon, I. N.(1957) **Elements of Partial Differential Equations**, McGraw Hill, New York
2. Amarnath, T. (2008) **An Elementary Course in Partial Differential Equations**, 2nd Edition, Narosa Publishing House.
3. John, F. (1982) **Partial Differential Equations**, Springer-Verlag, New York.

Course Outcomes (COs):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.1	Find solutions of partial differential equations and determine the existence, uniqueness of solution of partial differential equations.	3
C104.2	Apply the concepts of partial differential equations to solve problems in allied fields.	3
C104.3	Know the important theorems and their applications.	4

	MT 105 Programming in C++	Lecture
	Course Objectives: The objectives of this course are: • To understand how C++ improves C with object-oriented features. • To learn how to write inline functions for efficiency and performance. • To learn how to design C++ classes for code reuse and to learn how to overload functions and operators in C++.	
Unit 1	**Principles of Objective Oriented Programming** Object Oriented Programming Paradigm, Basic Concepts of Object Oriented Programming, Benefits of Object Oriented Programming, Object Oriented Languages, Applications of Object Oriented Programming, C++.	**12 L**
Unit 2	**Token Expressions & Control Structures** Tokens, Keywords, Identifiers and Constants, Data Types, Type Compatibility, Variables, Operators in C++,Implicit Conversions, Operator Overloading, Operator Precedence, Control Structures.	**12 L**
Unit 3	**Functions in C++, Classes & Objects.** The Main Function, Function Prototyping, Call by Reference, Return by Reference, Inline Functions, Function Overloading, Friend and Virtual Functions. Specifying a class, Member Functions, Arrays within a class, Static Member Functions, Arrays of Objects, Friendly Functions.	**12 L**
Unit 4	**Constructors & Destructors, Operator Overloading, Inheritance** Constructors, Parameterized Constructors, Copy Constructors, Dynamic Constructors, Destructors, Defining Operator Overloading, Overloading Operators, Rules for Overloading Operators, Type Conversions	**12 L**
Unit 5	**Pointers, Virtual Functions & Polymorphism, Working with Files, Exception handling** Pointers, Pointers to Objects, this pointer, Pointer to Derived Classes, Virtual Functions, Classes for File Stream Operations, Opening and Closing a File, File Modes, File Pointers, Input Output Operations, Updating a File	**12 L**
Suggested readings: 1. E. Balaguruswamy, (2012) **Object-Oriented Programming with C++**, 5th Edition, Tata McGraw Hill, New Delh 2. John R. Hubbard,(2000) **Schaum's Outline of Fundamentals of Computing with C++**, Schaum's Outline Series.		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C105.1	Visualize the features of C++ supporting object-oriented programming.	1
C105.2	Construct how to produce object-oriented software using C++	3
C105.3	Survey the major object-oriented concepts to implement object-oriented programs in C++, encapsulation, inheritance and polymorphism	4

AC-101: Practicing Cleanliness

(Compulsory; Campus-level Audit Course; Practical; 2 Credits)

Course Objectives (CObs):

- To make students aware of Clean India Mission and inculcate cleanliness practices among them.

	• Awareness program on
	  o Swachh Bharat Abhiyan (Clean India Mission)
	  o Clean Campus Mission
	  o Role of youth in Clean India Mission
	• Cleaning activities inside and surroundings of Department buildings.
	• Tree plantation and further care of planted trees
	• Waste(Liquid/Solid/e-waste) Management, Japanese 5-S practices
	• Planning and execution of collection of Garbage from different sections of University campus
	• Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance.
	• Cleanest School/Department and Cleanest Hostel contests
	• Painting and Essay writing competitions	

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	2
AC101.2	Plan and observe cleanliness programs at home and other places.	4
AC101.3	Practice Japanese 5-S practices in regular life.	3

	MT - 201: Number Theory	Lecture
	Course Objectives: • To know concept of arithmetic functions. • To study congruences and quadratic residues. • To know the concepts of primitive root theory.	
Unit 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	**12 L**
Unit 2	**Dirichlet multiplication and Formal power series:** 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.	**12 L**
Unit 3	**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.	**12 L**
Unit 4	**Quadratic residues and Quadratic Reciprocity law:** Quadratic residues, Legendre's symbol and its properties, Evaluation of $(-1\mid p)$ and $(2 \mid p)$, Gauss lemma, The Quadratic Reciprocity law and its applications, The Jacobi Symbol. Applications to Diophantine equations.	**12 L**
Unit 5	**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.	**12 L**

Suggested readings:

1. Apostol T. M. (1972), **Introduction to Analytic Number Theory**, 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)
2. Burton D. M. (1980), **Elementary Number Theory**, Universal Book Stall.
3. Silverman Joseph H. (2001), **A Friendly Introduction to Number Theory** (Second Edition), Prentice Hall.
4. Niven Ivan, Zuckerman Herbert S. and Montgomery Hugh L. (1991), **An introduction to the theory of numbers** (Fifth Edition), John Wiley and sons.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C201.1	Understand the concept of Mobius function $\mu(n)$, The Euler totient function $\phi(n)$, Mangolt function $\Lambda(n)$, Liouvilles function $\lambda(n)$, The divisor function $\sigma(n)$, Bell series.	2
C201.2	Explain Residue classes, Lagrange's theorem and its applications, Polynomial congruences with prime power moduli.	2
C201.3	Learn Quadratic residues, existence and non-existence of primitive roots.	2

	MT - 202: Complex Analysis	Lecture
	Course Objectives: • To make student aware of advances in complex analysis • To know Mobius transformation and conformal mappings • To Improve the logical thinking ability to find applications	
Unit 1	Power series, Analytic functions, Branch of a logarithm, Mobius (Bilinear) Transformations and Conformal Mappings.	**10 L**
Unit 2	Riemann-Stieltjes Integrals, Power Series representation of analytic functions, Taylor's Theorem, Cauchy's Estimate, Zeros of an analytic function, Liouville's theorem, Fundamental Theorem of Algebra, Maximum Modulus Theorem.	**15 L**
Unit 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.	**10L**
Unit 4	Singularities, Classification of Singularities, Laurent's series, Casorati-Weierstrass theorem, Residues, Cauchy's residue theorem, Evaluation of integrals, Meromorphic functions, The Argument principle, Rouche' theorem, Schwartz lemma.	**15 L**
Unit 5	Convex functions and Hadamard's three circles theorem, The space of continuous functions, Spaces of analytic functions, The Riemann mapping theorem	**10 L**

Suggested readings:

1. J. B. Conway, (1995) **Functions of One Complex variable,** Springer Int. Student Edition.
2. S. Ponnusammy and H. Silverman (2006) **Complex Variables with Applications**, Birkhauser.
3. S. Ponnusammy: **Foundations of Complex Analysis**, 2nd edition Alpha, Narosa Publishing House.
4. L. V. Ahlfors, (1996) **Complex Analysis**, McGraw-Hill Book Co.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C202.1	Acquire useful knowledge of complex analysis	**1**
C202.2	understand the concept of power series about complex analysis	**1**
C202.3	solve the complex integration in various forms	**4**
C202.4	gain the knowledge of singularities	**1**
C202.5	prepare themselves for competitive examinations:SET, NET, GATE etc.	**3**

M.Sc. Part I Semester II (Mathematics): Core Courses

	MT - 203: Linear Algebra	Lecture
	Course Objectives: • To develop skills and to acquire knowledge of Linear Algebra, Rings and Modules • To prepare students for further courses in mathematics and/or related disciplines (e.g. Commutative algebra, homological agebra, etc.). • To develop the ability to demonstrate underlying principles of the subject and the ability to solve unseen mathematical problems.	
Unit 1	Modules, Submodules, R-homomorphism, Isomorphism.	**12 L**
Unit 2	Cyclic modules, Faithful modules, Direct sum of modules, free modules, Rank.	**12 L**
Unit 3	Torsion and Torsion free modules, Structure theorem for finitely generated modules over PID, Application to group Theorem.	**12 L**
Unit 4	Jordan and Rational canonical forms.	**16 L**
Unit 5	Local rings, Noetherian modules, Primary decomposition for modules.	**08 L**

Suggested readings:

1. N. S. Gopalkrishnan (1988) **University Algebra**, Wiley – Eastern. (Sec. 3.6, 3.7, Sec. 5.10)
2. C. S. Musli (2001) **Introduction to Rings & Modules**. Cambridge University Press. (Sec. 2.1, 2.2, 2.3, 3.2)
3. I. N. Herstein (1988) Topics in Algebra, Wiley – Eastern.
4. M. F. Atiyah and I. G. MacDonald (2018) **Algebra**, CRC Press, Boca Raton.
5. J. Lambek (1966) **Lectures on Rings and Modules**, Blaisdell Publications, Massachusetts.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C203.1	Understand and interpret the concepts of modules and submodules, Homomorphism and isomorphism in modules, types of modules and group theorem.	**2**
C203.2	Understand the concepts of Jordan and Rational canonical forms and use them to solve problems involved in matrix theory and computer algebra.	**2**
C203.3	Understand the concepts of Local rings and modules, Noetherian modules, Primary decomposition for modules.	**2**

M.Sc. Part I Semester II (Mathematics): Core Courses

	MT - 204: Classical Mechanics	Lecture
	Course Objectives: • Gain deeper conceptual understanding of classical mechanics. • To understand how to represent the equations of motion for complicated mechanical systems using the Langrangian and Hamiltonian formulations of classical mechanics. • Advance skills and capability for formulating and solving problems.	
Unit 1	Mechanics of particle, Mechanics of the system of particle, constraints and their type, D'Alembert's principle and Lagrange's equations, velocity dependent potential and the dissipation function, simple applications of the Langrangian formations.	**10 L**
Unit 2	Hamilton's principle some techniques of the calculus of variations, Derivation of Langrangian equations from Hamilton's principle, Generalised coordinates, Holonomic & Non-holonomic systems, Extension of Hamilton's principle to non-holonomic system, Lagranges Equations of first kind and second kind, uniqueness of solution, conservation theorems and symmetry properties.	**10 L**
Unit 3	The independent co-ordinates of a rigid body, orthogonal transformations Formal properties of the transformations matrix, The Euler angles, The Cayley-Klein parameters and related quantities finite rotations, Rate of the change of a vector, linear momentum, Angular momentum and Kinetic energy of motion about a point. Tensors and dyadics, The inertia tensor and the moment of inertia, The eigen values of the inertia tensor and Principle axis transformations.	**15 L**
Unit 4	Legendre transformations and the Hamilton equation of motion, cyclic coordinates and conservation theorems, Routh's equations, Derivation of Hamilton's equation from a variational principle, The principle of least action.	**10 L**
Unit 5	The equations of canonical transformations, Generating Functions, Examples of Canonical transformations, Conditions for a transformation to be Canonical, Bilinear invariant conditions, Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity(statement only), Poisson Brackets, properties, Invariance of Poisson Bracket's with respect to Canonical transformations, Poisson's identity	**15 L**

Suggested readings:

1. H. Goldstein (2011), **Classical Mechanics**, Narosa Publishing Home, New Delhi. (1.1-1.6, 2.1-2.7, 4.1-4.5,4.9,5.1-5.4, 8.1-8.6, 9.1-9.6)
2. Carban and Steble, **Classical Mechanics**, John Wiley press Cambridge
3. Marian, (1970) **Classical Dynamics of particle & system**, Academic Press
4. Sudarsan & Mukunda (2015), **Classical Mechanics**, World Scientific Publishing Co Pte Ltd
5. J. C. Upadhyaya (2019), **Classical Mechanics,** Himalaya Publishing House.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C204.1	Define and understand basic mechanical concepts related to advanced problems of classical mechanical systems and application of Langrangian formation	3
C204.2	Derived the Lagrange's equation and Hamilton principle.	2
C204.3	Demonstrate knowledge and understanding of fundamental concept-- the Cayley-Klein parameters,linear & angular momentum, Tensors and dyadic, and Principle axis transformations.	3
C204.4	Understand the concept of Legendre's transformation and apply to derived the Hamilton's Equation.	2
C204.5	Understand the concept of canonical transformation and apply to derived Poisson's Identity&Poisson's Bracket's	2

M.Sc. Part I Semester II (Mathematics): Skill Based Course

	MT - 205: Python Programming	Lecture
Course Objectives: • To acquire proficiency in using different functions and capabilities of Python. • To demonstrate the use of Python to for plotting. • Be familiar with the built-in functions and Sympy module to solve problems in Algebra		
Unit 1	Installing Python, IDLE, Typing, Getting input, Printing, Variables, (Book [1])	**12 L**
Unit 2	For loop, numbers. Math operator, math functions, if, elseif statements (Book [1])	**12 L**
	strings, lists, while loop, Functions, arguments, local variables (Book [1])	**12 L**
Unit 3	Visualing data with graphs: Understanding the Cartesian Coordinate Plane, Working with Lists and Tuples, Creating Graphs with Matplotlib, Customizing Graphs, Plotting with Formulas, Newton's Law of Universal Gravitation, Projectile Motion. (Book [2])	**12 L**
Unit 4	Algebra and Symbolic math with Sympy: Defining Symbols and Symbolic Operations. Working with Expressions, Solving Equations, Solving Quadratic Equations, Solving for One Variable in Terms of Others, Solving a System of Linear Equations, Plotting Using SymPy, Plotting Expressions Input by the User, Plotting Multiple Functions. (Book [2])	**12 L**
Suggested readings: 1. Heinold Brian, (2012), **A Practical Introduction to Python Programming**, (Licensed under a Creative Commons Attribution-Non commercial-Share Alike 3.0 Unported License) Available online. (Ch: 1-4, 6-7, 9, 13) 2. Shah Amit, (2015), **Doing Math with Python**, No Starch Press Inc. William Pollock, USA. (Ch:2 and Ch: 4)		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C205.1	Acquire skill in Python package particularly basics of Python	**2**
C205.2	Represents data with the help of plotting in Python	**3**
C205.3	Understand symbolic mathematics and solve system of equations with Python programming.	**3**

	AC-201(A): Soft Skills **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)** **(Optional:)**	
	Course Objectives (CObs): • To. Acquire spoken English skill for all development • To develop personality development of the students • To improve group discussion, interview and presentation skill among the students	
Unit 1	**Introduction to soft skills** Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes& Mannerism.	**2 h**
Unit 2	**Self-Assessment** Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	**4 h**
Unit 3	**Communication Skills** Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	**8 h**
Unit 4	**Formal Group Discussion, Personal Interview & Presentation skills** Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing. Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	**4 h**
Unit 5	**Aptitude and analytical skills** Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic	**8 h**

	test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	
Unit 6	**Life skills** Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	**4 h**

Suggested readings:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201A.1	Improve communication skill	**3**
AC201A.2	Take self assessment and think of SWOT analysis	**3**
AC201A.2	Able to face interviews and do presentations with confidence.	**3**

\

AC-201(B): Practicing Sports Activities

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives (CObs):

- To motivate students towards sports and provide them required training.

SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	• General Fitness • Basic Fitness • Specific Fitness • History of the Game • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201B.1	Acquire sport skill among them self	3
AC201B.2	Keep them self physical and mentally fine.	3

AC-201(C): Practicing Yoga (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional:)	
	Course Objectives: • To motivate students towards yoga and provide them required training.
	• Yog: Meaning, Definition & Introduction, Objectives • Primary Introduction of Ashtanga Yoga • Preparation of Yogabhyas • Omkar Sadhana, Prayer, Guru Vandana • Sukshma Vyayamas • Suryanamaskar (12 Postures) • Asanas : ▪ Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan ▪ Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana ▪ Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana ▪ Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana • Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types • Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201C.1	Acquire Yoga skills for mental and physical health	3
AC201C.2	Develop self confidence for problems arise in their real life.	3

AC-201(D): Introduction to Indian Music (Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional: Campus-level)	
	Course Objectives: • To motivate students towards Indian music and provide them minimum required training.
	• Definition and brief about generation of Swar, Saptak, Thaat, Raag, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. • Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa. • Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) • Detailed information of Tambora • Detailed information of Harmonium and Tablaa. • Five filmy songs based on Indian Classical Music (Theory and Presentation) • Sound Management - Basic information of Sound Recording (including Practicals) • Composition of Music as per the Story • Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201D.1	Identify different types of Indian music.	3
AC201D.2	Develop more interest to learn and practice Indian music.	4

Distribution of Course papers for M.Sc. Part II (Mathematics)

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part II (Mathematics)					
Semester III : Theory Courses					
MT-301	Topics in Functional Analysis	Core course	04	100	03
MT-302	Numerical Analysis	Core course	04	100	03
MT-303	Topics in Field Theory	Core course	04	100	03
MT-304	Fluid Dynamics	Core course	04	100	03
MT -305	Statistical Techniques	Elective Course **(Any one)**	04	100	03
MT -306	Lattice Theory				
AC-301A/B/C/D	Choose one out of Four (AC-301A/ AC-301B/AC-301C/AC-301D) from Technology + Value Added Courses	Audit course	02	100	--
Semester IV : Theory Courses					
MT-401	Linear Integral Equations	Core course	04	100	03
MT-402	Operations Research	Core course	04	100	03
MT-403	Commutative Algebra	Core course	04	100	03
MT-404	Advanced Abstract Algebra	Elective courses **(Any two)**	08	100	03 **(for each corse)**
MT-405	Algebraic Topology				
MT-406	Theory of Special Functions				
MT-407	Cryptography				
AC-401A/B/C/D	Choose one out of Four (AC-401A/ AC-401B/AC-401C/AC-401D) from Professional and Social + Value Added Courses	Audit course	02	100	--

	MT-301: Topics in Functional Analysis	Lectures
	Course Objectives: • To acquire concepts and results of normed linear space, inner product spaces and some linear operations • The normed linear spaces which are complete metric space are especially very important for developing problem solving capabilities.	
Unit I	Normed linear spaces, Banach Spaces, Quotient spaces, Continuous linear Transformations. The Hahn-Banach theorem and its consequences, conjugate space and separability, Second conjugate space. The natural embedding of normed linear space and its second conjugate space, Weak *Topology on conjugate space.	**12 L**
Unit II	The open mapping theorem, Projection on Banach space, The closed graph theorem, the conjugate of an operations, The uniform boundedness theorem (Banach-Steinhauss theorem). Inner Product spaces, Hilbert space: Definition, examples and simple properties, Schwartz's inequality, Orthogonal complements, Projection theorem, Orthogonal sets.	**12 L**
Unit III	The Bessel's inequality, Fourier expansion and Parseval's equations, Gram-Schmidt orthogonalization process, Separable Hilbert space, The conjugate space, Riesz Theorem.	**12L**
Unit IV	Operations and their adjoint on a Hilbert space, self adjoint operators, Normal and unitary operators projections. Finite dimensional spectral theory.	**12 L**
Unit V	Determinants and spectrum of an operator, The spectral theorem, Fixed points, Definition and examples, Banach contraction mapping theorem, Brouwer's fixed point theorem, Schauder's fixed point theorem.	**12 L**

Suggested Readings:

1. Simmons G. F., (1963) **Introduction to Topology and Modern Analysis**, McGraw Hill Book Company New York 1963. (Chapter 9, Art 46 to 51. Chapter 10, Art 52 to 59, Chapter 11, Art 61 to 62, Appendix ONE)
2. Limaye B. V., (1996) **Functional Analysis**, second editions, New Age International (P), Ltd., Publishers. (chapter 6 Art 21 to 24, Appendix A)
3. B. Chaudhary and Sudarshan Nanda, **Functional Analysis with applications**, Wiley-Eastern.
4. Bachman G and Narici L, **Functional Analysis**, Academic Press.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C301.1	Know how functional analysis uses and unifies idea from vector spaces	2
C301.2	apply fundamental theorem from theory of normed and Banach space	3
C301.3	Understand and apply from theory of Hilbert spaces to others areas	2

	MT - 302: Numerical Analysis	Lecture
	Course Objectives: • To know concept of Numerical Method to solve systems of solutions. • To study interpolations, numerical and differential methods for solving problems in allied fields of mathematics. • To get the ability to solve differential equations with the techniques in numerical methods.	
Unit 1	Solution of Algebraic and Transcendental Equations: Bisection Method, Iteration Method, Method of False Position, Newton-Raphson Method, Ramanujan's Method, Muller's Method.	**12 L**
Unit 2	Interpolation: Errors in Polynomial Interpolation, Finite Differences, Detection of Errors by use of Difference Tables, Differences of a Polynomial, Newton's formulae for Interpolation, Central Difference, Interpolation with unevenly spaced points, Divided differences.	**12 L**
Unit 3	Numerical Differentiation and Integration: Numerical Differentiation, Maximum and Minimum values of a Tabulated Function, Numerical Integration.	**12 L**
Unit 4	Matrices and Linear systems of Equations: Basic Definitions, Solution of Linear Systems - Direct Methods, Solution of Linear Systems - Iterative Methods, Eigenvalue Problem.	**12L**
Unit 5	Numerical Solutions of Ordinary Differential Equations: Solution by Taylor's Series, Picard's Method of successive approximations, Euler's Method, Runge - Kutta methods, Predictor Corrector methods.	**12 L**

Suggested readings:

1. S. S. Sastry, (2004) **Introductory Methods of Numerical Analysis**, Prentice Hall of India Private Ltd. {Chapter 2, Art. 2.1-2.7, Chapter 3, Art. 3.1-3.7, 3.9, 3.11,Chapter 5, Art. 5.1 -5.4, {Chapter 6, Art.6.1-6.5, Chapter 7, Art. 7.1 - 7.6}.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain: Numerical **methods for Scientific and Engineering Computation**, New Age international Publishers.
3. V.N. Vedamurthy and N.Ch.S.N. Iyengar: **Numerical methods**, Vikash Publishing House.
4. C. Gerald and O. Wheatley: **Applied Numerical Analysis**, Addison Publishing company.
5. E. Balagurswamy: **Numerical Methods**, Tata McGraw-Hill.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C302.1	Acquire techniques of numerical methods	**2**
C302.2	Solve system of equations with the help of numerical techniques	**3**
C302.3	Find solutions of differential equations numerically	**3**

	MT - 303: Topics in Field Theory	Lecture
	Course Objectives: • To give knowledge of extensions on fields. • To study Galois Theory, Perfect fields of finite fields. • To acquire knowledge about Roots of unity, solvability of polynomials by radicals and constructability of geometrical figures	
Unit 1	**Algebraic Extensions of Fields:** Field Extension, Algebraic Extension, Minimal Polynomial, Finite Fields, Finite Extension	**12 L**
Unit 2	**Splitting Field and Irreducible Polynomial:** Algebraic closure, algebraically closed fields, Simple Extension, Splitting field, Irreducible polynomials and Eisenstein criterion, multiple roots, F-isomorphism.	**12 L**
Unit 3	**Normal and Separable Extensions:** Normal extension, Separable and Inseparable extensions, Perfect fields of finite fields. Purely Inseparable Extension.	**12 L**
Unit 4	**Galois Extensions:** Galois extensions, Galois Group, Fixed Field, Fundamental theorem of Galois theory, Fundamental theorem of Algebra.	**12 L**
Unit 5	**Solvability by Radicals:** Roots of unity, Cyclic Extension, Solvability by radicals, Geometric construction, Transcendental extensions, Transcendental base.	**12 L**

Suggested readings:

1. N.S. Gopalakrishnan, (2003) **University Algebra**, New Age International (P), Ltd., Publishers. (Chapter-4: Art.-4.1 to 4.9.)
2. P. B. Bhattacharyya, S. K. Jain and S. R. Nagpaul, **Basic Abstract Algebra**, Cambridge University Press, Second Edition.
3. N. Jacobson, (2012) **Basic Algebra I**, Second Edition, Hindustan Publishing Corporation.
4. M. Nagata, (1997) **Field Theory**, Marcel-Dekker Inc.
5. I. S. Luthar, I. B. S. Passi, (2004) **Algebra**, Vol. 4, Field Theory, Narosa Publishing House
6. T. A. Hungerford, Algebra, Graduate Texts in Mathematics, Vol. 73, Springer Verlag.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.1	Understand extensions on fields, Eisenstein criterion, reducible and irreducible polynomials, algebraically closed field.	**2**
C303.2	understanding fundamentals of Normal extensions, Separable and Inseparable extensions.	**2**
C303.3	understand the applicability of Galois theory and Roots of Unity, Solve the problems on solvability by radicals, basic knowledge of Transcendental extensions	**2**

	MT - 304: Fluid Dynamics	Lecture
	Course Objectives: • Create a base to understand the motion of fluid. • Develop various techniques to solve the problems of fluid flow. • Benefit at advanced studies in the various fields of fluid motion.	
Unit 1	**Kinematics:** Introduction to some identities, formulae & theorems in vector calculus, Properties of fluids, Types of fluids, Types of flows, Eulerian & Lagrangian Methods, Real fluids & Ideal fluids, Velocity of a fluid at a point, Streamlines & Pathlines, The velocity potential, Velocity vector, Local and Particle Rates of Change, The equation of Continuity, Acceleration of fluid, Conditions at a rigid Boundary, General Analysis of Fluid Motion.	**12L**
Unit 2	**Equation of Motion:** Pressure at a point in a fluid at rest, Pressure at a point in a moving fluid, Conditions at a boundary of two Inviscid Immiscible fluids, Euler's equation of motion, Bernoulli's equation, Discussion of the case of steady motion under conservative body forces, some potential theorems, some flows involving axial symmetry, Some special two-dimensional flows, Impulsive motion, Some further aspects of vertex motion.	**12 L**
Unit 3	**Three Dimensional Flows:** Introduction, Sources, Sinks, Doublets, Images in a Rigid infinite plane, Images in Solid spheres, Axi-symmetric flows, Stokes's Stream function, Some special forms of the stream function for Axi-symmetric irrotational motions.	**12 L**
Unit 4	**Two Dimensional Flows:** Meaning of two-dimensional flow, Use of cylindrical polar coordinates, Stream function, Complex potential for two dimensional irrotational incompressible flow, Complex velocity potentials for standard Two-dimensional flows-uniform stream, line sources & line sinks, line doublets, line vortices, Two-dimensional image systems, Milne-Thomson circle theorem-Applications, extension of circle theorem, Theorem of Blasius.	**12 L**
Unit 5	**Viscous Flow:** Stress components in a Real fluid, Relations between cartesian components of stress, Translation motion of fluid element, The rate of strain quadric and principal stresses, Some properties of the rate of strain quadric, Stress analysis in fluid motion, Relations between stress and rate of strain, Coefficient of viscosity& Laminar flow, The Navier-Stokes equation of motion of a viscous fluid, Some solvable problems in viscous flow, Steady viscous flow.	**12 L**

Suggested readings:

1. F. Chorlton, Textbook of Fluid Dynamics, CBS Publisher. Ch (1): 1.1-1.20; Ch (2): 2.1-2.11; Ch (3): 3.1-3.12; Ch (4): 4.1-4.5; Ch (5): 5.1-5.9; Ch (8): 8.1-8.11.
2. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press.
3. R. W. Fox, A. T. McDonald, P. J. Pritchard, Introduction to Fluid Mechanics, Sixth Edition, John Wiley & Sons.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C304.1	understand the concept of fluid & their types, lines to study of fluid flow.	2
C304.2	understand the equation of motion of fluid.	2
C304.3	understand the information regarding three-dimensional flows.	2
C304.4	understand the concept of two-dimensional flows.	2
C304.5	understand various models in viscous flows.	2

M.Sc. Part II Semester III (Mathematics): Elective Course (Select only one)

	MT 305-Statistical Techniques	Lecture
	Course Objectives: • To aware student about statistical concepts like mean, mode, median, regression, correlation, • To aware students about application of statistical techniques, sampling and distributions. • Students are expected to learn mathematical methods for Statistics, Mathematical Statistics, core Statistical Methods as per the syllabi provided by UGC or suggested by NET/SET.	
Unit 1	Revision of Basic concepts: Discrete and Continuous series, Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode.Range, Quartile deviation, Mean deviation, Standard deviation, Variance and coefficient of variation, Probability: Sample space, discrete probability, Mathematical theory of probability, independent events, Addition and Multiplication theorems of probability.	**12 L**
Unit 2	Conditional probability and Baye's theorem, Theoretical distributions: Random variable, probability distribution of a discrete and continuous random variable. Probability density function, mathematical expectation. Binomial, Poisson and Normal distributions and their properties.	**12 L**
Unit 3	Correlation: Definition, meaning, scatter diagram method, Karl Pearson's method, Probable error, Standard error and Rank correlation and concurrent deviations. Regression: Definition, meaning, two lines of regression, regression coefficients, standard error and relation between correlation and regression.	**12 L**
Unit 4	Sampling and Large sample tests: Introduction to sampling, Simple random sampling, stratified sampling and systematic sampling. Testing of hypothesis, level of significance, tests of significance for large samples. Tests for single proportion, difference of proportion, single mean, difference of means, difference of S.D.	**12 L**
Unit 5	Exact sampling distributions: Chi-Square variate and Chi-Square distribution, conditions of validity of Chi-Square test, applications of Chi-square distribution, Chi –Square test for population variance, Chi-square test for Goodness of fit and Independence of Attributes. Definition of student's 't' distribution and derivation, Fisher's 't' distribution constants of t-distribution, graph of t-distribution, application, test for single mean, test for difference of means, paired t-test testing significance of observed sample. Definition of F statistic, F-distribution, applications, F-test for equality of population variances	**12 L**

Suggested readings:

1. E.J. Dudewicz and S.N. Mishra (1988), Modern Mathematical Statistics, John Willey & Sons.
2. Erwin Kreyszig (1970) Introductory Mathematical Statistics, Willey International Ltd.
3. J.K. Goyal and J.N. Sharma (2014) Mathematical Statistics, Krushna Prakashan.
4. S.C. Gupta and V.K. Kapoor (2001): Mathematical Statistics, Sultan Chand & Co-New Delhi.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
MT 305.1	Upon successful completion of this course : 1. Students will understand Basic concepts : Discrete and Continuous series, Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode. Range, Quartile deviation, Mean deviation, Standard deviation, Variance and coefficient of variation. 4. Correlation: Definition, meaning, scatter diagram method, Karl Pearson's method, Probable error, Standard error and Rank correlation and concurrent deviations.	2
MT 305.2	Solving examples based on Sample space, discrete probability, Mathematical theory of probability, independent events, Addition and Multiplication theorems of probability, conditional probability and Baye's theorem.	2
MT 305.3	Making applications Theoretical distributions: Random variable, probability distribution of a discrete and continuous random variable.Probability density function, mathematical expectation.Binomial, Poisson and Normal distributions and their properties.	3
MT 305.4	Analzing statistical data to study Correlation, scatter diagram method, Karl Pearson's method, Probable error, Standard error and Rank correlation and concurrent deviations.	4

M.Sc. Part II Semester III (Mathematics): Elective Course (Select only one)

	MT-306: Lattice Theory	Lectures
	Course Objectives: • This course is mainly introduced for the students to understand Lattice Theory and to some extents Boolean algebras. • The syllabus of Lattice Theory discusses Modular lattice, Distribute Lattice, Boolean Lattices and Characterization theorem, Dedekind characterization, stone algebra. • The last units discuss standard and neutral elements, semi modular lattice and modular pairs.	
Unit I	Two Definitions of Lattices: Introduction to Posets, Duality principle, Semi-lattice, How to Describe Lattices: Join and Meet table, Covering, Some Algebraic Concepts: Homomorphism, sublattice, Lattice ideal, Congruence relations, Congruence lattice, The homomorphism theorem, Product of lattices, complete lattices, ideal lattice.	**10 L**
Unit-II	Polynomials. Identities and Inequalities, n-ry polynomial, lattice inequality, preservation of identities, Special Element: relatively complemented lattice, S(L), pseudocomplemnted semillatice, join and meet irreducible elements.	**14 L**
Unit- III	Distributive lattice, Stone, Nachbin, Hashimato theorem, Congruence Relations, Distributive Lattices with Pseudocomplementation: S(L) and D(L) and properties.	**12 L**
Unit- IV	Distributive, Standard and Neutral Elements, Distributive, Standard and Neutral Ideals, Structure Theorems	**12 L**
Unit- V	Semimodular lattices, isomorphism theorem and Modular pairs.	**12 L**

Suggested Readings:

- George Gratzer, (1978) **General Lattice Theory**, Academic press, New York. (Chapter 1: Sections 1, 2, 3, 4, 6, Chapter 2: Sections 3 , 6 Chapter 3: Section 2,3,4 Chapter 4: Section 2)
- Birkhoff G., (1968) **Lattice Theory**, Amer. Math. Soc., Colloq. Publ., New York, 1968
- Crawley P. and Dilworth R.P. (1973) **Algebraic theory of lattices**, Prentice-Hall, Englewood Cliffs, N.J.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C306.1	Understand Lattice and Lattice as an algebraic structures	**2**
C306.2	Explain Homomorphism between two Lattices, Boolean algebra	**2**
C306.3	understand neutral elements, structure theorem	**2**

AC-301(A): Computer Skills (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): • To inculcate different daily useful computer skills among students.		
Unit 1	**Elements of Information Technology** 1.1 Information Types: Text, Audio, Video, and Image, storage formats 1.2 Components: Operating System, Hardware and Software, firmware 1.3 Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector,smart boards 1.4 Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics	2 L
Unit 2	**Office Automation-Text Processing** 2.1 Views: Normal View, Web Layout View, Print Layout View, Outline View, ReadingLayout View 2.2 Working with Files: Create New Documents, Open Existing Documents, SaveDocuments to different formats, Rename Documents, Close Documents 2.3 Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text,Spelling and Grammar, paragraphs, indentation, margins 2.4 Lists: Bulleted and Numbered Lists, 2.5 Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Moveand Resize Tables, Moving the order of the column and/or rows inside a table, TableProperties 2.6 Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents, 2.7 Paragraph Formatting, Paragraph Attributes, Non-printing characters 2.8 Types of document files: RTF, PDF, DOCX etc.	5 L
Unit 3	**Office Automation-Worksheet Data Processing** 3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets, 3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells 3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells 3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts	5 L
Unit 4	**Office Automation- Presentation Techniques and slide shows** 4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation,Open an Existing Presentation, PowerPoint screen, Screen Layout 4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template,Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder orText box properties, Bulleted and numbered lists, Adding notes 4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replacefonts, Line spacing, Change case, Spelling check,	6 L

	Spelling options 4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing rowwidth, Adding a row/column, Deleting a row/column, Combining cells ,Splitting a cell,Adding color to cells, To align text vertically in cells, To change table borders,Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slideanimation/transitions.	
Unit 5	**Internet & Applications:** 5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing theInternet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers,Uniform resource locator 5.2 Internet Resources: Email, Parts of email, 5.3 Protecting the computer: Password protection, Viruses, Virus protection software,Updating the software, Scanning files, Net banking precautions. 5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, linkedin, orkut, online booking services 5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing 5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW(open course wares): Sakshat(NPTEL) portal, MIT courseware	**4 L**
Unit 6	**Cloud Computing Basics** 6.1 Introduction to cloud computing 6.2 Cloud computing models: SAS, AAS, PAS 6.3 Examples of SAS, AAS, PAS (DropBox, Google Drive, Google Docs, Office 365 Prezi, etc.)	**3 L**

Suggested readings:

1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & BartlettLearning, 2010, ISBN: 1449609821, 9781449609825
2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: CengageLearning, 2010, ISBN: 0538472464, 9780538472463
3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5,Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552
4. Cloud computing online resources

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	**2**
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	**3**

AC-301(B): Cyber Security (Technology + Value added Audit course; Practical; 2 Credits) (Optional: Campus + Program level)		
Course Objectives (CObs): • To make students aware of different daily useful cyber security skills/rules.		
Unit 1	Networking Concepts Overview Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet	3 h
Unit 2	Security Concepts Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	7 h
Unit 3	Security Threats and vulnerabilities Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes	7 h
Unit 4	Cryptography Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure	5 h
Unit 5	System & Network Security System Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax Security.	3 h
Unit 6	OS Security OS Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	2 h
Unit 7	Security Laws and Standards Security laws genesis, International Scenario, Security Audit, IT Act 2000 and its amendments.	3 h

Suggested readings:

1. Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon
2. BPB Publication, "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore , Aatif Jamshed
3. Create Space Independent Publishing Platform, "Cyber Security Basics", Don Franke, ISBN-13: 978-1522952190ISBN-10: 1522952195
4. Online references

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	3
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	2

AC-301(C): Typesetting with Latex

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- Acquire proficiency in basic typesetting of Latex
- Demonstrate the use of Latex for Latter, Bio-data typing,
- Be familiar with Research paper, article and Book typing with cross referencing and bibliography.

Unit 1	The Basics: Simple typesetting, Fonts, Typesize, The Document, Document class, Page style, Page numbering, Formatting lengths, Parts of a document, Dividing the document . Table of contents, Index and Glossary:	**07 L**
Unit 2	Table of contents, Index, Glossary, Displayed Text, borrowed words, Poetry in typesetting, making lists, Rows and Columns, Keeping tabs, Tables..	**08 L**
Unit 3	Typesetting Mathematics: The basics, Custom commands, More on mathematics, Mathematics miscellany, New operators, The many faces of mathematics, Symbols. Typesetting Theorems: Theorems in L ATEX, Designer theorems, The amsthm package,	**08 L**
Unit 4	Housekeeping. Several Kinds of Boxes: LR boxes, Paragraph boxes, Paragraph boxes with specific height, Nested boxes, Rule boxes Floats: The figure environment, The table environment. Cross References in LATEX. Pointing to a page—the package varioref, Pointing outside— the package, Footnotes, Margin pars, and Endnotes: Footnotes, Marginal notes, Endnotes. Bibliography.	**07 L**

Suggested readings:

1. E. Krishnan and G. S. Krishna, (2003), **Latex Tutorials —A Primer,** Indian TEX Users Group Floor III, SJP Buildings, Cotton Hills Trivandrum 695014, India.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301C.1	Acquire skill of mathematical typing Using Latex	**2**
AC301C.2	Write communication letters, mathematical note, research articles using Latex typesetting	**3**
AC301C.3	Type Books, Research thesis with figure, cross referencing and Bibliography	**5**

M.Sc. Part II Semester III (Mathematics) : Audit Courses

AC-301(D): Project on Topics in Mathematics

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- Develop skills to understand and analyze recent topics in Mathematics
- Make aware the students for research in Mathematics
- Make a project work on the knowledge acquired on the topic of interest

1	Choice of topics for project work	04 L
2	Collection of the materials such as books, references, website printouts etc	04 L
3	Analysis of the collected material in an uniform manner	10 L
4	Discussion and guidance from teacher or available expert of the field	04 L
5	Writing articles, research paper etc after finalization of the content	--
6	Preparation of the content of the project	04 L
7	Typing and Binding of the project work	04 L

Suggested readings: (**Sample projects/lists can be found on the following links**)

1. https://eduprojecttopics.com/product-category/mathematics/
2. https://scholarworks.boisestate.edu/math_gradproj/
3. https://uniprojectmaterials.com/mathematics/project-topics-materials-for-final-year-students

5.https://www.monash.edu/__data/assets/pdf_file/0009/2085399/MTH3000_Projects.pdf

6.https://www.uhd.edu/academics/sciences/mathematics-statistics/PublishingImages/Pages/ms-index/MathStatistics-SeniorProject.pdf

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301D.1	Analyze material available at different sources	4
AC301D.2	Write articles/research notes/review on particular topic of interest	3
AC301D.3	develop research skills	3

	MT-401: Linear Integral Equations	Lecture
	Course Objectives: The aim of this course is • To provide adequate knowledge of fundamentals of Fredholm, Volterra and singular integral equations • To understand different methods for finding the solutions of Fredholm, Volterra and singular integral equations. • To motivate students, how to solve problems on differential and integral equations using Laplace and Fourier transforms.	
Unit 1	Definition and classification of linear integral equations, Fredholm integral equation with separable kernel, Singular integral equations, Integro-differential equations, Homogeneous Fredholm equations and eigenfunctions.	**12 L**
Unit 2	Solutions of Fredholm integral equations by: Successive approximations Method, Successive substitution Method, Adomian decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties.	**12 L**
Unit 3	Solutions of Volterra integral equations: Successive approximations method, Neumann series, Successive substitution Method. Solution of Volterra integral equations by Adomian decomposition method, and the modified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels,	**12 L**
Unit 4	Applications of Laplace and Fourier transforms to solutions of Volterra integral equations, Symmetric Kernels: Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, expansion in eigenfunctions and bilinear form. Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations,	**12 L**
Unit 5	Operator method in the theory of integral equations, Solution of Volterra and Fredholm integrodifferential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems.	**12 L**

Suggested readings:

1. R. P. Kanwal, (1971) Linear Integral Equation- Theory and Technique: Academic Press.
2. Abdul-Majid Wazwaz,(2011) Linear and Nonlinear Integral Equations-Methods and Applications: Springer.
3. L. G. Chambers,(1976) Integral Equations- A Short Course: International Text Book Company.
4. M. A, Krasnov, et.al. (1971) Problems and exercises in Integral equations: Mir Publishers.
5. J. A. Cochran, (1972) The Analysis of Linear Integral Equations: McGraw Hill Pub..
6. 6. C. D. Green, (1969) Integral Equation Methods: Thomas Nelson and sons.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C401.1	Know the relation between differential and integral equations, and how to change from one to another.	2
C401.2	Understand different kinds of kernels and use techniques for solving problems on each kind.	2
C401.3	Use Laplace transform, Fourier transform for solving a wide range of differential and integral equations.	3

	MT-402: Operations Research	Lecture
	Course Objectives: • to introduce the theory of PERT and CPM • to understand the Queuing Models and decision theory • to acquire knowledge of replacement and Inventory models model for solving problems related to industry.	
Unit 1	PERT AND CPM: Introduction, Phases of project management, Network diagrams, Fulkerson's rule, slack, forward pass, backward pass, critical path, project duration, various floats, tabular form, differences between PERT and CPM, Project cost and crashing the Network.	**12 L**
Unit 2	Queuing Models: Introduction, application of Queuing models, characteristics, arrival and service distribution, Kendall's notation for Queuing models, Single channel queuing theory, M/M/I model and generalization, M/M/I:SIRO/model, M/M/1: FCFS/N/Finite queue length model, M/M/1:FCFS/n/N Limited source model, M/M/C:FCFS/ / Multichannel queuing theory model.	**12 L**
Unit 3	Decision theory: Steps involved in Decision theory, decision making under uncertainty, Minimax, Maximin, Maximax, Hurwitz and Laplace criteria. Decision making under risk, Expected monetary value and Expected opportunity loss criteria and EVPI, Decision trees.	**12 L**
Unit 4	Replacement Models: Introduction, Replacement of Items that deteriorate with time with no changes in money value, with change in value of money, replacement of items that fail suddenly, individual replacement policy, group replacement policy and staffing problems.	**12 L**
Unit 5	Inventory Models: Necessity and maintenance of Inventory, inventory costs, inventory control problems, inventory models with deterministic demand, with probabilistic demand, with price breaks, multi-item deterministic models, forecasting of demand, forecasting methods, seasonal demand, when to order, safety stock and how much to order.	**12 L**

Suggested readings:

1. V. K. Kapur: Quantitative Techniques for Management, Sultan Chand & Co. New Delhi.
2. P. K. Gupta and D.S. Hira: Operations Research, Sultan Chand & Co., New Delhi.
3. Taha, Operations Research: An introduction, Macmillan publishing Co.
4. Vohra N D, Quantitative techniques in management, Tata Mc-Graw Hill.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.1	analyze the results and propose solutions to the decision-making processes in Management and Engineering.	**4**
C402.2	describe mathematical tools needed to evaluate decision problems	**3**
C402.3	develop technical knowledge for replacement and inventory models to solve problem arises in allied fields.	**4**

	MT - 403: Commutative Algebra	Lecture
	Course Objectives: • To know concept of sequence of modules and R-module homomorphisms, Tensor products. • To study ring extensions. • To know the concepts of integral extensions and valuation domain.	
Unit 1	**Projective Modules:** Exact sequences, Projective modules, Finitely generated modules, Shanuel's lemma, Tensor product, Tensor product w. r. t. exact sequences, flat modules, Faithfully flat modules.	**15 L**
Unit 2	**Localisation:** Jacobson radical, Nakayama lemma, multiplicatively closed set, Localisation, Localisation and exact sequence, localisation and tensor product.	**10 L**
Unit 3	**Ideal and Chain conditions in modules:** Extension and Contraction of ideals, Artinian modules, Structure theorem of Artinian rings.	**10 L**
Unit 4	**Integral extensions:** Integral elements, Integral closure, Integral extensions, Going up theorem, Integrally closed domain, Going down theorem	**15 L**
Unit 5	**Valuation rings:** Valuation rings, Ordered group, valuation on a field, Discrete valuation rings, Dedekind domain.	**10 L**

Suggested readings:

1. Gopalakrishnan N. S. (2016), **Commutative Algebra**, Universities Press (India) Pvt. Ltd. (Chapter- I: Art.-1.2 to 1.4, Chapter-II: Art.- 2.2 to 2.3, Chapter-III: Art.- 3.1 to 3.3, Chapter-IV: Art.-4.1 to 4.3, Chapter-V: Art- 5.1 to 5.3).
2. Atiyah M. F. and Donald Mac (2007), **Introduction to Commutative Algebra**, Sarat Book House.
3. Eisenbud David (1995), **Commutative Algebra with a view toward Algebraic Geometry,** Springer Verlag, New York.
4. Jacobson N. (1980), **Basic Algebra Vol.-I & II**, Hindustan Publishing Corporation (India).
5. Zarski O. and Samuel P. (1975), **Commutative Algebra**, Springer.
6. Rowen L. (1988), **Ring theory Vol.-I & II**, Academic Press.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.1	Understand the concept of exact sequences, projective and flat modules.	**2**
C403.2	Explain the concepts of Artinian module and Artinian rings.	**2**
C403.3	Learn the Valuation rings and Discrete valuation rings.	**2**

M.Sc. Part II Semester IV (Mathematics): Elective Course

	MT - 404: Advanced Abstract Algebra	Lecture
	Course Objectives: • To introduce nil radical of an ideal of a ring and semiprime ideal. • to introduce Jacobson radical and prime radical of a ring. • To introduce the direct sum of rings and study more results on Noetherian rings.	
Unit 1	Basic concepts of maximal ideals, prime ideals and nil radical .of an ideal, semiprime ideal and primary ideals.	**12 L**
Unit 2	Minimal prime ideals, Prime avoidance theorem, Jacobson radical of a ring, semisimple ring and prime radical of a ring.	**12 L**
Unit 3	Quasi-regular element, J-radical, J-semisimple ring, regular ring.	**12 L**
Unit 4	Direct sum of rings, subdirectly reducible and irreducible rings.	**12 L**
Unit 5	Noetherian ring, irreducible ideals, irrdundant primary representation, Cohen's theorem and Krull intersection theorem.	**12 L**

Suggested readings:

1. D. M. Burton, (1970) **A first course in ring and ideals**, Addison-Wisley Publishing Company Inc.
   Chapter-V: Art.-5.1 to 5.16, Chapter-VIII: Art.- 8.1 to 8.21, Chapter-IX: Art.-9.4 to 9.6, Chapter-X: Art- 10.1 to 10.6, Chapter-XII: Art.-12.1 to 12.11.
2. N. Jacobson, (1980) **Basic Algebra Vol- I & II**, Hindustan Publishing Corporation, India.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C404.1	Know the different types of ideals and their importance	**2**
C404.2	Know Jacobson radical and prime radical of a ring with the relative concepts	**2**
C404.3	Know the direct sum of rings and some advanced results on Noetherian rings	**2**

	MT 405 Algebraic Topology	Lecture
	• To know the concept of Geometric complexes and simplicial homology. • To study simplicial approximations. • To know the homotopic paths and fundamental group.	
Unit 1	Geometric complexes, polyhedron, orientation of Geometric complexes.	**10 L**
Unit 2	Chains, Cycles, Boundaries, Homology groups, Examples and structure of homology groups, The Euler-Poincare theorem, Euler's theorem, Pseudo manifolds, Fundamental group of S_n.	**15 L**
Unit 3	Simplicial approximation, Induced homomorphism on the homology groups, The Brouwer's fixed point theorem.	**15 L**
Unit 4	Homotopic paths and Fundamental groups, Covering homotopy property for S_1, Examples of Fundamental groups	**10 L**
Unit 5	Relation between first homology group and fundamental group.	**10 L**

Suggested readings:

1. F.H. Croom, (1978) **Basic Concepts of Algebraic Topology**, Springer under graduate text. (Chapter-I: Art- 1.1 to 1.4, Chapter-II: Art-2.1 to 2.5, Chapter-III: Art-3.1 to 3.4, and Chapter-IV: Art-4.1 to 4.4.)
2. Satya Deo, (2003) **Algebraic Topology**-A primer, Hindustan Book Agency,.
3. B. K. Lahiri, (2005) **A First Course in Algebraic Topology**, Second Edition, Alpha Science Intl Ltd.
4. E. H. Spanier, (1994) **Algebraic Topology, Third Edition**, Springer Verlag New York Inc.
5. I .M. Singer & J.A. Thorpe, (1976) **Lecture Notes on Elementary Topology and Differential Geometry**, Springer Verlag New York.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C405.1	Understand the fundamental concepts and methods in algebraic topology.	**2**
C405.1	Explain the well known theorems: The Euler-Poincare theorem, Euler's theorem, Brouwer's fixed point theorem.	**2**
C405.1	Learn the relation between first homology group and fundamental group.	**2**

	MT – 406: Theory of Special Functions	Lecture
	Course Objectives: 1. To analyze properties of special functions by their integral representations and symmetries. 2. To determine properties of Legendre polynomials, Rodrigue's formula, Generating function and Fourier Legendre's serieswhich may be solved by application of special functions. 3. To determine properties of solution of Bessel's differential equation and Bessel's functions, Bessel's function of first kind and second kind, Orthogonality of Bessel's functions, The Hypergeometric Functions. 4. Study of Hypergeometric series, Euler's Integral Representation, the Hypergeometric equation, the Barnes Integral for the Hypergeometric function	
Unit I	The Gamma & Beta Functions: The Gamma and Beta integrals, Functions and their properties, The Euler Reflection formula, Riemann Zeta functions, Gauss's multiplication formula for $\Gamma(mx)$, Integral representation for Log $\Gamma(mx)$, The Bohr-Mollerup theorem.	**12 L**
Unit II	Legendre Polynomials: Solution of Legendre differential equation and Legendre polynomials, Rodrigue's formula, Generating function, Recurrence relations,	**12 L**
Unit III	Orthogonal and orthonormal functions, Orthogonal property of Legendre's polynomials, Fourier Legendre's series.	**12 L**
Unit IV	Bessel's Functions: Solution of Bessel's differential equation and Bessel's functions, Bessel's function of first kind and second kind, Orthogonality of Bessel's functions, Fourier Bessel's series.	**12 L**
Unit V	The Hypergeometric Functions: The Hypergeometric series, Euler's Integral Representation, the Hypergeometric equation, the Barnes Integral for the Hypergeometric function.	**12 L**

Suggested Readings:

1. George E. Andrews, Richard Askey, Ranjana Roy, (2010) **Special Functions**, Cambridge University Press. {Chapter 1; 1.1, 1.2, 1.3, 1.5, 1.6, 1.9, Chapter 2; 2.1,2.2, 2.3, 2.4}
2. R. K. Jain and S. R. K. Iyengar, (2008) **Advanced Engineering Mathematics**, Narosa Publishing House, New Delhi. {Chapter 7;7.1, 7.2, Chapter 7; 7.4, 7.5,
3. Mark A. Pinsky, (1991) **Partial Differential Equations and Boundary Value Problem with Applications**, McGraw - Hill, Ins. {Chapter 4; 4.2, Chapter 3; 3.2}
4. Earl D. Rainville, (1960) **Special Functions**, Chelsea Publishing Company, New York, (1960).
5. H. M. Srivastava, **A Treatise, On Generating Functions**, John Wiley & Sons, New York.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C406.1	list the basic concept of integral calculus and special functions of various engineering problem and to know the application of some basic mathematical methods via all these special functions.	2
C406.2	Explain the applications and the usefulness of these special functions.	2
C406.3	Justify the use of gamma function, beta function special functions, Hypergeometric function and Hypergeometric series to: evaluate different types of integral calculus problems and solve differential equations	3

	MT – 406: Cryptography	Lecture
	Course Objectives: • to know how pure mathematics like Finite Fields and Number Theory are used to secure our daily online communication. • Acquire knowledge of different cryptosystems and their mathematical settings	
Unit 1	**Introduction to Cryptography**: Classifications of Cryptography along with few applications of Cryptography in day-to-day activities, Purpose of Cryptography, Basic Terminology, Applications of Modern Algebra and Number Theory in Cryptography **Classical Ciphers**: Some Simple Ciphers - Ceaser Cipher, Shift Cipher, Affine Cipher, Substitution Ciphers with examples, Transposition Ciphers with examples **Cryptanalysis of Classical Ciphers:** Cryptanalysis of Affine Ciphers, Cryptanalysis of Substitution Ciphers, Cryptanalysis of Vigenere Cipher and Cryptanalysis of the Hill Cipher **Shannon's Theory, Perfect Secrecy, and the One-Time Pad:** Perfect Secrecy, Entropy, Properties of Entropy, Spurious Keys and Unicity Distance	08 L
Unit 2	**Mathematical Background for Cryptography:** Algorithm to produce an irreducible polynomial of degree n over $\mathbb{F}$. Modular exponentiation by the repeated squaring, Primality Testing, Probabilistic Algorithms, The Pseudo-prime Test, The Miller-Rabin Test, The Agrawal-Kayal-Saxena (AKS) Algorithm, Primitive Roots,	08 L
Unit 3	**Symmetric (Private) Key Ciphers:** **Block Ciphers**: Feistel Structure — Balanced and Unbalanced, DES Cipher, Substitution-Permutation Network, AES Cipher, Applications of finite fields in designing AES S-box, Modes of Operation **Pseudo-Random Bit Generator (PRBG)**: Random bit generators, Pseudo-random bit generators, Statistical tests, Cryptographically secure pseudorandom bit generation **Stream Ciphers**: Feedback shift registers, Stream ciphers based on LFSRs, Salsa20/20 and ChaCha20 stream ciphers	14 L
Unit 4	**Cryptographic Hash Functions:** Definition and examples of hash functions, Definition of cryptographic hash functions, Properties of cryptographic hash functions, design principle of commonly used cryptographic hash functions **SHA-1, SHA-2 Family:** Detailed discussion of SHA-1 algorithm, Detailed	06 L

	discussion of SHA-256 algorithm. Brief description of SHA-224, SHA-384 and SHA-512 algorithms **SHA-3 and Applications:** Brief description of SHA-3 competition, Keccak Algorithm, SHA-3 standardization, Applications of cryptographic hash functions	
Unit 5	**Asymmetric (Public) Key Ciphers:** **Introduction to Public Key Cryptography:** Trapdoor one-way function, Introduction to Non-secret encryption **Diffie-Hellman Key Exchange and RSA:** Description of Diffie-Hellman (DH) key exchange protocol, RSA cryptosystem with examples, Integer factorization, Attack on RSA cryptosystem **ElGamal Cryptosystem:** Discrete logarithm problem (DLP), ElGamal cryptosystem with examples, algorithm to solve DLP **Elliptic Curve Cryptography:** Elliptic Curves over the Reals, Elliptic Curves Modulo a Prime, Elliptic Curves over Finite Fields, Properties of Elliptic Curves, ElGamal Cryptosystems on Elliptic Curves. **Signature Schemes:** RSA Signature Scheme, Security Requirements for Signature Schemes, The ElGamal Signature Scheme and its variants, Security of the ElGamal Signature Scheme	**12 L**

Suggested readings:

1. Douglas R. Stinson and Maura B. Paterson,(2019) ***Cryptography Theory and Practice***, CRC Press, Fourth Edition.
2. Hans Delfs and Helmut Knebl,(2015) ***Introduction to Cryptography — Principles and Applications***, Springer, Third Edition.
3. Chuck Easttom, (2016) ***Modern Cryptography — Applied Mathematics for Encryption for Encryption and Information Security***, McGraw-Hill Education, 2016
4. Jonathan Katz and Yehuda Lindell, (2021) ***Introduction to Modern Cryptography***, CRC Press, Third Edition.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C407.1	explain symmetric and Asymmetric cryptography	2
C407.2	see how Finite Fields and Number Theory are used to design modern cryptosystems for securing our online communication	3
C407.3	explain how digital signature is used in place of handwritten signature on a document	3

	AC-401(A): Human Rights **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional:)**	
	Course Objectives (CObs): • To make students aware about human rights and human values.	
Unit 1	**Introduction to Human Rights** 1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties	**6 L**
Unit 2	**Human Rights in India** 2.1 Meaning and Significance of **:** 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies. 2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights 2.4: National Human Rights Commission	**8 L**
Unit 3	**Human Values** 3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values	**8 L**
Unit 4	**Status of Social and Economically Disadvantaged people and their rights** 4.1: Rights of women and children in the context of Social status 4.2: The Minorities and Human Rights 4.3: Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society	**8 L**
Suggested readings: 1. Human rights education – YCMOU, Nasik 2. Value education – SCERT, Pune 3. Human rights reference handbook – Lucille whare		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	**3**
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	**5**

	AC-401(B): Current Affairs (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional:)		
	Course Objectives (CObs): • To make students updated about current affairs of India and world.		
	Title	**Content**	**Hours**
Unit 1	Politics & Economy	• National & International Political Activity, Organization. • Economy & Business, Corporate world	**08 L**
Unit 2	Awards and recognitions	• National & International Awards and recognitions • Books and authors	**07 L**
Unit 3	Science & Technology	• Software, Automobile, Space Research • New inventions and discoveries	**07 L**
Unit 4	Environment & Sports	• Summit & conference, Ecology & Climate, Organization. • National & International Games, Olympics, commonwealth etc.	**08 L**

Suggested readings (Use recent years' data and current literature):

1. India 2019, by Publications Division Government of India
2. Manorama Year Book by Philip Mathew,
3. India 2019, Rajiv Maharshi
4. Quick General Knowledge 2018 with Current Affairs Update, Disha Experts
5. General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	**5**
AC401B.2	Summarize current affairs regularly.	**6**

M.Sc. Part II Semester IV (Mathematics): Audit Courses

AC-401(C): Review and Seminar of Research Papers in Mathematics		
(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)		
Course Objectives (CObs): • Develop presentation skills for particular topic of interest among the students • Students will acquire analytical thinking on the topic of interest		
Unit 1	Algebra, Semiring Theory, Commutative Algebra, Linear Algebra, Field Theory, Graph theory, Metric spaces, Fixed point theory, Topology, Lie Algebra, Number Theory etc	--
Unit 2	Analysis, Complex Analysis, Differential Equations, Numerical Analysis, Functional Analysis, Integral Equations, Fractional Differential Equations, Integral and Transform Theory etc	--
Unit 3	Mechanics, Fluid Dynamics, Classical Mechanics, Computational Fluid Mechanics, Fuzzy Mathematics, Coding theory, Cryptography etc	--
Unit 4	At least 02 seminars by students on their review done in above topics etc	--
Suggested readings: • **Research papers, Articles, Books, Monographs, recommended websites etc**		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401C.1	Prepare own notes for presentation	3
AC201C.2	Cultivate research skill	5
AC401C.3	Think analytically	3

AC-401(D): Vedic Mathematics

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- To enhance computation skills among the students.
- Improve clarity on mathematical concepts.
- Develop analytical thinking through Vedic Mathematics.

Unit 1	Actual Applications of the Vedic Sutras, Arithmetical Computations, Multiplication, Practical Application (compound multiplication), Practice and Proportion, Division by the Nikhilam method, Division by the Parevartpa method, Argumental Division, Factorization (of simple quadratics), Factorization (of harder quadratics), Factorization of Cubics etc., Highest Common Factor.	
Unit 2	Simple Equations (First Principles), Simple Equations (by Sunyam etc.), Merger Type of Easy Simple Equations, Extension method, Complex Mergers, Simultaneous Simple Equations, Miscellaneous (Simple) Equations, Quadratic Equations, Cubic Equations, Bi-quadratic Equations, Multiple Simultaneous Equations, Simultaneous Quadratic Equations.	
Unit 3	Factorization & Differential Calculus, Partial Fractions, Integration by Partial Fractions, The Vedic Numerical Code, Recurring Decimals, Straight Division, Auxiliary Fractions, Divisibility & Simple Osculators, Divisibility & Complex Multiplex Osculators, Sum & Difference of Squares	
Unit 4	Elementary Squaring, Cubing etc. Straight Squaring, Vargamula (square root), Cube Roots of Exact Cubes, Cube Roots (General), Pythagoras Theorem etc., Apollonius' Theorem, Analytical Conics.	

Suggested readings:

1. Jagadguru Shankaracharya, Sri Bharati Krisna Tirtha Maharaja,(1981), **Vedic Mathematics**, (edited by Dr. V. S. Agrawala), Motilal Banaridas, Delhi.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401D.1	recognize their hidden potential, improve their mathematical abilities	4
AC401D.2	Enhance academic performance particularly in mathematical calculations	3
AC401D.3	know the effectiveness of the Vedic mathematics techniques	2

****

Equivalence for M.Sc. (Mathematics) Courses

Old Syllabus (June 2017) (Semester pattern 60:40)		New Syllabus (June 2021) CBCS pattern (Semester pattern 60:40)	
Course code	**Paper**	**Course code**	**Paper**
Semester-1			
MT 101	Advanced Real Analysis	MT 101	Advanced Real Analysis
MT 102	Topology	MT 102	Topology
MT 103	Abstract Algebra	MT 103	Abstract Algebra
MT 104	Ordinary and Partial Differential Equations	MT 104	Partial Differential Equations
Any one of the following			
MT 105	Theory of Fuzzy sets	MT 105	Programming in C++
MT 106	Programming in C++	MT 105	Programming in C++
Semester II			
MT 201	General Measure Theory	MT 204	Classical Mechanics
MT 202	Complex Variables	MT 202	Complex Analysis
MT 203	Linear Algebra	MT 203	Linear Algebra
MT 204	Mathematical Methods	MT 205	Python Programming
Any one of the following			
MT 205	Number Theory	MT 201	Number Theory
MT 206	Classical Mechanics	MT 204	Classical Mechanics

Old Syllabus (June 2018) (Semester pattern 60:40)		New Syllabus (June 2022) CBCS pattern (Semester pattern 60:40)	
Course code	**Paper**	**Course code**	**Paper**
Semester III			
MT 301	Topics in Functional Analysis	MT 301	Topics in Functional Analysis
MT 302	Statistical Techniques	MT 305	Statistical Techniques
MT 303	Topics in Field Theory	MT 303	Topics in Field Theory
Any two of the following			
MT 304	Fluid Dynamics	MT 304	Fluid Dynamics
MT 305	Difference Equations	MT 304	Fluid Dynamics
MT 306	Theory of Lattices	MT 306	Theory of Lattices
MT 307	Elements of Graph Theory	MT 407	Cryptography
Semester-IV			
MT 401	Advanced Mathematical Methods	MT 406	Theory of Special Functions
MT 402	Operations Research	MT 402	Operations Research
MT 403	Commutative Algebra	MT 403	Commutative Algebra
Any two of the following			
MT 404	Advanced Abstract Algebra	MT 404	Advanced Abstract Algebra
MT 405	Advanced Numerical Methods	MT 302	Numerical Analysis
MT 406	Algebraic Topology	MT 405	Algebraic Topology
MT 407	Linear Integral Equations	MT 401	Linear Integral Equations