INSTITUTE OF ADVANCED STUDIES IN EDUCATION
(DEEMED TO BE UNIVERSITY)

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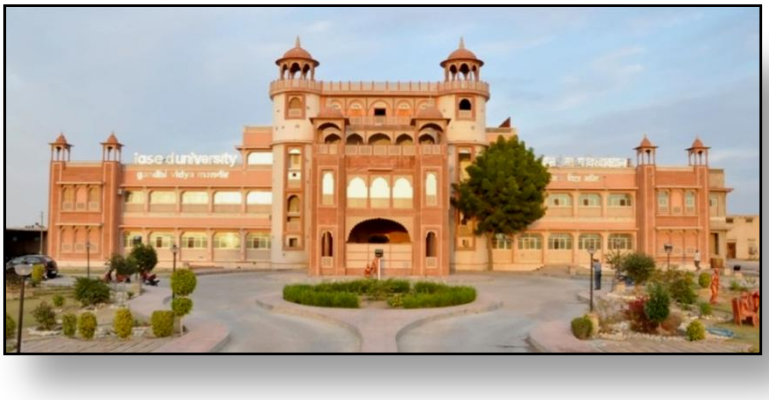
SYLLABUS MANUAL
FOR
MASTER OF SCIENCE IN MATHEMATICS

FACULTY OF SCIENCES
CHOICE BASED CREDIT SYSTEM (CBCS)
Session 2022-2024



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DEPARTMENT OF MATHEMATICS

FACULTY OF SCIENCES

About the Department:

The aim of the Department of Mathematics is to build a solid foundation for the assimilation of mathematical concepts and structures and to build mathematical skills such as creative, logical and analytical thinking. Software like Mathematica, Matlab, Scilab are used to enhance the understanding of fundamental mathematical concepts. It promotes the interest of the students in the subject by organizing the activities with their enthusiastic participation. The Department currently offers UG and PG courses for B.Sc., M.Sc. Programmes.

The Department focuses on training of the learners in Mathematical Sciences methodology so that they can conduct the high-level scientific research for the welfare of the society and industry. The teaching and research methodology are taught at the post-graduation level along with hands-on-training in the form of dissertation. The Department organizes conferences, workshops, seminars, debates, group discussions, webinars for enhancing the research, critical and analytical understanding of the learners. The Department also has collaboration with reputed research institutions in various research areas like classical general relativity and cosmology etc.

About the Programme:

The Master of Science in Mathematics is a two year Choice Based Credit System (CBCS) Programme following the semester scheme. The Programme offers core, elective and skill courses. The students in I and II semester have to complete six core courses in each semester and one skill course. In III semester students have to complete four core courses and have to opt one elective courses and one skill course. In IV semester students have to complete for two core courses and have to opt three elective courses and one skill course. The students have an opportunity to select elective courses from intra-department and inter-department and intra/inter-faculty for skill courses

Programme Code: MSM (Master of Science in Mathematics).

Programme Outcomes of PG in Mathematics:

On the completion of the M.Sc. (Mathematics) Programme, the students will be able to:

Programme Outcomes (POs)	
PO1	Apply knowledge of Mathematics, in all the fields of learning including higher research and its extensions.
PO2	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.
PO3	To inculcate and develop mathematical aptitude and the ability to think abstractly in the student.
PO4	To train students to apply their theoretical knowledge to solve problems.
PO5	To encourage the use of relevant software such as MATLAB, MATHEMATICA, MAPLE and Scilab, etc to solve problems.
PO6	To provide qualitative education through effective teaching learning processes by introducing projects, participative learning and latest software tools.

PO7	To inculcate innovative skills, team work, ethical practices among students so as to meet societal expectations.
PO8	To encourage collaborative learning and application of mathematics to real life situations.
PO9	To inculcate the curiosity for mathematics in students and to prepare them for future research.
PO10	The student shall acquire capability to evaluate hypothesis, methods and evidence within their proper contexts in any situation.
PO11	Getting Abilities Demonstrate the ability to conduct research independently and pursue higher studies towards Ph.D. degree in mathematics.
PO12	Numerical Techniques The student will be able to learn some useful approximation and interpolation techniques in Mathematics.

Program Specific Outcomes (PSOs):

Programme Specific Outcomes	
PSO1	To develop problem-solving skills and apply them independently to problems in pure and applied mathematics.
PSO2	To assimilate complex mathematical ideas and arguments.
PSO3	To improve your own learning and performance.
PSO4	To develop abstract mathematical thinking.
PSO5	Communicate mathematical ideas effectively, in writing as well as orally.
PSO6	Have sound knowledge of mathematical modeling, programming and computational techniques as required for employment in industry.
PSO7	Apply the knowledge of mathematical concepts in interdisciplinary fields.
PSO8	Model the real-world problems into mathematical equations and draw the inferences by finding appropriate solutions.
PSO9	Identify challenging problems in mathematics and find appropriate solutions.
PSO10	Qualify national level tests like NET/GATE etc.
PSO11	Evaluate hypotheses, theories, methods and evidence within their proper contexts.
PSO12	Recognize the need to engage in lifelong learning through continuous education, and research leading to higher degrees like PhD, D.Sc. etc.

Admission Procedure(s):

The details of the eligibility conditions and admission procedures are given in the admission forms and on the university website. The admission will be granted on the basis of merit as per University Bye-Laws. Reservation for SC, ST, PH, OBC, EWS etc. will be granted as per IASE (Deemed to be University) Bye-Laws adhering to Government rules.

Attendance Clauses:

1. For regular candidates in the Faculties of Sciences, the minimum attendance requirement shall be such that a candidate must have attended at least 75% of the lecturers delivered and tutorials held taken together as well as 75% of practical and CCA from the date of his/her admission.

2. Condonation for the shortage of attendance:

   The shortage of attendance up to the limits specified below may be condoned on valid reason(s):

   i) Up to 6%, each subject plus 5 attendances in all the aggregate subjects/papers may be condoned by the Vice-Chancellor on the recommendation of the Head of the Department for the Post-graduate classes.

   ii) The Scout, NSS, and NCC cadets sent out to parades and camps and such students who are deputed by the University to take part in games, athletics or cultural activities may, for purpose of attendance, be treated, as present for the days of their absence in connection with the aforesaid activities and that period shall be added to their subject wise attendance.

Guidelines for Choice Based Credit System:

Definition clauses:

1. **Academic Year**: Two consecutive (one odd + one even) semesters constitute one academic year.
2. **Choice Based Credit System (CBCS):** The CBCS provides choice for students to select from the prescribed elective and skill courses. A student needs to select **elective course** offered by the Departments and SWAYAM/MOOCs course of the same credit in which he/she is doing core courses. This shall be part of the core Programme during the third and fourth semesters. Each student has to complete **two skill courses** offered by the departments/faculties/any other institution(s). The students can choose the elective courses inter-department and skill courses from any other institution(s), inter-department, inter-faculty as well.
3. **Course**: Usually referred to, as 'papers' is a component of a Programme. All courses need not carry the same weight. The courses should define learning objectives and learning outcomes. A course may be designed to comprise lectures/ tutorials/laboratory work/ field work/ project work/ self-study etc. or a combination of some of these.
4. **CCC stands for 'Core Course Code' and ECC for Elective Course Code.**
5. **Credit Based Semester System (CBSS)**: Under the CBSS, the requirement for awarding a degree is prescribed in terms of number of credits to be completed by the students.
6. **Credit Point**: It is the product of grade point and number of credits for a course.
7. **Credit**: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one period of teaching (lecture or tutorial) or two periods of practical work/field work per week. Here one period normally equals to 50 minutes.

8. **Cumulative Grade Point Average (CGPA)**: It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.
9. **ESE** stands for '**End Semester Examination'** i.e. Even Semester & **SEE for 'Semester End Examination' i**.e. odd semester.
10. **Grade Point**: It is a numerical weight allotted to each letter grade on a 10-point scale.
11. **Letter Grade:** It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F.
12. **Programme**: An educational programme leading to award of the Postgraduate Degree in the Core subject he/she is pursuing.
13. **Semester Grade Point Average (SGPA)**: It is a measure of performance of work done in a semester. It is a ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.
14. **Semester**: Each semester will consist of 15-18 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be scheduled from July to November/ December and even semester from December/January to May.
15. **Skill Development Course(s) Resources**: The University may develop a provision for skill development course(s) by appointment, engagement, contract services of the resources; (human, institutional) at inter-department, intra-department, intra-faculty, inter-faculty, in this University or with any other University, institution of Research, institution of Technical Expertise, Professional and institution engaged in industrial activities for academic or/and technical development of skill.
16. **Transcript or Grade Card or Certificate:** Based on the grades earned, a statement of grades obtained shall be issued to all the registered students after every semester. This statement will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester along with statement of marks.

Grades and Grade Points: Methods to Ascertain

S. No.	Letter Grade	Meaning	Grade Point
1	'O'	Outstanding	10
2	'A+'	Excellent	9
3	'A'	Very Good	8
4	'B+'	Good	7
5	'B'	Above Average	6
6	'C'	Average	5
7	'P'	Pass	4
8	'F'	Fail	0
9	'Ab'	Absent	0

i) A student obtaining Grade F in a course shall be considered failed and will be required to reappear in the University End Semester Examination.

ii) For non-credit courses (Skill Courses) 'Satisfactory' or 'Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA

Grade Point assignment:

= and > 95 % marks Grade Point 10.0
90 to less than 95 % marks Grade Point 9.5
85 to less than 90 % marks Grade Point 9.0
80 to less than 85 % marks Grade Point 8.5
75 to less than 80 % marks Grade Point 8.0
70 to less than 75 % marks Grade Point 7.5
65 to less than 70 % marks Grade Point 7.0
60 to less than 65 % marks Grade Point 6.5
55 to less than 60 % marks Grade Point 6.0
50 to less than 55 % marks Grade Point 5.5
45to less than 50 % marks Grade Point 5.0
40 to less than 45 % marks Grade Point 4.5
36 to less than 40 % marks Grade Point 4.0

Computation of SGPA and CGPA:

(i) The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.

$$\textbf{SGPA}\ (S_i) = \Sigma\ (C_i \times G_i)\ /\ \Sigma C_i$$

where C_i is the number of credits of the ith course and G_i is the grade point scored by the student in the ith course.

(ii) The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a Programme, i.e.

$$\textbf{CGPA} = \Sigma\,(C_i \times S_i) \,/\, \Sigma C_i$$

where S_i is the SGPA of the ith semester and C_i is the total number of credits in that semester.

(iii) The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Illustration of Computation of SGPA and CGPA and Format for Transcripts:

(i) Computation of SGPA and CGPA

Illustration for SGPA

Course	Credit	Grade Letter	Grade Point	Credit Point
Course 1	4	A	8	4x8=32
Course 2	4	B+	7	4x7=28
Course 3	4	O	10	4x10=40
Course 4	4	C	5	4x5=20
Course 5	4	A+	9	4x9=36
Course 6	4	P	4	4x4=16
	24			172

Thus, SGPA =172/24 =7.16

Illustration for CGPA

	Semester- I	Semester- II	Semester- III	Semester- IV
Credit	**24**	**24**	**24**	**24**
SGPA	**7.25**	**7.25**	**7**	**6.25**

Thus, CGPA=(24x7.25+24x7.25+24x7+24x6.25)/96
=666/96
=6.93

Skill courses (Non credit):

The Department of Mathematics shall offer skill development courses. The skill development courses are offered by the department, or/and sustainable development courses offered by the department/faculty/any other institution(s).

Instructions for Distribution of Periods:

In view of the course content, the Department of Mathematics distributed the Periods between Theory/Tutorial/Practical as mentioned in course structure:

(i) L-T-P : 4-0-0, Means four lectures/week only (no tutorial and no practical) for theory.

(ii) L-T-P : 0-0-2, Means one practical of two periods/week only for Lab course.

Where L stands for lecture, T for tutorial and P for practical.

The Duration of the Period shall be fifty minutes. In each of these combinations, the first value stands for the same number of lecture instructions per week.

Medium of Instructions:

The medium of instructions for courses will be bilingual (Hindi and English).

Medium of Examinations:

Candidates are allowed to use only English medium for answering question papers in examinations.

Marking Scheme of Examination (SEE and ESE):

Type of Exam/Assessment	Semester	Maximum Marks Allotted	Duration	Type of Questions/Evaluation Methods
End Semester Examination (ESE)	**Even Semester (II and IV)**	**70**	**3 hours**	**Subject Specific 100 MCQ. MCQ stands for Multiple Choice Question which has 4 options with only 1 correct answer.**
Semester End Examination (SEE)	**Odd Semester (I and III)**	**70**	**3 hours**	**Subject Specific 100 MCQ. MCQ stands for Multiple Choice Question which has 4 options with only 1 correct answer.**
Continuous Comprehensive Assessment (CCA)	**Throughout Every Semester**	**30**	**-**	**Refer to Table A**
Skill Development Courses	**Once in I and II semester; Once in III and IV semester**	**70**	**3 hours**	**Subject Specific 100 MCQ. MCQ stands for Multiple Choice Question which has 4 options with only 1 correct answer.**

Table A:

SR. NO.	CCA: COMPONENT	MAXIMUM MARKS
1	Monthly test	**20X3 Test = 60**
2	Quizzes and Assignments	**10**
3	Viva-voce	**10**
4	Seminar/Symposia	**10**
5	Report writing	**10**
6	Workshop	**10**
7	Review of literature	**10**
8	Creativity/Innovation	**10**
9	Experimental Skill	**10**
10	Co-curricular activity	**10**
11	Attendance	**10**

EXPLANATION (METHOD TO ASCERTAIN MARKS FOR CCA): CCA will be reduced to 30 marks. Formula: Marks obtained/Total marksX30. For example: 60 divided by160X30 = 11.25

PROVISO-I: Provided that a candidate shall be granted a relaxation in the form of exemption from CCA component. However, the said exemption must not be provided in more than 3 components in a respective course.

PROVISO-II: Provided further that this will be mandatory for a candidate to appear in the monthly test conducted in the respective course.

Attendance in Lectures, Tutorials and Practical

Percentage	Marks Allotted
75% to 80%	02
81% to 85%	04
86% to 90%	06
91% to 95%	08
Above 96%	10

Evaluation of Practical/Lab/Projects/Dissertation:

Practical: Mathematica/MatLab/Scilab for Numerical Analysis			
1.	Daily Evaluation of Practical Records/Viva-Voce	5	Internal Evaluation (15 Marks)
2.	Seminar/Presentation	5	
3.	Attendance	5	
4.	Final Practical Performance and Viva-Voce	35	External Evaluation (35 Marks)
Total		50	Marks may be rounded off to nearest integer.
Project Works			
1.	Project Report Evaluation	70	Evaluation by two Examiners (one internal and one external)
2.	Project Presentation and Viva-Voce	30	

Skill Development Course Evaluation: Based on the performance of students and hands-on practice, the respective department/faculty where the students have completed the skill course, will declare the result as "satisfactory" or "unsatisfactory". The students have to secure two satisfactory declarations for the course completion from the respective department/faculty.

SWAYAM/MOOCs Course Evaluation (for Elective Course): The students have to opt for only those SWAYAM/MOOCs courses which are relevant to the subject and have the same credit points as offered in the course. The students have to pass the exam and earn the certificate.

Declaration of Result:

- **i.** A student acquiring minimum of 40% in the total CCA is eligible for the next semester
- **ii.** The student of I and II semester will be promoted to III semester only when s/he has cleared more than 50% or more courses including non-credit skill courses.
- **iii.** Both grading and marks system will be adopted reflecting the same in the grade cum mark card (i.e. statement of marks)
- **iv.** A student who does not pass the examination (ESE+SEE) in any course(s) or remains absent will be considered as 'FAIL' and permitted to appear in such course(s) in subsequent ESE and/or SEE or when the course is offered next time.
- **v.** A student who fails in one or more courses in a semester shall get three more chances to complete the same, after that the student is not eligible for the post-graduate programme. The students have to pay additional examination fees for the same.
- **vi.** Students have an opportunity to improve the credit with two additional chances. The credit obtained in the improvement examination will be final. The students have to pay additional examination fees for the same.
- **vii.** The university shall try to ensure to declare the result within a period of 20 days from the date of the completion of the examination and upload the same on the website of the university.

Grievance Redressal Mechanism:

a) The students will have the right to make an appeal against any component of evaluation. Such appeal has to be made to the Head of the Department concerned as the case may be, clearly stating in writing the reason(s) for the complaint / appeal.

b) The appeal will be assessed by the Chairman and he/she shall place it before the **Grievance Redressal Committee (GRC),** chaired by the Dean concerned, comprising of the HOD of the concerned Department and if needed Course Teacher(s) be called for suitable explanation; GRC shall meet at least once in a semester and prior to CCA finalization.

c) The Committee will consider the case and may give a personal hearing to the appellant before deciding the case. The decision of the Committee will be final and binding.

d) The online and offline grievance reporting form is available.

e) The grievance is to be redressed within 14 working days.

COURSE STRUCTURE

Courses	No. of Courses	Semester	Lecture (L)	Tutorial (T)	Practical (P)	Total Teaching Hours	Total Marks	Total Credits
Core Course (CC)	12	I and II	30	10	04	572	1100	42
	6	III and IV	18	6	00	312	600	24
Elective Course (EC)	4	III and IV	12	4	00	208	400	16
Project /Dissertation	1	IV	00	00	12	156	100	6
Skill/Sustainable Development Course (SC)	4	I, II, III and IV	12	00	00	156	400	Non-Credit
Total	26	I,II,III,IV	72	20	16	1404	2600	88

SEMESTER WISE COURSE STRUCTURE

Semester-I										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**SEE**	**CCA**	**Total**	
Core Courses	**MSM-101**	Advanced Abstract Algebra-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-102	Real Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-103	Topology-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-104	Ordinary Differential Equations	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-105	Numerical Analysis-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-106P	Mathematica/MatLab /Scilab Practicals based on course MSM-105	**26**	**0**	**0**	**2**	**35**	**15**	**50**	**1**
Skill Course	**MSM-107SC**	Elementary Number Theory	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*
Total			**325**	**18**	**5**	**2**	**385**	**165**	**550**	**21**
Total Credits for Semester-I										**21**
***Excluded in total**										

Semester-II										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**ESE**	**CCA**	**Total**	
Core Courses	**MSM-201**	Advanced Abstract Algebra-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-202	Complex Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-203	Topology-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-204	Partial Differential Equations	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-205	Numerical Analysis-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-206P	Mathematica/MatLab /Scilab Practicals based on Course MSM-205	**26**	**0**	**0**	**2**	**35**	**15**	**50**	**1**
Skill Course	**MSM-207SC**	Biomathematics	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*****
Total			**325**	**18**	**5**	**2**	**385**	**165**	**550**	**21**
Total Credits for Semester-II										**21**
***Excluded in total**										

Semester-III										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**SEE**	**CCA**	**Total**	
Core Courses	**MSM-301**	Differential Geometry and Tensor Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-302	Functional Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-303	Linear Algebra	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-304	Analytical Dynamics	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Elective Courses	**MSM-*** **	Elective-1	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Skill Course	**MSM-306SC**	Teaching Technology and Research Methodology In Mathematics and Service Learning	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*****
Total			**299**	**18**	**5**	**0**	**350**	**150**	**500**	**20**
Total Credits for Semester-III										**20**
***Excluded in total**										

Semester-IV										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**ESE**	**CCA**	**Total**	
Core Courses	**MSM-401**	Measure Theory and Integration	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-402	Mathematical Methods	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Elective Courses	**MSM-*****	Elective-2	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-***	Elective-3	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-***	Elective-4	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Skill Course	**MSM-*****	Sustainable Development Course	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*
Project Works			**156**	**0**	**0**	**12**	**70 (Viva)**	**30**	**100**	**6**
Total (*Excluded in total)			**455**	**18**	**5**	**12**	**420**	**180**	**600**	**26**
Total Credits for Semester-IV										**26**
Programme Grand Total of Credits										**88**

Elective Courses:

S. No.	**Elective Courses**	**Elective Course Code**	**Elective Course Title**
1.	Elective-1	MSM-305(A)	Fluid Mechanics
		MSM-305(B)	Special Theory of Relativity
		MSM-305(C)	4 Credit SWAYAM/MOOCs Course
2.	Elective-2 Elective-3 Elective-4	MSM-403(A)	Riemannian Geometry
		MSM-403(B)	Theory of Linear Operators
		MSM-403(C)	Computational Fluid Dynamics (CFD)
		MSM-403(D)	General Relativity and Cosmology
		MSM-403(E)	Fundamental of Operation Research
		MSM-403(F)	4 Credit SWAYAM/MOOCs Course

FIRST SEMESTER

Semester-I										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**SEE**	**CCA**	**Total**	
Core Courses	**MSM-101**	Advanced Abstract Algebra-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-102	Real Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-103	Topology-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-104	Ordinary Differential Equations	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-105	Numerical Analysis-I	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-106P	Mathematica/MatLab /Scilab Practicals based on course MSM-105	**26**	**0**	**0**	**2**	**35**	**15**	**50**	**1**
Skill Courses	**MSM-107SC**	Elementary Number Theory	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*
Total			**325**	**18**	**5**	**2**	**385**	**165**	**550**	**21**
Total Credits for Semester-I										**21**
***Excluded in total**										

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-101**	Course Type :	Core Course-01
Course Title :	**Advanced Abastract Algebra-I**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

This course is designed to give students a foundation for all future mathematics courses. The fundamentals of algebraic problem-solving are explained. Students will explore: foundations of Algebraic structures, Groups, Rings, Ideals, Fields, Homomorphism etc. The course also fulfills the objective to make students aware of the applicability of abstract mathematics in real world problems.

Course Outcomes: On the completion of the course, the students will be able to

1. Design, analyze and implement the concepts of homomorphism and isomorphism between groups and rings for solving different types of problems, for example, Isomorphism theorems, quotient groups, conjugacy etc**.**
2. Utilize the class equation and Sylow theorems to solve different related problems.
3. Identify and analyze different types of algebraic structures such as Solvable groups, Simple groups, Alternate groups, group action to understand and use the fundamental results in Algebra.
4. Understand unique factorization in various algebraic structures.
5. Create, select and apply appropriate algebraic structures such as finitely generated abelian groups, Ideals, Fields to explore the existing results.
6. Identify the challenging problems in modern mathematics and find their appropriate solutions.

UNIT-1 Teaching Hours (13)	**Groups-I:** Law of isomorphism. Direct product of groups. Theorems related to composition series. Jordan-Holder theorem. Definition of P-Group, H-Conjugate, Cauchy's theorems for finite abelian and finite group. Sylow's groups and subgroups, Sylow's theorems for a finite group, Applications and examplesof p-Sylow subgroups.
UNIT-2 Teaching Hours (13)	**Group-II:** Solvable groups, Simple groups, Applications and examples of solvable and simple groups. Group action on a set, Orbits and Stabilizers, The orbit-stabilizer theorem.
UNIT-3 Teaching Hours (13)	**Ring Theory:** Ring homomorphism and Isomorphism. Theorems on principal, maximal and prime ideals, Field of quotients of an integral domain, Imbedding of rings. Euclidean rings, Prime and relatively prime elements of a Euclidean ring, Direct product of rings.
UNIT-4 Teaching Hours (13)	Factorization in integral domain, Unique factorization theorem, Fermat's theorem, Polynomial rings, The division algorithm. Polynomials over the rational field, Primitive polynomial, Content of a polynomial. Gauss lemma, Eisenstein criteria, Polynomial rings over commutative rings, Unique Factorization Domains.

<table>
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<tr><td>Selected Readings</td><td colspan="3">1. Herstein I. N.: Topics in Algebra, 2nd Edition, Wiley India, 2016.
2. Surjeet Singh and Qazi Zameeruddin, Modern Algebra, 8th edition, Vikas Publishing House, 2006.
3. Jacobson, N.: Basic Algebra-I, 2nd Revised edition, Dover Publications, 2009.
4. Artin, M.: Algebra, Second Edition, Prentice Hall of India, 2011.
5. Darek F. Holt, Bettina Eick and Eamonaa. Obrien. Handbook of computational group theory,Chapman & Hall/CRC Press, 2005.
6. Fraleigh, J. B.: A first course in abstract algebra, 7th ed., Addison-Wesley Longman, 2002.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-102**	**Course Type :**	Core Course-02
Course Title :	**Real Analysis**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

This course is designed to provide a deeper and rigorous understanding of fundamental concepts viz. continuous functions, sequences and series of numbers as well as functions, and the Riemann-Stieltjes integral etc. The main focus of this course will be on theoretical foundation of the above said concepts and it will cultivate the rigorous mathematical logics and skills in the students.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply the knowledge of concepts of real analysis in order to study theoretical development of different mathematical techniques and their applications.
2. Understand the nature of abstract mathematics and explore the concepts in further details.
3. Identify challenging problems in real variable theory and find their appropriate solutions.
4. Understand the functions of several variables, continuity and Differentiation of vector-valued functions and directional derivatives.
5. Use theory of Riemann-Stieltjes integral in solving definite integrals arising in different fields of science and engineering.
6. Extend their knowledge of real variable theory for further exploration of the subject for going into research.

UNIT-1 Teaching Hours (13)	**The Riemann-Stieltjes Integral:** Definitions and existence of the integral, Linear properties of the integral, the integral as the limit of sums, Integration and Differentiation, Integration of vector valued functions. Function of bounded variation, First and second mean value theorems, Change of variable rectifiable curves.
UNIT-2 Teaching Hours (13)	**Sequence and series of Functions:** Pointwise and Uniform Convergence, Cauchy Criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes Integration, Bounded variation, Uniform convergence and Differentiation. Uniform convergence and bounded variation, Equicontinuous families of functions, uniform convergence and boundedness.
UNIT-3 Teaching Hours (13)	**Properties of Functions:** The stone-Weierstrass theorem and Weierstrass approximation of continuous function, illustration of theorem with examples. Properties of power series, exponential and logarithmic functions, trigonometric functions. Topology of R^n k-cell and its compactness, Heine-Borel Theorem, Bolzano Weirstrass theorem, Continuity, Compactness and uniform continuity.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Functions of several variables: continuity and Differentiation of vector-valued functions, Linear transformation of R^n, properties and invertibility, Directional Derivative, Chain rule, Partial derivative, Hessian matrix. The Inverse Functions Theorem and its illustrations with examples. The Implicit Function Theorem and illustration and examples. The Rank theorem illustration and examples.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
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2. Apostol, T. M.: Mathematical Analysis, New Delhi, Narosa, 2004.
3. Goldberg, S.: Methods of Real Analysis, Oxford & IBH, 1970.
4. Dieudonne, S.: Treatise on Analysis, Vol. I, Academic Press, 1960.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-103**	**Course Type :**	Core Course-03
Course Title :	**Topology-I**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The objective of the course on Topology is to provide the knowledge of Topological Spaces, metric space and their importance. To acquaint students with the concept of cardinal numbers, basics of topological spaces, metric space and continuous, compactness, connectedness properties in metric spaces and important mathematical concepts which can be generalized in metric spaces, so that students may learn and appreciate the nature of abstract Mathematics.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concepts of cardinal numbers and the basic definitions of open sets, neighborhood, interior, exterior, closure and their axioms in metric space.
2. Understand the concept of denses, completeness and contraction in metric space.
3. Understand continuity, compactness, and connectedness properties in metric space with useful examples.
4. Understand the concept of topological spaces and the basic definitions of open sets, neighborhood, interior, exterior, closure and their axioms in metric space.
5. Understand bases, sub-bases, continuity and homeomorphism in topological spaces.
6. Understand connectedness, path connected, connected components in topological spaces.

UNIT-1 Teaching Hours (13)	**Sets:** Finite and Infinite sets. Denumerable and Non denumerable sets, Countable and Uncountable sets. Equivalent sets. Concept of Cardinal numbers, Schroeder-Bernstein Theorem. Cardinal number of a power set, Addition of Cardinal numbers, Exponential of Cardinal numbers, Examples of Cardinal Arithmetic, Cantor's Theorem. Card X < Card P(X). Continuum Hypothesis. Zorn's lemma (statement only).
UNIT-2 Teaching Hours (13)	**Metric Spaces:** Definition of a metric, Compactness, Connectedness. Normed Linear Spaces. Spaces of Continuous functions as examples.
UNIT-3 Teaching Hours (13)	**Properties of Metric Space:** Bolzano-Weierstrass theorem. Cauchy and convergent sequences. Complete metric spaces. Continuity, Contraction mapping theorem. Banach fixed point theorem, Bounded and totally bounded sets. Cantor's Intersection Theorem. Nowhere dense sets. Baire's category theorem. Isometry. Embedding of a metric space in a complete metric space.
UNIT-4 Teaching Hours (13)	**Topology:** Definition and examples Open and closed sets. Neighborhoods and Limit Points. Closure, Interior and Boundary of a set. Relative topology. Bases and sub-bases. Continuity and homeomorphism, Pasting lemma. Connected spaces: Definition and examples, connected sets in the real line, Intermediate value theorem, components and path components, local connectedness and path connectedness.
Teaching And	1. Lecture method

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<tr><td>Selected Readings</td><td colspan="3">1. Munkres, J. R.: Topology, Second Edition, Prentice Hall of India, 2007.
2. Pervin, W. J.: Foundations of General Topology - Academic Press, 1964.
3. Simmons, G. F.: Introduction to Topology and Modern Analysis – Tata Mc Graw Hill, 1963.
4. Dugundji, J.: Topology - Prentice Hall of India, 1975.
5. Kelley, G. J. L.: General Topology, Van Nostrand, Princeton, 1955.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-104**	**Course Type :**	Core Course-04
Course Title :	**Ordinary Differential Equations**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

The Objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.
2. Understand the concept and applications of eigenvalue problems.
3. Understand differential equations of Strum Liouville type.
4. Apply various power series methods to obtain series solutions of differential equations.
5. Discuss various kinds of special functions in detail, their properties and relations.
6. Solve problems of ordinary differential equations arising in various fields.

UNIT-1 Teaching Hours (13)	**Linear differential equations of nth order**: fundamental sets of solutions, Wronskian, Abel's identity, theorems on linear dependence of solutions, adjoint, self-adjoint linear operator, Green's formula, Adjoint equations, the n^{th} order non-homogeneous linear equations, Variation of parameters, zeros of solutions, comparison and separation theorems.
UNIT-2 Teaching Hours (13)	**Fundamental existence and uniqueness theorem:** Dependence of solutions on initial conditions, existence and uniqueness theorem for higher order and system of differential equations, Eigenvalue problems, Sturm-Liouville problems, Orthogonality of eigenfunctions – Eigenfunction expansion in a series of orthonormal functions-Green's function method.
UNIT-3 Teaching Hours (13)	**Power series solution of linear differential equations**: ordinary and singular points of differential equations, Classification into regular and irregular singular points; Series solution about an ordinary point and a regular singular point, Frobenius method, Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equations and their general solutions.
UNIT-4 Teaching Hours (13)	**Various Methods:** Generating function, Recurrence relations, Rodrigue's formula, Orthogonality properties. Behaviour of solution at irregular singular points and the point at infinity. Linear system of homogeneous and non-homogeneous equations (matrix method) Linear and Non-linear autonomous system of equations, Phase plane, Critical points, stability, Liapunov direct method, Limit cycle and periodic solutions-Bifurcation of plane autonomous systems.

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2. Eastham, M.S.P.: Theory of ordinary differential equations, Van Nostrand, London, 1970.
3. Ross, S.L.: Differential equations (3rd edition), John Wiley & Sons, New York, 1984.
4. Rainville, E.D. and Bedient, P.E.: Elementary Differential Equations, McGraw Hill, NewYork, 1969.
5. Coddington, E. A. and Levinson, N.: Theory of ordinary differential equations, McGraw Hill, 1955.
6. King, A.C., Billingham, J. & Otto, S.R.: Differential equations, Cambridge University Press, 2006.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-105**	**Course Type :**	Core Course-05
Course Title :	**Numerical Analysis-I**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

This course is designed to introduce the basic concepts of Numerical Mathematics in order to solve the problems arising in various fields of application, for example in science, engineering and economics etc. that do not possess analytical solutions or difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. system of linear & nonlinear equations, interpolation and numerical integration.

Course Outcomes: On the completion of the course, the students will be able to

1. Identity and analyze different types of errors encountered in numerical computing.
2. Apply the knowledge of Numerical Mathematics to solve problems efficiently arising in science, engineering and economics etc.
3. Utilize the tools of the Numerical Mathematics in order to formulate the real-world problems from the view point of numerical mathematics.
4. Design, analyze and implement of numerical methods for solving different types of problems.
5. Create, select and apply appropriate numerical techniques with the understanding of their limitations so that any possible modification in these techniques could be carried out in further research.
6. Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently.

UNIT-1 Teaching Hours (13)	Examples from algebraic and transcendental equations where analytical methods fail. Examples from system of linear and non-linear algebraic equations where analytical solutions are difficult or impossible.Floating-point number and round-off, absolute and relative errors. **Solution of nonlinear equation in one variable** Fixed point iterative method - convergence and acceleration by Aitken's ^{2} -process. Newton-Raphson methods formula for triple roots and their convergence criteria, Ramanujan method, Bairstow's method, Sturm sequence for identifying the number of real roots of the polynomial functions, complex roots-Muller's method. Homotopy and continuation methods.

<table>
<tr><td>UNIT-2
Teaching Hours (13)</td><td colspan="3">Solving system of equations
Review of matrix algebra. Gauss-elimination with pivotal strategy. Factorization methods (Crout's,Doolittle and Cholesky). Tri-diagonal systems-Thomas algorithm. Iterative methods: Matrix norms, error analysis and ill-conditioned systems- Jacobi and Gauss-Seidel methods, Chebyshev acceleration. Introduction to steepest descent and conjugate gradient methods. Solutions of nonlinear equations: Newton-Raphson method, Quasilinearization (quasi-Newton's) method, successive over relaxation method.</td></tr>
<tr><td>UNIT-3
Teaching Hours (13)</td><td colspan="3">Interpolation
Review of interpolations basics, Lagrange, Hermite methods and error analyses, Splines-linear, quadratic and cubic (natural, Not a knot and clamped), Bivariate interpolation, Least-squares, Chebyshev and rational approximations.</td></tr>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Numerical integration
Review of integrations. Gaussian quadrature, Gauss-Legendre, Gauss-Chebyshev, Gauss-Lagaurre, Gauss-Hermite and error analyses, adaptive quadratures, multiple integration with constant and variable limits.</td></tr>
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</table>

Syllabus	running semester after giving a notice for a period one month.
Selected Readings	1. S.D. Cante & C de Boor: Elementary numerical analysis, Tata-Mc Graw-Hill,1980 3 edition. 2. D. Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3 edition. **3.** A Iserles: A first course in the numerical analysis of differential equations, Cambridge texts in appliedmathematics, 2008, 2 edition.

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-106P**	**Course Type :**	Core Course-06
Course Title :	**Mathematica/MatLab/Scilab Practicals based on MSM-105**		
Credit:	1	**Hours:**	2 Hours/Week
		Total Teaching Hours:	26 Hours
Max. Marks:	50	**Minimum Pass Marks:**	18
Practical Examination	35	**Minimum Pass Marks:**	13
Continuous & Comprehensive Assessment (CCA)	15	**Minimum Pass Marks:**	6
Attendance Eligibility	75 Percent In Respective Semester		
Examination	Practical Exam		
Duration	3 Hrs		

Objective:
This course is designed to provide understanding of implementation of basic numerical methods for solving different problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, etc. Further, this course will develop programming skills in the students in order to write and implement their own computer programs for solving problems arising in science, engineering and economics.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, numerical, etc.
2. Understand different implementation modes of a numerical method in order to solve a given problem efficiently.
3. Analyze and modify computer codes available in the scientific literature.
4. Utilize the symbolic tools of Computer Algebra System (CAS) for example MATLAB, MATHEMATICA , MAPLE, and Scilab independently and in their computer codes for solving a given problem.
5. Develop, select and apply numerical methods as a computer code with the understanding of their limitations so that they can be implemented in order to get acceptable results.

6. Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently using computer codes.

UNIT-1 Teaching Hours (6)	Introduction to Mathematica/MatLab/Scilab Programs for finding the root of the function using 1. Fixed-point iterative method 2. Newton-Raphson method 3. Newton-Raphson method for multiple roots 4. Ramanujan method 5. Mullers method
UNIT-2 Teaching Hours (8)	Programs for the solution of system of equations using 1. Gauss-elimination method with pivoting 2. Crout's LU Decomposition method 3. Doolittle LU Decomposition method 4. Thomas Algorithm 5. Gauss-Seidel iterative method 6. Jacobi iterative method 7. Conjugate gradient method
UNIT-3 Teaching Hours (6)	Programs on interpolation using 1. Lagrange interpolation method 2. Cubic Spline interpolation method 3. Rational function approximation
UNIT-4 Teaching Hours (6)	Program on numerical integration using 1. Gauss-Legendre method 2. Gauss-Chebyshev method 3. Gauss-Hermite method 4. Double integrals
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

	S. No.	CCA- Components	Max. Marks Allocation
Continuous & Comprehensive	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10

Assessment (CCA)	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 15.		
Semester End Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.		
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.		
Selected Readings	1. S.D. Cante & C de Boor: Elementary numerical analysis, Tata-Mc Graw-Hill,1980 3 edition. 2. D. Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3 edition. **3.** A Iserles: A first course in the numerical analysis of differential equations, Cambridge texts in appliedmathematics, 2008, 2 edition.		

M.Sc.(Mathematics) SEMESTER I			
Course Code:	**MSM-107SC**	**Course Type :**	Skill Course-01
Course Title :	**Elementary Number Theory**		
Credit:	3*	**Hours:**	3 Hours/Week
		Total Teaching Hours:	39 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to provide students an introduction to classical number theory and enable them to study higher courses in number theory.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply the knowledge of Number theory to attain a good mathematical maturity and enables to build mathematical thinking and skill.
2. Utilize the congruences, Chinese remainder theorem, indices, residue classes, Legendre symbols to solve different related problems.
3. Identify and analyze different types of divisibility tests, Euler's theorem, and Wilson theorem, Mobius inversion formula to formulate and solve various related problems.
4. Design, analyze and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares.
5. Create, select and apply appropriate number theoretic techniques such as primes, greatest integer functions to use in real life problems.
6. Identify the challenging problems in modern mathematics and find their appropriate solutions.

UNIT-1 Teaching Hours (9)	**Divisibility and Primes:** Recapitulation of Division algorithm, Euclid's algorithm, Least Common Multiples, Linear Diophantine equations. Prime numbers and Prime-power factorizations, Distribution of primes, Fermat and Mersenne primes, Primality testing and factorization.
UNIT-2 Teaching Hours (12)	**Congruences:** Recapitulation of basic properties of congruences, Residue classes and complete residue systems, Linear congruences. Reduced residue systems and the Euler-Fermat theorem, Polynomial congruences modulo p and Langrange's theorem, Simultaneous linear congruences, Simultaneous non-linear congruences, An extension of Chinese Remainder Theorem, Solvingcongruences modulo prime powers.
UNIT-3 Teaching Hours (9)	**Quadratic Residues and Quadratic Reciprocity Law:** Quadratic residues, Legendre's symbol and its properties, Euler's criterion, Gauss lemma, The quadratic reciprocity law and its applications, The Jacobi symbol, Applications to Diophantine equations.
UNIT-4 Teaching Hours (9)	**Sums of squares, Fermat's last theorem and Continued fractions:** Sums of two squares, Sums of four squares, The Pythagoras theorem, Pythagorean triples and their classification, Fermat's Last Theorem (Case $n = 4$).
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia

<table>
<tr><td></td><td colspan="3">5. Review of literature
6. Report writing
7. Group Discussion
8. Videos/Animation
9. Self-Learning/e-Learning
10. Workshops/Experiments
* The teaching and learning strategies may be change as per requirement of the students and their capabilities.</td></tr>
<tr><td rowspan="13">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
<tr><td>5.</td><td>Report writing</td><td>10</td></tr>
<tr><td>6.</td><td>Workshop</td><td>10</td></tr>
<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
<tr><td>Semester End Examination pattern for post graduate Programme</td><td colspan="3">NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.</td></tr>
<tr><td>Periodical Revision Of Syllabus</td><td colspan="3">1. Annual
2. However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.</td></tr>
<tr><td>Selected Readings</td><td colspan="3">1. G. A. Jones and J. M. Jones, Elementary Number Theory, Springer UTM, 2007.
2. Tom M. Apostol - Introduction to Analytic Number Theory, Springer, 1989.
3. D. Burton; Elementary Number Theory, McGraw-Hill, 2005.
4. Niven, H.S. Zuckerman & H.L. Montgomery, Introduction to the Theory of Numbers, Wiley, 2000.
5. H. Davenport, The Higher Arithmetic, Cambridge University Press, 2008.</td></tr>
</table>

SECOND SEMESTER

Semester-II										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**ESE**	**CCA**	**Total**	
Core Courses	**MSM-201**	Advanced Abstract Algebra-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-202	Complex Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-203	Topology-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-204	Partial Differential Equations	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-205	Numerical Analysis-II	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-206P	Mathematica/MatLab /Scilab Practicals based on Course MSM-205	**26**	**0**	**0**	**2**	**35**	**15**	**50**	**1**
Skill Courses	**MSM-207SC**	Biomathematics	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*****
Total			**325**	**18**	**5**	**2**	**385**	**165**	**550**	**21**
Total Credits for Semester-II										**21**
***Excluded in total**										

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-201**	**Course Type :**	Core Course-01
Course Title :	**Advanced Abstract Algebra-II**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

This course is designed to give students a foundation for advanced study in Algebra. The fundamental theorems of algebraic structures are explained. Students will explore the concepts of Modules, Field extensions, Einstein's irreducibility criterion, Galois extensions etc. Throughout the course, Advanced Core standards are taught and reinforced as the student learns how to apply the concepts in real-life situations.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply the knowledge of Algebra to attain a good mathematical maturity and enables to build mathematical thinking and reasoning.
2. Understand the concept of modules to solve different related problems.
3. Identify and analyze different types of algebraic structures such as algebraically closed fields, Splitting fields, Finite field extensions to understand and use the fundamental results in Algebra.
4. Design, analyze and implement the concepts of Gauss Lemma, Einstein's irreducibility criterion, separable extensions etc.
5. Create, select and apply appropriate algebraic structures such as Galois extensions, Automorphisms of groups and fixed fields, Fundamental theorem of Galois Theory to understand and use the Fundamental theorem of Algebra.
6. Identify the challenging problems in advanced Algebra to pursue further research.

UNIT-1 Teaching Hours (13)	**Modules Theory:** Modules, submodules and quotient modules, module homomorphisms, Isomorphism theorems of modules. Direct sums, Free modules, Finitely generated modules, Nakayama Lemma, Simple modules, Exact sequences of modules.
UNIT-2 Teaching Hours (13)	**Modules Theory and Ring:** Modules with chain conditions-Artinian and Noetherian modules, modules of finite length, Artinian rings, Noetherian rings, Hilbert basis theorem.
UNIT-3 Teaching Hours (13)	**Field Theory:** Extension fields**,** Finite and algebraic extensions. Degree of extension, algebraic elements and algebraic extensions, adjunction of an element of a field. Roots of a polynomial, Minimal Polynomials, Splitting fields, Construction with straight edge and compass. More about roots (Characteristic of a field), Simple and separable extensions, Theorems on roots and coefficients of polynomial separable and inseparable extensions. Finite fields.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Galois Theory: Monomorphism and their Linear Independence. Arten theorem on automorphism, Elements of Galois Theory, Fixed fields, Normal extension, Fundamental theorem of Galois theory, Radical extensions and solvability by Radicals. Galois groups over the rationales, degree, distance. Hilbert’s Bases theorem. Artinian rings.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
7. Group Discussion
8. Videos/Animation
9. Self-Learning/e-Learning
10. Workshops/Experiments
* The teaching and learning strategies may be change as per requirement of the students and their capabilities.</td></tr>
<tr><td rowspan="13">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
<tr><td>5.</td><td>Report writing</td><td>10</td></tr>
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<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
<tr><td>End Semester Examination pattern for post graduate Programme</td><td colspan="3">NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.</td></tr>
<tr><td>Periodical Revision Of Syllabus</td><td colspan="3">1. Annual
2. However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.</td></tr>
<tr><td>Selected Readings</td><td colspan="3">1. M. F. Atiyah and I. G. Macdonald: Introduction to Commutative Algebra, Addison - Wesley. (Part A).
2. I. N. Herstein: Topics in Algebra, 2nd Edition, Vikas Publishing House, 1976. (Part B).
3. C. Musili: Introduction to Rings and Modules, Narosa Publishing House, 1997.
4. Miles Reid: Under-graduate Commutative Algebra, Cambridge University Press, 1996.
5. M. Artin: Algebra, Prentice Hall of India, 1991.
6. N. Jacobson: Basic Algebra-I, HPC, 1984.
7. J. B. Fraleigh: A first courses in Algebra, 3rd edition, Narosa 1996.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-202**	**Course Type :**	Core Course-02
Course Title :	**Complex Analysis**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

The objective of this course is to introduce and develop a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions and to make students equipped with the understanding of the fundamental concepts of complex variable theory. In particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

Course Outcomes: On the completion of the course, the students will be able to

1. Know the fundamental concepts of complex analysis.
2. Evaluate complex integrals and apply Cauchy integral theorem and formula.
3. Evaluate limits and checking the continuity of complex function & apply the concept of analyticity and the Cauchy-Riemann equations.
4. Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.
5. Establish the capacity for mathematical reasoning through analyzing, proving and explaining concepts from complex analysis.
6. Extend their knowledge to pursue research in this field.

UNIT-1 Teaching Hours (13)	**Complex Variable Functions:** Analytic functions, Harmonic conjugates, Elementary functions, Cauchy's theorem and Integral formula, Morera's Theorem, Cauchy's Theorem for triangle, rectangle, Cauchy's Theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. Principle of analytic Continuation. Liouville's Theorem, Fundamental theorem of algebra.
UNIT-2 Teaching Hours (13)	**Complex Series and Singularities:** Series, Uniform convergence, Power series, Radius of convergences, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series. Rational Functions, Singularities, Poles, Classification of Singularities, Characterization of removable Singularities, poles. Behaviour of an Analytic function at an essential singular point.
UNIT-3 Teaching Hours (13)	Conformal transformations, bilinear transformation, cross-ratios and some special transformations. Theory of residues. Contour integration. Entire and Meromorphic functions. The Residue Theorem, Evaluation of Definite integrals, Argument principle, Rouche's Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications, Convex functions, Hadmard's Three circle theorem**.**

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Phragmen-Lindelof theorem, The Riemann mapping theorem, Weistrass factorization theorem. Harmonic functions, Mean Value theorem. Poisson’s formula, Poisson’s Integral formula, Jensen’s formula, Poisson’s-Jensen’s formula.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
7. Group Discussion
8. Videos/Animation
9. Self-Learning/e-Learning
10. Workshops/Experiments
* The teaching and learning strategies may be change as per requirement of the students and their capabilities.</td></tr>
<tr><td rowspan="13">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
<tr><td>5.</td><td>Report writing</td><td>10</td></tr>
<tr><td>6.</td><td>Workshop</td><td>10</td></tr>
<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
<tr><td>End Semester Examination pattern for post graduate Programme</td><td colspan="3">NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.</td></tr>
<tr><td>Periodical Revision Of Syllabus</td><td colspan="3">1. Annual
2. However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.</td></tr>
<tr><td>Selected Readings</td><td colspan="3">1. J. B. Conway: Functions of one complex variable, Narosa, 1987.
2. L.V. Ahlfors: Complex Analysis, McGraw Hill, 1986.
3. R. Nevanlinna: Analytic functions, Springer, 1970.
4. E. Hille: Analytic Theory, Vol. I, Ginn, 1959.
5. S. Ponnuswamy: Functions of Complex variable, Narosa Publications.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-203**	**Course Type :**	Core Course-03
Course Title :	**Topology-II**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The objective of the course on Topology is to provide the knowledge of Topological Spaces and their importance. To acquaint students with the concept of Homeomorphism and the topological properties and important mathematical concepts, this can be generalized in topological spaces, so that students may learn and appreciate the nature of abstract Mathematics.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concepts of topological spaces and their equivalence in metric spaces.
2. Understand the concept of product topology and quotient of topological spaces.
3. Understand continuity, compactness, connectedness, homeomorphism and topological properties.
4. Understand how points of space are separated by open sets, Housdroff spaces and their importance.
5. Understand the separation of axioms in topological spaces.
6. Understand regular and normal spaces and some important theorems in these spaces.

UNIT-1 Teaching Hours (13)	Compact spaces, Compact sets in the real line, limit point compactness, sequential compactness and their equivalence for metric spaces. Locally Compact spaces, compactification, Alexandroff's one point compactification. The axioms of countability: First axiom space, Second countable space, Separability and the Lindelof property and their equivalence for metric spaces.
UNIT-2 Teaching Hours (13)	The product topology, the metric topology, the quotient topology, Product invariant properties for finite products, Projection maps. Separation axioms: T_0-space and T_1-spaces, definitions and examples, the properties of hereditary and topological. Characterization of T_0 - and T_1-spaces.
UNIT-3 Teaching Hours (13)	T_2-space, unique limit for convergent sequences, Regularity and the T_3-axiom. Characterization of regularity, Metric spaces are T_2 and T_3. Complete regularity, Normality and the T_4 - axiom, Metric space is T_4, compact Hausdorff space and regular lindelof spaces are normal.
UNIT-4 Teaching Hours (13)	Urysohn's Lemma, Tietze's Extension Theorem, Complete normality and the T_5-axiom. Local finiteness, Para-compactness, Normality of a para-compact space, Metrizability, Urysohn metrization theorem.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing

	7. Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**		
Continuous & Comprehensive Assessment (CCA)	S. No.	CCA- Components	Max. Marks Allocation
	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		
End Semester Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.		
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.		
Selected Readings	1. J. R. Munkres: Topology, 2nd Ed., Prentice Hall of India (India), 2007. 2. W. J. Pervin: Foundations of General Topology - Academic Press, 1964. 3. G. F. Simmons: Introduction to Topology & Modern Analysis (McGraw-Hill Interl Edn), 1963. 4. G. J. L. Kelley, General Topology, Van Nostrand, Princeton, 1955. 5. J. Dugundji : Topology - Prentice Hall of India, 1975.		

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-204**	**Course Type :**	Core Course-04
Course Title :	**Partial Differential Equations**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The Objective of this course is to introduce first and higher order partial differential equations and their classification. This course explains various analytic methods for computing the solutions of various partial differential equations. It also explains various applications of partial differential equations in real physical phenomenon like wave equation of string, diffusion equations and heat flow equation to students.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand partial differential equations of first order (linear and nonlinear), second and higher order.
2. Apply various analytic methods for computing solutions of various PDEs.
3. Determine integral surfaces passing through a curve, characteristic curves of second order PDE and compatible systems.
4. Understand the formation and solution of some significant PDEs like wave equation, heat equation and diffusion equation.
5. Able to apply separation of variables method to solve PDEs like wave equation, heat equation and diffusion equation.
6. Apply the knowledge of PDEs and their solutions in order to understand physical phenomena.

UNIT-1 Teaching Hours (13)	**First Order Partial Differential Equations:** Basic definitions, Origin of PDEs, Classification, Geometrical interpretation. The Cauchy problems, the method of characteristics for Semi linear, quasi linear and Non-linear equations, complete integrals, Examples of equations to analytical dynamics, discontinuous solution and shockwaves.
UNIT-2 Teaching Hours (13)	**Second Order Partial Differential Equations:** Definitions of Linear and Non-Linear equations, Linear Superposition principle, Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs, Reduction to canonical forms, solution of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge's method.
UNIT-3 Teaching Hours (13)	**Wave equation:** Solution by the method of separation of variables and integral transforms The Cauchy problem, Wave equation in cylindrical and spherical polar coordinates. Laplace equation: Solution by the method of separation of variables and transforms. Dirichlet's, Neumann's and Churchills problems, Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates.
UNIT-4 Teaching Hours (13)	**Diffusion equation:** Fundamental solution by the method of variables and integral transforms, Duhamel's principle, Solution of the equation in cylindrical and spherical polar coordinates. Solution of boundary value problems: Green's function method for Hyperbolic, Parabolic and Elliptic equations.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the**

	students and their capabilities.		
Continuous & Comprehensive Assessment (CCA)	S. No.	CCA- Components	Max. Marks Allocation
	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		
End Semester Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.		
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.		
Selected Readings	1. I. N. Sneddon, Elements of PDE‟s, McGraw Hill Book company Inc., 2006. 2. L Debnath, Nonlinear PDE‟s for Scientists and Engineers, Birkhauser, Boston, 2007. 3. F. John, Partial differential equations, Springer, 1971. 4. F. Treves: Basic linear partial differential equations, Academic Press, 1975. 5. M.G. Smith: Introduction to the theory of partial differential equations, Van Nostrand, 1967. **6.** Shankar Rao: Partial Differential Equations, PHI, 2006.		

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-205**	**Course Type :**	Core Course-05
Course Title :	**Numerical Analysis-II**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to introduce the basic concepts of Numerical Mathematics in order to solve the problems arising in various fields of application, for example in science, engineering and economics etc. that do not possess analytical solutions or difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. numerical initial and boundary value problems of ordinary and partial differential equations etc.

Course Outcomes: On the completion of the course, the students will be able to

1. Identity and analyze different types of errors encountered in numerical computing.
2. Apply the knowledge of Numerical Mathematics to solve problems efficiently arising in science, engineering and economics etc.
3. Design, analyze and implement of numerical methods for solving different types of problems, viz. initial and boundary value problems of ordinary differential equations etc.
4. Design, analyze and implement of numerical methods for solving different types of problems, viz. initial and boundary value problems of ordinary differential equations etc.
5. Create, select and apply appropriate numerical techniques with the understanding of their limitations so that any possible modification in these techniques could be carried out in further research.
6. Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently.

UNIT-1 Teaching Hours (13)	Examples from ODE where analytical solution are difficult or impossible. Examples from PDEwhere analytical solution are difficult or impossible. Numerical solution of ordinary differential equations: Initial value problems**:** Picard's and Taylor series methods. Euler's and Modified Euler's methods, Runge-Kutta methods of second and fourth order, Runge-Kutta-Fehlberg methods.
UNIT-2 Teaching Hours (13)	Multistep methods - the Adams-Bashforth and Adams-Moulton predictor-corrector methods. Local and global errors, stability analyses for the above methods. Methods for systems and higher order differential equations. Boundary value problems**:** Shooting methods and cubic spline methods.
UNIT-3 Teaching Hours (13)	**Numerical solution of partial differential equations:** Elliptic equations: Difference schemes for Laplace and Poisson's equations. Parabolic equations: Difference methods for one-dimension, methods of Schmidt, Laasonen, Dufort-Frankel and Crank-Nicolson. Alternating direction implicit method for two-dimensional equation.
UNIT-4 Teaching Hours (13)	**Hyperbolic equations:** Difference methods for one-dimension- explicit and implicit schemes, D'Yakonov split and Lees alternating direction implicit methods for two-dimensional equations. Stability and convergence analyses for the above equations.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

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<tr><td rowspan="13">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
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<tr><td>6.</td><td>Workshop</td><td>10</td></tr>
<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
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2. R.L. Burden and JD Faires: Numerical Analysis, Thomson-Brooks/Cole, 1989, 7edition.
3. S. Larsson and V Thomee: Partial differential equations with numerical methods, Springer, 2008, 1 edition.
4. J.W. Thomas : Numerical partial differential equations: finite difference methods, Springer, 1998, 2 Edition.
5. D Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3 edn.
6. AIserles: A first course in the numerical analysis of differential equations, Cambridge texts in applied mathematics, 2008, 2 edition.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-206P**	**Course Type :**	Core Course-05
Course Title :	**Mathematica/MatLab/Scilab Practicals based on MSM-205**		
Credit:	1	**Hours:**	2 Hours/Week
		Total Teaching Hours:	26 Hours
Max. Marks:	50	**Minimum Pass Marks:**	18
Practical Examination	35	**Minimum Pass Marks:**	13
Continuous & Comprehensive Assessment (CCA)	15	**Minimum Pass Marks:**	6
Attendance Eligibility	75 Percent In Respective Semester		
Examination	Practical Exam		
Duration	3 Hrs		

Objective:
This course is designed to provide understanding of implementation of basic numerical methods for solving different problems viz. interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc. Further, this course will develop programming skills in the students in order to write and implement their own computer programs for solving problems arising in science, engineering and economics.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc.
2. Understand different implementation modes of a numerical method in order to solve a given problem efficiently.
3. Analyze and modify computer codes available in the scientific literature.
4. Utilize the symbolic tools of Computer Algebra System (CAS) for example MATLAB, MATHEMATICA, MAPLE and Scilab independently and in their computer codes for solving a given problem.
5. Develop, select and apply numerical methods as a computer code with the understanding of their limitations so that they can be implemented in order to get acceptable results.
6. Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently using computer codes.

UNIT-1 Teaching Hours (6)	Programs for solution of ordinary differential equations using 1. Euler's method and Modified Euler's method 2. Runge-Kutta 2 and 4 order methods 3. Runge-Kutta-Fehlberg order method
UNIT-2 Teaching Hours (6)	Programs for solution of ordinary differential equations using 1. Runge-Kutta for system of equations 2. Adam's Predictor-corrector method 3. Finite difference methods 4. Shooting methods

<table>
<tr><td>UNIT-3
Teaching Hours
(6)</td><td colspan="3">Programs for solution of partial differential equations using
1. Laplace equation
2. Poisson equation
3. Schmidt Method</td></tr>
<tr><td>UNIT-4
Teaching Hours
(6)</td><td colspan="3">Programs for solution of partial differential equations using
1. Crank-Nicolson method
2. ADI method
3. Explicit method for wave equation
4. Lees ADI method for wave equation</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
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<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
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	4. J.W. Thomas : Numerical partial differential equations: finite difference methods, Springer, 1998, 2 Edition. 5. D Kincade and W Cheney: Numerical analysis, American Mathematical Society, 2002, 3 edn. 6. AIserles: A first course in the numerical analysis of differential equations, Cambridge texts in applied mathematics, 2008, 2 edition.

M.Sc.(Mathematics) SEMESTER II			
Course Code:	**MSM-207SC**	**Course Type :**	Skill Course-02
Course Title :	**Biomathematics**		
Credit:	3*	**Hours:**	3 Hours/Week
		Total Teaching Hours:	39 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to provide understanding the mathematical problems in interdisciplinary subjects in particular life sciences.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the population growth models and its application to mathematical epidemiology.
2. Understand the blood flow in large and small blood vessels.
3. Understand the diffusion problem in biology.
4. Understand the Mendalh's mental theory, Equilibrium solutions.
5. Understand the flow in capillaries.
6. Identify the challenging problems in interdisciplinary subjects to solve various research problems.

UNIT-1 Teaching Hours (13)	Population growth, single spair time depend models, application to mathematical opidemiology, age structured models. Two and more spair model, Lotka-Voltarra equations, Pary predator models, Equil-solutions.
UNIT-2 Teaching Hours (13)	Biofluid dynamics, Blood flow in large and small blood vessels. Flow in capillaries, Application of Poinsots law, Sedimentation of red blood cells.
UNIT-3 Teaching Hours (13)	Diffusion problem in biology, Diffusion through membrane, transcapillan exchange. Solutions in simple cases.

<table>
<tr><td>UNIT-4 Teaching Hours (13)</td><td colspan="3">Engymes Kinetics, Mendalh’s mental theory, Equilibrium solutions.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
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3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
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<tr><td>Selected Readings</td><td colspan="3">1. Rubinov, S.L. : Introduction to Mathematical Biology.
2. Kapoor, J.N.: Mathematical Models in Biology and Medicines.
3. Murry, R.D.: Population Dynamics
4. Saxena, V.P.: Introduction to Biomaths, Wiley-Eastern.</td></tr>
</table>

THIRD SEMESTER

Semester-III										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**SEE**	**CCA**	**Total**	
Core Courses	**MSM-301**	Differential Geometry and Tensor Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-302	Functional Analysis	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-303	Linear Algebra	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-304	Analytical Dynamics	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Elective Courses	**MSM-*****	Elective-1	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Skill Courses	**MSM-306SC**	Teaching Technology and Research Methodology In Mathematics and Service Learning	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*****
Total			**299**	**18**	**5**	**0**	**350**	**150**	**500**	**20**
Total Credits for Semester-III										**20**
***Excluded in total**										

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-301**	**Course Type :**	Core Course-01
Course Title :	**Differential Geometry and Tensors Analysis**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The objective of this course is to make students familiar with basic concepts of differential geometry so as to deal with geometry of curves and spaces using the methods of differential calculus, able to know concepts of tensors notation.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the basic concepts and results related to space curves, tangents, normals and surfaces.
2. Explain the geometry of different types of curves and spaces.
3. Explain the physical properties of different curves and spaces.
4. Understand principal directions and curvatures, asymptotic lines and then apply their important theorems and results to study various properties of curves and surfaces.
5. Utilize Geodesics, it's all related terms, properties and theorems.
6. Understand the concept of tensors and its components to use in mathematical research problems.

UNIT-1 Teaching Hours (13)	**Curves in Space:** Definition of unit tangent vector, tangent line, Normal line and Normal plane. Contact of a curve and a surface. Equation of osculating plane. Fundamental unit vectors, equations of fundamental planes. Curvature, Torsion and skew curvature vectors. Serret-Frenet formulae and their applications. Definition and properties of the osculating circle and osculating spheres. Bertrand curves and their properties. Involute and evolute of space curves. Envelope of family of surfaces. Ruled surfaces: Definition and properties of developable and skew surfaces.
UNIT-2 Teaching Hours (13)	Parametric representation of a surface. First and Second fundamental forms and magnitudes of various surfaces. Orthogonal trajectories. Definition and Differential equation of lines of curvature (Excluding theorms). Definition and equation of curvature and torsion of asymptotic lines. Beltrami-Enneper Theorem. Fundamental equations of Surface Theory: Gauss equations, Gauss Characteristic equations, Weingarten equations and Mainardi-Codazai equations.
UNIT-3 Teaching Hours (13)	**Geodesics:** General differential equation of various standard surfaces. Notations and definitions of contravariant and covariant tensors of first and second order. Mixed tensors, higher order tensors. Contraction and Quotient law for tensors. Symmetric and skew symmetric tensors. Metric [Fundamental] tensor, conjugate metric tensors. Definitions and properties of first and second kind of Christoffel's symbols.
UNIT-4 Teaching Hours (13)	Laws of transformation of Christoffel's symbols. Covariant derivatives of contravariant and covariant tensors of first and second orders. Laws of covariant differentiation. Ricci's Theorem. Definition and properties of Riemann-Christoffel's tensor. Definition and properties of covariant curvature tensor. Contraction of Riemann-Christoffel Tensor-Ricci tensor.

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2. Thorpe, J. A.: Introduction to Differential Geometry, Springer-verlag.
3. Slemberg, S.: Lectures on Differential Geometry, P.H.I. (1964).
4. Docarmo, M.: Differential Geometry of Curves and surfaces, P.H.I. (1976).
5. Bansal, J. L.: Tensor Analysis, Jaipur Publishing House, (2004).
6. Gupta, P.P. and Malik, G.S.: Three Dimensional Differential Geometry, Pragati Prakashan, Meerut.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-302**	**Course Type :**	Core Course-02
Course Title :	**Functional Analysis**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course will develop a deeper and rigorous understanding of fundamental concepts of functional analysis, their properties and related theorems.

Course Outcomes: On the completion of the course, the students will be able to

1. Explain the fundamental concepts of functional analysis and their role in modern mathematics.
2. Utilize the concepts of functional analysis, for example continuous and bounded operators, normed spaces, Hilbert spaces and to study the behavior of different mathematical expressions arising in science and engineering.
3. Understand and apply fundamental theorems from the theory of normed and Banach spaces including the Hahn-Banach theorem, the open mapping theorem, the closed graph theorem and uniform boundedness theorem.
4. Understand the nature of abstract mathematics and explore the concepts in further details.
5. Explain the concept of projection on Hilbert and Banach spaces.
6. Understand the concept of eigen values and eigen-space of an operator on a Hilbert Space, spectrum of an operator on a finite dimensional Hilbert Space.

UNIT-1 Teaching Hours (13)	**Normed linear spaces. Banach Spaces:** Definition and examples. Quotient Spaces. Convexity of the closed unit sphere of a Banach Space. Examples of normed linear spaces which are not Banach. Holder's inequality. Minkowski's inequality. Linear transformations on a normed linear space and characterization of continuity of such transformations. The set $B(N, N')$ of all bounded linear transformations of a normed linear space N into normed linear space N'. Linear functionals, The conjugate space N^*, The natural imbedding of N into N^{**}. Reflexive spaces.
UNIT-2 Teaching Hours (13)	Hahn-Banach theorem and its consequences, Projections on a Banach Space. The open mapping theorem and the closed graph theorem. The uniform boundedness theorem. The conjugate of an operator, properties of conjugate operator.
UNIT-3 Teaching Hours (13)	**Inner product spaces, Hilbert Spaces:** Definition and Examples, Schwarz's inequality. Parallelogram Law, polarization identity. Convex sets, a closed convex subset of a Hilbert Space contains a unique vector of the smallest norm. Orthogonal sets in a Hilbert space. Bessel's inequality. orthogonal complements, complete orthonormal sets, Orthogonal decomposition of a Hilbert space. Characterization of complete orthonormal set. Gram-Schmidt orthogonalization process.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">The conjugate space H^* of a Hilbert space H. Representation of a functional f as $f(x) = (x, y)$ with y unique. The Hilbert space H^*. Interpretation of T^* as an operator on H. The adjoint operator T^* on $B(H)$. Self-adjoint operators, Positive operators. Normal operators. Unitary operators and their properties. Projections on a Hilbert space. Invariant subspace. Orthogonality of projections. Eigen values and eigen-space of an operator on a Hilbert Space. Spectrum of an operator on a finite dimensional Hilbert Space. Finite dimensional spectral theorem.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
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2. G. Backman and L. Narici: Functional Analysis (Academic), 2006.
3. B. V. Limaye: Functional Analysis (Wiley Eastern), 1998.
4. P. R. Halmos: Finite dimensional vector paces, Van Nostrand, 1958.
5. E. Kreyszig: Introduction to Functional Analysis with Applications, John Wiley & Sons, 2000.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-303**	**Course Type :**	Core Course-03
Course Title :	**Linear Algebra**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The objective of this course is to make students familiar with algebra of linear transformations, change of coordinate matrices, canonical forms in vector spaces and subspaces, inner product spaces, bilinear and different quadratic forms, useful in mathematical research and real world problems.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the algebra of linear transformation and its matrix representation.
2. Understand the change of coordinate matrix, transition matrix.
3. Able to know diagonalizability and canonical forms of a linear operator.
4. Understand the concept of inner product spaces, orthogonal complements, orthonormalization process of set of vectors.
5. Understand the bilinear and quadratic forms.
6. Apply the tests for positive definiteness, Singularvalue Decomposition and its applications.

UNIT-1 Teaching Hours (13)	**Recapitulation:** Vector Spaces, Subspaces, Linear Combinations and Systems of Linear Equations, Linear dependence and independence, Basis and Dimension, Maximal linearly independence subsets, Direct sums, Linear transformation, Linear Operators. Algebra of Linear transformations, Minimal polynomials, Regular and singular transformation, Range and rank of a transformation and its properties, characteristic roots and characteristic vectors. The matrix representation of a linear transformation, Composition of a linear transformation and matrix multiplication, The change of coordinate matrix, transition matrix, The dual space.
UNIT-2 Teaching Hours (13)	Characteristic polynomials, Diagonalizability, Invariant subspaces, Cayley-Hamilton theorem. Canonical Forms: Triangular canonical form, Nilpotent transformations, Jordan canonicalform, The rational canonical form
UNIT-3 Teaching Hours (13)	Inner Product Spaces, Orthogonal complements, Gram-Schmidt orthonormalization process. Positive Definite Matrices, Maxima, minima and saddle points, Tests for positive definiteness, Singularvalue Decomposition and its applications.
UNIT-4 Teaching Hours (13)	Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, rank andsignature, Sylvester's law of inertia.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method

<table>
<tr><td></td><td colspan="3">4. Seminar/Symposia
5. Review of literature
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8. Videos/Animation
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<tr><td>Selected Readings</td><td colspan="3">1. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India), 2003. Prentice-Hall of India, 1991.
2. N. Herstein, Topics in Algebra, 2nd Ed., John Wiley & Sons, 2006
3. S. Freidberg. A Insel, and L Spence: Linear Algebra, Fourth Edition, PHI, 2009.
4. J. Gilbert and L. Gilbert, Linear Algebra and Matrix theory, Academic Press, 1995.
5. S. Lang, Linear Algebra, Springer-Verlag, New York, 1989.
6. M. Artin, Algebra, Prentice Hall of India, 1994.
7. G. Strang: Linear Algebra and its Applications, Brooks/Cole Ltd., New Delhi, Third Edition, 2003.
8. L. Hogben-Handbook of Linear Algebra-Chapman and Hall-CRC (2006).</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-304**	**Course Type :**	Core Course-04
Course Title :	**Analytical Dynamics**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The Objective of this course is to introduce the motions in two and three dimensions under impulsive forces and their conservation properties. Introduction of Euler, Lagrange equations for solving various problems in real world, Hamilton's principle, action principle for solving various physical, chemical real world problems and scientific research problems.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the motion in two dimensions under impulsive forces.
2. Understand the Euler's dynamical equation for the motion of a rigid body and problems related to no external forces.
3. Understand the concept of calculus of variations with fundamental equations in solving various scientific problems.
4. Knowing the variational Methods of solving Boundary value problems in ordinary and partial differential equations.
5. Knowing the Hamilton's canonical equations of motion. Hamilton's principle and principle of least action in solving research problems.
6. Understand the general equations of motion in terms of Poisson brackets. Lagrange's brackets and their properties.

UNIT-1 Teaching Hours (13)	**Motion in 2D:** Motion in two dimensions under impulsive forces. Conservation of linear and angular momentum under finite and impulsive forces.
UNIT-2 Teaching Hours (13)	**Motion in 3D:** Lagrange's equations for finite as well as impulsive forces. Normal co-ordinates and normal modes of vibration. Motion in three dimensions. Euler's dynamical equation for the motion of a rigid body and problems related to no external forces.
UNIT-3 Teaching Hours (13)	**Calculus of variations:** Linear functionals, Minimal functional theorem, general variation of a functional. Euler-Lagrange equation, Various fundamental problems including isoperimetric problems of calculus of variations. Variational Methods of solving Boundary value problems in ordinary and partial differential equations.
UNIT-4 Teaching Hours (13)	**Hamilton's canonical equations of motion:** Hamilton's principle and principle of least action canonical transformations. Poisson brackets and their properties. General equations of motion in terms of Poisson brackets. Lagrange's brackets and their properties.
Teaching And	1. Lecture method

<table>
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<tr><td>Selected Readings</td><td colspan="3">1. Loney, S. L.: An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press.
2. Ray, M.: Dynamics of Rigid Bodies, Students Friends and Co.
3. Smart, E. H.: Advanced Dynamics, Vol.II, Macmillan.
4. Gupta, P. P.: Dynamics of Rigid Bodies II, Jaiprakash Nath, Agra.
5. Soarborough, James, B.: Numerical Analysis.
6. Freeman, H.: Finite Differences and Mathemaics for Acturial Students.
7. Richardson, H. C.: Calculus of Finite Differences.
8. Elsgotts, L. E.: Calculus of Variations.
9. Bansal, J. L.: Dynamics of a Rigid Body, Jaipur Publishing Co.,</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-305(A)**	**Course Type :**	Elective Course
Course Title :	**Fluid Mechanics**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is intended to provide a treatment of advanced topics in fluid mechanics where the students will be able to apply the techniques used in deriving arrange of important results and in research problems. The objective is to provide the student with knowledge of the fluid mechanics and an appreciation of their application to real world problems.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concept of rotational and irrotational flow, stream functions, velocity potential, sink, source, vortex etc.
2. Analyze simple fluid flow problems (flow between parallel plates, flow through pipe etc.) with Navier-Stoke's equation of motion.
3. Understand the phenomenon of flow separation and boundary layer theory.
4. Understand the concept of thermal conductivity.
5. Learn about the fundamental equations of the flow and energy.
6. Understand the two dimensional flows of inviscid fluids.

UNIT-1 Teaching Hours (13)	**Coordinate transformations:** Cartesian tensors, Basic Properties, Transpose, Symmetric and Skew tensors, Isotropic tensors, Deviatoric Tensors, Gradient, Divergence and Curl of a tensor field- Integral Theorems. Continuum Hypothesis: Configuration of a continuum, Mass and density, Description of motion, Material and spatial coordinates, Material and Local time derivatives, Stream lines, Path lines, Vorticity and Circulation, Examples. Transport formulas, Strain tensors, Principal strains, Strain-rate tensor, Stress components and Stress tensor, Normal and shear stresses, Principal stresses.
UNIT-2 Teaching Hours (13)	**Fundamental basic physical laws:** Law of conservation of mass, Principles of linear and angular momenta, Balance of energy, Examples. Motion of non-viscous fluids: Stress tensor, Euler equation, Bernoulli's equation, simple consequences, Helmholtz vorticity equation, Permanence of vorticity and circulation, Dimensional analysis, Nondimensional numbers.
UNIT-3 Teaching Hours (13)	**Motion of Viscous fluids:** Stress tensor, Navier-Stokes equation, Energy equation, Simple exact solutions of Navier-Stokes equation: (i) Plane Poiseuille and Hagen-Poiseuille flows (ii) Generalized plane Couette flow (iii) Steady flow between two rotating concentric circular cylinders Stokes's first and second problems. Diffusion of vorticity, Energy dissipation due to viscosity.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Two dimensional flows of inviscid fluids: Meaning of two-dimensional flow, Stream function, Complex potential, Line sources and sinks, Line doublets and vortices, Images, Milne-Thomson circle theorem and applications, Blasius theorem and applications.</td></tr>
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2. A.J.M. Spencer: Continuum Mechanics, Longman, 1980.
3. S. W. Yuan: Foundations of Fluid Mechanics, Prentice Hall, 1976.
4. P. Chadwick : Continuum Mechanics, Allen and Unwin, 1976.
5. L.E. Malvern : Introduction to the Mechanics of a Continuous Media, Prentice Hall, 1969.
6. Y.C. Fung, A First course in Continuum Mechanics, Prentice Hall (2nd edition), 1977.
7. Pijush K. Kundu, Ira M. Cohen and David R. Dowling, Fluid Mechanics, Fifth Edition, 2010.
8. C.S. Yih : Fluid Mechanics, McGraw-Hill, 1969.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER III			
Course Code:	**MSM-306SC**	**Course Type :**	Skill Course-03
Course Title :	**Teaching Technology and Research Methodology in Mathematics and Service Learning**		
Credit:	3*	**Hours:**	3 Hours/Week
		Total Teaching Hours:	39 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (SEE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	SEE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The Objective of this course is to introduce concept of teaching skill, teacher's role and responsibilities, research methodology, Roles and responsibilities of research student and guide. Introducing Mathematical research methodology, organizing a research paper in various format and software tools.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concept of effective teaching skill with influencing facts to serve future students.
2. Know the Teacher's role and responsibilities.
3. Understand the concept of research methodology, scientific methods in Mathematical sciences.
4. Know roles and responsibilities of research student and guide.
5. Know organizing a research paper and writing skill in different style.
6. Create ability to doing research and teaching profession for future career.

UNIT-1 Teaching Hours (13)	**Teaching Technology** Development of concept of teaching, Teaching skills, Chalk board skills, Teaching practices, Effective teaching, Models of teaching, Teaching aids (Audio-Visual), Teaching aids (projected and non-projected), Communication skills, Feed back in teaching, Teacher's role and responsibilities, Information technology for teaching.
UNIT-2 Teaching Hours (13)	**Research Methodology** Introduction to research and research methodology, Scientific methods, Choice of research problem, Literature survey and statement of research problem, Reporting of results, Roles and responsibilities of research student and guide.
UNIT-3 Teaching Hours (13)	**Mathematical research methodology** Introducing mathematics Journals, Reading a Journal article, Mathematics writing skills. Standard Notations and Symbols, Using Symbols and Words, Organizing a paper, Defining variables, Symbols and notations, Different Citation Styles, IEEE Referencing Style in detail. Package for Mathematics Typing, MS Word, Math Type, Open Office Math Editor, Tex, yEd Graph Editor, Tex in detail, Installation and Set up, Text, Formula, Pictures and Graphs, Producing various types of documents using TeX.

UNIT-4 Teaching Hours (13)	**Service Learning** Guidelines for service learning: One among the following can be considered as a service learning module: 1. Tie up with schools for teaching elementary mathematics in an easier way. 2. Developing e-content for particular topics which will be a Vehicle for Teaching CurriculumTheory, Assessment, and Design (as per the requirements). 3. **Math Exhibition:** To strengthen students' math skills, a mathematics camp can be organized in the school premises. Students will participate in challenging academic coursework of math, make projects related to mathematical concepts, and explore many inventions and historical aspects in mathematics. Students can strengthen and expand their scientific and mathematical knowledgewhile having fun. 4. Students can create a website for the Department of Mathematics/the project area, putting all theinformation about the activities and events coming up. 5. Students can assist in statistical research(based on its needs), in developing a survey tool, organizing and/or conducting the survey, compiling and analyzing data, or some combination ofthese or some other statistical undertakings. 6. Develop a mathematical model and should also be able to provide a solution for an existingreal world problem. After deciding, get approval from your respective mentors. 1. Each student will develop a learning/lesson plan composed of three (3-4) measurable learningobjectives. Examples of learning objectives are: a. Improve algebraic/problem solving skills. b. Improve methods of communicating mathematics to others effectively. c. Identify common mistakes and misconceptions that mathematics student make. 2. A minimum of fifteen (15) hours documented service is required during the semester. 3. A student must keep a log of the volunteered time. 4. A student must write a diary containing an analysis of the activities of the day and the servicesperformed. **5.** A student must write a reflective journal containing an analysis of the learning objectives.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

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2. Usha Rao, Educational teaching, Himalaya Publishing house, New Delhi 2001.
3. J. Mohanthy, Educational teaching, Deep & Deep Publications Pvt.Ltd., New Delhi 2001.
4. K. J. Sree and D. B. Rao, Methods of teaching sciences, Discovery publishing house, 2010.
5. E. B. Wilson, An introduction to scientific research, Reprint, Courier Corporation, 2012.
6. R. Ahuja, Research Methods, Rawat Publications, 2001.
7. G. L. Jain, Research Methdology, Mangal Deep Publictions, 2003.
8. B. C. Nakra and K. K. Chaudhry, Instrumentation, measurement and analysis, TMH Education, 2003.
9. L. Radhakrishnan, Write Mathematics Right: Principles of Professional Presentation, Exemplified with Humor and Thrills, Alpha Science International, Limited, 2013.
10. Cathryn Berger Kaye, The Complete Guide to Service Learning: Proven, Practical Ways to Engage Students in Civic Responsibility, Academic Curriculum, & Social Action, 2009.
11. Butin, D , Service-Learning in Theory and Practice -The Future of Community Engagement inHigher Education , Palgrave Macmillan US., 2010.</td></tr>
</table>

FOURTH SEMESTER

Semester-IV										
Courses	**Course Code(s)**	**Course Title**	**Teaching Hours**	**Load Allocation**			**Marks Allocation**			**Credits**
				L	**T**	**P**	**ESE**	**CCA**	**Total**	
Core Courses	**MSM-401**	Measure Theory and Integration	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-402	Mathematical Methods	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Elective Courses	**MSM-*****	Elective-2	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-***	Elective-3	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
	MSM-***	Elective-4	**52**	**3**	**1**	**0**	**70**	**30**	**100**	**4**
Skill Courses	**MSM-*****	Sustainable Development Course	**39**	**3**	**0**	**0**	**70***	**30***	**100***	*****
Project Works			**156**	**0**	**0**	**12**	**70 (Viva)**	**30**	**100**	**6**
Total (*Excluded in total)			**455**	**18**	**5**	**12**	**420**	**180**	**600**	**26**
Total Credits for Semester-IV										**26**
Programme Grand Total of Credits										**88**

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-401**	**Course Type :**	Core Course-01
Course Title :	**Measure Theory and Integration**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to consider theoretical foundations of concepts of mathematical analysis, viz. derivative, functions of several variables, measure theory and integration that have many important applications in different branches of pure and applied mathematics. Further, the objective is enable students familiar with these concepts and their fruitful applications.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply the knowledge of concepts of functions of several variables and measure theory in order to study theoretical development of different mathematical concepts and their applications.
2. Understand the nature of abstract mathematics and explore the concepts in further details.
3. Utilize the concepts of derivative for vector-valued functions in applications different fields for example management, industry and economics etc.
4. Recognize the need of concept of measure from a practical view point.
5. Understand measure theory and integration from theoretical point of view and apply its tools in different fields of applications.
6. Extend their knowledge of Lebesgue theory of integration by selecting and applying its tools for further research in this and other related areas.

UNIT-1 Teaching Hours (13)	Algebra of sets, sigma algebras, open subsets of real line, F and G sets, Borel sets. (Lebesgue) Outer measure of a subset of R, existence, non-negativity and monotonicity of Lebesgue outer measure, Relation between Lebesgue outer measure and length of an interval; Countable subadditivity of Lebesgue outer measure; translation invariance. (Lebesgue) measurable sets, (Lebesgue) measure, Complement, union, intersection and difference of measurable sets, denumerable union, and intersectionof measurable sets.
UNIT-2 Teaching Hours (13)	Countable additivity of measure; The class of measurable sets as an algebra, sigma-algebra, the measure of the intersection of a decreasing and increasing sequence of measurable sets; measures of limit superior, limit inferior of sequences of measurable sets. Measurable functions: Scalar multiple, sum, difference, and product of measurable functions.
UNIT-3 Teaching Hours (13)	Measurability of a continuous function and measurability of a continuous image of measurable function. Convergence pointwise and convergence in measures of a sequence of measurable functions. Lebesgue Integral: Characteristic function of a set, simple function, Lebesgue integral of a simple function, Lebesgue integral of a bounded measurable function, Lebesgue integral and Riemann integral of a bounded function defined on a closed interval; Lebesgue integral of a non-negative function; Lebesgue integral of a measurable function, Properties of Lebesgue integral.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Convergence theorems and Lebesgue integral; The bounded convergence theorem, Fatou’s lemma, Monotone convergence theorem, Lebesgue convergence theorem. Differentiation of monotone functions, Vitali covering lemma, Functions of bounded variation, Differentiability of an integral, Absolute continuity and indefinite integrals.</td></tr>
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<tr><td>Selected Readings</td><td colspan="3">1. H.L. Royden : Real Analysis, Macmillan, 1963.
2. P.K. Jain, V.P. Gupta, Pankaj Jain: Lebesgue Measure &Integration, New Age International, 2011.
3. P.R. Halmos : Measure Theory, East West Press, 1962
4. W. Rudin : Real & Complex Analysis, McGraw Hill, 1966.</td></tr>
</table>

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-402**	**Course Type :**	Core Course-02
Course Title :	**Mathematical Methods**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
The objective of the course is to acquaint the students with the knowledge of mathematical techniques frequently applied in various branches of engineering and sciences. Also, one of the objectives of this course is to equip the students with the mathematical background required for the development of such techniques.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the theory and applications of integral transforms.
2. Explain how integral transforms can be used to solve a variety of differential equations.
3. Solve integro-differential equations of Fredholm and Volterra type.
4. Understand the properties of various kinds of integral equations.
5. Apply the perturbation methods to solve first and second order differential equations involving constant and variable coefficients.
6. Develop their attitude towards problem solving.

UNIT-1 Teaching Hours (13)	**Integral Transforms:** General definition of integral transforms, Kernels, etc. Development of Fourier integral, Fourier transforms - inversion, Illustration on the use of integral transforms, Laplace, Fourier, Hankel transforms to solve ODEs and PDEs - typical examples. Discrete orthogonality and Discrete Fourier transform. Wavelets with examples, wavelet transforms.
UNIT-2 Teaching Hours (13)	**Integral Equations:** Definition, Volterra and Fredholm integral equations. Solution by separable kernel, Neumann's series resolvent kernel and transform methods, Convergence for Fredholm and Volterra types. Reduction of IVPs BVPs and eigenvalue problems to integral equations. Hilbert Schmidttheorem, Raleigh Ritz and Galerkin methods.
UNIT-3 Teaching Hours (13)	**Asymptotic Expansions:** Asymptotic expansion of functions, power series as asymptotic series, Asymptotic forms for large and small variables. Uniqueness properties and Operations. Asymptotic expansions of integrals; Method of integration by parts (include examples where the method fails), Laplace's method and Watson's lemma, method of stationary phase and steepest descent.

<table>
<tr><td>UNIT-4
Teaching Hours (13)</td><td colspan="3">Perturbation methods: Regular and singular perturbation methods: Parameter and co-ordinate perturbations. Regular perturbation solution of first and second order differential equations involving constant and variable coefficients. Include Duffings equation, Vanderpol oscillator, small Reynolds number flow. Singular perturbation problems, Matched asymptotic expansions, simple examples. Linear equation with variable coefficients and nonlinear BVP’s. Problems involving Boundary layers. Poincare-Lindstedt method for periodic solution. WKB method, turning points, zeroth order Bessel function for large arguments, solution about irregular singular points.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
7. Group Discussion
8. Videos/Animation
9. Self-Learning/e-Learning
10. Workshops/Experiments
* The teaching and learning strategies may be change as per requirement of the students and their capabilities.</td></tr>
<tr><td rowspan="13">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
<tr><td>5.</td><td>Report writing</td><td>10</td></tr>
<tr><td>6.</td><td>Workshop</td><td>10</td></tr>
<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
<tr><td>End Semester Examination pattern for post graduate Programme</td><td colspan="3">NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.</td></tr>
<tr><td>Periodical Revision Of Syllabus</td><td colspan="3">1. Annual
2. However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.</td></tr>
<tr><td>Selected Readings</td><td colspan="3">1. IN Sneddon: The use of Integral Transforms, Tata Mc Graw Hill, Publishing Company Ltd, New Delhi, 1974.
2. RP Kanwal: Linear integral equations theory & techniques, Academic Press, NewYork, 1971.
3. CM Bender and SA Orszag: Advanced mathematical methods for scientists and engineers, Mc Graw Hill, New York, 1978.
4. HT Davis: Introduction to nonlinear differential and integral equations, Dover Publications, 1962.</td></tr>
</table>

	5. AH Nayfeh: Perturbation Methods, John Wiley & Sons, New York, 1973. 6. D Hong, J Wang and R Gardner: Real analysis with introduction to wavelets and applications, Academic Press Elsevier (2006) 7. RV Churchill: Operational Mathematics, Mc. Graw Hill, New York, 1958.

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-403(A)**	**Course Type :**	Elective Course
Course Title :	**Riemannian Geometry**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:

This course is designed to consider theoretical foundations of concepts of Riemannian geometry, differentiable manifold, Riemannian metric, Curves and geodesics in Riemannian manifold. Geodesic curvature, Frenet formula. Hypersurfaces of Riemannian manifolds Gauss formula, Gauss equation, Sectional curvature for a hyper surface of a Riemannian manifold.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concept of charts, atlases, differentiable structures, topology induced by differentiable structures.
2. Understand the concept of transformation formula for components of tensors.
3. Understand the concept of curvature and torsion tensors.
4. Understand the sectional curvature for a hyper surface of a Riemannian manifold, Gauss map, Weingartan map and fundamental forms on hypersurface.
5. Understand the Riemannian metric, connections. Riemannian connections and their components, Parallel translation etc.
6. Develop their attitude towards problem solving.

<table>
<tr><td>UNIT-1
Teaching
Hours (13)</td><td colspan="3">Differentiable manifolds: Charts, Atlases, Differentiable structures, Topology induced by differentiable structures, equivalent atlases, complete atlases. Manifolds. Examples of manifolds. Properties of induced topology on manifolds. Tangent and cotangent spaces to a manifold. Vector fields. Lie bracket of vector fields.</td></tr>
<tr><td>UNIT-2
Teaching
Hours (13)</td><td colspan="3">Smooth maps and diffeomorphism. Derivative (Jacobi) of smooth maps and their matrix representation. Pull back functions. Tensor fields and their components. Transformation formula for components of tensors. Operations on tensors. Contraction, Covariant derivatives of tensor fields.</td></tr>
<tr><td>UNIT-3
Teaching
Hours (13)</td><td colspan="3">Riemannian Metric. Connections. Riemannian connections and their components, Parallel translation, Fundamental theorem of Riemannian Geometry. Curvature and torsion tensors. Bianchi identities, Curvature tensor of second kind. Sectional curvature. Space of constant curvature. Schur's theorem.</td></tr>
<tr><td>UNIT-4
Teaching
Hours (13)</td><td colspan="3">Curves and geodesics in Riemannian manifold. Geodesic curvature, Frenet formula. Hypersurfaces of Riemannian manifolds Gauss formula, Gauss equation, Codazzi equation, Sectional curvature for a hyper surface of a Riemannian manifold, Gauss map, Weingartan map and Fundamental forms on hypersurface. Equations of Gauss and Codazzi. Gauss theorem egregium.</td></tr>
<tr><td>Teaching And Learning Strategies</td><td colspan="3">1. Lecture method
2. Problem Solving method
3. Graphical method
4. Seminar/Symposia
5. Review of literature
6. Report writing
7. Group Discussion
8. Videos/Animation
9. Self-Learning/e-Learning
10. Workshops/Experiments
* The teaching and learning strategies may be change as per requirement of the students and their capabilities.</td></tr>
<tr><td rowspan="14">Continuous & Comprehensive Assessment (CCA)</td><td>S. No.</td><td>CCA- Components</td><td>Max. Marks Allocation</td></tr>
<tr><td>1.</td><td>Monthly test</td><td>20*3 Test=60</td></tr>
<tr><td>2.</td><td>Quizzes and Assignments</td><td>10</td></tr>
<tr><td>3.</td><td>Viva-voce</td><td>10</td></tr>
<tr><td>4.</td><td>Seminar/Symposia</td><td>10</td></tr>
<tr><td>5.</td><td>Report writing</td><td>10</td></tr>
<tr><td>6.</td><td>Workshop</td><td>10</td></tr>
<tr><td>7.</td><td>Review of literature</td><td>10</td></tr>
<tr><td>8.</td><td>Creativity/Innovation</td><td>10</td></tr>
<tr><td>9.</td><td>Experimental Skill</td><td>10</td></tr>
<tr><td>10.</td><td>Co-curricular activity</td><td>10</td></tr>
<tr><td>11.</td><td>Attendance</td><td>10</td></tr>
<tr><td colspan="3">Total 160 marks equivalent reduced to CCA original marks 30.</td></tr>
<tr><td>End Semester Examination pattern for post graduate Programme</td><td colspan="3">NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.</td></tr>
<tr><td>Periodical Revision Of Syllabus</td><td colspan="3">1. Annual
2. However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.</td></tr>
</table>

Selected Readings	1. Jersey, New York, London (Affiliated East-West Press Pvt. Ltd. New Delhi), 1998. 2. Y. Matsushima : Differentiable manifolds. Marcel Dekker Inc. New, York, 1972. 3. N.J. Hicks : Notes on differential Geometry D. Van Nostrand company Inc. Princeton, New 4. W.M .Boothby : An introduction to differentiable manifolds and Riemannian Geometry. Academic Press Inc. New York, 1975. 5. 4. K.S. Amur, D.J. Shetty and C.S. Bagewadi, An Introduction to Differential Geometry, Narosa Pub. New Dehli, 2010. 6. R.L. Bishop and Grittendo : Geometry of manifolds. Acamedic Press, New York, 1964. 7. L.P. Eisenhart: Riemannian Geometry. Princeton University Press, Princetion, New Jersey, 1949. 8. H. Flanders: Differential forms with applications to the physical science, Academic Press, New York, 1963. 9. R.L. Bishop and S.J. Goldberg : Tensor analysis on manifolds, Macmillan Co., 1968.

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-403(B)**	**Course Type :**	Elective Course
Course Title :	**Theory of Linear Operators**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
To teach the fundamentals of Banach Algebras and Spectral Operator Theory which are necessary for a deeper understanding of many adjacent mathematical fields (integral and differential equations, mathematical physics, harmonic analysis, operator theory etc.).

Course Outcomes: On the completion of the course, the students will be able to

1. Have understanding of main topics of Banach Algebras and Spectral Theory.
2. Terminology, notation and the basic results and concepts of Banach and Hilbert spaces.
3. Understand the concept of spectrum and resolvent, adjoint operators, compact operators, self-adjoint and normal operators, Gelfand Representation, Riesz-Fredholm Theory.
4. Relation of the subject with other branches of mathematics (Fourier analysis, complex functions, differential equations)
5. Prepare the students for reading the literature of a wide variety of subjects in which Hilbert space ideas are used.
6. Develop their attitude towards problem solving.

UNIT-1 Teaching Hours (13)	Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials.
UNIT-2 Teaching Hours (13)	Elementary theory banach algebra, Spectral radius of a bounded linear operator on a complex banach space.
UNIT-3 Teaching Hours (13)	General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces. Behaviors of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorem. Fredholm alternative for integral equations.
UNIT-4 Teaching Hours (13)	Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space. Positive operators. Monotone Sequences theorem for bounded self-adjoint operators on a complex Hilbert space, Square roots of a positive operator.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

Continuous & Comprehensive Assessment (CCA)	S. No.	CCA- Components	Max. Marks Allocation
	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		
End Semester			

Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.
Selected Readings	1. Kreyszig E., Introductory functional analysis with applications, Johan-Wiley & Sons, New York, 1978. 2. Halmos P.R., Introduction to Hilbert space and the theory of spectral multiplicity, 2nd Edition. Chelsea Pub., Co., N.Y. 1957. 3. Dunford N. and Schwartz, J.T., Linear operators-3 parts, Inter-science Wiley, New York, 1958-71. 4. Bachman G. and Narici, L., Functional analysis, Academic Press, New York, 1998.

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-403(C)**	**Course Type :**	Elective Course
Course Title :	**Computational Fluid Dynamics**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to introduce the computational methods applicable in fluid dynamics viz. finite difference methods, finite volume methods, finite element methods, etc.

Course Outcomes: On the completion of the course, the students will be able to
1. Identify and analyze problems using finite difference methods.
2. Understand the finite volume methods and its applications.
3. Understand the finite element methods and its applications in problem solving.

4. Apply FVM to solve boundary value problems.
5. Identifying computational problems in fluid dynamics and their solutions.
6. Extend their knowledge of computational fluid dynamics by selecting and applying its tools for further research in this and other related areas

UNIT-1 Teaching Hours (13)	**Finite Difference Methods:** Derivation of finite difference methods, finite difference method to parabolic, hyperbolic and elliptic equations, finite difference method to nonlinear equations, coordinate transformation for arbitrary geometry, Central schemes with combined space-time discretization-Lax- Friedrichs, Lax-Wendroff, MacCormack methods, Artificial compressibility method, pressure correction method - Lubrication model, Convection dominated flows – Euler equation – Quasilinearization of Euler equation, Compatibility relations, nonlinear Burger equation.
UNIT-2 Teaching Hours (13)	**Finite Volume Methods:** General introduction, Node-centered-control volume, Cellcentered- control volume and average volume, Cell-Centred scheme, Cell-Vertex scheme, Structured and Unstructured FVMs, Second and Fourth order approximations to the convection and diffusion equations (One and Two-dimensional examples).
UNIT-3 Teaching Hours (13)	**Finite Element Methods:** Introduction to finite element methods, one-and two dimensional bases functions – Lagrange and Hermite polynomials elements, triangular and rectangular elements.
UNIT-4 Teaching Hours (13)	**Finite element method for one-dimensional problem:** model boundary value problems, discretization of the domain, derivation of elemental equations and their connectivity, composition of boundary conditions and solutions of the algebraic equations. Finite element method for two-dimensional problems: model equations, discretization, interpolation functions, evaluation of element matrices and vectors and their assemblage.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

Continuous & Comprehensive Assessment (CCA)	S. No.	CCA- Components	Max. Marks Allocation
	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		

End Semester Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.
Selected Readings	1. T. J. Chung: "Computational Fluid Dynamics", Cambridge Univ. Press, 2003. 2. J Blazek, "Computational Fluid Dynamics", Elsevier, 2001. 3. Harvard Lomax, Thomas H. Pulliam, David W Zingg, "Fundamentals of Computational Fluid Dynamics", NASA Report, 2006. 4. C.A J. Fletcher: "Computational techniques for Fluid Dynamics", Vol. I & II, Springer Verlag 1991.

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-403(D)**	**Course Type :**	Elective Course
Course Title :	**General Relativity and Cosmology**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	

Objective:
This course is designed to introduce the theory of general relativity and cosmology, theory of gravitation, cosmological principles, Einstein's field equations and their cosmological solutions in various spaces to solve research problems in cosmology.

Course Outcomes: On the completion of the course, the students will be able to

1. Understand the concept of transformation of coordinates using tensors.
2. Understand the various types tensors useful in solving cosmological problems.
3. Understand the Planetary orbits and analogues of Kepler's laws in general relativity.
4. Solving Einstein's and its modified field equations.
5. Understand the problems in dynamical cosmology.
6. Extend these ideas to solve cosmological problems in current research areas.

UNIT-1 Teaching Hours (13)	**General Relativity:** Transformation of coordinates. Tensors. Algebra of Tensors. Symetric and skew symmetric Tensors. Contraction of tensors and quotient law. Reimannian metric, Parallel transport, Christoffel Symbols. Covariant derivatves. Intrinsic derivatives and geodesics, Reiemann Christoffel curvature tensor and its symmetry properties. Bianchi identities and Einstein tensor.
UNIT-2 Teaching Hours (13)	Review of the special theory of relativity and the Newtonian Theory of gravitation. Principle of equivalence and general covariance, geodesic principle. Newotonian approximation. Schwarzchild external solution and its isotropic form. Planetary orbits and analogues of Kepler's laws in general relativity. Adavance or perihelion of a planet. Bending of light rays in gravitational field.
UNIT-3 Teaching Hours (13)	Gravitational redshift of spectral lines. Reader echo delay. Energy- momentum tensor of a perfect fluid. Schwarzchild internal solution. Boundary conditions. Energy momentum tensor of an electromagnetic filed. Eistein-Maxwell equations. Reissner-Nordstrom solution. Cosmology: Mach's principle. Einstein modified field equations with cosmological term. Static Cosmological models of Einstein and De-Sitter, their derivation, properties and comparison with the actual universe.
UNIT-4 Teaching Hours (13)	Hubble's law. Cosmological principle's Weyl's postulate. Derivation of Robertson-Walker metric. Hubble and deceleration parameters. Redshift. Redsshift versus distance relation. Angular size versus redshift relation and source counts in Robertson-Walker space-time. Friedmann models. Fundamental equations of dynamical cosmology. Critical density. Closed and open Universes. Age of the universe. Matter dominated era of the universe. Einstein-de-Sitter model. Particle and even horizons. Eddington- Lamaitre models with Λ-trem. Perfect cosmological principle. Steady state cosmology.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

Continuous & Comprehensive Assessment (CCA)	S. No.	CCA- Components	Max. Marks Allocation
	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10
	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		

End Semester Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.
Selected Readings	1. C.E. Weatherburn An Introduction to Riemannian Geometry and the tensor Calculus, Cambridge University Press, 1950. 2. J.V. Narlikar, General Relativity and Cosmilogy, The Machmillann Company of India Ltd. 1978. 3. B.F. Shutz, A first course in genral relativity, Combridge University Press, 1990. 4. A.S. Eddington, The Mathematical Theory of Relativity, Cambridge University Press, 1965. 5. S. Weinberg Gravitation and Cosmology : Principle and applications of the general theory of relativity, John Wiley & Sons, Inc. 1972. 6. J.V. Narlikar, Introduction to Cosmology, Cambridge University Press, 1993.

M.Sc.(Mathematics) SEMESTER IV			
Course Code:	**MSM-403(E)**	**Course Type :**	Elective Course
Course Title :	**Fundamental of Operation Research**		
Credit:	4	**Hours:**	4 Hours/Week
		Total Teaching Hours:	52 Hours
Max. Marks:	100	**Minimum Pass Marks:**	36
Theory Examination (ESE):	70	**Minimum Pass Marks:**	25
Continuous & Comprehensive Assessment (CCA)	30	**Minimum Pass Marks:**	11
Attendance Eligibility	75 Percent In Respective Semester		
Examination	ESE	Mid. Test	
Duration	3 Hrs	1 Hr	
Objective: This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc. The major focus will be on formulation of real world phenomena from its physical considerations and implementation of			

optimization algorithms for solving these problems.

Course Outcomes: On the completion of the course, the students will be able to

1. Apply the knowledge of basic optimization techniques in order to get best possible results from a set of several possible solution of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.
2. Formulate an optimization problem from its physical consideration.
3. Select and implement an appropriate optimization technique keeping in mind its limitations in order to solve a particular optimization problem.
4. Understand theoretical foundation and implementation of similar type optimization techniques available in the scientific literature.
5. Continue to acquire knowledge and skills of optimization techniques that are appropriate to professional activities.
6. Extend their knowledge of basic optimization techniques to do interesting research work on these types of optimization techniques.

UNIT-1 Teaching Hours (13)	Basic concepts of probability. Conditional probability, Baye's theorem; Basic concepts of Poisson, exponential distributions, Definition, scope and objectives of Operation Research (O.R.), Different types of O.R. Models, basic ideas of convex sets. Linear programming problems-Simplex Method, two phase method, Duality.
UNIT-2 Teaching Hours (13)	Transportation and assignment problems. Theory of games: Competitive strategies, minimax and maximin criteria, two person zero-sum games with and without saddle point, dominance, fundamental theorem of game.
UNIT-3 Teaching Hours (13)	**Inventories:** Single item deterministic inventory models with finite and infinite rates of replenishment, economic lot-size model with known demand and its extension allowing backlogging of demand concept of price break, simple probabilistic models.
UNIT-4 Teaching Hours (13)	**Replacement problems:** Replacement of item that deteriorate, replacement of items that fail completely, group replacement policty, individual replacement policy, mortality tables, staffing problems. Queing theory-Ques with Poisson input and exponential service time, the queue length, waiting time and busy period in steady state case, model with service in phase, multiserver queueing models.
Teaching And Learning Strategies	1. Lecture method 2. Problem Solving method 3. Graphical method 4. Seminar/Symposia 5. Review of literature 6. Report writing **7.** Group Discussion **8.** Videos/Animation **9.** Self-Learning/e-Learning **10.** Workshops/Experiments *** The teaching and learning strategies may be change as per requirement of the students and their capabilities.**

	S. No.	CCA- Components	Max. Marks Allocation
Continuous & Comprehensive Assessment (CCA)	1.	Monthly test	20*3 Test=60
	2.	Quizzes and Assignments	10
	3.	Viva-voce	10
	4.	Seminar/Symposia	10
	5.	Report writing	10
	6.	Workshop	10

	7.	Review of literature	10
	8.	Creativity/Innovation	10
	9.	Experimental Skill	10
	10.	Co-curricular activity	10
	11.	Attendance	10
	Total 160 marks equivalent reduced to CCA original marks 30.		
End Semester Examination pattern for post graduate Programme	NET examination for PG or any other pattern notified by the University at the time of commencement of the respective semester.		
Periodical Revision Of Syllabus	1. Annual **2.** However, the University may revise the syllabus at any time during the running semester after giving a notice for a period one month.		
Selected Readings	1. Kanti Swaroop, Gupta, Man Mohan: Operations Research, Sultan Chand and Sons. 2. Goel and Mittal: Operations Research, Pragati Prakashan 3. Mittal, K.V.: Optimizadon Methods in O.R. and S. Analysis 4. Sharma, S.D.: Operations Research 5. Loomba, N.P.: Linear Programming. 6. Satty, T.L.: Mathematical Methods of Operations Research.		