Curriculum Book

and

Assessment and Evaluation Scheme

Based on

Outcome Based Education (OBE)

and

Choice-Based Credit System(CBCS)

in

M.Sc. Mathematics Program

2Year Degree Program

Revised as on 01 August 2023
Applicable w.e.f. Academic Session 2023-24

AKS University

Satna 485001, Madhya Pradesh, India

Faculty of Basic Science
Department of Mathematics

AKS University

Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
(Revised as on 01 August 2023)

CONTENTS

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AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

(Revised as on 01 August 2023)

Forwarding

I am thrilled to observe the updated curriculum of the Department of Mathematics for M.Sc. Mathematics Program, which seamlessly integrates the most recent technological advancements and adheres to the guidelines set forth by UGC. The revised curriculum also thoughtfully incorporates the directives of NEP-2020 and the Sustainable Development Goals.

The alignment of course outcomes(COs), Programme Outcome (POs) and Programme specific outcomes(PSOs) has been intricately executed, aligning perfectly with the requisites of NEP-2020 and NAAC standards. I hold the belief that this revised syllabus will significantly enhance the skills and employability of our students.

With immense satisfaction, I hereby present the revised curriculum for the *M.Sc. Mathematics* program for implementation in the upcoming session.

ER. Anant Soni
Pro Chancellor & Chairman
AKS University, Satna

01 August 2023

AKS University

Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
(Revised as on 01 August 2023)

From the Desk of the Vice-Chancellor

AKSUniversityiscurrentlyundergoingaprocesstorevampitscurriculumintoanoutcome-based approach, with the aim of enhancing the teaching and learning process. The foundation of quality of quality education lies in the implementation of a curriculum that aligns with both societal and industrial needs, focusing on relevant outcomes. This entails dedicated and inspired

Hence, it is of utmost importance to begin this endeavor by crafting an outcome-based curriculum in collaboration with academia and industry experts. This curriculum design should be informed by the latest technological advancements, market demands, the guidelines outlined in the National Education Policy (NEP) of 2020, and sustainable goals.

I'm delighted to learn that the revised curriculum has been meticulously crafted by the Mathematics Department, in consultation with an array of experts from the different universities of the mathematics research institutes and academia. This curriculum effectively integrates the principles outlined in the NEP-2020 guidelines, as well as sustainable goals. It also adeptly incorporates the latest advancements in the area of Mathematic.

Our University is known for conducting its academic programmes and examinations as per schedule. The credit based semester system at the postgraduate level and the choice based credit system for the two year (four semesters) Master's degree programme are working well.

To enhance student's skills, the curriculum integrates the research skills, research and progress. This well-rounded approach ensures that students receive a comprehensive education, fostering their skill development and preparing them for success in the field of Mathematics.

I am confident that the updated curriculum for Mathematics will not only enhance students' technical skills but also contribute significantly to their employability. During the process of revising the curriculum, I am pleased to observe that the mathematics department has diligently adhered to the guidelines provided by the UGC. Additionally, they have maintained a total credit requirement of Mathematics for M.Sc. Mathematics program.

It's worth noting that curriculum revision is an ongoing and dynamic process, designed to address the continuous evolution of technological advancements and both local and global concerns. This ensures that the curriculum remains responsive and attuned to the changing landscape of education and industry.

AKS University warmly invites input and suggestions from industry experts and technocrats and Alumni students to enhance the curriculum and make it more student-centered. Your valuable insights will greatly contribute to shaping an education that best serves the needs and aspirations of our students.

AKS University, Satna
01 August 2023

Professor B. A. Chopade
Vice- Chancellor

AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

(Revised as on 01 August 2023)

Preface

As par to four commitments to ongoing enhancement, the Department of Mathematics consistently reviews and updates its M.Sc. Mathematics program curriculum every two years. Through this process, we ensure that the curriculum remains aligned with the latest technological advancements, as well as local and global industrial and social demands.

During this procedure, the existing curriculum for the M.Sc. Mathematics Program undergoes evaluation by a panel of technocrats, industry specialists, and academics. Following meticulous scrutiny, the revised curriculum has been formulated and is set to be implemented starting from August 01,2023. This implementation is contingent upon the endorsement of the curriculum by the University's Board of Studies and Governing Body.

This curriculum closely adheres to the UGC model syllabus distributed in May 2023. It seamlessly integrates the guide lines set forth by the Ministry of Higher Education, Government of India, through NEP- 2020, as well as the principles of Sustainable Development Goals. In order to foster the holistic skill development of students, a range of practical activities, including Hands-On Training, Project planning and execution, Report Writing, Seminars, and Industrial On-Job Training, have been incorporated. Furthermore, in alignment with UGC's directives, the total credit all allocation on for the M.Sc. Mathematics program is capped at 87 credits.

This curriculum is enriched with course components in alignment with UGC guidelines, encompassing various disciplines such as ,Core Program Courses : 60 credits, Program Elective Courses: 04 credits, Open Electives: 04 credits, Research Courses :19 credits.

To ensure a comprehensive learning experience, detailed evaluations schemes and rubrics have also been meticulously provided.

For each course, a thorough mapping of Course Outcomes, Program Outcomes and Programme Specific Out comes has been undertaken. As the courses syllabus is being meticulously developed, various elements such as session outcomes, laboratory instruction, classroom instruction, self-learning activities, assignments, and mini projects are meticulously outlined.

We hold the belief that this dynamic curriculum will undoubtedly enhance independent thinking, skills, and overall employability of the students.

Dr. R.S. Nigam
Dean, Faculty of Basic Science
AKS University, Satna

01August2023

AKS University

Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
(Revised as on 01 August 2023)

Introduction

The Department of Mathematics was established in the academic year 2017. Department of Mathematics is a diverse and vibrant academic unit, of AKS University, consisting of expertise in Mathematics that offers a wide variety of courses and degree options in Pure Mathematics and Applied Mathematics at the Bachelors, Masters, and Ph.D. levels. Department of Mathematics is engaged in outstanding research in Pure and Applied Mathematics.

The department provides opportunities for the students to choose their careers in education and research in various fields of Mathematics. Department has striven to set high standards of teaching.. Graduates of Mathematics Department are distinctively placed in reputed institutions and organizations. It has been the cherished goal of the Department to inculcate in the students a desire to excel, to demonstrate originality and to develop a sense of responsibility towards the society. Accordingly, the Department continuously reviews and monitors the curriculum of its academic programs.

Vision

Imparting the quality of Mathematics education and inculcating education of the spirit of research through innovative teaching and research methodologies.

Mission

M-1: To provide an environment where student can learn, become competent users of Mathematics and understand the use of Mathematics in other disciplines.

M-2: To produce post graduate students with strong foundation to join research or to serve industry.

M-3: To provide the best possible facilities for our students, particularly in the area of computer facilities, library facilities and administrative support.

M-4: To strive by introducing the students to main ideas and methods of Mathematics for building up their reasoning and analytical skills.

Program Educational Outcomes (PEOs)

The Postgraduate students will:
PEO-1: Have significant opportunities in various service domains at National and International levels like banking, insurance, government jobs, consultancy, teaching, defence, industry, research and entrepreneurial pursuit.
PEO-2: Achieve peer recognition as an individual or as a team member having specialized knowledge and expertise to investigate, formulate, analyze and implement on the problems of pure, applied and computational mathematics to compete at global level.
PEO-3: Have leadership quality to handle all kind of circumstances in diversities by providing interdisciplinary and multidisciplinary learning environment.

PEO-4: Have continuous learning attitude to adopt new skills and techniques to overcome the problems related with new technologies.

PEO-5: Inculcate value system while working in a team assigned with a important targets they will contribute through their critical thinking and mathematical competence holding the ethical values.

Program Outcomes (Pos)

Students will:

1. **Advanced Mathematical Knowledge:** Students will: Graduates gain a comprehensive understanding of various branches of pure mathematics, including algebra, analysis, topology, geometry, number theory, and logic.

2. Problem-solving Skills: They develop advanced problem-solving skills, essential for various fields like finance, engineering, and data analysis and the ability to tackle complex mathematical problems using logical reasoning and critical thinking.

3. Research Abilities: Many pursue a Ph.D. after their M.Sc. to become mathematicians or professors. This can involve conducting research, publishing papers, and teaching at universities.

4.Quantitative Analysis: Graduates are adept at quantitative analysis, which is highly sought after in fields like finance, economics, and computer science.

5. Teaching and Academia: Many pursue careers in academia as professors or researchers, contributing to the development of mathematical theories and teaching future mathematicians.

6. Theoretical Understanding: A strong foundation in mathematical theory helps students understand abstract concepts and their applications in various areas, such as physics, computer science, and finance.

7. Communication Skills: Graduates learn to effectively communicate complex mathematical ideas both in written and oral forms, essential for presenting research findings or teaching.

8.Operations Research: Mathematicians optimize processes and solve complex problems in industries such as logistics, supply chain management and manufacturing.

9. Application in Industry: Graduates might find opportunities in sectors like finance, data analysis, cryptography, or technology, where strong analytical skills and problem-solving abilities are highly valued.

10.Engineering and Technology: Mathematics is the backbone of engineering and technology fields, enabling graduates to work in areas like cryptography, robotics, and computer graphics.

11.Government and Public Sector: Mathematicians are employed in government agencies for statistical analysis, policy development, and research.

12. Consulting: Mathematicians often work as consultants, providing expertise in problem-solving and quantitative analysis to various industries.

Program Specific Outcomes (PSOs)

Students will:

PSO-1: Understand the mathematical concepts and applications in the field of algebra, analysis, computational techniques, optimization, differential equations, engineering, finance and actuarial science.

PSO-2: Handle the advanced techniques in algebra, analysis, computational techniques, optimization, differential equations, engineering, finance and actuarial science to analyze and design algorithms solving variety of problems related to real life problems.

PSO-3: Develop necessary skills and expertise in the field of research and developments through seminar and dissertation.
PSO-4: Creates Mathematical Models.

Consistency/Mapping of PEOs with Mission of the Department

PEO	M1	M2	M3	M4
PEO-1	3	2	2	3
PEO-2	2	3	3	3
PEO-3	1	3	3	1
PEO-4	3	2	3	2
PEO-5	1	2	2	3

1: Slight (Low), 2: Moderate (Medium), 3: *Substantial (High) "-": No correlation*

GENERAL COURSE STRUCTURE & THEME

1. Definition of Credit

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit

2. **Range of Credits:**

In the light of the fact that a typical Model Two-year Post Graduate degree program in Basic Science has about 87 credits, the total number of credits proposed for the Two-year M.Sc.Mathematics is kept as considering NEP-20 and NAAC guidelines.

AKS University

Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
(Revised as on 01 August 2023)

3. Structure of PG Program in Mathematics:

The structure of PG program in Mathematics shall have essentially the following categories of courses with the breakup of credits as given:

Components of the Curriculum

(Program curriculum grouping based on course components)

Sl No	Course Component	% of total number of credits of the Program	Total number of Credits
2	Program Core (PCC)	68.97	60
3	Program Electives (PEC)	4.59	4
4	Open Electives (OEC)	4.59	4
5	Project(s) (PRC)/ On job Plant Training (OJT) and seminar	21.84	19
	Total	100.00	87

General Course Structure and Credit Distribution

Curriculum of M.Sc. Mathematics

Semester -I		**Semester - II**	
Course Title	Credit	Course Title	Credit
1. Advanced Abstract Algebra-I	3:1:0=4	1. Advanced Abstract Algebra-II	3:1:0=4
2. Real Analysis-I	3:1:0=4	2. Real Analysis-II	3:1:0=4
3.Topology	3:1:0=4	3.Complex Analysis-II	3:1:0=4
4.Complex Analysis-I	3:1:0=4	4.Ordinary and Partial differential Equations	3:1:0=4
5.Research Methodology	3:1:0=4	5. Advanced Discrete Mathematics	3:1:0=4
		6. Review of Literature	2:0:0=2
Total Credit	**20**	**Total Credit**	**22**
Semester -III		**Semester - IV**	
Course Title	Credit	Course Title	Credit
1.Operational Research	3:1:0=4	Analytic Number Theory	3:1:0=4
2. Integral Equation	3:1:0=4	Functional Analysis	3:1:0=4
3. Advanced Numerical Techniques	3:1:0=4	General Theory of Relativity	3:1:0=4

4. Special Function	3:1:0=4	Research Project and Seminar	10
5. Fundamentals of Computers & Programming	3:0:1=4	-	
6. Scientic writing	2:1:0=3	-	
Total Credit	**23**	**Total Credit**	**22**

RM: Research Methodology; Research Project: RP; T- Theory Course, P – Practical course.
1T means 1hr of teaching per week and 1P means 2hrs of teaching/practical /tutorial/lab per week for 15 weeks.

Total Credit : 87

Course code and Definition

L = Lecture
T = Tutorial
P = Practical
C = Credit
ESC = Engineering Science Courses
PEC = Professional Elective courses
OEC = Open Elective courses
IKS = Indian Knowledge System
SDGs = Sustainable Development Goals

Course level coding scheme:

Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course. Digit at hundred's place signifies the year in which course is offered. e.g.
101, 102 … etc. for first Semester.
201, 202 …. Etc. for second Semester.
301, 302 … for third Semester.
401. 402--- for Fourth Semester

Program Core Course

(Total Credit-60)

Sl.	CodeNo.	Subject	Semester	Credits
1	78MS101	Advanced Abstract Algebra-I	I	4
2	78MS102	Real Analysis-I	I	4
3	78MS103	Topology	I	4
4	78MS104	Complex Analysis-I	I	4
5	78MS201	Advanced Abstract Algebra-II	II	4
6	78MS202	Real Analysis-II	II	4
7	78MS203	Complex Analysis-II	II	4
8	78MS204	Ordinary and Partial differential Equations	II	4

9	78MS205	Advanced Discrete Mathematics	II	4
10	78MS301	Operational Research	III	4
11	78MS302	Integral Equation	III	4
12	78MS303	Advanced Numerical Techniques	III	4
13	78MS304	Special Function	III	4
14	78MS401	Analytic Number Theory	IV	4
15	78MS402	Functional Analysis	IV	4
Total Credit				**60**

Category-wise Courses

PROGRAM ELECTIVE COURSE (PEC)

(Total 01 from the Program elective subjects = 04 Credit)

Sl.	**CodeNo.**	**Subject**	**Semester**	**Credits**
1	78MS403- A	General Theory of Relativity	IV	**04**
2	78MS403- B	Jacobi polynomial and H-function	IV	04
3	78MS403-C	Advanced Mathematical Statistics	IV	04
4	78MS403-D	**Swayam/Mooc Course: (**Probability and Statistics)	IV	04
Total Credit				**04**

OPEN ELECTIVE COURSE (OEC)

(Total 01 from Open elective subjects= 04 Credits)

Sl.	CodeNo.	Subject	Semester	Credits
1	78MS305-A	Fundamentals of Computers & Programming	III	04
2	78MS305-B	Swayam/Mooc Course: (Math for Data Science)	III	04
3	78MS305-C	Swayam/Mooc Course: (Python Programming)	III	04
Total Credit				**04**

RESEARCH COURSE (RC)

(Any One Research Course from each semester = 19 Credits)

Sl.	**CodeNo.**	**Subject**	**Semester**	**Credits**
1	78MS105	Research Methodology	I	0:0:4=4
2	78MS206	Review of Literature	II	0:0: 2=2
3	78MS306-A	Scientic Writing	III	0:0:3=3
	78MS306-B	**Swayam/Mooc Course:** (Academic and Research Report Writing)	III	0:0:3=3
4	78MS451	Research Project and Seminar	IV	0:0:10=10
Total Credit				**19**

Induction Program

AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

(Revised as on 01 August 2023)

Induction program for students to be offered right at the start of the first year. It is mandatory. AKS University has design an induction program for 1st year student, details are below:

i. Physical activity
ii. Creative Arts
iii. Universal Human Values
iv. Literary
v. Proficiency Modules
vi. Lectures by Eminent People
vii. Visits to local Areas
viii. Familiarization to Dept./Branch & Innovations

Evaluation Scheme:

1. **For Theory Courses:**
   i. The weightage of Internal assessment is 50% and
   ii. End Semester Exam is 50%
   The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.
2. **For Practical Courses:**
   i. The weightage of Internal assessment is 50% and
   ii. End Semester Exam is 50%
   The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.
3. **For Summer Internship / Projects / Seminar etc.**
   Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc

Semester Wise Course Structure

Semester wise Brief of total Credits and Teaching Hours

Semester	L	T	P	Total Hour	Total Credit
Semester -I	15	5	00	20	20
Semester -II	17	5	00	22	22
Semester -III	18	5	00	23	23
Semester - IV	9	3	00	12	22
Total	59	18	00	77	87

Semester Wise Course Details

Semester – I

SN	Category	Code	Course Title	L	T	P	Total	Credit

AKS University

AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

(Revised as on 01 August 2023)

							Hour	
1	PCC	78MS101	Advanced Abstract Algebra-I	3	1	-	4	4
2	PCC	78MS102	Real Analysis-I	3	1	-	4	4
3	PCC	78MS103	Topology	3	1	-	4	4
4	PCC	78MS104	Complex Analysis-I	3	1	-	4	4
5	RC	78MS105	Research Methodology	3	1	-	4	4
			Total	15	5	-	20	20

Semester –II

S.N.	Category	Code	Course Title	L	T	P	Total H	Credits
1	PCC	78MS201	Advanced Abstract Algebra-II	3	1	-	4	4
2	PCC	78MS202	Real Analysis-II	3	1	-	4	4
3	PCC	78MS203	Complex Analysis-II	3	1	-	4	4
4	PCC	78MS204	Ordinary and Partial differential Equations	3	1		4	4
5	PCC	78MS205	Advanced Discrete Mathematics	3	1	-	4	4
6	RC	78MS206	Review of Literature	2	0	-	2	2
			Total	17	5		22	22

Semester-III

S. N.	Category	Code	Course Title	L	T	P	Total H	Credits
1	PCC	78MS301	Operational Research	3	1	-	4	4
2	PCC	78MS302	Integral Equation	3	1	-	4	4
3	PCC	78MS303	Advanced Numerical Techniques	3	1	-	4	4
4	PCC	78MS304	Special Function	3	1	-	4	4
5	**Open Elective Courses (OEC) - [Choose any one]**			3	0	1	4	4
	78MS305-A		**Electives I:** Fundamentals of Computers & Programming					

	78MS305-B	**Electives II: Swayam/Mooc Course:** (Math for Data Science)					
	78MS305-C	**Electives III: Swayam/Mooc Course:** (Python Programming)					
6	Research Courses [**Choose any one**]		3	0	-	3	3
78MS306-A		Scientific Writing					
78MS306-B		**Swayam/Mooc Course:** (Academic and Research Report Writing)					
		Total	18	4	1	23	23

Semester –IV

S.N.	Category	Code	Course Title	L	T	P	Total H	Credits
1	PCC	78MS401	Analytic Number Theory	3	1	-	4	4
2	PCC	78MS402	Functional Analysis	3	1	-	4	4
3	**Program Elective Courses(PEC)- [Choose any one]**			3	1	-	4	4
	78MS403- A		**Electives IV:** General Theory of Relativity					
	78MS403- B		**Electives V:** Jacobi polynomial and H-function					
	78MS403-C		**Electives VI:** Advanced Mathematical Statistics					
	78MS403-D		**Electives VII: Swayam/Mooc Course: (**Probability and Statistics)					
4	RC	78MS451	Research Project and Seminar					10
			Total	**9**	**3**	**-**	**12**	**22**

Total credit: 87

PCC – Program Core Courses,
PEC - Program Elective Courses
OEC - Open Elective Courses
RC -Research Course,
L – Lecture; T - Tutorial; P - Practical

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-I

Course Code:	78MS101
Course Title :	Advanced Abstract Algebra-I
Pre- requisite:	Students should have basic knowledge of group theory
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcome :

CO1-78MS101.1 Understand the importance of algebraic properties with regard to working within various number systems.

CO2-78MS101.2. Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.

CO3-78MS101.3. Students will determine whether a given binary operation on the given set gives algebraic structure by applying the axioms of Ring.

CO4-78MS101.4 Connecting ring theory to other areas of mathematics or applications in computer science, physics, or cryptography.

CO5-78MS101.5 Students will create the concept of a group action to real life problems such as Counting.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS101	Advanced Abstract Algebra-I	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS101	Advanced Abstract Algebra-I	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS101.1

Understand the importance of algebraic properties with regard to working within various number systems.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Approximate Hours

Item	AppX Hrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Group. **SO1.2** Understand the relationships between abstract algebraic structures with familiar numbers systems such as the integers and real numbers **SO1.3** Understand the relation between order of group and all its possible subgroups. **So1.4** Understand the hypothesis of Cauchy's Theorem **So1.5** Understand the concept of Mapping.	-	**Unit-1.0** Group-I: 1.1 Introduction of Group and properties of group 1.2 Implimentation of Cyclic group 1.3 Centre of a group 1.4 Tutirial -I 1.5 Normal subgroup 1.6 Quotient group 1.7 Class Equation 1.8 Composition series, Normal and subnormal series, 1.9 Jorden-Holder theorem 1.10 Tutirial -II 1.11Homomorphism of Group 1.12 Isomorphism of a group 1.13 Theorems on Mappings	**SL.1** Understand the concept of Set theory. **SL.2** Decide whether a given group is cyclic, and given a finite cyclic group. **SL.3** Understand to Find a generator for a subgroup of a given order.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between abstract algebraic structures with familiar numbers systems such as the Set of natural numbers, Set of rational numbers, Set of integers, Set of real numbers, Set of complex numbers.

ii. Application of group theory in real life.

iii. Derivation of Cauchy's Theorem for finite groups.

iv. Mapping defined on groups

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS101.2

Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the relationships between operations and mapping. **SO2.2** Learn about structure preserving maps between groups and their consequences. **SO2.3** Understand the concept of Composition series **SO2.4** Understand the Uses of Composition series in Jordan-Holder theorem **SO2.5**		**Unit-2.0** Group II: 2.1 Permutation groups 2.2 Composition series 2.3 Normal and subnormal series 2.4 Jordan-Holder theorem 2.5 Tutirial -I 2.6 Introduction of Ring 27 Unit element, Zero devisors 2.8 Elementary properties of Ring 2.9 Tutirial -II 2.10 Theorems on Ring 2.11 Nilpotent element	**SL.1** Verify relationships between operations satisfying various properties. **SL.2** Present concepts of the relationships between operations satisfying various properties **SL.3** Knowledge of polynomial and its degree

Understand the Relation of Ring and Various polynomials		2.12 Polynomial Ring in one and several variables.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between algebraic structures of ring with familiar numbers systems.
ii. Application of Ring group theory in real life.
iii. Permutation group.
iv. Mapping defined on Rings.
V. Polynomial Ring

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test

CO3-78MS101.3

Students will determine whether a given binary operation on the given set gives algebraic structure by applying the axioms of Ring.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the relationships between operations and mapping. **SO3.2** Structural Understanding: Exploring rings and subrings helps		**Unit-3.0 Ring** 3.1 SubRings : Definition,Properties 3.2 Quotent ring 3.3 Fundamental theorem on ring	**SL.1** Understand the concept of Mapping. **SL.2** Understand

mathematicians understand the underlying structure of mathematical objects, providing insight into their properties and behaviors. **SO3.3** Algebraic Properties: Understand the Rings and subrings properties, which help in studying algebraic properties such as factorization, divisibility, and solution of equations within these structures.		3.4 Ideals in quotent ring 3.5 Tutorial-I 3.6 Ring Homomorphism and Ring Isomorphism 3.7 Kernel of Homomorphism 3.8 Theorems on Ideals 3.9 Relation between Ring and Ideal 3.10 Tutorial-II 3.11 Theorems on Rings 3.12 Application of Ring in Real life.	the structure of kernel of Mapping

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between algebraic structures of ring with familiar numbers systems.
ii. Application of Ring group theory in real life.
iii. Permutation group.
iv. Mapping defined on Rings.
V. Polynomial Ring

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS101.4

Connecting ring theory to other areas of mathematics or applications in computer science, physics, or cryptography.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the examples of integral domains, exploring the properties that define them. **SO4.2** Understand the demonstration of, how they differ from other types of rings. **SO4.3** Understand The Difference between Integral domain and Field		**Unit-4.0 Integral domain and Field** 4.1 Integral domain : Definition and properties 4.2 Proof of the Properties Integral domain 4.3 Theorems on Integral Domain 4.4 Tutorial-I 4.5 Establish the relationship between Ring and Integral Domain 4.6 Field: Definition and properties 4.7 Proof of the Properties of Field 4.8 Establish the relationship between Ring and Field 4.9 Tutorial-II 4.10 Theorems on field 4.11 Theorems on Relation between Integral domain and Field 4.12 Implimentation of the conceptes in number system	**SL.1** Verify relationships between operations satisfying various properties. **SL.2** Basic properties of Ring with properties

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between algebraic structures of ring with familiar numbers systems.
ii. Application of Ring group theory in real life.
iii. Permutation group.
iv. Mapping defined on Rings.
V. Polynomial Ring

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS101.5

Students will create the concept of a group action to real life problems such as Counting.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Approximate Hours

Item	AppX Hrs
Cl	11
LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the concept of left and right ideal **SO5.2** Understand the relationships between quotent ring and Ideal. **SO5.3** Understand the relationships between ring and Ideal		**Unit-5.0 Ideals** 5.1 Ideals : Left and right ideals 5.2 Relation between Ideals and ring 5.3 Quotient Ring 5.4Relation between Ideal and Quotient Ring 5.5 prime ideals 5.6 Generator of Basic properties of ideals 5.7 Maximal ideas 5.8 Algebra of ideals 5.9 Ideals in quotent ring 5.10 PID (Principal Ideal Domain) 5.11 Tutorial	**SL.1** Verify relationships between operations satisfying various properties. **SL.2** understand the criteria to be a subring. **SL.3** Basic properties of Quotient ring .

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS101.1 Understand the importance of algebraic properties with regard to working within various number systems.	13	1	1	15
CO1-78MS101.2 Determine whether a given binary operation on the given set gives a group structure by applying the	12	1	1	14

axioms.				
CO1-78MS101.3 Students will determine whether a given binary operation on the given set gives algebraic structure by applying the axioms of Ring.	12	1	1	14
CO1-78MS101.4 Compute the expression of permutation groups by using permutation multiplication.	12	1	1	14
CO1-78MS101.5 Create the concept of a group action to real life problems such as Counting.	11	1	1	13
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	Group-I	05	03	02	10
CO-2	Group-II	05	03	02	10
CO-3	Ring	05	03	02	10
CO-4	Integral Domain and Field	05	04	01	10
CO-5	Ideals	05	04	01	10
Total		**25**	**17**	**08**	**50**

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6. Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Advanced Abstract Algebra	Dr.H.K.Pathak	Shree Sahitya Siksha Prakashan, Meerut.	------------------
2	Contemporary Abstract Algebra	J. A. Gallian	Narosa Publishing house, New Delhi	4th edition, 2009
3	Abstract Algebra,	D. S. Dummit & R. M.,Foote	John Wiley & Sons, Indian reprint, New Delhi	3rd edition, 2011
4	Basic Abstract Algebra	P.B. Bhattacharya , S.K.Jain &S.R. Nagpaul	Cambridge University press	--------------
5	Basic Algebra,Vol.	N.Jacosan	Hindustan Publishing Company	----------

	I,II & VIII			

b) Reference Book:

S. No.	Title	Author	Publisher	Edition & Year
1	Abstract Algebra	I.N. Herstein:, Macmillan	ISBN-10: 0471368792	3rd Edition, 1996
2	Topics in Algebra, John Wiley and Sons	I.N. Herstein	ISBN-10: 0471010901	2nd Edition,1975
3	An Introduction to Ring Theory	P.M. Cohn	Springer Undergraduate Series, ISBN-10: 1852332069	2001
4	Topics in Algebra	Herstein, I. N.	John Wiley & Sons, Indian reprint, New Delhi	2nd edition, 2006
5	A First Course in Abstract Algebra	Fraleigh, J. B.	Pearson Education India, New Delhi	7th edition, 2008

c) Suggetsed Digital Platform Web links :

Suggested Digital Platforms Web links:	https://epgp.inflibnet.ac.in https://www.highereducation.mp.gov.in/?page=xhzlQmpZwkylQo2b%2Fy5G7w%3D%3D http://www.bhojvirtualuniversity.com
Suggested Equivalent online courses:	https://nptel.ac.in/courses/111/106/111106137/ https://nptel.ac.in/courses/111/105/111105112/ https://ugemoocs.inflibnet.ac.in/index.php/courses/view ug/32

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Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics

Course Code : 78MS101

Course Title: Advanced Abstract Algebra-I

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Proble m-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-**78MS101.1** Understand the importance of algebraic properties with regard to working within various number systems.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3
CO2-78MS101.2. Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2
CO3-78MS101.3. Students will determine whether a given binary operation on the given set gives algebraic structure by applying the axioms of Ring.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO4-78MS101.4 Connecting ring theory to other areas of mathematics or applications in computer science, physics, or cryptography.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO5-78MS101.5 Students will create the concept of a group action to real life problems such as Counting.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-**78MS101.1** Understand the importance of algebraic properties with regard to working within various number systems.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5	-	Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12,1.13	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO2-78MS101.2. Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 1.11,1.12	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO3-78MS101.3. Students will be able to describe all elements in a cyclic subgroup by using generators.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 1.11,1.12	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO4- 78MS101.4 Connecting ring theory to other areas of mathematics or applications in computer science, physics, or cryptography.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 1.11,1.12	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO5-78MS101.5 Students will create the concept of a group action to real life problems such as Counting.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 1.11	SL5.1 SL5.2 SL5.3

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-I

Course Code:	78MS102
Course Title :	Real Analysis-I
Pre- requisite:	Students should have basic knowledge of and deep understanding of the theory of the functions of real variables and Riemann-Stieltjes Integral
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

CO1-78MS102.1 Understand the importance of properties of Riemann-Stieltjes integrals.

CO2-78MS102.2 Determine the Rearrangements of terms of a series.

CO3-78MS102.3 Demonstrate an understanding of the theory of sequence and Students will be able to describe all elements in Uniform Convergence of Sequence.

CO4-78MS102.4 Define and recognize the series and Students will compute the expression of Linear transformations.

CO5-78MS102.5 Students will create the concept of a Differential forms,Stoke's theoremto sequences, and series.

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS102	Real Analysis-I	4[3+1]	0	1	1	6	4

Legend:

CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

<table>
<tr><td rowspan="3">Board of Study</td><td rowspan="3">Couse Code</td><td rowspan="3">Course Title</td><td colspan="7">Scheme of Assessment (Marks)</td><td></td></tr>
<tr><td colspan="6">Progressive Assessment (PRA)</td><td>End Semester Assessment (ESA)</td><td>Total Marks (PRA+ ESA)</td></tr>
<tr><td>Class/Home Assignment 5 number 3 marks each (CA)</td><td>Class Test 2 (2 best out of 3) 10 marks each (CT)</td><td>Seminar one (SA)</td><td>Class Activity any one (CAT)</td><td>Class Attendance (AT)</td><td>Total Marks (CA+CT+SA +CAT+AT)</td><td></td><td></td></tr>
<tr><td>PCC</td><td>78MS102</td><td>Real Analysis-I</td><td>15</td><td>20</td><td>5</td><td>5</td><td>5</td><td>50</td><td>50</td><td>100</td></tr>
</table>

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

CO1-78MS102.1

Understand the importance of Understand the concept of Riemann-Stieltjes Integral

Approximate Hours

Item	AppXHrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Riemann-Stieltjes Integral**SO1.2** Understand the Properties of the Riemann Stieltjes Integral **SO1.3** Understand The fundamental theorem **SO1.4** Understand the Rectifiable Curves **SO1.5** Understand the Mean value theorem		**Unit-1.0** **1.1** Introduction of Riemann-Stieltjes Integral, **1.2** Some theorems on Riemann-Stieltjes Integral, **1.3** Riemann-Stieltjes Integral,as limit of sum **1.4** Some classes of Riemann-Stieltjesfunction. **1.5** Properties of the Riemann-Stieltjes Integral, **1.6** Integration **1.7** differentiation, **1.8** The fundamental theorem of calculus **1.9** Tutorial 1 **1.10** Mean value theorem **1.11** Integration of vector valued function **1.12** Rectifiable Curves-Introduction **1.13** Rectifiable Curves-theorems **1.14** Tutorial 2	**SL.1** Theorems on Riemann Stieltjes Integrals

SW-1 Suggested Sessional Work (SW):

a. Assignments:
i. State and prove fundamental theorem of calculus
ii. State and prove Mean Value theorem

iii. Properties of R S Integral.

iv. Theorems on Rectifiable Curve

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS102.2

determine Rearrangements of terms of a series**Approximate Hours**

Item	AppXHrs
Cl	5
LI	0
SW	1
SL	1
Total	7

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning**
SO2.1A Relation between the Riemann Integral and RS Integral, SO2.2Rearrangements of terms of a series, SO2.3Riemann's		**Unit2.0** 2.1A Relation between the Riemann Integral and Riemann stieltjes Integral, 2.2 Tutorial 1 2.3 Rearrangements of terms of a series 2.4 Tutorial 2 2.5 Riemann's theorem	**(SL.1)** Some examples on Riemann's

SW-2 Suggested Sessional Work (SW):
a. Assignments:
i. The sum of an absolute convergent series does not alter with any rearrangements of terms.
ii. State and prove Riemanns theorems

iii. some theorems on Riemanns

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS102.3

Students will be able to describe all elements in Uniform Convergence of Sequence

Approximate Hours

Item	AppXHrs
Cl	15
LI	0
SW	1
SL	1
Total	17

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the Cauchy criterion for uniform convergence SO3.2 Understand the Power series, SO3.3 Understand the Radius of Convergence SO3.4Understand the Radius of Convergence		**Unit-** **3.0** 3.1 Sequence and Series of function, 3.2 Point wise convergence in a metric space 3.3Pointwise and uniform convergence of sequence. 3.4 Cauchy criterion for uniform convergence, 3.5Test for uniform convergence 3.6 Weierstrass M-Test, 3.7 Abel's test 3.8 Direchlets test	**SL.1**Algebra of Power Series

		3.9 Uniform convergence and continuity, 3.10Weierstrass'sapproximation theorem, 3.11Power series, 3.12Uniqueness for power series, 3.13Radius of Convergence of power series, 3.14Abel's theorem, 3.15Tauber's theorem.	

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. state and prove Tauber's theorem.
ii. State and prove Weierstrass's approximation theorem
iii. State and prove Cauchy 's general principle.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS101.4

Students will compute the expression of Linear transformations

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the linear transformations SO4.2 Understand the Taylor's theorem SO4.3 Understand the Inverse function theorem		**Unit-4.0** 4.1 Linear transformation, 4.2 Derivatives in an open subset of R^n, 4.3Chain rule of Differentiation, 4.4Interchange of order of Differentiation, 4.4 Derivatives of higher order, 4.5 Taylor's theorem, 4.6 Inverse function theorem, 4.7The Implicit function theorem 4.8 Derivatives of higher order 4.9 interchange of order of differentiation 4.10 Tutorial 1 4.11 Repeated partial derivatives 4.12 Tutorial 2	**SL.1** Properties of Linear transformation

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Taylor's theorem
ii. Inverse function theorem
iii. The Implicit function theorem

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS101.5

Students will create the concept of a Differential forms ,Stoke's theorem.

Approximate Hours

Item	AppXHrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the concept of Jacobian **SO5.2** Understand the Properties of the Extremum problem **SO5.3** Understand The Differentiation of Integrals **SO5.4** Understand The Stoke's theorem		**Unit-5.0** 5.1Jacobian 5.2 Jacobian of Functions of functions 5.3 Jacobian of implicit functions, 5.4 Extremum problem with constraints, 5.5Lagrange's multiplier method, 5.6 Differentiation of Integrals 5.7Differential forms-Introduction 5.8 Elementary Properties 5.9 Basic K- forms 5.10 Product of basic K form 5.11 Tutorial 5.12Stoke's theorem-statement 5.13Stoke's theorem-Proof 5.14 Tutorial 2	**SL.1** Examples Lagrange's multiplier method.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS102.1 Understand the importance of Riemann-Stieltjes Integral .	14	1	1	16
CO1-78MS102.2 Determine the Rearrangements of terms of a series	5	1	1	7
CO1-78MS102.3 Students will be able to describe all elements in Uniform Convergence of Sequence	15	1	1	17
CO1-78MS102.4 Students will compute the expression of Linear transformations.	12	1	1	14
CO1-78MS102.5 Students will create the concept of a Differential forms,Stoke's theorem	14	1	1	16
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**					**Total Marks**
		R	**U**	**A**			
CO-1	Understand the importance of Riemann-Stieltjes Integral .	03	01	01			05
CO-2	Determine the Rearrangements of terms of a series	02	06	02			10
CO-3	Students will be able to describe all elements in Uniform Convergence of Sequence .	03	07	05			15

CO-4	Students will compute the expression of Linear transformations.	-	10	05			15
CO-5	Students will create the concept of a Differential forms,Stoke's theorem	03	02		-		05
Total		11	26		13		50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Real Analysis-I	Dr.H.K.Pathak	Shree Sahitya Siksha Prakashan, Meerut.	2018
2	Real Analysis	S. C. Malik	Willey Eastern Ltd.,ew Delhi, 1985.	
3	Real Analysis,.	N. L. Carothers,	Cambridge University Press, UK, 2000	
4	Elementary Analysis:	Kenneth A. Ross	The theory of Calculus, Springer, New York, 2004.	
5	Principles of Mathematical Analysis	Walter Rudin	3 rd Edition, McGraw – Hill International Book Company, Singapore, 1982.	

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS102
Course Title: Real Analysis-I

Course Outcome																
	PO 1	PO 2	PO3	PO4	PO5	PO 6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS102.1 Understand the importance of Understand the concept of Riemann-Stieltjes Integral .	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	
CO1-78MS102.2	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	

Determine the Rearrangements of terms of a series																
CO1-78MS102.3 Students will be able to describe all element in Uniform Convergence of Sequence.	2	3	1	1	1	1	3	2	2	1	2	2	1	2	1	
CO1-78MS102.4 Students will compute the expression of Linear transformations.	2	3	1	2	3	2	1	1	1	1	1	2	2	1	1	
CO1-78MS102.5 Students will create the concept of a Differential forms, Stoke's theorem	1	2	3	2	2	2	2	2	1	1	1	1	1	1	1	

Legend: 1 – Low, 2 – Medium, 3 – High

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS102.1** Understand the importance of properties of Riemann-Stieltjes integrals	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Riemann-Stieltjes Integral 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9. 1.10,1.11,1.12,1.13,1.14
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS102.2** Rearrangements of terms of a series	SO2.1 SO2.2 SO2.3		Unit-2 Rearrangements of term of series 2.1, 2.2, 2.3, 2.4,2.5
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS102.3** Students will be able to describe all elements in Uniform Convergence of Sequence	SO3.1 SO3.2 SO3.3 SO3.4		Unit-3 Uniform Convergence of Sequence 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10,3.11,3.12,3.13,2.14,3.15.
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS102.4** Students will compute the expression of Linear transformations	SO4.1 SO4.2 SO4.3		Unit-4 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7,4.8,4.9,4.10,4.11,4.12
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS102.5** Students will create the concept of a Differential forms, Stoke's theorem	SO5.1 SO5.2 SO5.3 SO5.4		Unit-5 5.1, 5.2, 5.3, 5.4, 5.5, 5.6,5.7,5.8,8.9,5.10,5.11,5.12,5.13,5.14

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-I

Course Title:	Topology
Course Code: -	78MS103
Prerequisite:	Students should review the fundamentals of B.Sc. class in topics of series and functions and basic knowledge of differential and integration.
Rationale:	The program aims to develop abstract and hypothetical thinking problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcomes (CO):

CO1-78MS103.1
Define and understand the concept of sets, theorems based on countable and uncountable sets, algebraicallyhypotheiss of continum ,topolocal space .Apply to know the interior , exteriorand boundary point, limit points. Continuous functions and homeomorphism.

CO2- 78MS103.2
Define and understand the basic concepts of countable spaces I and II ,lindelofftheorem,seperable space compactness and finite intersection property sequentially and countably compact set , logical compactness.connectness on real line component and locally connectness spaces

CO3- - 78MS103.3
Define and computeseperations axiomsT0,T1,T2,T3,T4and their characterstics and basic properties .lemma of uryshons and tietz extension

CO4- - 78MS103.4
Understand the definition of product compact space ,connected space, and path connectedness , path component . tychnoff product space in terma of subspace and its characterization projection map.

CO5- - 78MS103.5
Understand and state the embedding and metrization .embedding lemma and tychnoff embedding . the uryshonsmetrizationtheorem . nets and filters . topology convergence of nets ,hausdroffness and nets . compactness and nets filters and their convergence. Canonoical way of converting nets and filters and vice versa. Ultrafilter and compactness.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
PCC	**78MS103**	**Topology**	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others)
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.)
SL: Self Learning,
C:Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS103	**Topology**	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1- - 78MS103.1

Define and understand the concept of sets, theorems based on countable and uncountable sets, algebraicallyhypotheiss of continum ,topolocal space .Apply to know the interior , exterior and boundary point, limit points. Continuous functions and homeomorphism.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of sets and countable of numbers or uncountablility. **SO1.2** Understand the topological space with their properties and theorems. **SO1.3** Apply limit points , interior and exterior and boundary points. **So1.4** Understand the bases and subspace of a topological space. **So1.5** Understand the concept of	-	**Unit-1.0** 1.1.countable and uncountable sets. 1.2. cardinal number and its arithmetic. 1.3. schreoderbernstein theorem 1.4.cantor theorem and continuum hypotheis 1.5 topological space ,bases, 1.6 Tutorial-1 1.7. subspace ,neighbourhood 1.8. closure,inferior 1.9exterior ,boundary 1.10 limit points 1.11continous function and homeomorphism	**SL.1** State and prove schreoder Bernstein theorem **SL.2** Apply topological spce to find bases , closure , interior , exterior and boundary point , limit point. **SL.3** Apply theorems and problem based on continuous functions and homeomorphism and equivalence relation.

continuous and homeomorphism.		1.12 Tutorial- 2	

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. State and prove schreoder Bernstein theorem.
ii. Define topological space with their properties.
iii. Apply topological aspace and find bases , subspaces, interior point exterior points and boundary points and limit points as well as closure points.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS103.2

Define and understand the basic concepts of countable spaces I and II ,lindelofftheorem,seperable space compactness and finite intersection property sequentially and countably compact set , logical compactness.connectness on real line component and locally connectness spaces

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)

SO2.1 Define and understand the basic concepts of first and second countable space. **SO2.2** Perform seperable space and compactness and finite intersection property. **SO2.3** Understand the sequentially and countabily compact sets and logicalcompactnes s. **SO2.4** Define and separated sets connected space **SO2.5** Understand connectness on a real line.	-	**Unit-2.0** 2.1.countable space I & II 2.2. lindeloff theorem 2.3.seperable space 2.4-compactness 2.5. finite intersection property 2.6. sequentially and countabliy compact sets 2.7. logical comactness 2.8. separated sets and connected spaces. 2.9. connectness on a real line 2.10 component 2.11 locally connected space 2.12 Tutorial-1	**SL.1** Explore more advanced topics, compactness and finite intersection property **SL.2** Understand sequentially and countably compactness **SL.3** Apply connectness on a real line and locally connectned space.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the first and second countable space.
ii. Write the sequentially and countabily compact set and logically compactness.
iii. Write a short note on separated sets and connected space.
iv. Describe the method of connectness on a real line.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS103.3

Define and computeseperations axiomsT0,T1,T2,T3,T4and their characterstics and basic properties .lemma of uryshons and tietz extension

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO3.1 Define and Compute separation axioms **SO3.2** Understand the T0,T1,T3,T4 spaces **SO3.3** Apply the chain rule to compute basic properties of seperations axioms. **SO3.4** Understand mixed characterization of seperations axioms theorem **SO3.5** Identify uryshons lemma and tietz extension theorem.	-	**Unit-3.0** 3.1. separation axioms 3.2. T0 space 3.3. T1 space 3.4. T2 space 3.5. T3 space 3.6.T4 space 3.7. characterization 3.8basic properties 3.9. uryshons lemma 3.10. tietz extension theorem 3.11 theorems on seperations axioms 3.12 Tutorial-1	**SL.1** Apply seperations axioms with examples. **SL.2** Applycharactersctics and basic properties of seperationsaxioms.. **SL.3** Solve and prove uryshons lemma and tietz extension theorem.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the seperations axioms with exmples.
ii. Explain the characterization and basic properties of separation axioms.
iii. Write the uryshons lemma and tietz extension theorem.

b. Mini Project:

Oral presentation,

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS103.4

Understand the definition of product compact space ,connected space, and path connectedness , path component . tychnoff product space in terma of subspace and its characterization projection map.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Understand the definition of a product of compact space. **SO4.2** Solve and apply path connectedness and path components **SO4.3** Identify tychnoff product topology. **SO4.4** Identify The characterization map. **SO4.5** Recognize the theorem on product topology in compact and connectned space.	-	**Unit-4.0** 4.1.product of compact space 4.2connectd space 4.3.path connectedness 4.4. Path components 4.5 Tutorial-1 4.6. tychnoff product topology in terms of topological spaces. 4.7. its characterization projection map. 4.8.theorem on product space. 4.9.theorem on connected space 4.10. theorem on path connectedness 4.11theorem on path components. 4.12 Tutorial-2	**SL.1** Apply product of compact space. **SL.2** Apply path connectedness and path components. **SL.3** Analyze tychnoff product topology in terms of topological space.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

I. Explain the product space in a compact space and connectedness .

b. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS103.5

Understand and state the embedding and metrization .embedding lemma and tychnoff embedding . the uryshonsmetrizationtheorem . nets and filters . topology convergence of nets ,hausdroffness and nets . compactness and nets filters and their convergence. Canonoical way of converting nets and filters and vice versa. Ultrafilter and compactness.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the embedding and metrization. **SO4.2** Find embedding lemma and tychnoff embedding **SO4.3** Understand the uryshonsmetrization theorem **SO4.4** Interpret nets and filters **SO4.5**	-	**Unit-5.0** 5.1.Embedding and metrization 5.2. embedding lemma 5.3. tychnoff embedding 5.4 the uryshonsmetrization theorem 5.5. nets and filters 5.6 topology and convergence of nets 5.7. hausdroffness and nets 5.8 compactness and nets filtersand their convergence 5.9. canonical way of converting nets to filters and vice versa	**SL.1** Apply embedding and metrization theorem and prove. **SL.2** Use tychnoff embedding and the uryshonsmetrization theorem **SL.3** Apply nets and filters and convergence of nets and canonical way of converting nets ato filters and vice versa.

Understand convergence of nets and filters and vice versa.		5.10. ultrafilters 5.11compactness 5.12 Tutorial-1	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the short note on embedding and metrization .
ii. Write about nets and filter with their convergene and converting nets to filters and vice versa.

b. Mini Project:

Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS103.1 Define and understand the concept of sets, theorems based on countable and uncountable sets, algebraicallyhypotheiss of continum ,topolocal space .Apply to know the interior , exterior and boundary point, limit points. Continuous functions and homeomorphism	12	1	1	14
CO2-78MS103.2 Define and understand the basic concepts of countable spaces I and II ,lindelofftheorem,seperable space compactness and finite intersection property sequentially and countably compact set , logical	12	1	1	14

compactness.connectness on real line component and locally connectness spaces				
CO3-78MS103.3 Define and computeseperations axiomsT0,T1,T2,T3,T4and their characterstics and basic properties .lemma of uryshons and tietz extension	12	1	1	14
CO4-78MS103.4 Understand the definition of product compact space ,connected space, and path connectedness , path component . tychnoff product space in terma of subspace and its characterization projection map.	12	1	1	14
CO5-78MS103.5 Understand and state the embedding and metrization .embedding lemma and tychnoff embedding . the uryshonsmetrizationtheorem . nets and filters . topology convergence of nets ,hausdroffness and nets . compactness and nets filters and their convergence. Canonoical way of converting nets and filters and vice versa. Ultrafilter and compactness.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution	Total Marks

		R	U	A			
CO-1	Countable and topological space	02	04	05			07
CO-2	Compactness and connectedness	03	07	04			14
CO-3	Seperations axioms	02	06	02			10
CO-4	Product topology	03	03	02			11
CO-5	Embedding and metrizations.	03	02	02			08
Total		13	22	15			50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies
1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year

1	Topology	J. R. munkers	Prentice-hall of india	A first edition
2	Introduction to topology	G.F simmons	Tata McGraw Hill	Second editions
3	topology	James R munkers	Pearson education	2nd Edition 2006
4	general topology	J.L kelly	Springer verlag	New York 1966

Curriculum Development Team

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS103
Course Title: Topology

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1- 78MS103.1 Defineand understand the concept of sets, theorems based on countable and uncountable sets, algebraically hypotheiss of continum ,topolocal space .Apply to know the interior , exterior and boundary point, limit points. Continuous functions and homeomorphism	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3
CO2-	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2

78MS103.2 Define and understand the basic concepts of countable spaces I and II ,lindelofftheorem,seperable space compactness and finite intersection property sequentially and countably compact set , logical compactness.connectness on real line component and locally connectness spaces																
CO3-78MS103.3 Define and computeseperations axiomsT0,T1,T2,T3,T4and their characterstics and basic properties .lemma of uryshons and tietz extension	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO4-78MS103.4 Understand the definition of product compact space ,connected space, and path connectedness ,	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

path component . tychnoff product space in terma of subspace and its characterization projection map.																
CO5-78MS103.5 Understand and state the embedding and metrization embedding lemma and tychnoff embedding . the uryshonsmetrizationtheorem. nets and filters. topology convergence of nets , hausdroffness and nets. compactness and nets filters and their convergence. Canonoical way of converting nets and filters and vice versa. Ultrafilter and compactness	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS103.1** Defineand understand the concept of sets, theorems based on countable and uncountable sets, algebraically hypotheiss of continum ,topolocal space .Apply to know the interior , exterior and boundary point, limit points. Continuous functions and homeomorphism	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7, 1.8,1.9,1.10	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS103.2** Define and understand the basic concepts of countable spaces I and II ,lindelofftheorem,seperable space compactness and finite intersection property sequentially and countably compact set , logical compactness.connectness on real line component and locally connectness spaces	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS103.3** Define and computeseperations axiomsT0,T1,T2,T3,T4and their characterstics and basic properties .lemma of uryshons and tietz extension	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS103.4** Understand the definition of product compact space ,connected space, and path connectedness , path component . tychnoff product space in terma of subspace and its characterization	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL4.1 SL4.2

	projection map.				
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS103.5** Understand and state the embedding and metrization .embedding lemma and tychnoff embedding . the uryshonsmetrizationtheorem . nets and filters . topology convergence of nets , hausdroffness and nets. compactness and nets filters and their convergence. Canonoical way of converting nets and filters and vice versa. Ultrafilter and compactness.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL5.1 SL5.2 SL5.3

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-I

Course Code:	78MS104
Course Title :	Complex Analysis-I
perquisite:	Students should have basic knowledge of complex numbers
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcomes :

CO1-78MS104.1 Understand the importance of algebra of complex numbers with regard to working within various number systems.

CO2-78MS104.2. Students will determine a given function which is on the closed contour 'c' and the value of integration of this function .

CO3-78MS104.3. Students will Calculate Residues in some special cases by using Residue theorem.

CO4-78MS104.4 Students will compute the Expansion of Analytic function as power series by using Taylor and Laurent theorem.

CO5-78MS104.5 .Students will create the concept of a Mapping or Transformation and their representation

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS104	Complex analysis-I	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS104	Complex analysis-I	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS104.1

Understand the importance of algebra of complex numbers with regard to working within various number systems.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Understand the Algebra of complex numbers. **SO1.2** Understand the relationships between complex numbers structures with familiar numbers systems such as the integers and real numbers **SO1.3** Understand the concept of contur integration **So1.4** Understand the hypothesis of Cauchy's Theorem **So1.5** Understand the concept of function.	-	**Unit-1.0 The Complex Number systems, Analytic functions.** 1.1 Introduction of complex numbers 1.2 Geometric representation of complex numbers 1.3 limit, continuity and differentiability of complex function 1.4 Analytic function. 1.5 Tutorial-I 1.6 complex integration 1.7 Cauchy's Theorem. 1.8 Cauchy Gaursat theorem 1.9 Cauchy integral formula. 1.10 Cauchy integral formula for derivative of the function 1.11 Cauchy integral formula for Higher order derivatives. 1.12 Tutorial-II	**SL.1** Understand the complex numbers. **SL.2** knowledge of the difference and division between two complex numbers. **SL.3** Properties of Modulus and Argument of complex numbers.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between complex numbers structures with familiar numbers systems such as the Set of natural numbers, Set of rational numbers, Set of integers, Set of real numbers, Set of complex numbers.
ii. Geometric representation of complex numbers.

iii. State and proof cauchy Gaursat theorem.

iv. Cauchy integral formula for Higher order derivative.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS104.2

Students will determine a given function which is on the closed contour c and the value of integration of this function.

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO2.1 Understand the concept of Moderate 's theorem SO2.2 Learn about structure preserving maps between groups and their consequences. SO2.3 Understand the concept of Composition series SO2.4 Understand the Uses of Composition series in Jordan-Holder theorem SO2.5 Understand the Relation of Ring and Various polynomials		**Unit-2.0 Complex Integration:** 2.1 Morera's theorem 2.2 Cauchy's inequality 2.3 Liousville's theorem 2.4 Certain theorem on power series 2.5 Tutorial-I 2.6 Fundamental theorem of algebraic function 2.7the concept of Taylor's series 2.8 the concept of Taylor's theorem 2.9 Theorems on inequality 2.10 Expansion of analytic function as power series 2.11 the concept of Laurent theorem 2.12 Tutorial-I	**SL.1** Evaluation Elementary function of a complex variables **SL.2** Knowledge of the Analyticity of the sum function of a series **SL.3** Knowledge of some Elementary properties of complex numbers.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. State and prove Morera 's theorem.
ii. State and prove cauchy inequality.
iii. State and prove Liousville's theorem.
iv. State and prove Fundamental theorem of algebra.
V. Taylor's series.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO3-78MS104.3

Students will Calculate Residues in some special cases by using Residue theorem .

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Understand the principal of Argument SO3.2 Rouche's theorem SO3.3 the concept of Maximum Modulus principal		**Unit-3.0 principal of Argument and Rouche's theorem** 3.1 Maximum Modulus principle. 3.2 Minimum Modulus principle. 3.3 the concept of Schwartz lemma. 3.4 Laurent's series. 3.5 Tutorial –I 3.6 Meromorphic function. 3.7 The poles and zeros of a Meromorphic function . 3.8 singular and classification of singularity . 3.9 some Theorems on poles . 3.10 Inverse function theorem 3.11 The concept of Argument principle. 3.12 Tutorial –II	**SL.1** Knowledge of the poles and zeros of a Meromorphic function. **SL.2** Understand an application of Rouche's theorem.

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. The concept of Argument principle.
ii. Application of Rouche's theorem .
iii. Definition of Meromorphic function.
iv. State and prove Maximum Modulus theorem.
V. Schwarz lemma.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS104.4

Students will compute the Expansion of Analytic function as power series by using Taylor and Laurent theorem.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the concept of Residues at a singularity SO4.2 Residues at infinity SO4.3 Understand the importance of Residues theorem		**Unit -4 Residue Theory and Calculus of Residue.** 4.1 Understand the Residue. 4.2 Cauchy Residue theorem. 4.3 Evaluation of Integrals. 4.3 Branches of many valued function 4.4 Residue at infinity 4.5 Tutorial –I 4.6 The residue at a singularity. 4.7 Special reference to arg z, log z 4.8 Evaluation of definite Integrals by contour integration 4.9 some residue theorem 4.10 Residue at a simple poles 4.11 Integration round the unit circle 4.12 Tutorial –I	**SL.1** • Calculation of Residues in some special cases. • Evaluation of definite integral by contour integration.

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Evaluation of definite integral by contour integration.
ii. Application of Residues theorem.
iii. State and prove cauchy residue theorem .
iv. Calculation of residues in some special cases.
V. Evaluation of integrals.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS104.5

Students will create the concept of a Mapping or Transformation and their representation.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO5.1 Understand the concept of Mapping or Transformation. SO5.2 Product of two Bilinear Transformation. SO5.3 Conformal mapping.		**Unit-5.0 Understand the Bilinear Transformations & Conformal Mappings.** **5.1** Tthe concept of Mappings or Transformation. 5.2 Bilinear Transformation. 5.3 their properties and Classification. 5.4 Definition and Example of conformal mapping. 5.5 Tutorial -I 5.6 Space of analytic function. 5.7 Hurwitz theorem. 5.8 Montel's. theorem. 5.9 Riemann mapping. 5.10jacobian of a Transformation. 5.11 Some Elementary Transformation. 5.12 Tutorial -II	**SL.1** knowledge of the linear Transformation. **SL.2** The Representation of a conformal mapping.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS104.1 Understand the importance of algebra of complex numbers with regard to working within various number systems.	. **12**	1	1	12

CO1-78MS104.2 Students will determine a given function which is on the closed contur c ' and also find the value of integration of this function .	. **12**	1	1	12
CO3-78MS101.3 Students will Calculate Residues in some special cases by using Residue theorem .	. **12**	1	1	12
CO4-78MS101.4 Students will compute the Expansion of Analytic function as power series by using Taylor and Laurent theorem.	12	1	1	12
CO1-78MS104.5 Students will create the concept of a Mapping or Transformation and their representation.	12	1	1	12
Total Hours	60	5	5	70

- **Suggestion for End Semester Assessment**
- Suggested Specification Table For(ESA)

CO	Unit Titles	Marks Distribution			**Total Marks**
		R	**U**	**A**	

CO-1	Understand the importance of algebra of complex numbers with regard to working within various number systems.	03	01	01	05
CO-2	Students will determine a given function which is on the closed contur c ' and also find the value of integration of this function .	02	05	03	10
CO-3	Students will Calculate Residues in some special cases by using Residue theorem .	03	06	06	15
CO-4	Students will compute the Expansion of Analytic function as power series by using Taylor and Laurent theorem.	-	10	05	15
CO-5	Students will create the concept of a Mapping or Transformation and their representation.	03	02	-	05
Total		11	26	13	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Complex variables and applications	R.V.Churchill,J.W. Brown	McGraw-Hill,New York,	2nd edition, 1989
2.	Fundamentals of complex analysis	S.Ponnuswamy,	Narosa Publishing house	4th edition, 1985
3.	Theory and Problems of complex variables	Lars.V.Ahlfors,	McGraw-Hill,New York McGraw Hill book company International	Edition, Singapore,1979

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS104
Course Title: Complex Analysis-I

Course Outcome	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P O 12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1- **78MS101.1** Understand the importance of algebraic properties with regard to working within various number systems.	2	1	2	3	2	2	2	3	1	2	2	1	2	3	1	2
CO2- 78MS101.2. Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.	3	2	2	2	2	3	2	3	1	2	3	1	2	3	1	2
CO3- 78MS101.3. Students will be able to describe all elements in a cyclic subgroup by using generators.	2	3	2	2	3	2	2	1	3	1	2	2	3	2	2	2

CO4-78MS101.4 Students will compute the expression of permutation groups by using permutation multiplication.	2	3	3	2	2	3	2	1	2	3	3	3	2	1	1	2
CO5-78MS101.5 Students will create the concept of a group action to real life problems such as Counting.	2	3	3	3	2	2	2	1	2	1	2	2	3	3	2	2

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-**78MS101.1** Understand the importance of algebraic properties with regard to working within various number systems.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9,1.10	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO2-78MS101.2. Students will determine whether a given binary operation on the given set gives a group structure by applying the axioms.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO3-78MS101.3. Students will be able to describe all elements in a cyclic subgroup by using generators.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO4-78MS101.4 Students will compute the expression of permutation groups by using permutation multiplication.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO5-78MS101.5 Students will create the concept of a group action to real life problems such as Counting.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL5.1 SL5.2

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

M.Sc. **Semester-I**

Course Code:	78MS105
Course Title :	[Research Methodology]
Pre- requisite:	Among then of great importance are first, the actuality of the theme of the research; second-the choice of adequate research instruments and taxonomy to the chosen object field.
Rationale:	Think of a research rationale as a set of reasons that explain why a study is necessary and important based on its background.

Course Outcome :

CO1-78MS105.1 Students will understand research approaches.

CO2-78MS105.2 With the help of this course, students will be able to take up and implement a research project/ study.

CO3-78MS105.3. Define a research problem.

CO4-78MS105.4 The Students will develop skills in qualitative and quantitative data analysis and presentation.

CO5-78MS105.5 To teach students different techniques of research modelling, data collection,designing and planning of experiments.

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS105	Research Methodology	4[3+1]	0	1	1	6	4

Legend:

CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)

SW: Sessional Work (includes assignment, seminar, mini project etc.),

SL: Self Learning, **C:**Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment: Theory

Board of Study	Couse Code 78MS105	Course Title Research Methodology	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS105	Research Methodology	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS105.1 Students will understand research approaches.

Approximate Hours

Item	AppX Hrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of research meaning, SO1.2 Understand the research approaches SO1.3 Recognize the mathematical objects of methodology. SO1.4 Learn about research process SO1.5 Understand the criteria of good research	-	**Unit-1.0** **1.1** Introduction of Research **1.2** : Meaning, **1.3** Objectives, **1.4** Motivation **1.5** Types of Research **1.6** Research Approaches, **1.4** Significance of Research, **1.5** Research Methods 1.6 tutorial-1 **1.7** versus of Research Methodology, **1.8** Research 1.9 Scientific Method, **1.10** Importance of knowing 1.11 how research is done, **1.12** Research Process, **1.13** Criteria of good research, **1.14** Problems encountered by researchers in India.	**SL.1** Understand the concept. Research Methodology **SL.2** Understand significance of research **SL.3** Understand the concept of research process

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. explain the significance of research,
ii. write the Criteria of good research, ;
iii. write Problems encountered by researchers in India

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

78MS105.2: With the help of this course, students will be able to take up and implement a research project/ study.

Approximate Hours

Item	AppXHrs
Cl	11
SW	1
SL	1
Total	13

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO2.1 . What is a research problem **SO2.2 discuss** Selecting the problem **SO2.3** To learn about Necessity of defining the problem **SO2.4** **Explain** defining a problem		**UNIT 2** **2.1** What is a research problem **2.2** , Selecting the problem **2.3** Necessity of defining the problem **2.4** find the research problem **2.5** research problem **2.6**types of research problem **2.7** Technique involved in problem **2.8** Explain Technique 2.9 involved in problem **2.10** defining a problem **2.11** tutorial	**SL.1** Learn about research problem **SL.2** Understand the concept. Selecting the problem

SW-2 Suggested SessionalWork(SW):

a. Assignments:-

(1) Difine the research problem

(2) Understand the basics of Selecting the problem

b. MiniProject:

Power Point Presentation

c. Other Activities (Specify): Class Test.

CO3-78MS105.3. Define a research problem.

Approximate Hours

Item	AppXHrs
Cl	13
LI	0
SW	1
SL	1
Total	15

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO3.1 To Understand the Meaning of Research Design **SO3.2**To learn Research Design. **SO3.3Explain** Features of a good design **SO3.4 To** Understand different type of Research Design	.	**Unit-3** **3.1.1** Meaning of Research Design **3.2** Define Research Design **3. 3** Need for Research Design. 3.4 Need for Research Design area **3.5** Features of a good design **3.6** Important concepts of research design 3.7 relating to research design **3.8 Tutorial** **3.9** Different research designs. **3.10** Basic Principles of Experimental Designs. 3.11 Types of Experimental Designs. **3.12** good design **3.13** problem of good research design	**SL.1** To learn Research Design **SL.2** To learn Important concepts of Research Design

SW-3 SuggestedSessionalWork(SW):

a. Assignments:-

(1) Basic Features of a good design

(2) Different research designs

b. MiniProject:
Oral presentation, Poster presentation,

c.Other Activities (Specify): Class Test.

CO4-78MS105.4 The Students will develop skills in qualitative and quantitative data analysis and presentation.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO4.1 To Understand concept Central Tendency **SO4.2**To learn Measures of Relationship . **SO4.3** To understand Multiple Correlation and Regression **SO4.4**ExplainSimple Regression Analysis .		**Unit-4** **4.1**Statistics in Research **4.2** Measures of Central Tendency 4.3 Central Tendency **4.4** Measures of Dispersion **4.5** Measures of Asymmetry (Skewness) **4.6** Measures of Relationship **4.7** Simple Regression Analysis **4.8** Regression Analysis **4.9** Multiple Correlation and Regression **4.10** Regression **4.11** Partial Correlation. **4.12** Tutorial	1. Statistics in Research 2. Measures of Relationship

SW-4 **SuggestedSessionalWork(SW):**

Assignments:

(1) Partial Correlation.

(2) Simple Regression Analysis.

a. **MiniProject:**

Oral presentation, Power Point Presentation.

c.Other Activities (Specify): No

CO5-78MS105.5 To teach students different techniques of research modelling, data collection,designing and planning of experiments.

Approximate Hours

Item	AppXHrs
Cl	10
LI	0
SW	1
SL	1
Total	12

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO5.1 To understand Report Writing **SO5.2**To learn about Different steps in writing report **SO5.3** Explain Types of report .		**Unit 5** **5.1** Significance of Report Writing **5.2** Example of Report Writing 5.3 Problem define **of** Report Writing **5.4.** Different steps in writing report. **5.5** Layout of a research report **5.5** Types of report **5.6** Oral Presentation **5.6** Mechanics of writing a research report 5.7 tutorial -1 5.8 research report **5.9** Precautions for writing research reports. 5.10 writing research reports.	1. To learn about Types of report 2. Definition and examples of Report Writing

SW-5 SuggestedSessionalWork(SW):

a. **Assignments:-**

(1) Binary operation , group and sub types of group.

(2) Definition and examples of rings and field.
(3) homeomorphism and isomorphism of group.

b. MiniProject:
Oral presentation, Power Point Presentation,

c. OtherActivities(Specify):
Report writing

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS105.1 Students will Understand research approaches.	14	1	1	13
CO2-78MS105.2 With the help of this course, students will be able to take up and implement a research project/ study.	11	1	1	10
CO3-78MS105.3. Define a research problem.	13	1	1	12
CO4-78MS105.4 The Students will develop skills in qualitative and quantitative data analysis and presentation.	12	1	1	13
CO5-78MS105.5 To teach students different techniques of research modelling, data collection,designing and planning of experiments.	10	1	1	11
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**	**Total Marks**

		R	U	A			
CO-1	Research meaning	03	01	01			05
CO-2	Research problem	02	06	02			10
CO-3	Research Design	03	07	05			15
CO-4	Central Tendency	-	10	05			15
CO-5	Research report	03	02		-		05
Total		11	26		13		50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture 2. Tutorial 3. Presentation 4 . Group Discussion 5. Online sources 6 .Seminar 7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Research Methodology Methods and Techniques	C.R.Kothari	Wishwa Prakashan	Publishers Second Edition.
2	Research Methodology for Biological Sciences Abstract Algebra,	N. Gurumani	MJP Publishers	
3	Introduction to educational technology.	Sampath.K., Panneerselvam. Aand Santhanam.	New Delhi: Sterling Publishers	(2nd revised). (1984),

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS105
Course Title: Research Methodology

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Governments and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS105.1 Students will understand research approaches.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3
CO2-78MS105.2 With the help of this course, students will be able to take up and implement a research project/ study.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2
CO3-78MS105.3. Define a research problem.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO4-78MS105.4 The Students will develop skills in qualitative and quantitative data analysis and presentation.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO5-78MS105.5 To teach students different techniques of research modelling, data collection,designing and planning of experiments.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS105.1** Students will understand research approaches.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9,1.10	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS105.2** With the help of this course, students will be able to take up and implement a research project/ study.	SO1.1 SO1.2 SO1.3 SO1.4		Unit-2 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS105.3.** Define a research problem.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS105.4** The Students will develop skills in qualitative and quantitative data analysis and presentation.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS105.5** To teach students different techniques of research modelling, data collection,designing and planning of experiments.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL5.1 SL5.2 SL5.3

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-II

Course Code:	78MS201
Course Title :	Advanced Abstract Algebra-II
Pre- requisite:	Students should have basic knowledge of group theory and Mapping
Rationale:	The objective of Advanced Abstract Algebra is to deepen the understanding and explore more advanced topics in the field of abstract algebra. Abstract algebra is a branch of mathematics that studies algebraic structures such as groups, rings, fields, and modules, focusing on their properties and relationships.

Course Outcome :

78MS201.1 Determine whether a particular subset of a ring R is a subring, ideal, or radical.

78MS201.2. Prove elementary facts about subrings and ideals from the relevant definitions and other elementary facts;

78MS201.3. Prove basic relationships between subrings and ideals (e.g., all ideals are subrings but not all subrings are ideals)

78MS201.4 Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.

78MS201.5 Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS201	Advanced Abstract Algebra-II	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.)
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA + CAT+AT)		
PCC	78MS201	Advanced Abstract Algebra-II	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS201.1 Determine whether a particular subset of a ring R is a subring, ideal, or radical.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Finite Group. **SO1.2** Understand the relationships between subgroups **SO1.3** Understand the construction of composition series **So1.4** Understand the hypothesis of Cauchy's Theorem **So1.5** Understand the hypothesis of Sylow's Theorem	-	**Unit-1 Finite Groups** **1.1** Composition series **1.2** Solvable group **1.3** Theorems on Solvable group **1.4** p-Subgroup **1.5** Nilpotent group **1.6** Tutorial-I **1.7** Commutator sub-group of a group **1.8** Theorems on Commutator sub-group **1.9** Cauchy's theorem for finite abelian group **1.10** Cauchy's theorem for finite abelian group **1.11** Sylow's theorem **1.12** Tutorial-II	**SL.1** Understand the properties of group, ring, subgroup **SL.2** learn to formation of Quotient group **SL.3** Understand the concept of Improper and proper subgroups

SW-1 Suggested Sessional Work (SW):

a. Assignments:

Solvable group, Nilpotent group, commutator sub-group of a group, Cauchy's theorem, Sylow's theorem.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2- 78MS201.2
Prove elementary facts about subrings and ideals from the relevant definitions and other elementary facts

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the relationships between Ring and modules **SO2.2** Learn about properties associated with modules **SO2.3** Understand the concept of Submodule **SO2.4** Understand the concept of Quotient module **SO2.5** Understand the proof of Fundamental Theorem on Modules		**Unit-2.0 Module -I** **2.1** Introduction **2.2** Definition **2.3** Submodules **2.4** Properties of Modules **2.5** Tutorial-I **2.6** Theorems on Modules **2.7** Theorems on SubModules **2.8** Semisimple modules **2.9** Algebra of modules **2.10** Theorems on Algebra of modules **2.11** Quotient modules **2.12** Fundamental Theorem on Modules	**SL.1** learn the no. of properties of Module **SL.2** Understand the proof of elemetary properties of module

SW-2 Suggested Sessional Work (SW):
a. Assignments:
i. Module and Submodule
ii. Algebra of Module
iii. Quotient Module
iv. Mapping defined on Rings
V. Kernel of mapping

b. Other Activities (Specify):
Quiz, Class Test.

CO3- 78MS201.3
Prove basic relationships between subrings and ideals (e.g., all ideals are subrings but not all subrings are ideals)

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the concept Domain, Codomain and Range of mapping **SO3.2** Understand the concept of Range of module. **SO3.3** Understand the kernel of Homomorphism of module. **S03.4** Understand the Notherian and Artinian modules **S03.5** Understand the relation of Ring		**Unit-3.0 Module –II** **3.1** Primary Modules **3.2** Theorem on Primary Modules **3.3** Uniform modules **3.4** Theorem on Uniform modules **3.5** Domain and Codomain of modules **3.6** Mapping defined on modules **3.7** Homomorphism of modules **3.8** Isomorphism of modules	**SL.1** Understand the concept of mapping on Module. **SL.2** Understand the structure of kernel of Mapping

with Notherian and Artinian modules.		**3.9** Kernel of Homomorphism of modules **3.10** Finitely generated modules **3.11** Notherian and Artinian modules **3.12** Theorem on Notherian and Artinian modules	

SW-3 Suggested Sessional Work (SW):

a. Assignments:

b. Other Activities (Specify):
Quiz, Class Test.

CO4- 78MS201.4

Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the relation between vector space and Transformation **SO4.2** Understand the index of Nilpotent transformations **SO4.3**		**Unit-4.0 Canonical Forms** **4.1** Vector Space **4.2** Canonical Forms **4.3** Similarity of linear transformations **4.4** Invariant subspace Reduction to triangular form **4.5** Theorems on Invariant subspace **4.6** Nilpotent transformations **4.7** Index of Nilpotency **4.8** Theorems on Nilpotent	**SL.1** Vector Space **SL.2** Concept of Transformation or mapping

Understand The concept of Jordan blocks and Jordan forms		transformations **4.9** Invariants of Nilpotent transformation **4.10** Jordan blocks **4.11** Jordan forms **4.12** Theorems on Jordan forms	

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between algebraic structures of ring with familiar numbers systems.
ii. Application of Ring group theory in real life.
iii. Permutation group.
iv. Mapping defined on Rings.
V. Polynomial Ring

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS201.5

Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Understand the concept Field theory **SO5.2** Understand the		**Unit-5.0 Field theory** 5.1 Field theory 5.2 Extension field 5.3 Algebraic Extension	**SL.1** Verify relationships between vector space and its

relationships between Algebraic Extension Transcendental Extension **SO5.3** Understand the relationships between seperable and Insepearable Extension		5.4 Theorems on Algebraic Extension 5.5 Transcendental extensions 5.6 Theorems on Transcendental Extension 5.7 Seperable extension 5.8 Inseperable extension 5.9 finite field 5.10 Perfect field 5.11 Normal extension of a Field 5.12 Tutorial	subspace **SL.2** understand the degree of extension

SW-5 Suggested Sessional Work (SW):

a. Assignments:

i. Field theory

ii. Extension field theory

iii. Application of Field theory

b. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
78MS201.1 Determine whether a particular subset of a ring R is a subring, ideal, or radical.	12	1	1	14
78MS201.2. Prove elementary facts about subrings and ideals from the relevant definitions and other elementary facts.	12	1	1	14
78MS201.3. Prove basic relationships between subrings and ideals (e.g., all ideals are subrings but not all subrings are	12	1	1	14

ideals)				
78MS201.4 Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.	12	1	1	14
78MS201.5 Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	Finite Group	05	03	02	10
CO-2	Module-I	05	03	02	10
CO-3	Module-II	05	03	02	10
CO-4	Canonical form	05	04	01	10
CO-5	Field Theory	05	04	01	10
Total		**25**	**17**	**08**	**50**

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6. Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Advanced Abstract Algebra	Dr.H.K.Pathak	Shree Sahitya Siksha Prakashan, Meerut.	------------------
2	Contemporary Abstract Algebra	J. A. Gallian	Narosa Publishing house, New Delhi	4th edition, 2009
3	Abstract Algebra,	D. S. Dummit & R. M.,Foote	John Wiley & Sons, Indian reprint, New Delhi	3rd edition, 2011
4	Basic Abstract Algebra	P.B. Bhattacharya , S.K.Jain &S.R. Nagpaul	Cambridge University press	--------------
5	1. Topics in Algebra,	Herstein, I. N.,	John Wiley & Sons, Indian reprint, New Delhi	2nd edition, 2006.

b) Reference Books:

S. No.	Title	Author	Publisher	Edition & Year
1	Abstract Algebra	I.N. Herstein	Macmillan, 3rd Edition,	1996, ISBN-10:

2.	Topics in Algebra,	I.N. Herstein	John Wiley and Sons, 2nd Edition	1976, N-10: 0471010901
3.	First Course in Abstract Algebra	Fraleigh, J. B. A	7th edition (Pearson Education India, New Delhi	2008

c) Suggetsed Digital Platform Web links :

Suggested Digital Platforms Web links:	https://epgp.inflibnet.ac.in https://www.highereducation.mp.gov.in/?page=xhzlQmpZwkylQo2b%2Fy5G7w%3D%3D http://www.bhojvirtualuniversity.com
Suggested Equivalent online courses:	https://nptel.ac.in/courses/111/106/111106137/ https://nptel.ac.in/courses/111/105/111105112/ https://ugemoocs.inflibnet.ac.in/index.php/courses/view ug/32

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS201
Course Title: Advanced Abstract Algebra-II

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
78MS201.1 Determine whether a particular subset of a ring R is a subring, ideal, or radical.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3

78MS201.2 Prove elementary facts about subrings and ideals from the relevant definitions and other elementary facts	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2
78MS201.3. Prove basic relationships between subrings and ideals (e.g., all ideals are subrings but not all subrings are ideals)		3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
78MS201.4 Learn about the concept of linear independence of vectors over a field, and	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

the dimension of a vector space															
78MS201.5 Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**78MS201.1** Determine whether a particular subset of a ring R is a subring, ideal, or radical.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	SL1.1 SL1.2 SL1.3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**78MS201.2**. Prove elementary facts about subrings and ideals from the relevant definitions and other elementary facts.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10,2.11,2.12	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**78MS201.3**. Prove basic relationships between subrings and ideals (e.g., all ideals are subrings but not all subrings are ideals)	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10,3.11,3.12	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**78MS201.4** Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.	SO1.1 SO1.2 SO1.3		Unit-4 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7,4.8,4.9,4.10,4.11,4.12	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**78MS201.5** Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.	SO1.1 SO1.2 SO1.3		Unit-5 5.1, 5.2, 5.3, 5.4, 5.5, 5.6,5.7,5.8,8.9,5.10,5.11, 5.12,	SL5.1 SL5.2

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-II

Course Code:	78MS202
Course Title :	Real Analysis-II (Lebesgue Measure & Integration)
Pre- requisite:	Students should have basic knowledge of and deep understanding of the theory of the Lebesgue measure & Integration.
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

CO1-78MS202.1 Understand the importance of properties of Lebesgue outer measure and Borel measurability of sets

CO2-78MS202.2 Determine the Measurable function and Lebesgue Integral

CO3-78MS202.3 Demonstrate an understanding of the theory of Four derivatives and Lebesgue Differentiation theorem

CO4-78MS202.4 Define and recognize the series and Students will compute the expression of L^p Space and convex function .

CO5-78MS202.5 Students will create the concept of a Riesz theorem and uniform convergence.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS202	Real Analysis-II	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS202	Real Analysis-II	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS202.1 Understand the importance of properties of Lebesgue outer measure and Borel measurability of sets

Approximate Hours

Item	AppXHrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Lebesgueouter measure **SO1.2** Understand the Properties of Measurable set **SO1.3** Understand the Regularity of a measure. **SO1.4** Understand the Lebesgue Measurability of Sets, **SO1.5** Understand the Non- measurable of Sets.		**Unit-1.0** 1.1Introduction 1.2 Lebesgueouter measure 1.3 Lebesgue Measurable set. 1.4 Regularity of a measure. 1.5Borel measurability of Sets. 1.6 Borel Set – Examples 1.7 Translational Invariant 1.8Lebesgue Measurability of Sets, 1.9Non- measurable of Sets. 1.10 F σ *and* $F_\delta$sets Algebra of sets 1.11 First fundamental theorem	**SL.1** A set A is measurable iff its complement A' is measurable.

		1.12 Second fundamental theorem 1.13 Tutorial 1	

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Let E be a measurable set then any translate E+y is measurable where y is a real number furthermore m (E+y) = m(E)

ii State and prove Second fundamental form of measurable set**.**

iii If E_1 and E_2 are any measurable set then show that

$m(E_1 \cup E_2) + m(E_1 \cap E_2) = m(E_1) + m(E_2)$

iv Prove that the Intersection and Difference of two measurable sets are measurable.

V A Borel measurable set is Lebesgue measurable.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO2-78MS202.2 Determine the Measurable function and Lebesgue Integral

Approximate Hours

Item	AppXHrs
Cl	15
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.**1** Understand the		**Unit2.0**	**SL1** Some Properties of Lebesgue Measurable

concept of LebesgueMeasurable function, SO2.2 Understand the Properties of Lebesgue measurable functions. SO2.3 Understand the Integral of Non negative Measurable function. SO2.4Understand the Properties of Measurable se.		2.1Measurable function, 2.2Properties of Lebesgue measurable functions. 2.3 Integral of Non negative Measurable function. 2.4 Step function 2.5 Operations on Measurable functions 2.6 Characteristic Function of set 2.7 Integration of series 2.8 Borel measurable function 2.9 Littlewood's three principles, 2.10Fatou's lemma 2.11 Reimann andLebesgue integral. 2.12The general integral 2.13 Properties of the Lebesgue integral for bounded measurable function 2.14 Lebesgue bounded convergence theorem 2.15 Lebesgue dominated convergence theorem	function

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Operations on Measurable functions.
ii. Show that a step function is a measurable function
iii. Theorems on Measurable function
iv Show that every function defined on a set of measure zero is measurable .
v The limit of convergence sequence of measurable function is measurable

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS202.3 Demonstrate an understanding of the theory of Four derivatives and Lebesgue Differentiation theorem

Approximate Hours

Item	AppXHrs
Cl	10
LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the the four derivatives. Lebesgue SO3.2 Understand the Differentiation of an Integral SO3.3 Understand the Functions of Bounded Variation SO3.4Understand the Jordan Decomposition theorem		**Unit-3.0** 3.1 The four derivatives. - Introduction 3.2 Tutorial 1 3.3 Lebesgue Differentiation Theorem 3.4 Differentiation of an Integral-lemma 3.5 Fundamental theorem of Integral Calculus 3.6 Functions of Bounded Variation 3.7 Tutorial 2 3.8 Jordan Decomposition theorem	**SL.1** Examples of function of bounded variation

		3.9 Absolute continuous function 3.10Integral of the derivatives	

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. state and prove Jordan Decomposition theorem

ii. State and prove Lebesgue Differentiation Theorem

iii. State and prove Fundamental theorem of Integral Calculus.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO4-78MS101.4

CO4-78MS202.4 Define and recognize the series and Students will compute the expression of L^p Space and convex function .

Approximate Hours

Item	AppXHrs
CI	11
LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)

SO4.1 UnderstandTheL^p-Space SO4.2 Understand theConvex function SO4.3Understand the Holder and Minkowski's Inequalities for L^p SO4.4 Completeness of L^p-Space.		**Unit-4.0** 4.1Introduction The L^p-Space 4.2 Theorems of L^p-Space 4.3 Convex function 4.4 Theorems on Convex function 4.5 Jensen's Inequality. 4.6 Holder Inequalities for L^p-Space. 4.7Minkowski's Inequalities for L^p-Space 4.8 Completeness of L^p-Space 4.9 L^p-Space is normed linear space 4.10 Riesz-Fischer theorem 4.11 Tutorial 1	**SL.1** Some theorems of L^p-Space

SW-4 Suggested Sessional Work (SW):

a. Assignments:

(i) Jensen's Inequality.
(ii) Holder Inequalities for L^p-Space.
(iii) Minkowski's Inequalities for L^p-Space

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS202.5 Students will create the concept of a Riesz theorem and uniform convergence

Approximate Hours

Item	Appx Hrs
Cl	11
LI	0
SW	1
SL	1

Total	13

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the concept Convergence in measure **SO5.2** Understand the Riesz theorem **SO5.3** Understand Uniform Convergence **SO5.4**Understand Egoroff's theorem		**Unit-5.0** 5.1 Convergence in measure, 5.2 Riesz theorem 5.3Uniform Convergence - L^p is complete 5.4Uniform Convergence - L^∞ is complete 5.5 Almost Uniform Convergence-Example 1 5.6 Almost Uniform Convergence- Example 2 5.7 Theorems on Convergence in measure, 5.8 Test of consistency 5.9 Lebesgue integrable function on [0,1] 5.10 Egoroff's theorem 5.11 Tutorial 1	**SL.1** If <fn> is a Cauchy sequence then it has limit

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS202.1 Understand the importance of properties of Lebesgue outer measure and Borel measurability of sets	13	1	1	15
CO2-78MS202.2 Determine the Measurable function and Lebesgue Integral	15	1	1	17
CO3-78MS202.3 Demonstrate an understanding of the theory of Four derivatives and Lebesgue Differentiation theorem	10	1	1	12
CO4-78MS202.4 Define and recognize the series and Students will compute the expression of L^p Space and convex function .	11	1	1	13
CO5-78MS202.5 Students will create the concept of a Riesz theorem and uniform convergence.	11	1	1	13
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**					**Total Marks**
		R	**U**	**A**			
CO-1	Understand the importance of properties of Lebesgue outer measure and Borel measurability of sets	03	01	01			05
CO-2	Determine the Measurable function and Lebesgue Integral	02	06	02			10

CO-3	Demonstrate an understanding of the theory of Four derivatives and Lebesgue Differentiation theorem	03	07	05			15
CO-4	Define and recognize the series and Students will compute the expression of L^p Space and convex function .	-	10	05			15
CO-5	Students will create the concept of a Riesz theorem and uniform convergence.	03	02		-		05
Total		11	26		13		50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Real Analysis	Dr.H.K.Pathak	Shree Sahitya Siksha Prakashan, Meerut.	2018
2	Real Analysis	S. C. Malik	Willey Eastern Ltd.,ew Delhi, 1985.	
3	Real Analysis,.	N. L. Carothers,	Cambridge University Press, UK, 2000	
4	Elementary Analysis:	Kenneth A. Ross	The theory of Calculus, Springer, New York, 2004.	
5	Principles of Mathematical Analysis	Walter Rudin	3 rd Edition, McGraw – Hill International Book Company, Singapore, 1982.	

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code :78MS202
Course Title: Real Analysis-II

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS202.1 Understand the importance of properties of Lebesgue outer measure and Borel measurability of sets.	2	3	1	2	1	2	1	2	1	1	2	1	2	2	1	
CO1-78MS202.2 Determine the Measurable function and Lebesgue Integral	2	3	1	1	1	1	1	1	1	1	1	1	1	2	2	
CO1-78MS202.3	3	3	1	2	1	1	3	2	2	1	2	2	1	2	3	

Demonstrate an understanding of the theory of Four derivatives and Lebesgue Differentiation theorem																
CO1-78MS202.4 Define and recognize the series and Students will compute the expression of L^p Space and convex function .	2	3	1	2	3	2	3	1	1	1	1	2	2	1	1	
CO1-78MS202.5 Students will create the concept of a Riesz theorem and uniform convergence	3	2	3	1	2	1	2	3	1	1	1	1	1	1	1	

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS202.1** Understand the Lebesgue outer measure and measurable set	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Lebesgue outer measure and measurable set1.1,1.2,1.3,1.4,1.5,1.6,1.7, 1.8,1.9,1.10,1.11,1.12,1.13	SL1.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS202.2** Measurable function and Lebesgue Integral	SO2.1 SO2.2 SO2.3 So2.4		Unit-2 Measurable function and Lebesgue Integral**:**2.1, 2.2, 2.3,2.4,2.5,2.6,2.7,2.8,2.9,2.10,2.11,2.12,2.13,1.14,2.15	SL2.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS202.3** Students will be able to describe all elements in Differentiation and Integration	SO3.1 SO3.2 SO3.3 SO3.4		Unit-3 Differentiation and Integration 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7,3.8,3.9,3.10	SL3.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS202.4** Students will compute the expression The L^p-space	SO4.1 SO4.2 SO4.3 SO4.4		Unit-4 The L^p-space 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10,4.11	SL4.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS202.5** Students will create the concept of a Convergence in Measure:	SO5.1 SO5.2 SO5.3 SO5.4		Unit-5Convergence in Measure: 5.1, 5.2, 5.3, 5.4, 5.5, 5.6,5.7,5.8,5.9,5.10,5.11	SL5.1

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-II

Course Code:	78MS203
Course Title :	Complex Analysis-ll
quisite:	Students should have basic knowledge of complex numbers
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcome :

CO1-78MS203.1 This course gives more Understanding about Analysis in mathematics.

CO2-78MS203.2. Students will be equipped with the understanding of the fundamental concepts of complex variable theory and skill of contour integration.

CO3-78MS203.3. This course involved complex number properties of them,analytic function,residues fundamental theorem.

CO4-78MS203.4 With this Course students are prepared to learn about advance complex analysis.

CO5-78MS203.5 Students will Constructing mobius transformations mapping given circle to given Circle.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS203	Complex Analysis-ll	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS203	Complex Analysis-II	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including

Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes .

CO1-78MS203.1 This course gives more Understanding about Analysis in mathematics.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO1.1 Understand the concept of analytic function **SO1.2** Understand the relationships between two functions, analytic and entire functions. **SO1.3** Understand the concept of contur integration **So1.4** Understand the hypothesis of Cauchy's Theorem **So1.5** Understand the concept of function.		**Unit-1.0 The spaces of Analytic functions** 1.1 Introduction of analytic function 1.2 spaces of analytic functions. 1.3 limit, continuity and differentiability of complex function 1.4 introduction of entire function. 1.5 Tutorial –I 1.6 complex integration. 1.7 The Weierstress factorization theorem. 1.8 The Concept of Gamma function. 1.9 The Riemann zeta function. 1.10 Extension of zeta function. 1.11 Riemann s functional equations. 1.12Tutorial –II	**SL.1** Understand the complex numbers. **SL.2** knowledge of the difference of Analytic and Entire functions. **SL.3** Properties of Analytic function.

SW-1 Suggested Sessional Work (SW):

a. Assignments:
i. Relationships between complex numbers structures with familiar numbers systems such as the Set of natural numbers, Set of rational numbers, Set of integers, Set of real numbers, Set of complex numbers.
ii. State and prove Weierstress factorization theorem
iii. State and prove Gamma functions
iv Riemann s zeta function.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS203.2. Students will be equipped with the understanding of the fundamental concepts of complex variable theory and skill of contour integration.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Understand the concept of Runge's theorem. SO2.2 Learn about Analytic Continuation. SO2.3 Understand the concept of Power series. SO2.4 Understand the Uses of Analytic function. SO2.5 Understand the concept of mitteg-Leffer's theorem		**Unit-2.0 Analytic Continuation.** 2.1 Introduction 2.2 Analytic Continuation 2.3 Runge' s theorem. 2.4 Uniqueness of Analytic Continuation. 2.5 Tutorial –I 2.6 power series method of Analytic Continuation. 2.7 Application of Riemann hypothesis in number theory. 2.8 tutorial 2.9 Theorems on Analytic function. 2.10 Expansion of Riemann 's functional equations. 2.11 the concept of Mittag-Leffler's theorem 2.12 Tutorial –II	**SL.1** Analytic function of a complex variables. **SL.2** Knowledge of the Analyticity of the sum function of a series **SL.3** Knowledge of Analytic Continuation.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. State and prove Runge's theorem.

ii. State and prove Mittag - Leffler's theorem.

iii. The Uniqueness of direct Analytic Continuation along a curves

iv. Analytic Continuation.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO3-78MS203.3. This course involved complex number properties of them,analytic function,residues fundamental theorem.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO3.1 Understand the principal of SO3.2 Rouche's theorem SO3.3 the concept of Maximum Modulus principal		**Unit-3.0 Harmonic Functions.** 3.1 Introduction 3.2 harmonic functions. 3.3 the concept of Schwartz lemma. 3.4 basic properties of harmonic functions. 3.5 Tutorial –I 3.6 Schwarz's reflection principle 3.7 Monodromy theorem. 3.8 Monodromy theorem and its consequences. 3.9 some Theorems on harmonic functions 3.10 Subharmonic functions 3.11 Harmonic Functions on a disc. 3.12 Tutorial –II	**SL.1** Knowledge of the poles and zeros of a Meromorphic function. **SL.2** Understand an application of Rouche's theorem.

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. The concept of harmonic functions
ii. Application of harmonic functions
iii. Schwarz's reflection principle.

iv. State and prove Monodromy theorem.
V. Schwarz lemma.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS203.4 With this Course students are prepared to learn about advance complex analysis.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO4.1 Understand the concept of Greens function. SO4.2 understand the Canonical product SO4.3 Understand the importance of Dirichlet problem.		**Unit -4.0** **Canonical products, Convergence of Entire functions.** 4.1 Introduction 4.2 Harnax's Inequality and theorem . 4.3 The Dirichlet problem 4.4 The concept of Greens functions. 4.5 Tutorial-I 4.6 Canonical products. 4.7 Jensen formula. 4.8 The Poisson -Jensen formula 4.9 Exponents of Convergence. 4.10 Convex functions. 4.11 The convergent function of Entire functions 4.12 Tutorial-II	**SL.1** The concept of Greens functions. **SL.2** Evaluation of Poisson - Jensen formulae

SW-4 Suggested Sessional Work (SW):
a. Assignments:
i. Evaluation of Poisson -Jensen formulas.
ii. Application of the Dirichlet problem.
iii. State and prove Harnax's Inequality and theorem .
iv. Canonical products.
V. Greens functions

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS203.5
Students will Constructing mobius transformations mapping given circle to given Circle.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO5.1 Understand the concept of Bloch's theorem SO5.2 theorems on the Analytic function SO5.3 the concept of range of Analytic		**Unit-5.0 The Range of an Analytic functions.** 5.1 Introduction 5.2 Analytic function 5.3 Bloch's theorem. 5.4 Application of Bloch's theorem. 5.5 Definition and Example Of Bloch's Constant. 5.6 Tutorial-I 5.7 The Little Picard theorem. 5.8 the definition of branch of the logarithm 5.9 Schottky 's theorem. 5.10 the Great Picard theorem. 5.11 Application of Picard theorem. 5.12 Tutorial-II	**SL.1** knowledge of the Analytic function. . **SL.2** The Concept Bloch's theorem.

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS203.1 This course gives more Understanding about Analysis in mathematics	. 12	1	1	14
CO2-78MS104.2. Students will be equipped with the understanding of the fundamental concepts of complex variable theory and skill of contour integration.	12	1	1	14
CO3-78MS104.3. This course involved complex number properties of them, analytic function, residues fundamental theorem.	. 12	1	1	14
CO4-78MS203.4 With this Course students are prepared to learn about advance complex analysis.	12	1	1	14
CO5-78MS203.5 Students will Constructing Mobius transformations mapping given circle to given Circle	12	1	1	14
Total Hours	60	5	5	70

- **Suggestion for End Semester Assessment**

Suggested Specification Table For(ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO1-	Unit-1.0 The spaces of Analytic functions, Entire functions.	03	01	01	05
CO2-	Unit-2.0 Analytic Continuation.	02	05	03	10
CO3-	Unit-3.0 Harmonic Functions.	03	06	06	15
CO4-	Unit -4 Canonical products, Convergence of Entire functions	-	10	05	15
CO5-	Unit-5.0 The Range of an Analytic functions.	03	02	-	05
Total		11	26	13	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written
Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Fundamental Theorem of Complex Analysis	S.Punnuswamy	narosa publishing house	2nd edition, New Delhi 2005
2	Fundamentals of complex analysis	S.Ponnuswamy,	Narosa Publishing house	4th edition, 1985

3.	Theory and Problems of complex variables	M.R.spiegel	McGraw-Hill,New York McGraw Hill book company International	Edition, Singapore,1979

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6. Mr.Ghanhyam sen, Assistant Professor, Department of Mathematics.
7. Ms. Pushpa Kushwaha, Assistant Professor, Department of Mathematics.
8. Ms. Arpana Tripathi, Assistant Professor, Department of Mathematics

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS203
Course Title: Complex Analysis-ll

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO2	PSO 3	PSO4

Course Outcome	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
.**CO1-78MS203.1** This course gives more Understanding about Analysis in mathematics.	2	1	2	2	1	2	3	2	1	1	1	1	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>

.**CO2-78MS203.2**. Students will be equipped with the understanding of the fundamental concepts of complex variable theory and skill of contour integration	2	1	1	2	1	2	1	1	1	2	1	1	3	2	1	1
.**CO3-78MS203.3** This course involved complex number properties of them,analytic function,residues fundamental theorem.	2	1	2	2	1	3	2	1	2	2	1	1	2	2	1	1

CO4-78MS203.4 With this Course students are prepared to learn about advance complex analysis	2	1	2	2	2	1	2	2	3	2	2	2	2	1	1	1
CO5-78MS203.5 Students will Constructing mobius transformations mapping given circle to given Circle	2	2	2	2	2	2	2	2	2	1	1	3	1	1	2	1

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laborato ry Inst ru ction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO178MS203.1** This course gives more Understanding about Analysis in mathematics.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO278MS203.2**. Students will be equipped with the understanding of the fundamental concepts of complex variable theory and skill of contour Integration.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3--78MS203.3**. This course involved complex number properties of them,analytic function,residues fundamental theorem.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS203.4** With this Course students are prepared to learn about advance complex analysis	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10.	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS203.5** Students will Constructing mobius transformations mapping given circle to given Circle	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 5.1, 5.2, 5.3, 5.4, 5 .5, 5.6, 5.7, 5.8,5.9,5.10	SL5.1 SL5.2

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
Department of Mathematics

Semester-II

Course Code:	78MS204
Course Title :	Ordinary and Partial Differential Equations
Pre- requisite:	Students should have basic knowledge of calculus, linear algebra, and ODE theory.
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcome :

CO1- 78MS204.1 Solve first-order non-linear differential equations and linear differential equations.

CO2- 78MS204.2 Formulate mathematical models using ODEs to represent real-world problems.

CO3- 78MS204.3. Formulate differential equations for various mathematical models.

CO4- 78MS204.4 Study techniques for handling linear PDEs and understand their behavior and applies partial derivative equation techniques to predict the behavior of certain phenomena.

CO3- 78MS204.5 Apply numerical methods (e.g., Euler's method, Runge-Kutta methods) to approximate solutions of ODEs.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
Department of Mathematics

Program Core (PCC)	78MS204	Ordinary and Partial Differential Equations	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+ SA +CAT+AT)		

PCC	78MS204	Ordinary and Partial Differential Equations	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1- 78MS204.1

Solve first-order non-linear differential equations and linear differential equations.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Students should be able to identify ordinary differential		**Unit-1.0** **Ordinary Differential equation of first order and First Degree**: 1.1 concept of differential	**SL.1** Student get knowadge to solve Homogeneous Differential equation **SL.2**

equations that can be solved using the various methods. **SO1.2** Develop skills in solving initial value problems using the variable separable method **SO1.3** Develop the ability to solve linear differential equations using integrating factors. **So1.4** Recognize exact differential equations and understand the conditions for exactness **So1.5** Student understand the concept of Bernoulli's equation and its application in modeling various physical phenomena	-	equation 1.2 Classifies the differential equations with respect to their order and degree 1.3 explination of variable separable method 1.4 questions based on variable separable method 1.5 Explination of Homogeneous Differential equation method 1.6 Questions of Homogeneous Differential equation method 1.7 Concept of Linear Differential equation in y and x 1.8 Questions of Linear Differential equation in y and x 1.9 Questions of Bernoulli's equation 1.10 Tutorial-1 1.11 Exact Differential equation 1.12 Integrating factor	Student understand how to solve different differential equation

SW-1 Suggested Sessional Work (SW):

a. Assignments:
i. Write all the formula of exat equation.
ii. Write a short note on application of Differential equation.
b. Other Activities (Specify):
Quiz, Class Test.

CO2- 78MS204.2

Formulate mathematical models using ODEs to represent real-world problems.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the concept of Linear Differential equation with Constant coefficients SO2.2 Evaluate complimentary function by different rules SO2.3 Evaluate particular integral by different rules SO2.4 Understand the concept of		**Unit-2.0** **Ordinary simultaneous Differential equation** 2.1 Introduction of Linear Differential equation with Constant coefficients 2.2 Rules of CF 2.3 Questions of CF 2.4 Rules for solving PI 2.5 Questions of PI 2.6 Introduction of simultaneous Differential equation in Different form 2.7 Tutorial -1 2.8 Methods of solving	**SL.1** Apply rules of CF & PI to evaluate Differential equation **SL.2** Students apply methods for solving Simultaneous linear Differential equation

Simultaneous linear Differential equation SO2.5 Evaluate Different problems of Simultaneous linear Differential equation with Constant coefficients		Simultaneous linear Differential equation with Constant coefficients 2.9 Rules of solving Simultaneous linear Differential equation with Constant coefficients 2.10 Questions of Simultaneous linear Differential equation with Constant coefficients 2.11 Some different questions of Simultaneous linear Differential equation with Constant coefficients 2.12 Tutorial -2	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Make a list of all formula of Complimentary function.

ii. Make a list of all formula of particular integral.

b. Other Activities (Specify):

Class Test.

CO3- 78MS204.3

Formulate differential equations for various mathematical models.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the concept of PDE SO3.2 Understand the methods of formation of PDE SO3.3 Apply Charpit formula for solving Differential equation SO3.4 Apply Lagrange method for solving Differential equation SO3.5 Understand the concept of Linear partial Differential equation with constant coefficie		**Unit-3.0 Partial Differential equation** 3.1 Introduction of PDE 3.2 Difference between PDE and ODE with examples 3.3 Formation of PDE by eliminating arbitrary constant 3.4 Formation of PDE by eliminating arbitrary function 3.5 Explination of Lagrange method by formula 3.6 Questions of Lagrange method 3.7 Explination of Charpit methods by formula 3.8 Questions of Charpit methods 3.9 Linear partial Differential equation with constant coefficients(**CF & PI FOR PDE**) 3.10 Questions for CF 3.11 Questions of PI 3.12 Tutorial -1	**SL.1** Define and understand partial differential equation **SL.2** Define and understand Charpit and Lagrange method

SW-3 Suggested Sessional Work (SW):
a. Assignments:
i. write the difference between pde and ode.
ii. Application of PDE .
iii. Write all formula of unit.

b. Mini Project:
Oral presentation

c. Other Activities (Specify):
Class Test.

CO4- 78MS204.4

Study techniques for handling linear PDEs and understand their behavior and applies partial derivative equation techniques to predict the behavior of certain phenomena.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO 4.1 Understand the fundamental concepts of Linear Differential equation of second order with variable coefficient SO 4.2 Student apply different method of inspection		**Unit-4.0 Linear Differential equation of second order with variable coefficient** 4.1 Explination of Linear Differential equation of second order with variable coefficient 4.2 explanation of	**SL.1** Verify relationships between operations satisfying various properties.

method SO 4.3 Student apply change the independent variable method SO 4.4 Student apply Removal of first derivative method SO 4.5 Understand the fundamental concepts of variation of parameter		methods of solution of Linear Differential equation of second order with variable coefficient 4.3 Formula of inspection method 4.4 case 1 of inspection method 4.5 Case 2 of inspection method 4.6 Case 3 of inspection method 4.7 inspection method, when one integral known 4.8 change the independent variable 4.9 Questions of change the independent variable 4.10 Removal of first derivative 4.11 formula for variation of parameter 4.12 Questions of variation of parameter	

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Write all the methods of methods of solution of Linear Differential equation of second order with variable coefficient

b. Other Activities (Specify): Class Test.

CO5-78MS101.5

Apply numerical methods (e.g., Euler's method, Runge-Kutta methods) to approximate solutions of ODEs.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the application of ODE SO 5.2 Understand the application of PDE SO 5.3 Apply Picard's method to solve ODE SO 5.4 Apply Euler's method to solve ODE SO 5.5 Understand concept of one Dimensional Heat and wave equation		**Unit-5.0 Application of ODE and PDE'S** 5.1 Give explanation of Application of ODE 5.2Explination of different Numerical methods for Solution of Ordinary Differential equation. 5.3 Formula and simple Questions of Picard's method 5.4 Some more questions of Picard's method 5.5 Formula and simple Questions of Taylor's method 5.6 Some more questions of Picard's method 5.7 Formula and simple Questions of Euler's method 5.8 Formula and Questions modified 5.9 Formula and simple Questions of Runge-kutta method 5.10 Method of separation of variables	**SL.1** Learn application of ODE **SL.2** Learn application of PDE

		5.11 one Dimensional Heat equation 5.12 one Dimensional wave equation	

SW-5 Suggested Sessional Work (SW):

a. Assignments:

i. Write the application of ODE.

ii Write the application of PDE.

b. Other Activities (Specify):

Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1- 78MS204.1 Solve first-order non-linear differential equations and linear differential equations.	12	1	1	14
CO1- 78MS204.2 Formulate mathematical models using ODEs to represent real-world problems.	12	1	1	14
CO1- 78MS204.3 Formulate differential equations for various mathematical models.	12	1	1	14
CO1- 78MS204.4 Study techniques for handling linear PDEs and understand their behavior andapplies partial derivative equation techniques to predict the behavior of certain phenomena.	12	1	1	14

CO1- 78MS204.5 Apply numerical methods (e.g., Euler's method, Runge-Kutta methods) to approximate solutions of ODEs.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution					Total Marks
		R	U	A			
CO1-	Solve first-order non-linear differential equations and linear differential equations.	05	04	01			10
CO2-	Formulate mathematical models using ODEs to represent real-world problems.	02	06	02			10
CO3-	Formulate differential equations for various mathematical models.	03	05	02			10
CO4-	Study techniques for handling linear PDEs and understand their behavior and applies partial derivative equation techniques to predict the behavior of certain phenomena.	05	03	02			10
CO5-	Apply numerical methods (e.g., Euler's method, Runge-Kutta methods) to approximate solutions of ODEs.	02	04	04	-		10
Total		17	22	11			50

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program
Department of Mathematics

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Partial Differential equation	Dr.H.K.Pathak	Shree Sahitya Siksha Prakashan, Meerut.	Edition 2023-24
2	ODE & PDE	M.D.Rai Singhania	S. Chand Publications	20th Edition
3	Mathematics 1	D.K.Jain	Shree ram publication	

4	Ordinary Differential Equations with Applications	G.F.Simmons	Tata McGraw Hill	

b) Reference Book:

S. No.	Title	Author	Publisher	Edition & Year
1	Ordinary Differential Equations	M.L. Jain and Satbir Mehla	Jeevansons Publications	Thirteenth Edition
2	Calculus and Ordinary Differential Equations	S.K Mishra and K.K Pradhan	VK Global Publications	2023-24 edition
3	Partial Differential Equation-With Boundary Value Problems	Dr. H.K. Pathak and J.P. Chauhan	Shree Shiksha Sahitya Prakashan;	Fourth Revised Edition Reprint 2021-2022
4	Partial Differential Equations	**S. G. Venkatachalapathy**	Margham Publications	

c) Online books:

Suggested Digital Platforms Web links:	https://old.mu.ac.in/wp-content/uploads/2020/12/Paper-IV-Ordinary-Diffrential-Equation.pdf
Suggested Equivalent online courses:	https://onlinecourses.nptel.ac.in/noc24_ma37/preview

Curriculum Development Team:

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS204
Course Title: Ordinary and Partial Differential Equations

Course Outcome																
	PO 1	P O 2	PO3	PO 4	PO5	PO 6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO 1	PS O 2	PSO 3	PS O 4
	Adv anc ed	Pr o bl	Resear ch Abiliti	Qu ant itat	Teac hing and	The ore tica	Com muni catio	Oper ation s	Appli catio n in	Engi neeri ng	Go ver nm	Cons ultin g	Under stand the	Ha ndl e	Develo p necess	Cre ate s

	Mathematical Knowledge	em-solving Skills	es	ive Analysis	Academia	l Understanding	n Skills	Research	Industry	and Technology	ent and Public Sector		mathematical concepts and applications in the field of algebra	the advanced techniques	ary skills and expertise in the field of research	Mathematical Models
CO1- **78MS204. 1** Solve first-order non-linear differential equations and linear differential equations.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	2
CO2- 78MS204. 2. Formulate mathematical models using ODEs to represent real-world problems.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	1
CO3- 78MS204.3 . Formulate	1	3	2	2	1	1	3	2	1	1	3	1	2	1	2	

differential equations for various mathematical models.															
CO4- 78MS204.4 Study techniques for handling linear PDEs and understand their behavior and applies partial derivative equation techniques to predict the behavior of certain phenomena.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO5- 78MS204.5 Apply numerical methods (e.g., Euler's method, Runge-Kutta	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

methods) to approximate solutions of ODEs.																

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11, 12 PSO 1,2, 3, 4	CO1- 78MS204.1 Solve first-order non-linear differential equations and linear differential equations.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,	CO2- 78MS204.2. Formulate mathematical models using ODEs to	SO1.1 SO1.2 SO1.3		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2

12 PSO 1,2, 3, 4	represent real-world problems.	SO1.4 SO1.5		2.11,2.12	
PO 1,2,3,4,5,6 7,8,9,10,11, 12 PSO 1,2, 3, 4	CO3- 78MS204.3. Formulate differential equations for various mathematical models.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10,3.11,3.12	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11, 12 PSO 1,2, 3, 4	CO4- 78MS204.4 Study techniques for handling linear PDEs and understands their behavior and applies partial derivative equation techniques to predict the behavior of certain phenomena.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10,4.11,4.12	SL4.1
PO 1,2,3,4,5,6 7,8,9,10,11, 12 PSO 1,2, 3, 4	CO5- 78MS204.5 Apply numerical methods (e.g., Euler's method, Runge-Kutta methods) to approximate solutions of ODEs.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 5.11,5.12	SL5.1 SL5.2

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-I

Course Code:	78MS205
Course Title :	[Advanced Discrete Mathematics]
Pre- requisite:	Among then of great importance are first, the actuality of the theme of the research; second-the choice of adequate research instruments and taxonomy to the chosen object field.
Rationale:	Think of a research rationale as a set of reasons that explain why a study is necessary and important based on its background.

Course Outcome :

CO1- 78MS205.**1** Learn the structure of graphs and familiarize the basic concepts used to analyses different problems in different branches such as chemistry, computer science etc.

CO2- 78MS205.**2**. Analyze characterization of special graphs.

CO3- 78MS205.**3**. Understand the importance of algebraic properties with regard to working within various number systems.

CO4- 78MS205.**4** Acquire knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.

CO5- 78MS205.**5** Learn the equivalence of deterministic and non deterministic finite accepters.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Program Core (PCC)	78MS205	Advanced Discrete Mathematics	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS205	Advanced Discrete Mathematics	15	20	5	5	5	50	50	100

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1- 78MS205.**1** Learn the structure of graphs and familarize the basic concepts used to analyses different problems in different branches such as chemistry, computer science etc.

Approximate Hours

Item	AppX Hrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Group. **SO1.2** Understand the Proposition logic **SO1.3** Understand the relation between Circuits & cycles		**Unit-1.0** 1.1 Formal Logic statements 1.2 Symbolic representation 1.3 Tautologies 1.4 Quantifiers 1.5 Proposition logic 1.6 . Graph Theory 1.7 Definition of (undirected)graph, 1.8 Sub graph, Paths, 1.9 Circuits & cycles.	**SL.1** Understand the concept of Symbolic representation **SL.2** Decide whether a Connectivity **SL.3** Express a given simple graph ,Weight Graph ,

		1.10 simple graph ,Weight Graph , 1.11 Degree of vertices, 1.12 Connectivity. 1.13 Planer graph their properties.	.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. simple graph ,Weight Graph ,

ii Explain the Symbolic representation

CO2- 78MS205.**2**. Analyze characterization of special graphs.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the Kuratowski's Theorem SO2.2 Learn about Matrix representation of Graphs. SO2.3 Understand the		**Unit-2.0** 2.1Euler's formula 2.2connected planar graphs. 2.3 Complete graph 2.4 complete Bipartite graphs. **2.5** Kuratowski's Theorem (statement only) and its use.	**SL.1** Verify complete Bipartite graphs **SL.2** Present concepts of the incidence matrices of a Graph **SL.3** Knowledge of

concept of connected planar graphs.		2.6 Matrix representation of Graphs. 2.7Tutorial-1 2.8Adjacency matrices of a Graph 2.9 incidence matrices of a Graph. 2.10 Isomorphic Graph 2.11 Homomorphism Graph 2.12 Tutorial-2	Homomorphism Graph

SW-2 Suggested Sessional Work (SW):
a. Assignments:
i. Write the Adjacency matrices of a Graph.
ii.Write the Kuratowski's Theorem

CO3- 78MS205.**3**. Understand the importance of algebraic properties with regard to working within various number systems.

Approximate Hours

Item	AppX Hrs
Cl	11
LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the partially		**Unit-3.0** 3.1 introduction of Lattices	**SL.1** Direct products.

ordered set SO3.2 Explain Some Special Lattices SO3.3 Distributive Lattices		3.2 partially ordered set 3.3partially ordered set and their properties. 3.4 Tutorial-1 3.5 Sublattices 3. 6Tutorial-2 3.7 Direct products. 3.8Explain Some Special Lattices 3.9 Complete Lattices 3.10 Complemented Lattices 3.11 Distributive Lattices	**SL.2** Complemented Lattices **SL.3** Distributive Lattices

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Relationships between partially ordered set and their properties
ii. Explain the Distributive Lattices
iii Lattices as algebraic systems .

CO4- 78MS205**.4** Acquire knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.

Approximate Hours

Item	AppX Hrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 understand the Switching Algebra SO4.2Using AND,OR & NOT gates.		**Unit-4.0** 4.1 Boolean Algebras as Lattices. 4.2 Various Boolean identities, 4.3 Sub Algebra. 4.4Booleanforms 4.5equivalence, 4.6Minterms Boolean forms, 4.7Sum of products 4.8 canonical forms. 4.9Switching Algebra 4.10examples. 4.11Apllication of BooleanAlgebra 4.12Boolean Algebra to Switching Theory 4.13 Using AND,OR & NOT gates.	**SL.1** Verify the Various Boolean identities, **SL.2** Equivalence, **SL.3** canonical forms.

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Boolean Algebras as Lattices.
ii. Boolean forms
iii. Switching Theory

b. Other Activities (Specify):
Quiz, Class Test.

CO5- 78MS205**.5** Learn the equivalence of deterministic and non deterministic finite accepters.

Approximate Hours

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Item	AppX Hrs
Cl	11
LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand Minimal Spanning tree SO5.2 Understand Finite state machines		**Unit-5.0** **5.1**Definition of tree 5.2 types of tree 5.3networks, 5.4 Spanning Tree, cut-sets. 5.5Minimal Spanning tree 5.6Kruskal'sAlgorithm 5.7 Finite state machines 5.8 types of Finite state machines 5.8 transition table diagrams. 5.9Equivalence of finite state machines. 5.10 Reduced Machines 5.11 Tutorial	**SL.1**Verify the types of Finite state machines **SL.2** Equivalence of finite state machines

SW-5 Suggested Sessional Work (SW):

a. Assignments:

i. Equivalence of finite state machines
ii. Spanning Tree
iii. Finite state machines

b. Other Activities (Specify):
Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1- 78MS205.**1** Learn the structure of graphs and familarize the basic concepts used to analyses different problems in different branches such as chemistry, computer science etc.	13	1	1	12
CO2- 78MS205.**2**. Analyze characterization of special graphs.	12	1	1	14
CO3- 78MS205.**3**. Understand the importance of algebraic properties with regard to working within various number systems.	11	1	1	13
CO4- 78MS205.**4** Acquire knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.	13	1	1	12

CO5- 78MS205**.5** Learn the equivalence of deterministic and non deterministic finite accepters.	11	1	1	11
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**					**Total Marks**
		R	**U**	**A**			
CO-1	Learn the structure of graphs and familarize the basic concepts used to analyses different problems indifferent branches such as chemistry, computer science etc.	03	01	01			05
CO-2	Analyze characterization of special graphs.	02	06	02			10
CO-3	Understand the importance of algebraic properties with regard to working within various number systems.	03	07	05			15
CO-4	Acquire knowledge of Boolean algebras and Boolean function and understand how these	-	10	05			15

	concepts arise in certain real life problems.						
CO-5	Learn the equivalence of deterministic and non deterministic finite accepters. .	03	02		-		05
Total		11	26		13		50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Discrete Mathematical Structure with Applications to computer science	J.P.Tremblay & R. Manohar		
2	Finite mathematics	Seymour Lepschutz		
3	Elements of Discrete Mathematics	C.L.Liu		
4	Discrete mathematics and its applications	Kenneth H. Rosen		
5	Discrete and combinatorial mathematics An applied introduction	R.P. Grimaldi		

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS205
Course Title: Advanced Discrete Mathematics

Course Outcome	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS205.1 Learn the structure of graphs and familiarize the basic concepts used to analyses different problems in different branches such as chemistry,	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3

computer science etc.																
CO2-78MS205.2. Analyze characterization of special graphs.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2
CO3-78MS205.3. Understand the importance of algebraic properties with regard to working within various number systems.		3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
CO4-78MS205.4 Acquire knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

CO5- 78MS205.5 Learn the equivalence of deterministic and non deterministic finite accepters.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-** 78MS205.**1** Learn the structure of graphs and familiarize the basic concepts used to analyses different problems in different branches such as chemistry, computer science etc.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10	SL1.1 SL1.2 SL1.3
PO 1,2,3,4,5,6 7,8,9,10,11,12	**CO2-** 78MS205.**2**. Analyze characterization of special graphs.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2

PSO 1,2, 3, 4					
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-** 78MS205.**3**. Understand the importance of algebraic properties with regard to working within various number systems.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-** 78MS205.**4** Acquire knowledge of Boolean algebras and Boolean function and understand how these concepts arise in certain real life problems.	SO1.1 SO1.2 SO1.3		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-** 78MS205.**5** Learn the equivalence of deterministic and non deterministic finite accepters.	SO1.1 SO1.2 SO1.3		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL5.1 SL5.2 SL5.3

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Code:	78MS301
Course Title :	Operational Research
Pre -requisite:	Students should have basic knowledge of Operational Research
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcome :

CO1-78MS301.1

To learn graphical method and the simplex algorithm for solving a linear programming problem.

CO2-78MS301.2.

To learn more optimization techniques for solving linear programming models transportation problem and integer programming problem.

CO3-78MS301.3.

Understand optimization techniques for solving some network related problems.

CO4-78MS301.4

To learn sensitivity analysis and parametric programming, which describes how various changes in the problem affect its solution

CO5-78MS301.5

Ability to think innovatively to do research in high level in mathematics and interdisciplinary fields.

AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			Cl	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS301	Operational Research	4[3+1]	0	1	1	6	4

Legend:

CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)

SW: Sessional Work (includes assignment, seminar, mini project etc.),

SL: Self Learning,

C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS301	Operational Research.	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS301.1 To learn graphical method and the simplex algorithm for solving a linear programming problem.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Linear programming. **SO1.2** Understand the relationships between basics feasible solution. **SO1.3** Understand the concept of graphical method. **So1.4** Understand the multiplication formula **So1.5** Understand the concept of programming.	-	**Unit-1.0 Linear programming problem.** 1.1 Introduction 1.2 The definition of general Linear programming problem. 1.3 Formulation of the Linear programming problem. 1.4 Solution by graphical method. 1.5 tutorial 1 1.6 graphical solution of Linear programming. 1.7 Relation between basics feasible solution. 1.8 tutorial 2 1.9 Simplex method. 1.10 understand the Simplex method 1.11 question based on linear programming 1.12 tutorial 3	**SL.1** Understand the definition of general Linear programming. **SL.2** knowledge of the general Linear programming. **SL.3** Properties of general Linear programming

SW-1 Suggested Sessional Work (SW):

a. Assignment:

i. Formulation of the Linear programming problem.

ii. graphical solution of Linear programmingiii. Application of Linear programming.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO2-78MS301.2. . To learn more optimization techniques for solving linear programming models transportation problem and integer programming problem.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the concept of linear programming. SO2.2 Learn about the concept oflinear programming problem by Big –M method. SO2.3 Understand the concept of Duality. SO2.4 Understand the Uses of Linear programming. SO2.5 Understand the concept of duality.		**Unit-2.0 Solution of linear programming problem** 2.1 Introduction. 2.2 Understand the Concept linear programming 2.3 linear programming problem by Big –M method. 2.4 To phase method. 2.5 Alternative forms of generating functions. 2.6 The concept of duality 2.7 properties of duality 2.8 tutorial 1 2.9 fundamental theorem of duality. 2.10 tutorial 2 2.11 Dual Simplex methods. 2.12 Application of duality.	SL.1 To understand linear programming problem. SL.2 Knowledge of the Alternative forms of generating functions. SL.3 Knowledge of some properties of linear programming.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Definition and Example of linear programming problem.
ii. Define Alternative forms of generating functions.
iii. The concept of duality

¡v fundamental theorem of duality.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.
c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS301.3. Understand optimization techniques for solving some network related problems.

Approximate Hours

Item	AppX Hrs
CI	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the principle of Traveling salesman problem. SO3.2 Understand the assignment problem SO3.3 the concept of sequencing problem.		Unit-3.0 **Assignment problem**.: 3.1 Introduction. 3.2 solution of assignment problem 3.3 unbalanced assignment problem. 3.4 Crew assignment problem. 3.5 tutorial 1 3.6 Traveling salesman problem 3.7 sequencing problem. 3.8 Processing n jobs on two machines. 3.9 n Jobs on three machines. 3.10 n Jobs on m machines. 3.11 Processing two jobs through m machines. 3.12 tutorial 2	**SL.1** Knowledge of the.unbalanced assignment problem. **SL.2** Understand an application of solution of assignment problem

SW-3 Suggested Sessional Work (SW):
a. Assignment:
¡. solution of assignment problem
ii. Describe Traveling salesman problem.
iii. Processing two jobs through m machines.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS301.4 To learn sensitivity analysis and parametric programming, which describes how various changes in the problem affect its solution.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the concept of transportation problem. SO4.2 understand the.North- west corner method. SO4.3 Understand the importance of transportation problem.		**Unit -4 Transportation problem.** 4.1 Introduction 4.2 Initial basics feasible solution. 4.3 North- west corner method. 4.3 least- cost method. 4.4 Vogels Approximation method. 4.5 tutorial 1 4.6 Optimally test by MODI method . 4.7 Stepping stone method. 4.8 some properties of transportation. 4.9 Expansion of stepping stone methods 4.10 Application of transportation problem. 4.11 Degeneracy in transportation problem 4.12 tutorial 2	**SL.1** knowledge of the transportation problem **SL.2** Expansion of Stepping stone method.

SW-4 Suggested Sessional Work

i. **To solve** Initial basics feasible solution.
ii. Application of transportation problem.
iii. The Expansion of Stepping stone method.
iv. Calculation of Vogel's Approximation method.
V. Degeneracy in transportation problem.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.
c. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS301.5 Ability to think innovatively to do research in high level in mathematics and interdisciplinary fields.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
O5.1 Understand the concept of network Techniques. **SO5.2** Construction of network **SO5.3** Constraints in network.		**Unit-5.0 Network Analysis:** **5.1** Introduction . 5.2 Constraints in network. 5.3 Construction of network 5.4 Definition and Example of networks. 5.5 tutorial 1 5.6 Critical path methods PERT 5.7. PERT Calculations Resources. 5.8 tutorial 2 5.9 Leveling by network Techniques. 5.10 Advances of network (PERT/CPM). 5.11 Application of network Techniques. 5.12 tutorial 3	**SL.1** knowledge of the network Techniques. **SL.2** knowledge of the Construction of network.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS301.1 To learn graphical method and the simplex algorithm for solving a linear programming problem.	**12**	1	1	14
CO2-78MS301.2 To learn more optimization techniques for solving linear programming models transportation problem and integer programming problem.	. **12**	1	1	14
CO3-78MS301.3. Understand optimization techniques for solving some network related problems.	12	1	1	14
CO4-78MS301.4 .To learn sensitivity analysis and parametric programming , which describes how various changes in the problem affect its solution.	12	1	1	14
CO5-78MS301.5 Ability to think innovatively to do research in high level in mathematics and interdisciplinary fields.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table For(ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO1-	UNIT-1 linear programming problem.	03	01	01	05
CO2-	UNIT -2 Solution of linear programming problem.	02	05	03	10
CO3-	Unit-3 Assignment problem.	03	06	06	15
CO4-	Unit-4 . Transportation problem	-	10	05	15
CO5-	Unit 5 Network Analysis	03	02	-	05
Total		11	26	13	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S.No.	Title	Author	Publisher	Edition
1	Operations Research	Dr. H.K. Pathak, Dr. Pradeep k.joshi	Shiksha Sahitya prakashan new delhi	2nd edition, 2000
2	Operations Research with applications.	S.D.sharma	Shiksha Sahitya prakashan	CO 2002
3	Operations Research - An introduction,	Prem Kumar Gupta and D.S. Hira	S. Chand & Company Ltd. New Delhi	
4	Operations Research - An introduction,	H.A. Tha	Macmillan Publishing co. Inc. New York.	
5	Operations Research	PK Gupta and Manmohan	Pragti prakashan New Delhi	2003

b) Reference Book:

S. No.	Title	Author	Publisher	Edition & Year
1	Industrial Engineering Series,	F.S, Hiller and G.J. Lieberman	(This book comes with a CD containing software)	1995

2	Linear Programming	G. Hadley	Narosa Publishing House. 1995	
3	Linear and Dynamic programming	G. Hadley	Wesley Reading Mass	

c) Suggetsed Digital Platform Web links :

Suggested Digital Platforms Web links:	https://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf
Suggested Equivalent online courses:	https://www.amirajcollege.in/wp-content/uploads/2020/10/3151910-operations-research-theory-and-applications-by-j.-k.-sharma-z-lib.org_.pdf

Curriculum Development Team

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS301
Course Title: Operational Research

Course Outcome	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1- **78MS301.1 to** learn graphical method and the simplex algorithm for solving a linear programming problem.	2	1	3	2	1	2	3	3	1	1	2	1	1	2	1	2

CO2- .**78MS301.2**. To learn more optimization techniques for solving linear programming models transportation problem and integer programming problem.	2	1	3	2	1	2	3	3	1	2	2	1	3	2	1	1
CO3- .**78MS301.3**.. Understand optimization techniques for solving some network related problems.	2	1	2	2	1	3	3	2	2	2	1	1	2	2	1	1

CO4- **78MS301.4 To learn sensitivity** analysis and parametric programming, which describes how various changes in the problem affect its solution.	2	1	2	2	2	2	3	2	3	2	2	2	2	1	1	1
CO5- **78MS301.5** Ability to think innovatively to do research in high level in mathematics and interdisciplinary fields.	2	2	2	2	3	3	2	2	2	1	1	3	1	1	2	1

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-**78MS301.1** to learn graphical method and the simplex algorithm for solving a linear programming problem.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 linear programming problem. 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1 .8,1.9,1.10 1.11 1.12	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO2-.**78MS301.2**. To learn more optimization techniques for solving linear programming models transportation problem and integer programming problem.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 solution of linear programming problem. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10 2.11 2.12	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO3-**78MS301.3**..Understand optimization techniques for solving some network related problems.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 . Assignment problem: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10,3.11 3.12	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO4-**78MS301.4 To learn sensitivity** analysis and parametric programming , which describes how various changes in the problem affect its solution.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 Transportation problem: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10. 4.11 4.12	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO5-**78MS301.5** Ability to think innovatively to do research in high level in mathematics and interdisciplinary fields.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 **Network Analysis:** 5.1, 5.2, 5.3, 5.4, 5 .5, 5.6, 5.7, 5.8,5.9 5.10 5.11 5.12	SL5.1 SL5.2

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Title:	Integral Equation
Course Code: -	78MS302
Prerequisite:	Students should review the fundamentals of Laplace transform and differential equation.
Rationale:	The program aims to develop advanced problem-solving in initial value problem and boundary value problem and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcomes (CO):

CO1-- 78MS302.1
Define and understand the concept of laplace transform and differential equation and their classification, definition of integral transform .fredholm and Volterra integral equation.
CO2-- 78MS302.2
Define and understand the basic concepts of integral transform method, laplacetransform , convolution integral. Application of Volterra with convolution type kernels.solution of the Cauchy type singular integral equation. And the hilbert kernel.

CO3-- 78MS302.3
Define and compute, symmetric kernels, orthonormal system of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations with symmetric kernels.

CO4-- 78MS302.4
Understand and definition of a boundary value problem for an ordinary equation of a second order and reduction to a fredholm integral equation of the second kind. Dirac delta function. Green function approach to reduce the boundary value problem of a self adjoint differential equation with homogenous boundary condition to integral equation form.

CO5- - 78MS302.5
Understand the integral representation formulae for the solution of the laplace and Poisson equations. Newtonian single layer and double layer potentials. Integral equation formulation of boundary value problem for laplace equations.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
PCC	78MS302	Integral equation	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others)
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.)
SL: Self Learning,
C:Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+ SA +CAT+AT)		

				(CT)						
PCC	**78MS302**	**Integral equation**	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-- 78MS302.1

Define and understand the concept of laplace transform and differential equation and their classification, definition of integral transform .fredholm and Volterra integral equation.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the basic concept of integral equation and their types. **SO1.2** Understand the how to find eigenvalues and	-	**Unit-1.0** 1.1.define of integral equation and her classification. 1.2. eigenvalues and eigen functions. 1.3. fredholm integral equation of kind with	**SL.1** Define the integral equation and their types with their examples. **SL.2** Apply fredholm and Volterra integral

eigen functions in integral equation. **SO1.3** Apply reduction to a system of algebraic equation in integral equation of Volterra and fredholm equation. **So1.4** Understand the Condition of uniform convergence and uniqueness series solution. **So1.5** Understand theapplication of iterative scheme of Volterra integral equation of the second kind.		seperable kernels. 1.4.reduction to a system of algebraic equation. 1.5.an approximation method. 1.6 Tutorial-1 1.7. method of successive approximation. 1.8. iterative scheme for fredholm integral equation of second kind 1.9 condition of uniform convergence and uniqueness series solution 1.10resolvent kernel and its results. 1.11application of iterative scheme to Volterra integral equation of the second kind. 1.12 Tutorial- 2	equation to find the eigen values and eigenfunctions. **SL.3** Apply fredholm and Volterra integral equation to solve method of successive approximation and iterative scheme for all kinds.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Analyze and define the concept of integral equation with their types and cases with example.
ii. Volterra integral equation to find the eigen values and eigenfunctions
iii. Find the application of iterative scheme to Volterra integral equation of the second kind

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2- 78MS302.2

Define and understand the basic concepts of integral transform method, laplacetransform , convolution integral. Application of Volterra with convolution type kernels.solution of the Cauchy type singular integral equation. And the hilbert kernel.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Define and understand integral transform. **SO2.2** Perform basic Convolution tofind the application of Volterra integral equation with kernels. **SO2.3** Understand the	-	**Unit-2.0** 2.1.integral transform method 2.2. fourier transform 2.3.laplace transform 2.4-convolution integral 2.5. application of Volterra integral equation with convolution type kernels. 2.6.solution of the Cauchy type singular integral equation. 2.7.the Hilbert kernel.	**SL.1** Explore laplace transform and fourier transform with their relation . **SL.2** Understand the concept of Volterra integral equation with convolution type kernels. **SL.3** Apply Hilbert type and

concept of singular integral equation **SO2.4** Define and compute the Cauchy type and Hilbert type kernels. **SO2.5** Understand the solution of Cauchy type and Hilbert type singular integral equation.		2.8. convolution type kernels. 2.9. solution of the Hilbert type singular integral equation. 2.10. singular integral equation. 2.11 solution of Cauchy type and Hilbert type singular integral equation. 2.12 Tutorial-1	Cauchy type to find the solution of singular integral equations.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the integral transform with their types.
ii. Write the Volterra integral equation with convolution type kernels.
iii. Write a short note on Hilbert type and Cauchy type to find the solution of singular integral equations.
iv. Describe the method singular integral equation and use in caychy type and hibert type kernels.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

CO3- 78MS302.3

Define and compute, symmetric kernels, orthonormal system of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations with symmetric kernels.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Define and compute Symmetric kernels **SO3.2** Understand the eigen values and eigen functions for symmetric kernels. **SO3.3** Apply and computesolution of integral equations with symmetric kernels. **SO3.4** Understand The properties of eigen values and eigen functions	-	**Unit-3.0** 3.1. symmetric kernels 3.2. orthonormal system of functions 3.3. fundamental properties of eigenvalues 3.4. and eigen functions for symmetric kernels 3.5. solution of integral equations with symmetric kernels. 3.6.eigenvalues and eigen functions 3.7. system of functions 3.8properties of eigen values 3.9. properties of eigen functions 3.10. integral equations with symmetric kernels	**SL.1** Apply symmetric kernels and orthonormal system of functions. **SL.2** Apply the fundamental properties to find the eigen values and eigen functions of integral equations.. **SL.3** Solve the integral equation with symmetric kernels.

SO3.5 Identify the integral equation with symmetric kernels.		3.11 Questions of symmetric kernels 3.12 Tutorial-1	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the symmetric kernels and orthonormal system of functions.
ii. Explain the fundamental properties of eigen values and eigen functions.
iii. Write the solution of integral equation with symmetric kernels.

b. Mini Project:

Oral presentation,
c. Other Activities (Specify):
Quiz, Class Test.

CO4- 78MS302.4

Understand and definition of a boundary value problem for an ordinary equation of a second order and reduction to a fredholm integral equation of the second kind. Dirac delta function. Green function approach to reduce the boundary value problem of a self adjoint differential equation with homogenous boundary condition to integral equation form.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the definition of boundary value problem. **SO4.2** Analyze theboundary value problem for an ordinary equation of the second order . **SO4.3** Identify the dirac delta function with their properties. **SO4.4** Identify green function approach to reduce boundary value problem of a self adjoint differential equations. **SO4.5** Recognize with homogenous boundary condition to integral equations.	-	**Unit-4.0** 4.1.definition of boundary value problem for an ordinary equation of the second order . 4.2 and its reduction to a fredholm integral equations of the second kind. 4.3.dirac delta function 4.4. green functions 4.5 Tutorial-1 4.6.green function approach to reduce boundary value problem of a self adjoint differential equations. . 4.7. with homogenous boundary condition to integral equations. 4.8.construction of green functions. 4.9.reduction of boundary value problem into integral equations. 4.10. properties of dirac delta functions. 4.11problem based on boundary value problem . 4.12 Tutorial-2	**SL.1** Apply boundary value problem for an ordinary equation of the second kind. **SL.2** Apply Boundary value problem to reduce in a fredholm integral equation of the second kind. **SL.3** Analyze and interpret green functions to reduce boundary value problem of a self adjoint differential equations with homogenous boundary conditions to integral equations.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

I. Explain green functions to reduce boundary value problem of a self adjoint differential equations with homogenous boundary conditions to integral equations.

b. Other Activities (Specify):
Quiz, Class Test.

CO5- 78MS302.5

Understand the integral representation formulae for the solution of the laplace and Poisson equations. Newtonian single layer and double layer potentials. Integral equation formulation of boundary value problem for laplace equations.

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand laplace equation and poisons equations. **SO4.2** Understand single and double layer of Newtonian potential in	-	**Unit-5.0** 5.1.integral representation formulas for the laplace equation. 5.2. integral representation formulas for the poisons equation. 5.3. Newtonian single layer potential	**SL.1** Apply integral representation formulas for the laplace equation. And poisons equations. **SL.2** Use Newtonian single and double layer potential in integral

integral equations. **SO4.3** Understand the concept of formulation of boundary value problem for laplace equation. **SO4.4** Interpret poisons equations. **SO4.5** Understand boundary value problem for laplace and poisson equations.		5.4 Newtonian double layer potential 5.5. integral equation formulation of boundary value problem for laplace equation. 5.6 laplace equation 5.7. poisons equations 5.8 problems on laplace equations 5.9. problems on poisons equations 5.10. boundary value problem forlaplace equation 5.11boundary value problem for poisons equation. 5.12 Tutorial-1	equations. **SL.3** Apply integral equation formulation of boundary value problem for laplace equation.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the integral representation formulas for the laplace equation. And poisons equations.
ii. Write integral equation formulation of boundary value problem for laplace equation

b. Mini Project:

Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS302.1 Define and understand the concept of laplace transform and differential equation and their classification, definition of integral transform .fredholm and Volterra integral equation.	12	1	1	14
CO2-78MS302.2 Define and understand the basic concepts of integral transform method, laplacetransform , convolution integral. Application of Volterra with convolution type kernels.solution of the Cauchy type singular integral equation. And the hilbert kernel	12	1	1	14
CO3-78MS302.3 Define and compute, symmetric kernels, orthonormal system of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations with symmetric kernels	12	1	1	14
CO4-78MS302.4 Understand and definition of a boundary value problem for an ordinary equation of a second order and reduction to a fredholm integral equation of the second kind. Dirac delta function. Green function approach to reduce the boundary value problem of a self adjoint differential equation with homogenous boundary condition to integral equation form.	12	1	1	14

CO5-78MS302.5 Understand the integral representation formulae for the solution of the laplace and Poisson equations. Newtonian single layer and double layer potentials. Integral equation formulation of boundary value problem for laplace equations.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution					Total Marks
		R	U	A			
CO-1	Integral equation	02	04	05			07
CO-2	Integral transform	03	07	04			14
CO-3	Symmetric kernels	02	06	02			10
CO-4	Boundary value problem and green functions	03	03	02			11
CO-5	Integral representation	03	02	02			08
Total		13	22	15			50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies
1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Linear integral equation	R.P. kanwal	Academic press	New York , 1971
2	Integral equation and calculus of variation	Dr. jagbirsingh	Maharshi Dayanand university	2021

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS302
Course Title: Integral Equation

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1- 78MS302 Define and understand the concept of laplace transform and differential equation and their classification, definition of integral transform .fredholm and Volterra integral equation.	2	3	1	2	1	2	1	1	1	1	1	1	2	2	1	
CO1-78MS302.2 Define and understand the basic concepts	2	3	1	1	1	1	1	1	1	1	1	1	1	2	2	

of integral transform method, laplacetransform , convolution integral. Application of Volterra with convolution type kernels.solution of the Cauchy type singular integral equation. And the hilbert kernel																
CO1-78MS302.3 Define and compute, symmetric kernels, orthonormal system of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations with symmetric kernels.	3	3	1	2	1	1	3	2	2	1	2	2	1	2	3	
CO1-78MS302.4 Understand and definition of a	2	3	1	2	3	2	3	1	1	1	1	2	2	1	1	

boundary value problem for an ordinary equation of a second order and reduction to a fredholm integral equation of the second kind. Dirac delta function. Green function approach to reduce the boundary value problem of a self adjoint differential equation with homogenous boundary condition to integral equation form.																
CO1-78MS302.5 Understand the integral representation formulae for the solution of the laplace and Poisson equations. Newtonian single layer and double layer potentials. Integral	3	2	3	1	2	1	2	3	1	1	1	1	1	1	1	

equation formulation of boundary value problem for laplace equations.																

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS302.1** 78MS302 Define and understand the concept of laplace transform and differential equation and their classification, definition of integral transform .fredholm and Volterra integral equation.	SO1.1 SO1.2 SO1.3 SO1.4		Unit-1.0 Approximation1.1,1.2,1.3,1.4, 1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12,1.13,1.14,	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS302.2** Define and understand the basic concepts of integral transform method, laplacetransform , convolution integral. Application of Volterra with convolution type kernels.solution of the Cauchy type singular integral equation. And the hilbert kernel.	SO2.1 SO2.2 SO2.3 So2.4		Unit-2 System of linear equations :2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9,2.10,2.11,2.12,2.13,2.14,2.15.	SL2.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS302.3** Define and compute, symmetric kernels, orthonormal system of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations with symmetric kernels.	SO3.1 SO3.2 SO3.3		Unit-3 Iteratives method 3.1, 3.2, 3.3, 3.4, 3.5,3.6,3.7	SL3.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS302.4** Understand and definition of a boundary value problem for an ordinary equation of a second order and reduction	SO4.1 SO4.2 SO4.3 SO4.4		Unit-4 Eigen value problem 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10,4.11,4.12	SL4.1

	to a fredholm integral equation of the second kind. Dirac delta function. Green function approach to reduce the boundary value problem of a self adjoint differential equation with homogenous boundary condition to integral equation form.				
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS302.5** Understand the integral representation formulae for the solution of the laplace and Poisson equations. Newtonian single layer and double layer potentials. Integral equation formulation of boundary value problem for laplace equations.	SO5.1 SO5.2 SO5.3 SO5.4		Unit-5Numerical Integration 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 ,5.7,5.8,5.9,5.10,5.11,5.12	SL.5.1

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Code:	**78MS303**
Course Title :	**Advanced Numerical Techniques**
Pre- requisite:	Students should have basic knowledge of and deep understanding of the theory of the advanced numerical techniques.
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

CO1-78MS303.1 Understand the importance of Uniform approximation by polynomials, Errors and their computations.

CO2-78MS303.2 Determine the Systems of Linear Equations

CO3-78MS303.3 Demonstrate an understanding of the theory of Iteratives method

CO4-78MS303.4 Define and recognize the Eigen value problem

CO5-78MS303.5 Students will create the concept of a Numerical Integrationand methodbased on Interpolation

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			Cl	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS303	Advanced Numerical Techniques	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+ SA +CAT+AT)		
PCC	78MS303	Advanced Numerical Techniques	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

CO1-78MS303.1 Understand the importance of Uniform approximation by polynomials, Errors and their computations.

Approximate Hours

Item	AppXHrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Uniform approximation **SO1.2** Understand the Principles of floating point, **SO1.3** Understand the Errors and their computations. **SO1.4** Understand the data fitting		**Unit-1.0** 1.1 Uniform approximation by polynomials 1.2 least squares approximation 1.3 Rational approximation 1.4 Weighted least square approximation 1.5 Approximation of function-chebyshev polynomials 1.6 Tutorial 1 1.7 Principles of floating point 1.8 Errors and their computations. 1.9 Error in series approximation 1.10 Tutorial 2 1.11 Multiple linear least square 1.12 Curve fitting by a polynomial 1.13 data fitting 1.14 Fitting a straight line	**SL1.1** Orthogonal polynomial

SW-1 Suggested Sessional Work (SW):

a. Assignments:

(i) Obtain a linear polynomial approximation to the function f(x) = x^3 on the interval [0,1] using the least square approximation with W(x)=1

(ii) Certain experimental values of x and given below (0,-1) (2,5) (5,12) (7,20) in the straight lines $y=a_0+a_1x$ is fitted to the above data find the approximate value of a_0 and a_1.

(iii)find the approximate value of a_0 and a_0 and a_1 so that the function $z=a_0+a_1x + a_2y$ is fitted to the data given below (0,0,2) (1,1,4) (2,3,3) (4,2,16) (6,8,6)

(iv)Define Errors and their computations

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO2-78MS303.2 Determine the Systems of Linear Equations

Approximate Hours

Item	AppXHrs
Cl	15
LI	0
SW	1
SL	1
Total	17

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO2.1 Understand the concept Systems of Linear Equations SO2.2 Understand the Partial Pivoting And Complete Pivoting SO2.3 Understand the		**Unit2.0** 2.1 Introduction of Systems of Linear Equations 2.2 Bisection method 2.3 Newton Raphson method 2.4 Regula falsi	**SL.1** computational procedure for LU Decomposition method

Factorization method, SO2.4 Understand the 3 Gauss-elimination		method 2.5 Secant method 2.6 Tutorial 1 2.7 Factorization method 2.8 Gauss-elimination method 2.9 Gauss -Jordan method 2.10 Tutorial 2 2.11 Partial Pivoting 2.12 Necessity for pivoting 2.13 Complete Pivoting 2.14 Tutorial 3 2.15 Residual error correction method	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

(I) Solve the System of Equation by Factorization Method

$$3x + 2y + 7z = 4$$
$$2x + 3y + z = 5$$
$$3x + 4y + z = 7$$

.

(ii) Solve the system of Equation by Gauss Elimination method with partial pivoting

$$10x - y + 2z = 4$$
$$x + 10y - z = 3$$
$$2x + 3y + 20z = 7$$

(iii) Solve the System of Equation by Triangularization Method

$$x + 5y + z = 14$$
$$2x + y + 3z = 13$$
$$3x + y + 4z = 17$$

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify): Quiz, Class Test.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

O3-78MS303.3 Demonstrate an understanding of the theory of Iteratives method

Approximate Hours

Item	AppXHrs
Cl	7
LI	0
SW	1
SL	1
Total	9

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the theJacobi method SO3.2 Understand the conjugate gradient methods SO3.3 Understand the Gauss-Seidel methods with convergence analysis		**Unit-3.0** 3.1 Introduction of Iterative methods 3.2 Tutorial 1 3.3 Jacobi method 3.4 Gauss-Seidel methods 3.5 Gauss-Seidel methods with convergence analysis 3.6 Tutorial 2 3.7 conjugate gradient methods.	**SL.1** Solve the many problems system of Equation by Gauss Seidel method in third iterations

SW-3 Suggested Sessional Work (SW):
a. Assignments:
1. Solve the Equation by Jacobi Method

$$6x + 3y + 12z = 35$$
$$8x - 3y + 2z = 20$$
$$4x + 11y - z = 33$$

2.Solve the Equation by Jacobi Method

$$20x + y - 2z = 17$$
$$3x + 20y - z = -18$$
$$2x - 3y + 20z = 25$$

3.Solve the system of Equation by Gauss Seidel method

$$x + 2y + z = 3$$
$$2x + 3y + 3z = 10$$
$$3x - y + 2z = 13$$

4.Solve the system of Equation by Gauss Seidel method

$$10x + y + z = 12$$
$$2x + 10y + z = 13$$
$$x + y + 5z = 7$$

5.Solve the system of Equation by Gauss Seidel method

$$8x - 3y + 2z = 20$$
$$4x + 11y - z = 33$$
$$6x + 3y + 12z = 35$$

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO4-78MS303.4 Define and recognize the Eigen value problem

Approximate Hours

Item	AppXHrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)

SO4.1 Understand Eigen value and Eigen vectors SO4.2 Understand the Householder's method SO4.3Understand Eigen values of a symmetric tridiagonal matrix, SO4.4 understand and problems solving on Interpolation		**Unit-4.0** 4.1 Eigen value 4.2 Eigen vectors of matrix . 4.3 Tutorial 1 4.4 Householder's method 4.5 Eigen values of a symmetric tridiagonal matrix 4.6 Tutorial 2 4.7 Singular value decomposition 4.8 Interpolation - Introduction 4.9 review of Lagrange interpolation techniques. 4.10 Tutorial 3 4.11 Error in Lagrange 's interpolation techniques. 4.12 Tutorial 4	**SL.1** Some problems on Eigen value and eigen vectors

SW-4 Suggested Sessional Work (SW):

a. **Assignments:**
   (i) Determine the Eigen values and Eigen vectors of the following matrix:

$$\begin{bmatrix} 5 & 0 & 1 \\ 0 & -2 & 0 \\ 1 & 0 & 5 \end{bmatrix}$$

(ii) Evaluate $\log_{10} 301$ by using Lagrange's interpolation formula given

$\log_{10} 300$	$\log_{10} 304$	$\log_{10} 305$	$\log_{10} 307$
2.4771	2.4829	2.4843	2.4871

(iii) Obtain the singular value decomposition of the following matrix:

$$\begin{bmatrix} 1 & 2 \\ 1 & 1 \\ 1 & 3 \end{bmatrix}$$

(iv) Evaluate $\log_{10} 656$ by using Lagrange's interpolation formula given

$\log_{10} 654$	$\log_{10} 658$	$\log_{10} 659$	$\log_{10} 661$
2.8156	2.8182	2.8189	2.8202

.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.
c. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS303.5 Students will create the concept of a Numerical Integrationand method based on Interpolation**.**

Approximate Hours

Item	Appx Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the concept Method based on Interpolation **SO5.2** Understand the Gauss quadrature method **SO5.3** Understand Initial Value Problems for Ordinary Differential Equations **SO5.4** Understand Predictor and Corrector scheme		**Unit-5.0** 5.1Method based on Integration 5.2 Simpson's rule 5.3 Trapezoidal rule 5.4 Tutorial 1 5.5 Newton's- Cotes method 5.6 Gauss quadrature method. 5.7 Tutorial 2 5.8 Initial Value Problems for Ordinary Differential Equations 5.9Runge-Kutta method, 5.10 Predictor 5.11 Corrector scheme 5.12 Stability and Convergence analysis.	**SL.1** Problems on Euler method

SW-3 Suggested Sessional Work (SW):
a. Assignments

(i) Use Runge - Kutta method to obtain

y when $x = 1.1$ $given\ that$ 1.2 $when\ x = 1$ and y satisfies the equations $\frac{dy}{dx} = 3x + y^2$

(ii) Use Runge - Kutta method to find

y when $x = 1.2$ in step of 0.1 given that satisfies the equations

$\frac{dy}{dx} = x^2 + y^2$, y(1) = 1.5

(iii) Show that the sum of cotes number is unity

(iv) Find $\int_0^1 \frac{1}{1+x^2} dx$ by using Trapezoidal rule where the interval is divided into 6 equal parts.

(v) Apply Milne' Simpson method to find a solution of the differential equation $\frac{dy}{dx}$ = 1+x y^2 with initial condition y(0)=1 for x=0.4, 0.5 given that

X	0.1	0.2	0.3
Y	1.101	1.223	1.355

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS303.1 Understand the importance of Uniform approximation by polynomials, Errors and their computations.	14	1	1	16
CO2-78MS303.2 Determine the Systems of Linear Equations	15	1	1	17
CO3-78MS303.3 Demonstrate an understanding of the theory of Iteratives method	7	1	1	10
CO4-78MS303.4 Define and recognize the Eigen value problem	12	1	1	14

CO5-78MS303.5 Students will create the concept of a Numerical Integrationand method based on Interpolation	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**					**Total Marks**
		R	**U**	**A**			
CO-1	Understand the importance of Uniform approximation by polynomials, Errors and their computations.	03	01	01			05
CO-2	Determine the Systems of Linear Equations	02	06	02			10
CO-3	Demonstrate an understanding of the theory of Iteratives method	03	07	05			15
CO-4	Define and recognize the Eigen value problem	-	10	05			15
CO-5	Students will create the concept of a Numerical Integrationand method based on Integration	03	02		-		05
Total		11	26		13		50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Numerical Analysis	S.S.Sastry	Prentice hall India.	2015
2	Numerical methods fore scientific and engineering computations	M.K.Jain,S.R.K. Iyenger.		
3	Numerical Analysis	G.Shankar Rao	New age international publishers ,new-Hydrabad.	2006

AKS University

Faculty of Basic Science

Department of Mathematics

Curriculum & Syllabus of M.Sc. Mathematics program

Curriculum Development Team

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS303
Course Title: Advanced Numerical Techniques

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1- 78MS303Understand the importance of Uniform approximation by polynomials, Errors and their computations.	2	3	1	2	1	2	1	1	1	1	1	1	2	2	1	
CO1-78MS303.2 Determine the Systems of Linear Equations	2	3	1	1	1	1	1	1	1	1	1	1	1	2	2	
CO1-78MS30	3	3	1	2	1	1	3	2	2	1	2	2	1	2	3	

3.3 Demonstrate an understanding of the theory of Iteratives method																
CO1-78MS303.4 Define and recognize the Eigen value problem	2	3	1	2	3	2	3	1	1	1	1	2	2	1	1	
CO1-78MS303.5 Students will create the concept of a Numerical Integrationand method based on Interpolation	3	2	3	1	2	1	2	3	1	1	1	1	1	1	1	

Legend: 1 – Low, 2 – Medium, 3 – High

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS303.1** Understand the importance of Uniform approximation by polynomials, Errors and their computations.	SO1.1 SO1.2 SO1.3 SO1.4		Unit-1.0 Approximation1.1,1.2,1.3,1.4, 1.5,1.6,1.7,1.8,1.9,1.10,1.11,1 .12,1.13,1.14,	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS303.2** Determine the Systems of Linear Equations	SO2.1 SO2.2 SO2.3 So2.4		Unit-2 System of linear equations :2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9,2.10,2. 11,2.12,2.13,2.14,2.15.	SL2.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS303.3** Demonstrate an understanding of the theory of Iteratives method	SO3.1 SO3.2 SO3.3		Unit-3 Iteratives method 3.1, 3.2, 3.3, 3.4, 3.5,3.6,3.7	SL3.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS303.4** Define and recognize the Eigen value problem	SO4.1 SO4.2 SO4.3 SO4.4		Unit-4 Eigen value problem 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10,4.11,4.12	SL4.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS303.5** Students will create the concept of a Numerical Integration	SO5.1 SO5.2 SO5.3 SO5.4		Unit-5Numerical Integration 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 ,5.7,5.8,5.9,5.10,5.11,5.12	SL.5.1

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Code:	78MS304
Course Title :	Special function
Perquisite:	Students should have basic knowledge of complex numbers
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcome :

CO1-78MS304.1 understand the property of special function like Gaus hypergeometric legendra function with their integral representations.

CO2-78MS304.2. Understand the concept of bessel's function hermit function etc with its properties like recurrence relation orthogonal properties generating function etc.

CO3-78MS304.3. Understand how special function is useful in differential equation.

CO4-78MS304.4 explain the application and the usefulness of these special function

CO5-78MS304.5 classify and explain the function different types of differential equation.

Curriculum & Syllabus of M.Sc. Mathematics program

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			Cl	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS304	Special function	4[3+1]	0	1	1	6	4

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS304	Special function	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS304.1 understand the properties of special function like Gauss hyper geometrc legendra function with their integral representations.

Approximate Hours

Item	AppX Hrs
Cl	10
LI	0

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

SW	1
SL	1
Total	12

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Understand the concept of Gamma functions. **SO1.2** Understand the relationships between beta and gamma functions. **SO1.3** Understand the concept of Beta function. **So1.4** Understand the multiplication formula **So1.5** Understand the concept of function.	-	**Unit-1.0 Gamma function and Beta function:** 1.1 Introduction of Gamma function. 1.2 The definition of Gamma functions. 1.3 Eulerian Definition. 1.4 Euler's Products. 1.5 Evaluation of Gamma functions. 1.6 Beta function: 1.7 Introduction 1.8 definition of Beta function. 1.9 Multiplication formulas. 1.10 Related functions.	**SL.1** Understand the complex numbers. **SL.2** knowledge of the gamma function and beta function. **SL.3** Properties of Gamma functions. .

SW-1 Suggested Sessional Work (SW):

a. Assignment:

i.Evaluation of Gamma and beta terms..
ii. Gauss 's multiplication formula.

iii. State and prove Beta function.

iv. Application of Gamma functions.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS304.2. Understand the concept of bessel's function hermit function etc with its properties like recurrence relation orthogonal properties generating function etc.

Approximate Hours

Item	AppX Hrs
Cl	10
LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the concept of bessel's functions. SO2.2 Learn about the concept of Recurrence relation. SO2.3 Understand the concept of Jn(x) SO2.4 Understand the Uses of Bessel's functions. SO2.5 Understand the concept of recurrence relation with example.		**Unit-2.0 Bessel Functions. :** 2.1 Introduction. 2.2 Definition of Bessel functions. 2.3 Definition of Jn(x) 2.4 Generating function of Jn(x). 2.5 Alternative forms of generating functions. 2.6 Bessel's differential equations. 2.7 Recurrence relation for Jn(x). 2.8 Bessel 's Integral. 2.9 tutorial 1 2.10 Application of bessel's functions.	**SL.1** Evaluation Bessel's differential equations. **SL.2** Knowledge of the Bessel's functions. **SL.3** Knowledge of some properties of bessel's functions.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Definition and Example of Bessel's functions.
ii. Define Alternative forms of generating functions.

iii. The Recurrence relation for Jn(x).
iv. Bessel's differential equations.

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.
c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS304.3. Understand how special function is useful in differential equations.

Approximate Hours

Item	AppX Hrs
Cl	11
LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understand the principle of legendre polynomials. SO3.2 Understand the Laplaces first integral form. SO3.3 the concept of orthogonal properties.		**Unit-3.0 Legendre Polynomials.** 3.1 Introduction. 3.2 Recurrence relation. 3.3 the concept of legendre polynomials 3.4 Generating function for legendre polynomials 3.5 tutorial 1 3.6 Rodriguez formula. 3.7 Hypergeometric forms of Pn(x) 3.8 some other generating functions 3.9 Laplaces first integral form, **3.10 Legendre 's differential equations.** **3**.11 Orthogonal properties.	**SL.1** ● Knowledge of the generating functions for legendre polynomials. ● Understand an application of legendre polynomials.

SW-3 Suggested Sessional Work (SW):
a. Assignment:
ii. Application of legendre polynomials.
iii. Evaluation of legendre differential equations.
iv. State and prove Rodrigues formula.

V. Orthogonal properties.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO4-78MS304.4 explain the application and the usefulness of these special function.

Approximate Hours

Item	AppX Hrs
Cl	10
LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the concept of harmite 's polynomials. SO4.2 understand the generating functions. SO4.3 Understand the importance of harmite 's polynomials.		**Unit -4 Hermite's Polynomials:** 4.1 Introduction 4.2 Recurrence relation. 4.3 Evaluation of Rodrigues Formula. 4.3 Generating function. 4.4 Bat'sman generating functions. 4.5 tutorial 1 4.6 Hermite's differential equations. 4.7 Evaluation of orthogonal properties. 4.8 some properties of harmite 's function. 4.9 Expansion of polynomials. 4.10 more generating functions .	**SL.1** knowledge of the harmite 's polynomials. **SL.2** Expansion of polynomials, Recurrence relation.

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Evaluation of Rodrigues formula for generating functions.
ii. Application of Hermite 's polynomials.
iii. The Expansion of polynomials.
iv. Calculation of Hermite 's differential equations.
V. More generating functions.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO5-78MS304.5 The classify and explain the function different types of differential equations.

Approximate Hours

Item	AppX Hrs
Cl	9
LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO5.1 Understand the concept of Rodrigues formula. SO5.2 Generaliged Laguerre polynomials. SO5.3 Orthogonal properties.		**Unit-5.0 Laguerre polynomials.:** **5.1** Introduction . 5.2 simple Laguerre polynomials: 5.3 Introduction the Laguerre polynomials Ln(x) 5.4 Definition and Example of Laguerre polynomials. 5.5 Generating function. 5.6 Recurrence relation. 5.7. Laguerre difficult equations. 5.8 Rodrigues Formula.,Orthogonal properties. 5.9 Generaliged Laguerre polynomials: Rodrigues formula,Orthogonal properties, expansion of polynomials.	**SL.1** ● knowledge of the Recurrence relation and generating functions. ● knowledge of the expansion of polynomials.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS304.1 understand the properties of special function like Gauss hyper geometrc legendra function with their integral representations.	. **10**	1	1	12
CO2-78MS304.2. Understand the concept of bessel's function hermit function etc with its properties like recurrence relation orthogonal properties generating function etc.	. **10**	1	1	12
CO3-78MS304.3. Understand how special function is useful in differential equations.	11	1	1	13
CO4-78MS304.4 Explain the application and the usefulness of these special function.	10	1	1	12
CO5-78MS304.5 The classify and explain the function different types of differential equations.	9	1	1	11
Total Hours	50	5	5	60

- **Suggestion for End Semester Assessment**

Suggested Specification Table For(ESA

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	**UNIT-1**: Gamma function and beta function.	03	01	01	05
CO-2.	**UNIT 2:** Bessel's functions & Bessel's differential equations.	02	05	03	10

CO-3	**Unit-3**: Legendre Polynomials.	03	06	06	15
CO-4	**Unit- 4:** Harmite's polynomials. & harmite differential equations.	-	10	05	15
CO-5	**Unit 5:** Laguerre polynomials.& Generaliged Laguerr polynomials.	03	02	-	05
Total		11	26	13	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition
1	Special Functions & Their Applications	N. N. Lebedev	New Edition	1972
2.	Differential Equation with Special function	J.N. Sharma & R.K. Gupta	Krishna Prakashan Mandir	-
3.	Integral Calculus	Shanti Narayan and Dr. P.K. Mittal	S. Chand & Company Pvt.Ltd. Ram Nagar New Delhi	-
4.	Differential Equations	Shepley L.Ross	Second Edition , john Willy & sons, New York	Second Edition 1974

b) Reference Books :

S. No.	Title	Author	Publisher	Edition
1	Special function	Rainville E.D	The Macmillan ,New York,	2nd edition, 1971
2	Special function and their applications	Lebdev	Prentice hall Englewood cliffs	New Jersey USA 1995
3	Special function with applications	Saran N. Sharma and trivedi	Pragti prakashan	Edition, 1986

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS304
Course Title: Special Function

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS304.1 understand the properties of special function like Gauss hyper geometrc legendra function with their integral representations	2	1	2	2	1	2	3	2	1	1	1	1	1	2	1	2
CO2-78MS304.2. Understand the concept of bessel's function hermit function etc with its properties like recurrence relation orthogonal properties generating function etc	2	1	3	2	1	2	1	1	1	2	1	1	3	2	1	1

CO3-.78MS304.3. Understand how special function is useful in differential equations.	2	1	2	2	1	3	2	1	2	2	1	1	2	2	1	1
CO4-78MS304.4 explain the application and the usefulness of these special function	2	1	2	2	2	1	2	2	3	2	2	2	2	1	1	1
CO5-78MS304.5 The classify and explain the function different types of differential equations.	2	2	3	2	2	2	2	2	2	1	1	3	1	1	2	1

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-78MS304.1 understand the properties of special function like Gauss hyper geometrc legendra function with their integral representations	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Gamma function and beta function. 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9, 1.10	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO2-.78MS304.2. Understand the concept of Bessel's function hermit function etc with its properties like recurrence relation orthogonal properties generating function etc	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Bessel's functions & Bessel's Differential equations. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO3-78MS304.3 Understand how special function is useful in differential equations.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 Legendre Polynomials. 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10,3.11	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO4-78MS304.4 explain the application and the usefulness of these special function	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 Harmite 's polynomials. &harmite differential equations 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10.	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO5-78MS304.5 The classify and explain the function different types of differential equations.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 Laguerre polynomials.& Generaliged Laguerre polynomials. 5.1, 5.2, 5.3, 5.4, 5 .5, 5.6, 5.7, 5.8,5.9,	SL5.1 SL5.2

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Code: **78MS305**
Course Title: Fundamentals of Computers & Programming
Pre-requisite: Student should have basic knowledge of elementary mathematics.
Rationale: The rationale behind discrete mathematics is grounded in its practical applications to computer science and related fields.

Course Outcome:

78MS305.1: Understand and apply the programming concepts of C++ which is important for mathematical investigation and problem solving.
78MS305.2: Use mathematical libraries for computational objectives.
78MS305.3: Represent the outputs of programs visually in terms of well formatted text and plots.
78MS305.4: Apply the knowledgeto solve complex problems and contribute meaningfully to the development of various software and systems.

78MS305.5:UnderstandMicrosoft Office is favored in professional settings due to its extensive features, compatibility, and support, while OpenOffice might be more suitable for personal use or organizations looking for a free and basic office suite.

SchemeofStudies:

Board ofStudy	Course Code	CourseTitle	Scheme of studies(Hours/Week)					TotalCredits (C)
			Cl	LI	SW	SL	Total StudyHours(CI+LI+SW+SL)	
OEC	78MS305	Fundamentals of Computers & Programming	3	1	2	1	7	4

Legend:
CI: ClassroomInstruction(Includesdifferentinstructionalstrategiesi.e.Lecture(L)andTutorial (T)andothers),
LI: LaboratoryInstruction(IncludesPracticalperformancesinlaboratoryworkshop, field or other locations using different instructional strategies)
SW: Sessional Work(includesassignment, seminar, miniprojectetc.),
SL: SelfLearning, **C:**Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback ofteachertoensureoutcomeofLearning.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Scheme of Assessment
Theory

Board of Study	Couse Code	Course Title	**Scheme of Assessment (Marks)**							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks (PRA+ ESA)**
			Class/ Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA+CAT +AT)		
OEC	78MS305	Fundamentals of Computers & Programming	15	20	5	5	5	50	50	100

Course-CurriculumDetailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

78MS305.1: **Understand and apply the programming concepts of C++ which is important for mathematical investigation and problem solving.**

Approximate Hours

Item	AppX Hrs
Cl	10
LI	02
SW	2
SL	1
Total	15

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO1.1 Understanding Types and components for computer fundamental **SO1.2** Explain computer Software **SO1.**3 discuss Email, chat boat and wed Blogs. **SO1.4** define Virtual Reality (VR), and Augmented Reality (AR).	1.1 Working with DOS commands 1.2 Introduction of programming language	**Unit-1.Computer Fundamental:** 1.1 Characteristics of Computer Fundamental, 1.2 Types and components of Computer Fundamental 1.3 Input Devices, Output Devices,3D Printing 1.4 Storage Devices. Smart Devices, DOS Commands. **Introduction to Programming Languages & Software** 1.5 Computer Software, 1.6 Operating System 1.7 Mobile App Software, 1.8 Social Media Software: Instant Messaging, Email, Chat Boat, and Web Blogs. **Introduction to cutting-edge technologies:** 1.9 Digital Trust, Blockchain, Internet of Things (IoT), 5G, Cyber Security, 1.10 Cloud Computing, Quantum Computing. Introduction to AI, Chat GPT, Google Bard, Microsoft Bing, ML, Virtual Reality (VR), and Augmented Reality (AR)	1. Learn about Computer Software, Operating System. 2. Google Bard, Microsoft Bing, ML.

SW-1 SuggestedSessionalWork(SW):

a. **Assignments:-**
   (1) Characteristics, types and componentsComputer Fundamental.
   (2) Digital Trust, Blockchain, Internet of Things (IoT), 5G, Cyber Security,Cloud Computing, Quantum Computing. Introduction to AI, ChatGPT.
   (3) Computer Software, Operating System, Mobile App Software,Social Media Software.

b. **MiniProject:**
   Oral presentation, Poster presentation, Power Point Presentation.

c.Other Activities (Specify):
Quiz, Class Test.

78MS305.2: Use mathematical libraries for computational objectives.

Approximate Hours

Item	AppXHrs
Cl	10
LI	02
SW	2
SL	2
Total	16

SessionOutcomes (SOs)	**Laboratory Instruction (LI)**	**ClassroomInstruction (CI)**	**SelfLearning (SL)**
SO2.1 define Programming Language. **SO2.2 discuss**History of C and Types of C Variables. **SO2.3** To learn about Data types. **SO2.4 Explain**arithmetic operators and relational operators.	2.1 Programming in C. 2.2 Operators in C.	**Unit-2** :**Getting Started with C**: 2.1 Programming Language, Types, Translators, Flowcharts, what is C, 2.2 History of C, The C Character set 2.3 Types of C, Constants 2.4 Types of C Variables, C keywords 2.5 Identifiers, and literals, Data types 2.6 Basic input & output function – printf and scanf, Math library 2.7 arithmetic operators 2.8 Relational operators 2.9 Assignment operators, logical operators, increment and decrement operators 2.10 conditional operator.	1. Types of C, Constants and Types of C Variables. 2. Basic input & output function.

SW-2 SuggestedSessionalWork(SW):

a. Assignments:-

(1) Programming Language, Types, Translators, Flowcharts.
(2) All topics of c.
(3) What is operator and types of operator.

b. MiniProject:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

78MS305.3: Represent the outputs of programs visually in terms of well formatted text and plots.

Approximate Hours

Item	AppXHrs
Cl	10
LI	02
SW	2
SL	2
Total	16

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**SelfLearning (SL)**
SO3.1 To UnderstandControl instructions. **SO3.2**To learn Loops control structure. **SO3.3 Explain** array and character array.	3.1 Proramming in c for control statements. 3.2 Programming Array in C.	**Unit-3 Control Structure:** 3.1 Control instructions, if, if-else, if-else if, nested if 3.2 Loops control structure: while loop, for loop 3.3 Loops control structure: do–while loop, odd loop, nested loop 3.4 Break, continue, case-control structure 3.5 goto, exit statement switch statement. **Array:** 3.6 Array 3.7 Array initialization 3.8 2D array 3.9 Initialization of 1D and 2D array	1. Control instructions and Loops control structure. 2. What is Array.

		3.10 Character Array.	

SW-3 SuggestedSessionalWork(SW):

a. Assignments:-
(1) Control instructions and Loops control structure.
(2) Break, continue, case-control structure.
(3) What is array and types of array.

b. MiniProject:
Oral presentation, Poster presentation, Power Point Presentation.

c.Other Activities (Specify):
Quiz, Class Test.

78MS305.4:Apply the knowledgeto solve complex problems and contribute meaningfully to the development of various software and systems.

Approximate Hours

Item	AppXHrs
CI	10
LI	02
SW	2
SL	2
Total	16

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)
SO4.1 To UnderstandNeed of function. **SO4.2** To learn types of function. **SO4.3** To understand Advance C Concepts.	4.1. Programming function in C. 4.2 Passing parameter in the function.	**Unit-4 Function:** 4.1 Need of function 4.2 Declaring a function 4.3 Defining 4.4 Calling function 4.5 Types of function 4.6 Passing parameter in the function. **Advance C Concepts:** 4.7 Pointers	1. What is function and types of function. 2. Pointers and Array of Pointers. 3. String and String Functions

SO4.4 Explain Array of Pointers.		4.8 Array of Pointers 4.9 Call by value 4.10 all by reference,Structure and union,String,String Functions	

SW-4 **SuggestedSessionalWork(SW):**

a. Assignments:

(1) declaring a function, defining, calling function,types of function, passing parameter in the function.

(2) Pointers, Array of Pointers, Call by value,Call by reference, structure and union, String, String Functions.

b. MiniProject:

Oral presentation, Poster presentation, Power Point Presentation.

c.Other Activities (Specify):

NA

78MS305.5:Understand Microsoft Office is favored in professional settings due to its extensive features, compatibility, and support, while OpenOffice might be more suitable for personal use or organizations looking for a free and basic office suite.

Approximate Hours

Item	AppXHrs
CI	10
LI	02
SW	2
SL	2
Total	16

SessionOutcomes (SOs)	LaboratoryInstruction (LI)	ClassroomInstruction (CI)	SelfLearning (SL)

SO5.1 To understandIntroduction and FeaturesMS Office. **SO5.2** To learn about Open Office. **SO5.3**Explain Google Workspace. **SO5.4** define Computer Networks.	5.1**.** Documents editing in MS-word. 5.2 Creating table in MS-EXCEL.	**Unit 5 (1)** **MS Office Vs Open Office:** 5.1 Introduction and Features (Comparison). 5.2MS Word: Introduction, Features, and Applications, 5.3Menus & Commands, 5.4 Toolbars & Buttons 5.5MS Excel:- Introduction, working with MS Excel, Use of Formulas and Functions. **5**.6 MS PowerPoint:- Introduction, working with MS PowerPoint, Creating a Presentation. 5.7 Computer Networks**:-**LAN and WAN and Internet, Bluetooth, Wi-Fi, Li-Fi, Client-Server architecture. 5.8Cloud-Based Services: 5.9Google Workspace: DOCS, Sheets, Slides, Forms, Calendar, 5.10 Chat, Meet, Contacts, Maps,Jam board; YouTube	1. Introduction and FeaturesMS Office. 2. Computer Networks and Google Workspace.

SW-5 SuggestedSessionalWork(SW):

a. **Assignments:-**

(1) Introduction and Features MS Office.
(2) LAN and WAN and Internet, Bluetooth, Wi-Fi, Li-Fi, Client-Server architecture.
(3) Explain Google Workspace.

b. **MiniProject:**NA
c. **OtherActivities(Specify):**NA

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	**Laboratory Instruction (LI)**	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
78MS305.1: Understand and apply the programming concepts of C++ which is important for mathematical investigation and problem solving.	10	2	2	2	16
78MS305.2: Use mathematical libraries for computational objectives.	10	2	2	2	16
78MS305.3: Represent the outputs of programs visually in terms of well formatted text and plots.	10	2	2	2	16
78MS305.4:Apply the knowledgeto solve complex problems and contribute meaningfully to the development of various software and systems.	10	2	2	2	16
78MS305.5:Understand Microsoft Office is favored in professional settings due to its extensive features, compatibility, and support, while OpenOffice might be more suitable for personal use or organizations looking for a free and basic office suite.	10	2	2	2	16
Total Hours	50	10	10	10	80

Suggestion for End Semester Assessment

Suggested Specification Table(ForESA)

CO	UnitTitles	MarksDistribution			Total Marks
		R	U	A	
CO-1	Computer Fundamental	03	01	01	05
CO-2	Getting Started withC,Operator	02	02	01	05
CO-3	Control Structure , Array	03	07	05	15
CO-4	Function and Advance C Concepts	04	06	05	15
CO-5	MS Office Vs Open Office	03	04	03	10
Total		15	20	15	50

Legend: R:Remember, U:Understand, A:Apply

TheendofsemesterassessmentforIntroduction to Portland cement willbeheld with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wiseteachers for above tasks. Teachers can also design different tasks as per requirement, for endsemesterassessment

SuggestedInstructional/ImplementationStrategies:

1. ImprovedLecture
2. Tutorial
3. CaseMethod
4. GroupDiscussion
5. RolePlay
6. Visittocementplant
7. Demonstration
8. ICTBasedTeachingLearning(VideoDemonstration/TutorialsCBT,Blog,Facebook, Twitter,WhatsApp,Mobile,Onlinesources)
9. Brainstorming

Suggested Learning Resources:

A. Books:

S. No.	Title	Author	Publisher	Edition &Year
1	"Computer Fundamentals"	Pradeep K. Sinha and Priti Sinha	BPB Publications	Fourth Edition
2	"Let Us C" BPB Publications, 2007	YashvantKanetkar	BPB Publications,	Seventh Edition 2007
3	Learning Computer Fundamentals, MS Office and Internet & Web Tech.	Maidasani, D.	Laxmi Publications	2005

Curriculum Development Team

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

CO, PO and PSO Mapping

Course: M.Sc. Mathematics
CourseCode: 78MS305
Course Title: Fundamentals of Computers & Programming

Course Outcomes	ProgramOutcomes												ProgramSpecific Outcome			
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO1 0	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates hematica Models
CO.1 : **78MS305.1** Computer Fundamental	1	1	2	2	3	2	3	2	2	1	3	2	2	3	3	1
CO.2 : **78MS305** .2 Getting Started withC, Operator	1	1	2	2	1	2	3	2	1	1	2	2	2	2	2	1
CO.3 : **78MS305** .3 Control Structure , Array	2	2	1	1	1	2	2	2	1	2	1	2	1	1	2	2
CO.4 : **78MS305** .4 Function and Advance C Concepts	3	2	2	2	3	2	3	2	2	1	2	3	3	3	3	2

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

CO.5 : **78MS305** .5 MS Office Vs Open Office	3	2	1	1	1	3	3	3	1	1	2	2	3	3	1	3

Legend:1–Low,2–Medium,3–High

Course Curriculum Map:

POs&PSOsNo.	Cos No.&Titles	SOsNo.	LaboratoryInstruction (LI)	Classroom Instruction(CI)	SelfLearning(SL)
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4,5	CO.1 : **78MS305.1** Computer Fundamental	SO1.1, SO1, SO1.3,SO1.4		Unit-1. 1.1.1,1.1.2,1.1.3,1.1.4, 1.2.1,1.2.2,1.2.3,1.1.4, 1.3.1, 1.3.2,1.3.3 1.1.4	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4,5	CO.2 : **78MS305**.2 Getting Started withC, Operator	SO2.1, SO2.2, SO2.3,SO2.4		Unit-2 2.1.1,2.1.2,2.1.3,2.1.4 ,2.1.5,2.1.6,2.1.7 2.2.1,2.2.2.,2.2.3,2.2. 4,2.2.5	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4,5	CO.3 : **78MS305**.3 Control Structure , Array	SO3 .1S O3. 2 SO3.3		Unit-3 : 3.1.1,3.1.2,3.1.3,3.1.4, 3.1.5,3.1.6,3.1.7	

				3.2.1,3.2.2,3.2.3,3.2.4,3.2.5	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4,5	CO.4 **: 78MS305**.4 Function and Advance C Concepts	SO4.1 SO4.2 SO4.3 SO4.4		Unit-4: 4.1.1,4.1.2,4.1.3,4.1.4,4.1.5 4.2.1,4.2.2,4.2.3,4.2.4,4.2.5,4.2.6,4.2.7	
PO1,2,3,4,5,6 7,8,9,10,11,12 PSO1,2,3,4,5	CO.5 **: 78MS305**.5 MS Office Vs Open Office	SO5.1 SO5.2 SO5.3 SO5.4		Unit5: 5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-III

Course Code:	78MS306-A
Course Title :	Scientific writing
Pre -requisite:	Graduate Student Standing
Rationale:	This course will guide graduate students through the process of scientific writing. Students will select a project of interest for which there is existing data. With this data, we will cover developing sound objectives, writing a scientific manuscript including basic analyses, developing figures, and then presenting scientific results at a conference

Course Outcome :

CO1-78MS306-A .1
Do review of literature

CO2-78MS306-A .2
Write review paper thesis write and Generate report

CO3-78MS306-A .3
Aware to format of publications

CO4-78MS306-A .4
Understand concept of impact factor, H index

CO5-78MS306-A.5
Understand implementation of Softwares to writing research papers and plotting the graphs.

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
RC	78MS306-A	Scientific Writing	2	1	1	1	(2+1+1+1)	3

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.
Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:
Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)		
			Progressive Assessment (PRA)	**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)

			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
RC	78MS306-A	Scientific Writing	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1- 78MS306-A .1
Do review of literature.

Approximate Hours

Item	AppX Hrs
Cl	9
LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO1.1 Understanding the Structure and Purpose of Research Writing **SO 1.2** Developing Skills for Effective Research Writing **SO 1.3** Mastering the Concepts of Bibliography and References	-	**Unit-1.** **1.1** Basic Concept of research journal **1.2** concept of Thesis Writing and Report Generation **1.3** Writing Research Abstract **1.4** Introduction, Review of Literature **1.5** discuss Result and Conclusion **1.6** discuss how to read a paper **1.7** concept of writing **1.8** Concepts of Bibliography **1.9** References	**SL.1** Practice by reviewing examples of well-written research papers or theses available in digital libraries or academic databases to see how experienced researchers organize and present their work. **SL.2** Write a brief introduction that sets the context for a chosen research topic, clearly stating the research problem and objectives.

SW-1 Suggested Sessional Work (SW):
a. Assignment:
i. Read a research papers and make a summary.
b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

CO2-78MS306-A .2
Write review paper thesis write and Generate report**.**

Approximate Hours

Item	AppX Hrs
CI	9

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO 2.1 Understanding the Significance and Structure of Report Writing **SO 2.2** Mastering Presentation and Publication Formats **SO 2.3** Developing Skills for Effective Oral and Poster Presentations:		**Unit:-2** **2.1** Significance of Report Writing **2.2** Steps of Report Writing **2.3** Types of Research Reports **2.4** Types of Research Reports **2.5** Formats of Publication in Research Journal/ Book/ Conference Etc **2.6** Concept of Impact Factor, H-Index **2.7** Seminar Presentation: Power Poin For Oral And Poster Presentations Reference. **2.8** Oral Presentations **2.9** Poster Presentations	**SL 1** Gain a solid understanding of the different types of reports and publication formats, enabling you to choose the appropriate format for your work. **SL2** Research and study various types of research reports, such as technical reports, case studies, and white papers.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. study various types of research and make a report.

b. Mini Project:

Oral presentation, Power Point Presentation.

CO3-78MS306-A .3
Aware to format of publications

Approximate Hours

Item	AppX Hrs
CI	9
LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Understanding the Significance and Steps of Report Writing **SO3.2** Familiarity with Types of Research Reports and Presentation Methods: **SO3.3** Mastering Advanced Tools and Techniques for Research Communication:		Unit 3 **3.1** Typesetting Mathematical Text With LATEX **3.2** Sample Document, Type Style **3.3** understand Environments, Lists, Centering, Tables, **3.4** study Vertical And Horizontal spacing **3.5** learn Equation Environments, Fonts, **3.6** Hats And Underlining, Braces **3.7** Arrays And Matrices **3.8** learn Customized Commands **3.9** Theorem–Like Environments Math Styles	**SL 1** Exploration and Practice with LaTeX **SL 2** Practice creating LaTeX documents by writing and typesetting various mathematical expressions, tables, and customized commands

SW-3 Suggested Sessional Work (SW):

a Assignment:

1 Access online tutorials and documentation for LaTeX to learn the basics of typesetting mathematical text.

b. Mini Project:

Oral presentation, Power Point Presentation.

CO4-78MS306-A .4
Understand concept of impact factor, H index

Approximate Hours

Item	AppX Hrs
Cl	9
LI	0
SW	1
SL	1
Total	11

SW-4 Suggested Sessional Work (SW):

a Assignment:

1 Practice creating simple documents.

b. Mini Project:

Oral presentation, Power Point Presentation.

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO 4.1 Comprehension of Document Structure and Tools. **SO4.2** Skill Development in Document Creation **SO4.3** Proficiency in Data Analysis Tools		**UNIT 4** **4.1** understand Document Classes and the Overall Structure **4.2** learn how to give Titles for Documents **4.3** learn Sectioning Commands **4.4** Inputting Files, Inputting Pictures, Making a Bibliography **4.5** Making an Index **4.6** Packages. **4.7** Slides **4.8**Computer usage for collecting/analyzing data-simulation using Fortran/C/Mathematica/Matlab/ MathCAD/IBM-SPSS. **4.9**understand how to insert Pictures and graph in paper	**SL 1** Study the official documentation and online tutorials for LaTeX or other document preparation **SL2** Create sample documents with various structures (articles, reports, books) using LaTeX or another system,

CO5-78MS306-A.5

Understand implementation of Softwares to writing research papers and plotting the graphs.

Approximate Hours

Item	AppX Hrs
Cl	9
LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO 5.1 Introduction to MATLAB Environment and Basic Operations **SO 5.2** Participants will develop skills in creating, saving, and executing script and function files, as well as handling data operations **SO5.3** Working with Arrays and Plotting Data		**Unit-5** **5.1** learn Basics of MATLAB, Window **5.2** understand Input-Output, File types, Working with arrays of numbers. **5.3** Creating and Printing Simple Plots, **5.4** Creating, Saving and Executing a Script file **5.5** Creating and Executing a function file. **5.6** Indexing, Matrix manipulation, Creating Vectors, Matrix and Array operations **5.7** Saving and Loading Data, Plotting Simple Graphs. **5.8**, Plotting Simple Graphs. **5.9** presentation	**SL 1** Explore MATLAB Documentation and Tutorials **SL2** Write and execute simple script and function files to automate calculations and tasks, starting with basic examples

SW-3 Suggested Sessional Work (SW):

a Assignment:

1 Create and customize simple plots using sample data, and practice saving and exporting these plots for use in reports and presentations.

b. Mini Project:

Oral presentation, Power Point Presentation

Brief of Hours suggested for the Course Outcome

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS306-A .1 Do review of literature.	**9**	1	1	11
CO2-78MS306-A .2 Write review paper thesis write and Generate report**.**	**9**	1	1	11
CO3-78MS306-A .3 Aware to format of publications	**9**	1	1	11
CO4-78MS306-A .4 Understand concept of impact factor, H index	**9**	1	1	11
CO5-78MS306-A.5 Understand implementation of Softwares to writing research papers and plotting the graphs.	**9**	1	1	11
Total Hours	45	5	5	65

Suggestion for End Semester Assessment

Suggested Specification Table For(ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO1-78MS306-A .1 Do review of literature.	Review of Literature	2	3	5	10
CO2-78MS306-A .2 Write review paper thesis write and Generate report**.**	Report Writing	2	3	5	10

CO3-78MS306-A .3 Aware to format of publications	Typesetting Mathematical Text With LATEX	2	3	5	10
CO4-78MS306-A .4 Understand concept of impact factor, H index	Packages	1	1	3	05
CO5-78MS306-A.5 Understand implementation of Softwares to writing research papers and plotting the graphs.	MATLAB	2	3	10	15
Total		9	13	28	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S.No.	Title	Author	Publisher	Edition
1	Scientific writing Booklet	Marc E. Tischler		

2	Scientific Writing For Graduate Students	F. Peter Woodford The Rockefeller University, New York	Library of Congress catalogue card number 68-56104,USA	
3	American Medical Association Manual of Style:a Guide for Authors and Editors	Williams & Wilkins	Baltimore	9th , 1998
4	Author's Handbook of Styles for Life Science Journals.; Iverson, Cheryl, Ed.;	Atlas, Michel C	CRC Press: Boca Raton,	1996
5	Byrne, Daniel W. Publishing your Medical Research Paper: What They Don't Teach You in Medical School	Williams & Wilkins:	Baltimore	1998

b) Reference Book:

S. No.	Title	Author	Publisher	Edition & Year
1	Interpreting the Medical Literature	Gehlbach, Stephen H.	McGraw Hill Medical Publishing Division: New York,	4^{th}, 2002
2	Successful Scientific Writing: a Step-bystep Guide for Biomedical Scientists,;	Matthews, Janice R.; Bowen, John M.; Matthews, Robert W.	Cambridge University Press: New York,	2nd ed. & 2000
3	Writing Papers in the Biological Sciences	McMillan, Vicky.	Bedford Books: Boston	3rd ed., 2001.
4	Short Guide to Writing about Biology, ,	Pechenik, Jan A. A	Longman: New York	4th ed.,2001.

5	Essentials of Writing Biomedical Research Papers	Zeiger, Mimi.	McGraw-Hill, Health Professions Division: New York	2nd ed. 2000.

c) Suggetsed Digital Platform Web links :

Suggested Digital Platforms Web links:	http://www.organicworldwide.net/writing.html http://www.mang.canterbury.ac.nz/courseinfo/AcademicWriting/Scientific.html http://mason.gmu.edu/~arichar6/logic.htm - Logical Fallacies In Scientific Writing; A. Stephen Richardson http://www.stark.kent.edu/writing/outline.html - outlines http://bio.winona.edu/delong/EcoLab/21%20Suggestions.html - Twenty-One Suggestions for Writing Good Scientific Papers: http://www.mco.edu/lib/instr/libinsta.html - Instructions to Authors in the Health Sciences (a plethora of journals) B

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS306-A
Course Title: Scientific writing

Course Outcome	PO1	PO 2	P O 3	PO 4	PO5	PO 6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS306-A .1 Do review of literature.	2	1	3	2	1	2	3	3	1	1	2	1	1	2	1	2

CO2-78MS306-A .2 Write review paper thesis write and Generate report**.**	2	1	3	2	1	2	3	3	1	2	2	1	3	2	1	1
CO3-78MS306-A .3 Aware to format of publication	2	1	2	2	1	3	3	2	2	2	1	1	2	2	1	1
CO4-78MS306-A .4 Understand concept of impact factor, H index	2	1	2	2	2	2	3	2	3	2	2	2	2	1	1	1
CO5-78MS306-A.5 Understand implementation of Softwares to writing research papers and plotting the graphs.	2	2	2	2	3	3	2	2	2	1	1	3	1	1	2	1

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO1-78MS306-A** .1 literature.	SO1.1 SO1.2 SO1.3		Unit-1.0 linear programming problem. 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8, 1.9	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO2-78MS306-A .2** Write review paper thesis write and Generate report.	SO1.1 SO1.2 SO1.3		Unit-2 solution of linear programming problem. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO3-78MS306-A .3** Aware to format of publications	SO1.1 SO1.2 SO1.3		Unit-3 . Assignment problem: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO4-78MS306-A .4** Understand concept of impact factor, H index	SO1.1 SO1.2 SO1.3		Unit-4 Transportation problem: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9	SL4.1 SL4.2

PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	**CO5-78MS306-A.5** Understand implementation of Softwares to writing research papers and plotting the graphs.	SO1.1 SO1.2 SO1.3		Unit-5 **Network Analysis:** 5.1, 5.2, 5.3, 5.4, 5 .5, 5.6, 5.7, 5.8,5.9	SL5.1 SL5.2

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Curriculum & Syllabus of M.Sc. Mathematics program

Semester-IV

Course Code: 78MS401 .

Course Title : Analytic Number Theory

Pre- requisite:
- Basic knowledge of complex analysis
- Familiarity with number theory concepts
- Understanding of basic calculus

Rationale: Analytic number theory aims to understand the distribution of prime numbers, study their arithmetic properties, and investigate connections between prime numbers and other mathematical objects.

78MS401.1 Be able to effectively express the concepts and results of number theory.

78MS401.2 Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.

78MS401.3 Understand distribution of prime numbers and prime number theorem.

78MS401.4 Learn the concept of quadratic residue and Quadratic reciprocity laws.

78MS401.5 Get a basic knowledge in Cryptography.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	LI	SW	SL	Total Study Hours (CI+LI+SW+SL)	
Program Core (PCC)	78MS401	Analytic Number Theory	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),

LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.)
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:
Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+ SA + CAT+AT)		
PCC	78MS401	Analytic Number Theory	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS401.1 Be able to effectively express the concepts and results of number theory.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Real-world applications of Dirichlet series and Euler products in number theory. **SO1.2** Students will understand the concepts of Dirichlet Series and Euler Products, and their applications in number theory.	-	**Unit-1 Dirichlet Series and Euler Products** 1.1 Introduction 1.2 Briefly review the concepts of complex analysis 1.3 Dirichlet characters and the Dirichlet convolution. 1.4 Definition and Convergence of Dirichlet Series 1.5 Introduce the need for Dirichlet series in number theory. 1.6 Dirichlet Characters 1.7 Tutorial-I 1.8 Euler Products 1.9 Explore applications of Euler products in number theory 1.10 Work through examples of Dirichlet series and Euler products. **1.11** Motivate the study of Euler products by discussing their role in representing certain arithmetic functions **1.12** Tutorial-II	SL.1 Basic knowledge of complex analysis SL.2 Familiarity with number theory

SW-1 Suggested Sessional Work (SW):

a. **Assignments:**

Exercises and problems related to Dirichlet series and Euler products .

b. Mini Project:
Oral presentation

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS401.2 Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Students will understand the concept of functions defined by series and the half plane of convergence of a Dirichlet series. **SO2.2** Convergence and divergence criteria		**Unit-2.0 The Function defined by Series, The half plane of convergence of a Dirichlet Series.** 2.1 Briefly review complex numbers, complex functions, and series convergence 2.2 Introduction to Functions Defined by Series 2.3 Power Series 2.4 Introduce the notion of the interval of convergence for a power series. 2.5 Tutorials-I 2.6 Function Representation 2.7 The concept of the Taylor	**SL.1** Basic knowledge of complex analysis **SL.2** Understanding of series convergence

		series and its role in representing functions. 2.8 Examples and Applications 2.9 Half Plane of Convergence: Introduction 2.10 Convergence in a Half Plane 2.11 Conditions for Convergence 2.12 Tutorials-II	

SW-2 Suggested Sessional Work (SW):

a. Assignments:
Assign exercises and problems related to functions defined by series and Dirichlet series convergence for further practice.
b. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS401.3 Understand distribution of prime numbers and prime number theorem.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Student able to understand the Dirichlet Series Representation **SO3.2** Student able to Identify the poles of the function $F(s)/s$ within the contour. and Student able to use		**Unit-3.0** **The Integral formula for the coefficients of Dirichlet Series** 3.1 Brief overview of Dirichlet series 3.2 Importance of coefficients in analyzing the behaviour of series 3.3 Statement of the integral formula for coefficients 3.4 Definition of Dirichlet series	**SL.1** Definition of Dirichlet Series SL.2 Derivation of Euler's Formula for

the residue theorem to evaluate the integral. The residues at the poles contribute to the value of the integral.		3.5 Convergence and divergence criteria 3.6 Basic properties and examples. 3.7 Introduction to analytic continuation 3.8 The need for analytic continuation in Dirichlet series 3.9 Key theorems and concepts related to analytic continuation 3.10 Application of complex integration to Dirichlet series 3.11 Application of the integral formula in number theory 3.12 Tutorial	Dirichlet Series

SW-3 Suggested Sessional Work (SW):

a. Assignments:

The Integral formula for the coefficients of Dirichlet Series.

b. Other Activities (Specify):

Quiz, Class Test.

CO4-78MS401.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the Basics of Convergence and Divergence **SO4.2** Student will Learn		**Unit-4.0 Analytic Properties of Dirichlet Series** **4.1** Introduction **4.2** Convergence of Dirichlet Series **4.3** Pointwise convergence **4.4** Uniform convergence **4.5** Application of Dirichlet's	SL.1 Ensure you have a solid understanding of complex analysis, including topics like complex numbers, power series, and

about the concept of analytic continuation for Dirichlet series.		Theorem to prime distribution **4.6** Extension to more general arithmetic functions **4.7** Tutorial-I **4.8** Introduction to analytic continuation **4.9** Connection between Dirichlet Series and Analytic Continuation **4.10** Mean value formula for Dirichlet Series. **4.11** Advanced analytic techniques in the study of Dirichlet Series **4.12** Tutorial-II	contour integration. **SL.2** Familiarize yourself with basic concepts in number theory, such as prime numbers, arithmetic functions, and Euler's totient function.

SW-4 Suggested Sessional Work (SW):
a. Assignments:
Analytic Properties of Dirichlet Series
b. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS401.5 Understanding of the concepts, principles, and mathematical framework of the General Theory of Relativity.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the concept of zeta function **SO5.2** Understand the application of Hurwitz zeta function		**Unit-5.0** zeta function **5.1** Gamma Function **5.2** Properties of Gamma Function **5.3** Examples on Gamma Function **5.4** The Riemann zeta function and its analytic continuation **5.5** Hurwitz zeta function **5.6** Integral representation of	**SL.1** Knowledge of complex number **SL.2** Knowledge of Gamma Function

		Hurwitz zeta function **5.7** Tutorial-I **5.8** Analytic Continuation of Hurwitz zeta function **5.9** Examples on analytic Continuation of Hurwitz zeta function. **5.10** Calculation of Hurwitz Zeta Function **5.11** Examples **5.12** Tutorial-I	

SW-5 Suggested Sessional Work (SW):

a. Assignments:

Bending of light rays in a gravitational field. Gravitational redshift ,Spectral lines. nergy-momentum tensor of a perfect fluid. Schwarzschild internal solution. Boundary conditions. Energy-Momentum tensor of an electromagnetic field.

b. Other Activities (Specify):

Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
78MS401.1 Be able to effectively express the concepts and results of number theory.	12	1	1	14
CO2-78MS401.2 78MS401.2 Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.	12	1	1	14
78MS401.3 Understand distribution of prime numbers and prime number theorem.	12	1	1	14
78MS401.4 Learn the concept of quadratic residue and Quadratic	12	1	1	14

reciprocity laws.				
78MS401.5Get a basic knowledge in Cryptography.	12	1	1	14
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	Dirichlet Series and Euler Products	05	05	05	15
CO-2	Convergence of Dirichlet Series	05	05	05	15
CO-3	coefficients of Dirichlet Series	03	01	02	06
CO-4	Analytic Properties of Dirichlet Series	03	03	02	08
CO-5	Zeta Function	03	01	02	06
Total		**25**	**17**	**08**	**50**

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources

6. Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Introduction to Analytic Number Theory	T. M. Apostol	Narosa Pub. House	1989
2	Introduction to Analytic Number Theory	Apostol, T. M.,	Springer International Student Edition,Narosa Publishing House, New Delhi	1993.
3	An Introduction to the Theory of Numbers	Hardy, G.H. and Wright, E. M.	Oxford University Press	4th Edition, 1960
4	An Introduction to the Theory of Numbers	Niven, I. and Zuckerman, H.	Wiley Eastern, New Delhi	5th Edition, 2000
5	A classical introduction to modern number theory	Kenneth Ireland and Michael Rosen	Springer	(2010)

Curriculum Development Team

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS401
Course Title: Analytic Number Theory

Course Outcome	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12	PSO 1	PSO 2	PSO 3	PS O 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS401.1 Be able to effectively express the concepts and results of number theory.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3

78MS401.2 Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2
78MS401.3 Understand distribution of prime numbers and prime number theorem.		3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
78MS401.4 Learn the concept of quadratic residue and Quadratic reciprocity laws.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
78MS401.5 Get a basic knowledge in Crypto - graphy.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-78MS401.1 Be able to effectively express the concepts and results of number theory.	SO1.1 SO1.2		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11.1.12	SL1.1 SL1.2 SL1.3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS401.2 Learn basic theory of arithmetical functions and Dirichlet multiplication averages of some arithmetical functions.	SO1.1 SO1.2		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 2.11,1.12	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS401.3 Understand distribution of prime numbers and prime number theorem.	SO1.1 SO1.2		Unit-3 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8,3.9,3.10, 3.11,3.12	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS401.4 Learn the concept of quadratic residue and Quadratic reciprocity laws.	SO1.1 SO1.2		Unit-4 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10, 4.11,4.12	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS401.5 Get a basic knowledge in Crypto - graphy.	SO1.1 SO1.2		Unit-5 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8,5.9,5.10. 5.11,5.12	SL5.1 SL5.2

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Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-IV

Course Code:	78MS402
Course Title :	Functional Analysis
Pre- requisite:	Students should have basic knowledge of and deep understanding of the theory of the advanced numerical techniques.
Rationale:	The program aims to develop advanced problem-solving and analytical skills and prepares students for careers in academia, research, industry, or other sectors that require advanced mathematical expertise.

Course Outcomes:

CO1-78MS402.1 Understand the importance of Normed Linear spaces and Banach spaces

CO2-78MS402.2 Determine the Fundamental theorems on Normed linear space

CO3-78MS402.3 Demonstrate an understanding of the Applications of Normed linear space

CO4-78MS402.4 Define and recognize the Hilbert Spaces

CO5-78MS402.5 Students will create the concept of aOperator Theory and Sturm-Liouville System

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Core (PCC)	78MS402	**Functional Analysis**	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
PCC	78MS402	Functional Analysis	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS402.1 Understand the importance of Normed Linear spaces and Banach spaces

Approximate Hours

Item	AppXHrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 Understand the concept of Normed linear spaces **SO1.2** Understand the Banach space **SO1.3** Understand the Basic properties of finite dimensional Normed spaces. **SO1.4** Understand Completion of a Normed linear space		**Unit-1.0** 1.1 Norm 1.2 Normed linear spaces. 1.3 Tutorial 1 1.4 Quotient space of Normed linear space 1.5 Subspace 1.6 Completeness, 1.7 Banach space 1.8 Equivalent norms. 1.9 Basic properties of finite dimensional Normed spaces 1.10 Tutorial 2 1.11 Projections 1.12 Completion of a Normed linear space, 1.13 Riesz lemma	**SL1.1**Examples of offinite dimensional Normed spaces

SW-1 Suggested Sessional Work (SW):

a. Assignments:

(i) State and prove Riesz lemma

(ii) Any finite dimensional normed linear space is a Banach space

(iii) Define Norm and Normed Linear Space and Show that $\mathbb{R}^{\boldsymbol{n}}$ *is nls with the following norms*

$$(i)\ \| x \|_1 = \sum_{i=1}^{n} |x_i|\ (ii)\ \| x \|_2 = \left(\sum_{i=1}^{n} |x_i|^2\right)^{\frac{1}{2}}$$
$$(iii)\ \| x \|_\infty = \max_{1\le i\le n} |x_i|$$

(iv) Show that l_∞ c are normed linear space with the norm

$\| x \| = \lim_{n\to\infty} |x_n|$ define a norm on c

(v)Show that the real linear space R and the complex linear space are Banach space under the **norm**

$\| \boldsymbol{x} \| = |\boldsymbol{x}|$, $\boldsymbol{x} \in \boldsymbol{C}$ **or R**

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO2-78MS402.2 Determine the Fundamental theorems on Normed linear space

Approximate Hours

Item	AppXHrs
Cl	10
LI	0
SW	1
SL	1
Total	11

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning**
SO2.1 Understand the concept Bounded linear transformations		**Unit2.0** **2.1** Bounded linear transformations 2.2 Dual spaces with	S.L.1 some theorems on weak and strong convergence

SO2.2 Understand the dual spaces **SO2.3** Understand the Open mapping and closed graph theorems **SO2.4** Understand the Weak Convergence		examples 2.3 Tutorial 1 2.4 Weak Convergence, 2.5 Uniform boundedness principle 2.6 Uniform boundedness theorem 2.7 Consequences. 2.8 Tutorial 2 2.9 Open mapping theorem 2.10 Closed graph theorems.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

(I) State and prove closed graph theorems

(ii)State and prove uniform boundedness theorem

(iii) State and prove open mapping theorem

(iv) Weak convergence does not necessarily imply strong convergence.

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO3-78MS402.3 Demonstrate an understanding of the Applications of Normed linear space.

Approximate Hours

Item	AppXHrs
Cl	10
LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO3.1 Understand the theHahn-Banach theorem for real linear space **SO3.2** Understand the Complex linear spaces **SO3.3** Understand the Reflexive spaces **SO3.4** Understand the Solvability of linear equations in Banach spaces..		**Unit-3.0** 3.1 Hahn-Banach theorem for real linear space 3.2 linear spaces, 3.3 Banach's theorem 3.4 Complex linear spaces. 3.5 Reflexive spaces. 3.6 Tutorial 1 3.7 Weak Sequential Compactness. 3.8 Solvability of linear equations in Banach spaces.. 3.9 Tutorial 2 3.10 application of Hahn-Banach theorem	**SL.1** Solve the many problems reflexive space

SW-3 Suggested Sessional Work (SW):

a. Assignments:

(i) State and prove Hahn Banach theorem for a real normed linear space

(ii)Show that every finite dimensional nls is reflexive

(iii) State and prove Banach theorem

(iv) Define reflexive space with one example

b. Mini Project:

Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):

Quiz, Class Test.

CO4-78MS402.4 Define and recognize the Hilbert Spaces

Approximate Hours

Item	AppXHrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Understand the Inner-product spaces **SO4.2** Understand the Hilbert spaces **SO4.3** Understand the Cauchy-Schwarz Inequality **SO4.4** Understand and problems solving on Structure of Hilbert spaces.		**Unit-4.0** 4.**1** Inner-product spaces 4.2 Cauchy-Schwarz Inequality 4.3 The Triangle Inequality, 4.4 Polarization Identity 4.5 Hilbert spaces, 4.6 Orthonormal Sets. 4.7 Bessel's inequality. 4.8 Parseval's identity 4.9 Structure of Hilbert spaces. 4.10 Projection theorem 4.11Riesz - Fischer theorem 4.12 Riesz representation theorem 4.13 Tutorial 1 4.14 Tutorial 2	**SL.1** Some problems on Reflexivity of Hilbert spaces

SW-4 Suggested Sessional Work (SW):

a. **Assignments:**

(i) State and prove Bessel’s inequality

(ii) Prove that every inner product space is a normed space

(iii) State and prove Riesz -Fischer theorem,

(iv) State and prove Riesz representation

(v) State and prove Parseval's identity

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

CO5-78MS402.5 Students will create the concept of aOperator Theory and Sturm-Liouville System.

Approximate Hours

Item	Appx Hrs
Cl	13
LI	0
SW	1
SL	1
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO5.1 Understand the conceptLinear Operators **SO5.2** Understand the Self-Adjoint operators **SO5.3** Understand Normal and Unitary operators **SO5.4** Understand The The Closed Range Theorem. **SO5.5** Understand The Sturm-Liouville Problems		**Unit-5.0** 5.1 Linear Operators, 5.2 Adjoint of an operator on a Hilbert space. 5.3 Tutorial 1 5.4 Self-Adjoint operators 5.5 Positive operators, 5. 6Compact Operators, 5.7 Invertible operators, 5.8 Identity operators 5.9 Projection operators, 5.10 Normal and Unitary operators.	**SL.1** Application to Sturm-Liouville Problems.

		5.11 The Closed Range Theorem. 5.12Sturm-Liouville Problems. 5.13 Tutorial 2	

SW-3 Suggested Sessional Work (SW):
a. Assignments

(i) State and prove The Closed Range Theorem
(ii) Prove that Every positive operator is self adjoint
(iii) An operator T on a Hilbert space H is unitary if and only if it is an isometric isomorphism of H onto itself
(iv) Let T be an operator on H then prove that I*=I where I is the identity operator

b. Mini Project:
Oral presentation, Poster presentation, Power Point Presentation.

c. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS402.1 Understand the importance of Normed Linear spaces and Banach spaces	13	1	1	15
CO2-78MS402.2 Determine the Fundamental theorems on Normed linear space	10	1	1	12
CO3-78MS402.3 Demonstrate an understanding of the Applications of	10	1	1	12

Normed linear space				
CO4-78MS402.4 Define and recognize the Hilbert Spaces	14	1	1	16
CO5-78MS402.5 Students will create the concept of a Operator Theory and Sturm-Liouville System	13	1	1	15
Total Hours	60	5	5	70

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**					**Total Marks**
		R	**U**	**A**			
CO-1	Understand the importance of Normed Linear spaces and Banach spaces	03	01	01			05
CO-2	Determine the Fundamental theorems on Normed linear space	02	06	02			10
CO-3	Demonstrate an understanding of the Applications of Normed linear space	03	07	05			15
CO-4	Define and recognize the Hilbert Spaces	-	10	05			15
CO-5	Students will create the concept of an Operator Theory and Sturm-Liouville System	03	02		-		05
Total		11	26		13		50

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Functional Analysis with Application.	H. K. Pathak		Third Revised Edition :2018-2019
2	Functional Analysis	Rudin W.		McGraw Hill,2000
3	Introduction to Functional Analysis	A.H. Siddique	Real world education publisher New Delhi	2014

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS402
Course Title: Functional Analysis

Course Outcome	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS402.1 Understand the importance of Normed Linear spaces and Banach spaces	3	2	2	2	1	2	1	1	2	1	1	1	2	2	1	
CO2-78MS402.2 Determine the Fundamental theorems on Normed linear space	2	3	1	1	1	1	2	1	1	1	1	1	1	2	2	
CO3-78MS402.3 Demonstrate an understandi	3	3	1	1	1	1	3	2	2	1	2	2	1	2	3	

ng of the Applications of Normed linear space																
CO4-78MS402.4 Define and recognize the Hilbert Spaces	2	3	1	2	3	2	3	1	1	2	1	2	2	1	1	
CO5-78MS402.5 Students will create the concept of aOperator Theory and Sturm-Liouville System	3	2	3	1	2	1	2	3	1	1	1	1	1	1	1	

Legend: 1 – Low, 2 – Medium, 3 – High

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,1 2 PSO 1,2, 3, 4	**CO1-78MS402.1** Understand the importance of Normed Linear spaces and Banach spaces.	SO1.1 SO1.2 SO1.3 SO1.4		Unit-1.0 Normed Linear spaces and Banach spaces1.1,1.2,1.3,1.4,1.5,1.6.1.7,1.8,1.9,1.10,1.11,1.12, 1.13	SL1.1
PO 1,2,3,4,5,6 7,8,9,10,11,1 2 PSO 1,2, 3, 4	**CO2-78MS402.2** Determine the Fundamental theorems on Normed linear space	SO2.1 SO2.2 SO2.3 So2.4		Unit-2 Fundamental theorems on Normed linear space2.1, 2.2, 2.3, 2.4,2.5,2.6,2.7,2.8,2.9,2.10	SL2.1
PO 1,2,3,4,5,6 7,8,9,10,11,1 2 PSO 1,2, 3, 4	**CO3-78MS402.3** Demonstrate an understanding of the Applications of Normed linear space	SO3.1 SO3.2 SO3.3 SO3.4		Unit-3 Applications of Normed linear space 3.1, 3.2, 3.3, 3.4, 3.5 ,3.6,3.7,3.8,3.9,3.10	SL3.1
PO 1,2,3,4,5,6 7,8,9,10,11,1 2 PSO 1,2, 3, 4	**CO4-78MS402.4** Define and recognize the Hilbert Spaces	SO4.1 SO4.2 SO4.3 SO4.4		Unit-4 Hilbert Spaces 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.9,4.10,4.11,4.12,4.13,4.14	SL4.1
PO 1,2,3,4,5,6 7,8,9,10,11,1 2 PSO 1,2, 3, 4	**CO5-78MS402.5** Students will create the concept of aOperator Theory and Sturm-Liouville System	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5		Unit-5Operator Theory and Sturm-Liouville System 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 ,5.7,5.8,5.9,5.10,5.11,5.12,5 .13	SL5.1

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-IV

Course Code:	78MS403
Course Title :	General Theory of Relativity
Pre- requisite:	Students should have basic knowledge of group theory and Mapping
Rationale:	The objective of the General Theory of Relativity, developed by Albert Einstein, is to provide a comprehensive and mathematically rigorous description of gravity as a fundamental force in the universe. It aims to explain the behavior of massive objects and the curvature of space time in the presence of matter and energy.

Course Outcome:

78MS403.1 Understanding of Einstein's Field Equations.

78MS403.2 Understanding of the concept of tensor calculus, which is essential for expressing and manipulating the equations of General Relativity.

78MS403.3 Students should gain insights into the properties of black holes, their formation, and their role in the universe.

78MS403.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena.

78MS403.5 Understanding of the concepts, principles, and mathematical framework of the General Theory of Relativity.

Scheme of Studies:

Board of Study	**Course Code**	**Course Title**	**Scheme of studies (Hours/Week)**					**Total Credits (C)**
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Elective Core (PEC)	78MS403	General Theory of Relativity	4[3+1]	0	1	1	6	4

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.)
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA + ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3) 10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA + CAT+AT)		
Program Elective Core (PEC)	78MS403	General Theory of Relativity	15	20	5	5	5	50	50	100

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

78MS403.1 Understanding of Einstein's Field Equations.

Approximate Hours

Item	AppX Hrs
Cl	15
LI	0
SW	1
SL	1
Total	17

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 understand the Coordinate system and its dimension **SO1.2** understand the difference between vector and tensor **SO1.3** understand the law of Transformation **SO1.4** understand the properties of tensor **SO1.5** understand the properties of Christoffel's Symbols	-	**Unit-1 Tensor** **1.1** Transformation of coordinates **1.2** Summation Convention **1.3** Kronecker Delta **1.4** Tensor: definition **1.5** Algebra of tensors : Addition, Subtraction and Multiplication **1.6** Types of Tensors **1.7** Rank of tensors **1.8** Tutorials-I **1.9** Inner product of two vectors **1.10** Fundamental tensor **1.11** Quotient law of tensors **1.12** Christoffel's Symbols **1.13** Properties of Christoffel's	**SL.1** Transformation of coordinates **SL.2** Kronecker delta **SL.3** Outer product and contraction

		Symbols **1.14** Law of transformation for Christoffel's Symbols. **1.15** Tutorial-II	

SW-1 Suggested Sessional Work (SW):

a. Assignments:
Kronecker Delta,Tensor,Types of Tensors, Rank of tensors, Inner product of two vectors,Fundamental tensor, Quotient law of tensors, Christoffel's Symbols

b. Mini Project:
Oral presentation

c. Other Activities (Specify):
Quiz, Class Test.

78MS403.2 Understanding of the concept of tensor calculus, which is essential for expressing and manipulating the equations of General Relativity.

Approximate Hours

Item	AppX Hrs
Cl	14
LI	0
SW	1
SL	1
Total	16

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO2.1 Understand the Covariant Differentiation **SO2.2** Understand the rank of tensors **SO2.3** 2.1 Understand the Ricci's Theorem		**Unit-2.0 Covariant Differentiation** 2.1 Covariant Differentiation 2.2 Covariant Differentiation of a tensor of rank one 2.3 Covariant Differentiation of a tensor of rank two 2.4 Gradient of a scalar 2.5 Curl of a vector	**SL.1** learn to find the covariant derivative of vectors **SL.2** Understand the application of Divergence,curl and

SO2.4 Understand the concept of Riemannian Christoffel's curvature tensor **SO2.5** Understand the Bianchi Identities		2.6 Divergence of a vector 2.7 Ricci's Theorem 2.8 Riemannian Christoffel's curvature tensor :Introduction 2.9 Riemannian Christoffel's curvature tensor :Properties 2.10 Tutorials-I 2.11 Covariant curvature tensor 2.12 Properties of Covariant curvature tensor 2.13 Bianchi Identities 2.14 Tutorials-II	gradient

SW-2 Suggested Sessional Work (SW):
a. Assignments:
Covariant Differentiation, Gradient of a scalar, Curl of a vector, Divergence of a vector, Ricci's Theorem, Riemannian Christoffel's curvature tensor, Covariant curvature tensor, Properties of Covariant curvature tensor, Bianchi Identities.

b. Other Activities (Specify):
Quiz, Class Test.

78MS403.3 Students should gain insights into the properties of black holes, their formation, and their role in the universe.

Approximate Hours

Item	AppX Hrs
Cl	10
LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)

SO3.1 Understand the hypothesis of the theory of relativity **SO3.2** Understand the hypothesis of Newtonian Theory of gravitation **SO3.3** Understand Principle of equivalence **S03.4** Understand the hypothesis of General covariance **S03.5** Understand the application of Einstein's field equations		**Unit-3.0 Theory of relativity** 3.1 Review of the special theory of relativity 3.2 Review of Newtonian Theory of gravitation 3.3 Principle of equivalence 3.4 General covariance 3.5 Geodesic principle 3.6 Differential Equation of Geodesics 3.7 Newtonian approximation of relativistic equations of motion 3.8 Einstein's field equations :Introduction 3.9 derivation of Einstein's field equations 3.10 Newtonian approximation	**SL.1** Understand the concept of Einstein's field equations **SL.2** Understand the solution of differential equation

SW-3 Suggested Sessional Work (SW):

a. Assignments:

Special theory of relativity, General theory of relativity, Difference between special theory of relativity and General theory of relativity, Newtonian Theory of gravitation, Principle of equivalence, General covariance, Geodesic principle.

Newtonian approximation of relativistic equations of motion. Einstein's field equations and its Newtonian approximation

b. b. Mini Project:

Oral presentation, Power point presentation

c. Other Activities (Specify):

Quiz, Class Test.

78MS403.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena

Approximate Hours

Item	AppX Hrs
Cl	10

LI	0
SW	1
SL	1
Total	12

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO4.1 Understand the hypothesis of General relativity **SO4.2** Understand the Schwarzschild external solution **SO4.3** Understand The Kepler's Laws		**Unit-4.0 General relativity** **4.1** General relativity:Introduction **4.2** Christoffel's Symbols of Second kind **4.3** Line element **4.4** Fundamental Tensor **4.5** Schwarzschild external solution-part I **4.6** Schwarzschild external solution-part II **4.7** Isotropic form **4.8** Planetary orbits **4.9** Anologues of Kepler's Laws in general relativity **4.10** Advance of perihelion of a planet.	**SL.1** learn the properties of Christoffel's Symbols **SL.2** Learn the properties of metric tensor

SW-4 Suggested Sessional Work (SW):

a. Assignments:

Schwarzschild external solution and its isotropic form. Planetary orbits and anologues of Kepler's Laws in general relativity. Advance of perihelion of a planet.

b. Mini Project:

Oral presentation

c. Other Activities (Specify):

Quiz, Class Test.

78MS403.5 Understanding of the concepts, principles, and mathematical framework of the General Theory of Relativity.

Approximate Hours

Item	AppX Hrs
Cl	11

LI	0
SW	1
SL	1
Total	13

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)
SO5.1 Understand the concept of gravitational field **SO5.2** Understand the role of Energy-momentum tensor **SO5.3** Understand the calculation of Schwarzschild internal solution		**Unit-5.0 Gravitational field** 5.1 Bending of light rays in a gravitational field 5.2 Gravitational redshift 5.3 Gravitational redshift of spectral lines 5.4 Radar echo-delay 5.5 Energy-momentum tensor 5.6 Energy-momentum tensor of a perfect fluid 5.7 Schwarzschild internal solution-Part-I 5.8 Schwarzschild internal solution-Part-II 5.9 Boundary conditions 5.10 Electromagnetic field 5.11 Energy-Momentum tensor of an electromagnetic field	**SL.1** Knowledge of gravitational Force **SL.2** Knowledge of gravitational red shift

SW-5 Suggested Sessional Work (SW):

a. Assignments:

Bending of light rays in a gravitational field. Gravitational redshift ,Spectral lines. nergy-momentum tensor of a perfect fluid. Schwarzschild internal solution. Boundary conditions. Energy-Momentum tensor of an electromagnetic field.

b. Other Activities (Specify):
Quiz, Class Test.

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
78MS403.1 Understanding of Einstein's Field Equations.	15	1	1	17
78MS403.2 Understanding of the concept of tensor calculus, which is essential for expressing and manipulating the equations of General Relativity.	14	1	1	16
78MS403.3 Students should gain insights into the properties of black holes, their formation, and their role in the universe.	10	1	1	12
78MS403.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena.	10	1	1	12
78MS403.5 Understanding of the concepts, principles and mathematical framework of the General Theory of Relativity.	11	1	1	13
Total Hours	60	5	5	70

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
CO-1	Tensor	05	05	05	15
CO-2	Covariant Differentiation	05	05	05	15
CO-3	Theory of Relativity	03	01	02	06
CO-4	General Relativity	03	03	02	08
CO-5	Gravitational Field	03	01	02	06
Total		**25**	**17**	**08**	**50**

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6. Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Theory of Relativity	S.R.Roy and Raj Bali	Jaipur Publishing House,Jaipur	1987
2	General Relativity and Cosmology	S. K. Shrivastva	PHI, NewDelhi.	-
3	General Relativity and Cosmology	J.V. Narlikar	The Macmillan Company of India Limited	1978
4	Introducing Einstein's Relativity	Ray A. d'Inverno	Oxford University Press, In print, ISBN 0-19-859686-3.	1992
5	Tensor Calculus and Riemannian Geometry	J.K. Goyal &K.P.Gupta	Pragati Prakasan	1972

b) Reference Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Relativity Thermodynamics and Cosmology,	Tolman Richard C.	The Clarendon Press, Oxford, London	(Hindi)1934
2	Mathematical theory of relativity ,	A.S.Edington,	Cambridge At The University Press	1923
3	Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity.	Steven Weinberg,	Wiley	Ist Eition,1972

4	Einstein's general theory of relativity, sigbom Hervik,	Øyvind GrØn	Springer science &Business Media.	2007
5	An Introduction to cosmology	Jayant,V.Narlikar	Cambridge University Press	2010

c) Suggetsed Digital Platform Web links :

Suggested Digital Platforms Web links:	1.http://www.gutenberg.org/ebooks/5001 2.https://www.googleadservices.com/pagead/aclk?sa=L&ai=DChcSEwiwofuE7v-EAxVdwUwCHZS-B20YABAAGgJ0bQ&ase=2&gclid=EAIaIQobChMIsKH7hO7_hAMVXcFMAh2UvgdtEAMYASAAEgJHtfD_BwE&ohost=www.google.com&cid=CAASJeRoxBtCkX3PcVWlqe9GzlNxcQJNYrgF9vbHAHKw7kFLxnrh7M&sig=AOD64_3XX3ZyfwFLiVnLoibj5kLQmz7Bzg&q&nis=4&adurl&ved=2ahUKEwib6fWE7v-EAxWMr1YBHdA-AzkQ0Qx6BAgJEAE 3.https://www.freebookcentre.net/Physics/Relativity-Books-Download.html

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Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code : 78MS403
Course Title: General Theory of Relativity

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
78MS403.1 Understanding of Einstein's Field Equations.	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	3
78MS403.2 Understanding of the concept of tensor calculus, which is essential for expressing and manipulating the equations of General	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	2

Relativity.																
78MS403.3 Students should gain insights into the properties of black holes, their formation, and their role in the universe.		3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
78MS403.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2
78MS403.5 Understanding of the concepts, principles and mathematical framework of the General Theory of Relativity.	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS403.1 Understanding of Einstein's Field Equations.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 Group 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10, 1.11,1.12,1.13,1.14,1.15	SL1.1 SL1.2 SL1.3
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS403.2 Understanding of the concept of tensor calculus, which is essential for expressing and manipulating the equations of General Relativity.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 Ring 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10, 1.11,1.12,1.13,1.14	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS403.3 Students should gain insights into the properties of black holes, their formation, and their role in the universe.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL3.1 SL3.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	78MS403.4 Understanding of the concept of gravitational waves, their detection, and their significance as a powerful tool to study astrophysical phenomena.	SO1.1 SO1.2 SO1.3		Unit-4 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10	SL4.1 SL4.2
PO 1,2,3,4,5,6 7,8,9,10,11,12	78MS403.5	SO1.1 SO1.2		Unit-5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6,	SL5.1 SL5.2

PSO 1,2, 3, 4	Understanding of the concepts, principles and mathematical framework of the General Theory of Relativity.	SO1.3		2.7, 2.8,2.9,2.10,2.11	

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AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Semester-IV

Course Code:	78MS404
Course Title:	Jacobi Polynomial and H-Function
Pre-requisite:	Higher knowledge of mathematics.
Rationale:	Theaimofthecourseistointroducetothefieldofmathematicswithemphasisonitsusetosolverealworldproblemsforwhichsolutionsaredifficulttoexpressusingthe different methods. Itexplorestheessentialtheorybehindmethodsfordevelopingsystemsthatdemonstrateintelligentbehaviorincludingdealingwithuncertainty,learning from experience and following problem-solving strategies founding nature.

Course Outcomes:

CO-78MS404.1: Understanding of special functions and their importance in various mathematical and physical applications.

CO-78MS404.2: Using Jacobi polynomials as a basis and apply them to various mathematical and physical problems.

CO-78MS404.3: Understand the concept of applied in manipulating and solving problems involving the H-function.

CO-78MS404.4: Understand the concept of integral transforms, specifically the H-transform, and its use in solving integral equations.

CO-78MS404.5: Understanding of fractional calculus and its importance in modeling complex systems with fractional derivatives and integral.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Scheme of Studies

Board of Study	Course Code	Course Title	Scheme of studies(Hours/Week)					Total Credits(C)
			Cl	LI	SW	SL	Total Study Hours(CI+LI+SW+SL)	
Program Elective Course (PEC)	78MS404	Jacobi Polynomial and H-Function	4	0	1	1	6	6

Legend:
CI: ClassroomInstruction(Includesdifferentinstructionalstrategiesi.e.Lecture(L)andTutorial (T)andothers),
LI: LaboratoryInstruction(IncludesPracticalperformancesinlaboratoryworkshop,fiel dorotherlocationsusingdifferentinstructionalstrategies)
SW: SessionalWork(includesassignment,seminar,miniprojectetc.),
SL: SelfLearning,
C: Credits.
Note:
SW&SLhastobeplannedandperformedunderthecontinuousguidanceandfeedba ckofteacherto ensure outcome ofLearning.

Scheme of Assessment:
Theory

Board of Study	Course	CourseTitle	Scheme of Assessment (Marks)							
			ProgressiveAssessment(PRA)						**EndSemesterAssessment (ESA)**	**TotalMarks** (PRA+ESA)
			Class/HomeAssignment5number 3 markseach (CA)	Class Test2 (2best out of3)10 marks each(CT)	Seminar one (SA)	Class Activity anyone (CAT)	ClassAttendance (AT)	TotalMarks (CA+CT+SA+CAT+AT)		
Progrm Elective Course (PEC)	78MS 404	Jacobi Polynomial and H-Function	15	20	5	5	5	50	50	100

Course-CurriculumDetailing:

This course syllabus illustrates the expected learning achievements, both at the course and sessionlevels, which students are anticipated to accomplish through various modes of instruction includingClassroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self-Learning (SL). Asthecourseprogresses,studentsshouldshowcasetheirmasteryofSessionOutcomes(SOs),culminatingintheoverallachievementof CourseOutcomes (COs) uponthecourse's conclusion.

CO-78MS404.1: Understanding of special functions and their importance in various mathematical and physical applications.

ApproximateHours

Item	AppXHrs
CI	12
LI	0
SW	2
SL	1
Total	15

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**
SO1.1 Understand the concept of Jacobi polynomial **SO1.2**Understand the concept of special function	.	**Unit-1.0** Jacobi polynomial 1.1 Introduction 1.2 Recurrence relation 1.3 Examples of recurrence relation 1.4 Rodrigue's formula 1.5 Examples of Rodrigues formula 1.6 Generating functions 1.7 Examples of generating function 1.8 Orthogonal	1. Writes special functions and their importance

		properties 1.9 Expansions of polynomials. 1.10 Uses of recurrence relation. 1.11 Uses of properties 1.12 Solve polynomials	

SW-1SuggestedSessionalWork(SW):

Assignments:

i. Numerical based on Jacobi polynomial.
ii. Numerical based on recurrence relation
iii. Solve related example generating function

CO-78MS404.2: Using Jacobi polynomials as a basis and apply them to various mathematical and physical problems.

ApproximateHours

Item	AppXHrs
Cl	12
LI	0
SW	2
SL	1
Total	15

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**

SO2.1 Understand the concept variable **SO2.2**Understand the concept of Differentiation	.	**Unit-2.0 H** Functionon one variable 2.1. Definition and notation. 2.2. Related examples 2.3. Differentiation formulas 2.4. Related examples 2.5. Partial derivatives 2.6. Examples of partial derivatives 2.7. Parameters 2.8. Parameter related examples 2.9. Expansion formula 2.10. Solve partial differential 2.11. Uses of parameters 2.12. Solve expansion formula	1. Writes exampl es of one variable 2. Solve Partial derivati veswith exampl es.

SW-1SuggestedSessionalWork(SW):

Assignments:

iv. Numerical based differentiationFunction.
v. Numerical based on partial derivatives.
vi. Examples of expansion formula.

CO-78MS404.3: Understand the concept of applied in manipulating and solving problems involving the H-function.

ApproximateHours

Item	AppXHrs
Cl	12
LI	0
SW	2
SL	1
Total	15

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**
SO3.1 Understand the concept of partial two variables **SO3.2**Usesof properties and functions	.	**Unit-3.0** The H Functions of two variables 3.1. Definition and notation. 3.2. Related examples 3.3. Examples of two variables, 3.4. elementary properties 3.5. Related examples of elementary properties 3.6. Uses of elementary properties 3.7. Special cases 3.8. Examples of special cases 3.9. Uses of special cases 3.10. Definitions 3.11. Elementary examples 3.12. Two variables examples	1. Writes examples of two variables 2. Writes examples of special cases.

SW-1SuggestedSessionalWork(SW):

Assignments:

vii. Numerical based on two variables.
viii. Numerical based on elementary properties
ix. Writes related examples special cases.

CO101.4: Understand the concept of integral transforms, specifically the H-transform, and its use in solving integral equations.

ApproximateHours

Item	AppXHrs
Cl	12
LI	0
SW	2
SL	1
Total	15

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**
SO4.1 Understand the concept of H-Functions **SO4.2**Application of H-Functions **SO4.3** How to learn one and two variable on H-Functions	.	**Unit-4.0** Finite Summation formulas 4.1. H- Functions of two variables 4.2. Examples of H- function 4.3. Derivatives 4.4. Related examples of derivatives 4.5. Examples of H- Functions of two variables 4.6. Contiguous relations 4.7. Example of contiguous relation 4.8. Total Count of recurrences. 4.9. Example of Total Count of recurrences. 4.10. Basic H function 4.11. Derivation examples 4.12. Examples of H functions	1. H-Functions of two variables

SW-1SuggestedSessionalWork(SW):

Assignments:

i. Questions based on H- Functions.
ii. Questions based on Count of recurrences.
iii. Questions based on one and two variables.

CO-78MS404.5: Understanding of fractional calculus and its importance in modeling complex systems with fractional derivatives and integrals.**ApproximateHours**

Item	AppXHrs
Cl	12
LI	00
SW	02
SL	01
Total	15

SessionOutcomes (SOs)	**LaboratoryInstruction (LI)**	**ClassroomInstruction (CI)**	**Self-Learning (SL)**
SO5.1 Understand the concept of finite and infinite series **SO5.2**uses some method to solve the examples.	.	**Unit-5.0** Method and schemes 5.1. Writes different methods 5.2. sum of finite series. 5.3. sum of infinite series. 5.4. Examples of finite series 5.5. Uses of finite and infinite deries 5.6. Example of infinite series 5.7. Double summation formulas 5.8. Uses of summation formula 5.9. Example of double summation formula 5.10. Uses of finite	1. Method for obtaining sum of finite or infinite series.

		series 5.11. Uses of infinite series 5.12. Uses of Double summation	

SW-1SuggestedSessionalWork(SW):

Assignments:

i. Different types of methods
ii. Writes Examples of finite and infinite series.

Brief of Hours suggested for the Course Outcome:

CourseOutcomes	ClassLecture (Cl)	SessionalWork (SW)	Self-Learning (Sl)	Total hour(Cl+SW+Sl)
O1-78MS404.1: nderstanding of special functions and their importance in various mathematical and physical applications.	12	02	01	15
O2-78MS404.2:Using Jacobi polynomials as a basis and apply them to various mathematical and physical problems	12	02	01	15
O3-78MS404.3: nderstand the concept of applied in manipulating and solving problems involving the H-function.	12	02	01	15
O4-78MS404..4: nderstand the concept of integral transforms, specifically the H-transform, and its use in solving integral equations.	12	02	01	15
O4-78MS404.5: nderstanding of fractional calculus and its importance in modeling complex systems with	12	02	01	15

fractional derivatives and integrals.				
TotalHours	60	10	5	75

SuggestionforEndSemesterAssessment

SuggestedSpecificationTable(ForESA)

CO	UnitTitles	MarksDistribution			TotalMarks
		R	U	A	
CO-1	Jacobi polynomial	03	02	03	08
CO-2	The H Functions of one variables	03	01	05	09
CO-3	The H Functions of two variables	03	07	02	12
CO-4	Finite Summation formulas	03	05	05	13
CO-5	Method and schemes	03	02	03	08
Total		15	17	18	50

Legend: R:Remember, U:Understand, A:Apply

TheendofsemesterassessmentforIntroductiontoPortlandcementwillbeheldwithwrittenexaminationof50 marks

Note.DetailedAssessmentrubricneedtobepreparedbythecoursewiseteachersforabovetasks. Teacherscanalsodesigndifferenttasksasperrequirement,forendsemesterassessment.

SuggestedInstructional/ImplementationStrategies:

1. ImprovedLecture

2. Tutorial
3. CaseMethod
4. GroupDiscussion
5. RolePlay
6. Visittocementplant
7. Demonstration
8. ICTBasedTeachingLearning(VideoDemonstration/TutorialsCBT,Blog,Facebook, Twitter, WhatsApp,Mobile,Onlinesources)
9. Brainstorming

Suggested Learning Resources:

A. Books:

S. No.	Title	Author	Publisher	Edition &Year
1	Special Functions	Rainville. E.D.	The Macmillan Co. New. York.	1971
2	The H- Functions of One and Two Variables with applications.	Shrivastava. H.M., Gupta K.C. and Goyal. S.P.	South Asian Publication New Delhi	-
3	The H-Function: Theory and Applications	A.M. Mathai and R.K. Saxena.	-	-
4	Special functions and Their Applications.	Lebdev. N.N.	Prentice Hall. Englewood Hall phase new Jersy USA	1965

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CO, PO and PSO Mapping

CourseTitle:M.Sc. Mathematics
Course Code: -78MS404
Course Title: Jacobi Polynomial and H-Function

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1:Understanding of special functions and their importance in various mathematical and physical applications	3	2	2	2	2	1	1	1	1	1	1	3	2	2	3	3
CO2:Using Jacobi polynomials as a basis and apply them to various mathematical and physical problems	2	3	3	2	2	2	1	1	1	1	1	3	2	3	2	3

CO3:Understand the concept of applied in manipulating and solving problems involving the H-function**.**	3	2	3	3	2	2	1	1	1	1	1	3	2	2	2	3
CO4:Understand the concept of integral transforms, specifically the H-transform, and its use in solving integral equations.	3	3	3	2	2	2	1	1	1	1	1	3	2	2	3	2
CO5: Understanding of fractional calculus and its importance in modeling complex systems with fractional derivatives and integrals.	3	2	3	2	2	2	1	1	1	1	1	3	2	2	3	2

Course Curriculum Map:

POs&PSOsNo.	COsNo.&Titles	SOsNo.	LaboratoryInstruction(LI)	Classroom Instruction(CI)	SelfLearning(SL)
PO: 1,2,3,4,5,6,7, 8,9,10,11,12 PSO: 1,2,3,4	CO1:Understanding of special functions and their importance in various mathematical and physical applications.	SO1.1 SO1.2		Unit-1.0 Jacobi polynomial 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	
PO: 1,2,3,4,5,6,7, 8,9,10,11,12 PSO: 1,2,3,4	CO2:Using Jacobi polynomials as a basis and apply them to various mathematical and physical problems	SO2.1 SO2.2		Unit-2The H Functions of one variables 2.1,2.2,2.3,2.4,2.5,2.6,2.7, 2.8,2.9,2.10,2.11,2.12	
PO: 1,2,3,4,5,6,7, 8,9,10,11,12	CO3:Understand the concept of applied in manipulating and solving problems	SO3.1 SO3.2		Unit-3 : The H Functions of two variables	

PSO: 1,2,3,4	involving the H-function.	SO3.3		3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,3.10,3.11,3.12	
PO: 1,2,3,4,5,6,7, 8,9,10,11,12 PSO: 1,2,3,4	CO4:Understand the concept of integral transforms, specifically the H-transform, and its use in solving integral equations.	SO4.1 SO4.2 SO4.3		Unit-4: Finite Summation formulas 4.1,4.2,4.3,4.4,4.5,4.6,4.7,4.8,4.9,4.10,4.11,4.12	
PO: 1,2,3,4,5,6,7, 8,9,10,11,12 PSO: 1,2,3,4	CO5: Understanding of fractional calculus and its importance in modeling complex systems with fractional derivatives and integrals.	SO5.1 SO5.2		Unit5:Method and schemes5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,5.10,5.11,5.12	

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AKS University
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Curriculum & Syllabus of M.Sc. Mathematics program

Semester-IV

Course Code:	78MS405
Course Title :	ADVANCED MATHEMATICAL STATISTIC
Pre- requisite:	Students should have basic knowledge of calculus, linear algebra, and ODE theory.
Rationale:	Advanced mathematical statistics provides a deeper understanding of statistical inference, which involves drawing conclusions about populations based on sample data. It explores the theoretical foundations of estimation and hypothesis testing, enabling practitioners to make more informed and rigorous statistical inferences.

Course Outcome :

CO1-.78MS405.1 Learn the statistical methods to describe the central or typical value in a set of data to have clear understanding of the concept of central tendency and its importance in summarizing data.

CO2-78MS405.2. To understand the concepts in probability theory and the probability distributions associated with various random variables foundational knowledge and skills.

CO3-78MS405.3. Theory of Estimators typically covers the mathematical foundations and principles behind statistical estimation to develop a clear understanding of the fundamental concepts of statistical estimation, including point estimation and interval estimation.

CO4-78MS405.4 To understanding and applying exact methods for generating and studying sampling distributions, Learn and apply exact sampling methods, which may include techniques such as Monte Carlo simulation, bootstrapping, permutation tests, or other re-sampling methods.

CO5-78MS405.5 Analysis of Variance (ANOVA) typically covers the statistical methods used to analyze differences among group means in a dataset to develop a solid understanding of the fundamental concepts of Analysis of Variance, including the partitioning of variance and the comparison of group means.

Scheme of Studies:

Board of Study	Course Code	Course Title	Scheme of studies (Hours/Week)					Total Credits (C)
			CI	**LI**	**SW**	**SL**	**Total Study Hours (CI+LI+SW+SL)**	
Program Elective Course (PEC)	78MS405	ADVANCED MATHEMATICAL STATISTIC	4[3+1]	0	1	1	6	4

Legend:
CI: Classroom Instruction (Includes different instructional strategies i.e. Lecture (L) and Tutorial (T) and others),
LI: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies)
SW: Sessional Work (includes assignment, seminar, mini project etc.),
SL: Self Learning,
C:Credits.

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

Scheme of Assessment:

Theory

Board of Study	Couse Code	Course Title	Scheme of Assessment (Marks)							
			Progressive Assessment (PRA)						**End Semester Assessment (ESA)**	**Total Marks** (PRA+ ESA)
			Class/Home Assignment 5 number 3 marks each (CA)	Class Test 2 (2 best out of 3)10 marks each (CT)	Seminar one (SA)	Class Activity any one (CAT)	Class Attendance (AT)	Total Marks (CA+CT+SA +CAT+AT)		
Program Elective Course (PEC)	**78MS405**	ADVANCD MATHEMATICAL STATISTIC	15	20	5	5	5	50	50	100

Course-Curriculum Detailing:

This course syllabus illustrates the expected learning achievements, both at the course and session levels, which students are anticipated to accomplish through various modes of instruction including Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW), and Self Learning (SL). As the course progresses, students should showcase their mastery of Session Outcomes (SOs), culminating in the overall achievement of Course Outcomes (COs) upon the course's conclusion.

CO1-78MS405.1 Learn the statistical methods to describe the central or typical value in a set of data to have clear understanding of the concept of central tendency and its importance in summarizing data.

Approximate Hours

Item	AppX Hrs
CI	12
LI	0
SW	1
SL	2
Total	15

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO1.1 concept of central tendency in statistics . **SO1.2** Differentiate between mean, median, and mode **SO1.3** Identify the properties and characteristics of each measure of central tendency **So1.4** Calculate	-	**Unit-1.0 Central tendencies** **1.1** Definitions of central tendencies, **1.2** Calculation of mean **1.3** Calculation of median **1.4** Calculation of mode **1.5** Calculation of mode **1.6** Measure of dispersions with variance in detail,	**SL.1** write all formula used in central tendencies **SL.2** learn all formula used in correlation and regeneration

and interpret percentiles and quartiles in various contexts **So1.5** Use statistical software (e.g., Excel, R, Python) to calculate and analyze measures of central tendency.		**1.7** Method of least square for curve fitting, **1.8** Correlation concept and formula **1.9** Questions based on corelation **1.10** Regression concept and formula **1.11** Regression Question based on formula **1.12** Tutorial	

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. write all formula of measure of central tendency.

ii. Write any 3 Application of mean, median and mode in real life.

iii. Write any 3 Application of corelation and Regression in real life.

b.Other Activities (Specify):

Class Test.

CO2-78MS405.2 To understand the concepts in probability theory and the probability distributions associated with various random variables foundational knowledge and skills.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	2
Total	15

Session Outcomes (SOs)	Laboratory Instruction (LI)	Class room Instruction (CI)	Self Learning (SL)

SO2.1 Define and understand random variables and their types SO2.2 Explore the concept of probability distributions associated with random variables . SO2.3 Understand the probability density/mass function and cumulative distribution function SO2.4 Calculate and interpret the expected value (mean) and variance of random variables SO2.5 Explore higher moments of probability distributions		**Unit-2.**0 Probability &Distributions 1.1 Theory of probability & distributions: various definitions, 1.2 additive & multiplicative law, 1.3 Bayes' theorem. 1.4 Continuous variable, 1.5 Mathematical expectation, 1.6 Binomial distribution 1.7. Poisson distribution 1.8 Normal distribution, 1.9 Rectangular distribution, 1.10 Exponential distribution, 1.11Moment generation function, 1.12marginal & conditional probability distributions & conditional expectation .	**SL.1** Write all formula of probability **SL.2** Write and learn all formula of distribution

SW-2 Suggested Sessional Work (SW):
a. Assignments:
i. write the application of probability.

b. Other Activities (Specify):
Presentation

CO3-78MS405.3 Theory of Estimators typically covers the mathematical foundations and principles behind statistical estimation to develop a clear understanding of the fundamental concepts of statistical estimation, including point estimation and interval estimation.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO3.1 Define parameters, estimators, and estimate SO3.2 Study point estimators and their properties. SO3.3 Explore methods for constructing point estimates, such as the method of moments and maximum likelihood estimation		**Unit-3.0 Estimators** 3.1 Theory of estimators: Unbiasedness 3.2 consistency 3.3questions based on consistency 3.4 concept of efficiency and sufficiency, 3.5 questions based on efficiency and sufficiency 3.6 Tutorial 1 3.7 maximum likelihood estimators 3.8 Question based on maximum likelihood estimators 3.9 Cramer-Rao inequality 3.10 formula of Cramer-Rao inequality 3.11 questions based on Cramer-	**SL.1** To learn about Theory of estimators.

		Rao inequality 3.12 Tutorial 2	

SW-3 Suggested Sessional Work (SW):
a. Assignments:
i. write application of Cramer-Rao inequality

CO4-78MS405.4 To understanding and applying exact methods for generating and studying sampling distributions, Learn and apply exact sampling methods, which may include techniques such as Monte Carlo simulation, bootstrapping, permutation tests, or other re-sampling methods.

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**
SO4.1 Gain a solid understanding of sampling distributions, including the concept of a sampling distribution and its importance in statistical inference. SO4.2 Learn and apply exact sampling methods SO4.3 Develop the ability to make		**Unit-4.0** **Sampling distributions** 4.1 explanation of Exact sampling distributions 4.2 methods of sampling 4.3 t tests formula 4.4 Question based on t tests	**SL.1** Learn all testing used in this unit

statistical inferences based on the observed data, considering the uncertainty inherent in the sampling process SO4.4 Apply the knowledge gained to solve real-world problems SO4.5 Problem solving		4.5 F tests formula 4.6 Question based on F tests 4.7 Z tests formula 4.8 Question based on Z tests 4.9 Wilcoxon's signed rank sumtest 4.10 Medial test and Mann Whitney 4.11 U-test 4.12 run test for randomness	

SW-4 Suggested Sessional Work (SW):
a. Assignments:
i. write a short note on different testing .

CO5-78MS405.5. Analysis of Variance (ANOVA) typically covers the statistical methods used to analyze differences among group means in a dataset to develop a solid understanding of the fundamental concepts of Analysis of Variance, including the partitioning of variance and the comparison of group means

Approximate Hours

Item	AppX Hrs
Cl	12
LI	0
SW	1
SL	1
Total	14

Session Outcomes (SOs)	**Laboratory Instruction (LI)**	**Class room Instruction (CI)**	**Self Learning (SL)**

SO5.1 Define terms such as treatment, factor, level, and error. SO5.2 Learn and apply the one-way ANOVA technique for comparing means across more than two groups SO5.3 Extend the understanding to two-way ANOVA for studying the effects of two independent variables SO5.4 Explore post hoc tests for identifying specific group differences after detecting a significant ANOVA result SO5.5 Apply ANOVA techniques in the context of experimental designs		**Unit-5.0** **Analysis of variance** 5.1 Analysis of variance: one way classifications 5.2 two-way classifications. 5.3 difference between one and two-way classifications 5.4 Basic principles of design: Replication, 5.5 randomization, 5.6 questions based on randomization, 5.7 local control, 5.8 lay out and analysis of completely randomized, 5.9 randomized block 5.10 Latin square design, 5.11 missing plot techniques in randomized block 5.12 Latin square design.	**SL.1** Understand one and two-way classifications

Brief of Hours suggested for the Course Outcome

Course Outcomes	Class Lecture (Cl)	Sessional Work (SW)	Self Learning (Sl)	Total hour (Cl+SW+Sl)
CO1-78MS405.1 Learn the statistical methods to describe the central or typical value in a set of data to have clear understanding of the concept of central tendency and its importance in summarizing data.	12	1	2	15
CO1-78MS405.2 To understand the concepts in probability theory and the probability distributions associated with various random variables foundational knowledge and skills.	12	1	2	15
CO1-78MS405.3 Theory of Estimators typically covers the mathematical foundations and principles behind statistical estimation to develop a clear understanding of the fundamental concepts of statistical estimation, including point estimation and interval estimation.	12	1	1	14
CO1-78MS405.4 To understanding and applying exact methods for generating and studying sampling distributions, Learn and apply exact sampling methods, which may include techniques such as Monte Carlo simulation, bootstrapping, permutation tests, or other re-	12	1	1	14

sampling methods.				
CO1-78MS405.5 Analysis of Variance (ANOVA) typically covers the statistical methods used to analyze differences among group means in a dataset to develop a solid understanding of the fundamental concepts of Analysis of Variance, including the partitioning of variance and the comparison of group means	12	1	1	14
Total Hours	60	5	7	72

Suggestion for End Semester Assessment

Suggested Specification Table (For ESA)

CO	**Unit Titles**	**Marks Distribution**			**Total Marks**
		R	**U**	**A**	
CO-1	Measure of central tendencies	05	04	01	10
CO-2	Theory of probability & distributions	02	06	02	10
CO-3	Theory of estimators:	03	05	02	10
CO-4	Sampling and testi ng	05	03	02	10
CO-5	Analysis of variance	05	04	01	10
Total		20	22	08	50

Legend: R: Remember, U: Understand, A: Apply

The end of semester assessment for Introduction to Portland cement will be held with written examination of 50 marks

Note. Detailed Assessment rubric need to be prepared by the course wise teachers for above tasks. Teachers can also design different tasks as per requirement, for end semester assessment.

Suggested Instructional/Implementation Strategies

1. Improved Lecture
2. Tutorial
3. Presentation
4. Group Discussion
5. Online sources
6 .Seminar
7. Workshop

Suggested Learning Resources:

a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1	Fundamental of Statistics,	Gun, A.M., Gupta, M.K. and Dasgupta, B.	World Press, Kolkata	Vol I,2013
2	Mathematics of Statistics. Part II.	Kenney, J.F. and Keeping, E.S.	Chapman & Hall.	2nd Edition.1951
3	Introduction to the Theory of Statistics,	Mood, A.M. Graybill, F.A. and Boes, D.C.	Tata McGraw-Hill Pub. Co. Ltd.	3rd Edn.2011.

AKS University
Faculty of Basic Science
Department of Mathematics
Curriculum & Syllabus of M.Sc. Mathematics program

Curriculum Development Team

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Cos,POs and PSOs Mapping

Course Title: M.Sc. Mathematics
Course Code: 78MS405
Course Title: ADVANCED MATHEMATICAL STATISTICS

Course Outcome	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
	Advanced Mathematical Knowledge	Problem-solving Skills	Research Abilities	Quantitative Analysis	Teaching and Academia	Theoretical Understanding	Communication Skills	Operations Research	Application in Industry	Engineering and Technology	Government and Public Sector	Consulting	Understand the mathematical concepts and applications in the field of algebra	Handle the advanced techniques	Develop necessary skills and expertise in the field of research	Creates Mathematical Models
CO1-78MS405.1 Learn the statistical methods to describe the central or typical value in a set of data to have clear understanding of the concept of central tendency and	2	3	1	2	1	2	2	2	1	1	1	1	2	1	1	2

its importance in summarizing data. .																
CO2-78MS405.2. To understand the concepts in probability theory and the probability distributions associated with various random variables foundational knowledge and skills.	1	3	2	1	1	1	1	1	1	2	3	1	3	1	1	1
CO3-78MS405.3.. Theory of Estimators typically covers the mathematical foundations and principles behind statistical estimation to develop a clear understanding of the fundamental concepts of statistical estimation, including point estimation and interval estimation.	1	3	2	2	1	1	3	2	1	1	3	1	2	1	2	
CO4-78MS405.4 **To** understanding and applying exact methods for generating and studying sampling distributions, Learn and apply exact sampling methods, which may include	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

techniques such as Monte Carlo simulation, bootstrapping, permutation tests, or other re-sampling methods.																
CO5-78MS405.5 Analysis of Variance (ANOVA) typically covers the statistical methods used to analyze differences among group means in a dataset to develop a solid understanding of the fundamental concepts of Analysis of Variance, including the partitioning of variance and the comparison of group means	2	3	2	2	1	1	3	2	1	1	3	1	2	1	2	2

Legend: 1 – Low, 2 – Medium, 3 – High

Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction(LI)	Classroom Instruction (CI)	Self Learning (SL)
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO1-**78MS405.1** Learn the statistical methods to describe the central or typical value in a set of data to have clear understanding of the concept of central tendency and its importance in summarizing data**.**	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-1.0 1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,1.10,1.11,1.12	SL1.1 SL1.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO2-**78MS405**.2.To understand the concepts in probability theory and the probability distributions associated with various random variables foundational knowledge and skills.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-2 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8,2.9,2.10 2.11,2.12	SL2.1 SL2.2
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO3-**78MS405**.3. Theory of Estimators typically covers the mathematical foundations and principles behind statistical estimation to develop a clear understanding of the fundamental concepts of statistical estimation, including point estimation and interval estimation.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-3 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7,3.8,3.9,3.10,3.11, 3.12	SL3.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO4-**78MS405.4** To understanding and applying exact methods for generating and studying sampling distributions, Learn and apply exact sampling methods, which may include techniques such as Monte Carlo simulation, bootstrapping, permutation tests, or other re-sampling methods.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-4 4.1,4.2,4.3, 4.4, 4.5, 4.6, 4.7, 4.8,4.9,4.10,4.11,4.12	SL4.1
PO 1,2,3,4,5,6 7,8,9,10,11,12 PSO 1,2, 3, 4	CO5-**78MS405**.5 Analysis of Variance (ANOVA) typically covers the statistical methods used to analyze differences among group means in a dataset to develop a solid understanding of the fundamental concepts of Analysis of Variance, including the partitioning of variance and the comparison of group means.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit-5 5.1, 5.2, 5.3, 5..4, 5..5, 5..6, 5..7, 5..8,5.9,5.10,5.11,5.12	SL5.1

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