M.Sc. Mathematics (Two-Year) Programme

Regulations & Curriculum-2019

DST-FIST Assisted
Department of Mathematics
1. Definitions and Nomenclature

1.1 University refers to Annamalai University.

1.2 Department means any of the academic departments and academic centres at the University.

1.3 Discipline refers to the specialization or branch of knowledge taught and researched in higher education. For example, Botany is a discipline in the Natural Sciences, while Economics is a discipline in Social Sciences.

1.4 Programme encompasses the combination of courses and/or requirements leading to a Degree. For example, M.A., M.Sc.

1.5 Course is an individual subject in a programme. Each course may consist of Lectures/Tutorials/Laboratory work/Seminar/Project work/Experiential learning/ Report writing/viva-voce etc. Each course has a course title and is identified by a course code.

1.6 Curriculum encompasses the totality of student experiences that occur during the educational process.

1.7 Syllabus is an academic document that contains the complete information about an academic programme and defines responsibilities and outcomes. This includes course information, course objectives, policies, evaluation, grading, learning resources and course calendar.

1.8 Academic Year refers to the annual period of sessions of the University that comprises two consecutive semesters.

1.9 Semester is a half-year term that lasts for a minimum duration of 90 days. Each academic year is divided into two semesters.

1.10 Choice Based Credit System A mode of learning in higher education that enables a student to have the freedom to select his/her own choice of elective courses across various disciplines for completing the Degree programme.

1.11 Core Course is mandatory and an essential requirement to qualify for the Degree.

1.12 Elective Course is a course that a student can choose from a range of alternatives.

1.13 Value-added Courses are optional courses that complement the students’ knowledge and skills and enhance their employability.

1.14 Credit refers to the quantum of course work in terms of number of class hours in a semester required for a programme. The credit value reflects the content and duration of a particular course in the curriculum.

1.15 Credit Hour refers to the number of class hours per week required for a course in a semester. It is used to calculate the credit value of a particular course.

1.16 Programme Outcomes (POs) are statements that describe crucial and essential knowledge, skills and attitudes that students are expected to achieve and can reliably manifest at the end of a programme.
Programme Specific Outcomes (PSOs) are statements that list what the graduate of a specific programme should be able to do at the end of the programme.

Learning Objectives also known as Course Objectives are statements that define the expected goal of a course in terms of demonstrable skills or knowledge that will be acquired by a student as a result of instruction.

Course Outcomes (COs) are statements that describe what students should be able to achieve/demonstrate at the end of a course. They allow follow-up and measurement of learning objectives.

Grade Point Average (GPA) is the average of the grades acquired in various courses that a student has taken in a semester. The formula for computing GPA is given in section 11.3.

Cumulative Grade Point Average (CGPA) is a measure of overall cumulative performance of a student over all the 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.

Letter Grade is an index of the performance of a student in a particular course. Grades are denoted by the letters S, A, B, C, D, E, RA, and W.

Programme Offered and Eligibility Criteria
The Department of Mathematics offers a Two Year M.Sc. Mathematics Programme.

<table>
<thead>
<tr>
<th>Faculty of Science</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M.Sc. Mathematics</td>
<td>A pass in B.Sc. (Mathematics) with not less than 50% of marks in Part–III.</td>
</tr>
</tbody>
</table>

In the case of SC/ST and Differently-abled candidates, a pass is the minimum qualification for the above Programme.

Reservation Policy
Admission to the various programmes will be strictly based on the reservation policy of the Government of Tamil Nadu.

Programme Duration
The Two Year Master's Programme consist of two academic years.

Each academic year is divided into two semesters, the first being from July to November and the second from December to April.

Each semester will have 90 working days (18 weeks).

Programme Structure
The Two Year Master's Programme consists of Core Courses, Elective Courses (Departmental & Interdepartmental), and Project.

Core courses
These are a set of compulsory courses essential for each programme.

The core courses include both Theory (Core Theory) and Practical (Core Practical) courses.

Elective courses
Departmental Electives (DEs) are the Electives that students can choose from a range of Electives offered within the Department.
5.3.2 **Interdepartmental Electives (IDEs)** are Electives that students can choose from amongst the courses offered by other departments of the same faculty as well as by the departments of other faculties.

5.3.3 **Students shall take a combination of both DEs and IDEs.**

5.4 **Experiential Learning**
5.4.1 Experiential learning provides opportunities to students to connect principles of the discipline with real-life situations.

5.4.2 In-plant training/field trips/internships/industrial visits (as applicable) fall under this category.

5.4.3 Experiential learning is categorised as Core.

5.5 **Project**
5.5.1 Each student shall undertake a Project in the final semester.

5.5.2 The Head of the Department shall assign a Research Supervisor to the student.

5.5.3 The Research Supervisor shall assign a topic for research and monitor the progress of the student periodically.

5.5.4 Students who wish to undertake project work in recognised institutions/industry shall obtain prior permission from the University. The Research Supervisor will be from the host institute, while the Co-Supervisor shall be a faculty in the parent department.

5.6 **Value added Courses (VACs)**
5.6.1 Students may also opt to take Value added Courses beyond the minimum credits required for award of the Degree. VACs are outside the normal credit paradigm.

5.6.2 These courses impart employable and life skills. VACs are listed in the University website and in the Handbook on Interdepartmental Electives and VACs.

5.6.3 Each VAC carries 2 credits with 30 hours of instruction, of which 60% (18 hours) shall be Theory and 40% (12 hours) Practical.

5.6.4 Classes for a VAC are conducted beyond the regular class hours and preferably in the II and III Semesters.

5.7 **Online Courses**
5.7.1 The Heads of Departments shall facilitate enrolment of students in Massive Open Online Courses (MOOCs) platform such as SWAYAM to provide academic flexibility and enhance the academic career of students.

5.7.2 Students who successfully complete a course in the MOOCs platform shall be exempted from one elective course of the programme.
5.8 **Credit Distribution**
The credit distribution is organised as follows:

<table>
<thead>
<tr>
<th></th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses</td>
<td>65-75</td>
</tr>
<tr>
<td>Elective Courses</td>
<td>15</td>
</tr>
<tr>
<td>Project</td>
<td>6-8</td>
</tr>
<tr>
<td><strong>Total (Minimum requirement for award of Degree)</strong></td>
<td><strong>90-95</strong></td>
</tr>
</tbody>
</table>

*Each Department shall fix the minimum required credits for award of the Degree within the prescribed range of 90-95 credits.*

5.9 **Credit Assignment**
Each course is assigned credits and credit hours on the following basis:
1 Credit is defined as
1 Lecture period of one hour per week over a semester
1 Tutorial period of one hour per week over a semester
1 Practical/Project period of two or three hours (depending on the discipline) per week over a semester.

6 **Attendance**

6.1 Each faculty handling a course shall be responsible for the maintenance of *Attendance and Assessment Record* for candidates who have registered for the course.

6.2 The Record shall contain details of the students’ attendance, marks obtained in the Continuous Internal Assessment (CIA) Tests, Assignments and Seminars. In addition the Record shall also contain the organisation of lesson plan of the Course Instructor.

6.3 The record shall be submitted to the Head of the Department once a month for monitoring the attendance and syllabus coverage.

6.4 At the end of the semester, the record shall be duly signed by the Course Instructor and the Head of the Department and placed in safe custody for any future verification.

6.5 The Course Instructor shall intimate to the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students.

6.6 Each student shall have a minimum of 75% attendance in all the courses of the particular semester failing which he or she will not be permitted to write the End-Semester Examination. The student has to redo the semester in the next year.

6.7 Relaxation of attendance requirement up to 10% may be granted for valid reasons such as illness, representing the University in extracurricular activities and participation in NCC/NSS/YRC/RRC.

7 **Mentor-Mentee System**

7.1 To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach certain number of students to a member of the faculty who shall function as a Mentor throughout their period of study.
7.2 The Mentors will guide their mentees with the curriculum, monitor their progress, and provide intellectual and emotional support.

7.3 The Mentors shall also help their mentees to choose appropriate electives and value-added courses, apply for scholarships, undertake projects, prepare for competitive examinations such as NET/SET, GATE etc., attend campus interviews and participate in extracurricular activities.

8 Examinations

8.1 The examination system of the University is designed to systematically test the student’s progress in class, laboratory and field work through Continuous Internal Assessment (CIA) Tests and End-Semester Examination (ESE).

8.2 There will be two CIA Tests and one ESE in each semester.

8.3 The Question Papers will be framed to test different levels of learning based on Bloom’s taxonomy viz. Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation/Creativity.

8.4 Continuous Internal Assessment Tests
8.4.1 The CIA Tests shall be a combination of a variety of tools such as class tests, assignments, seminars, and viva-voce that would be suitable to the course. This requires an element of openness.

8.4.2 The students are to be informed in advance about the assessment procedures.

8.4.3 The pattern of question paper will be decided by the respective faculty.

8.4.4 CIA Test-I will cover the syllabus of the first two units while CIA Test-II will cover the last three units.

8.4.5 CIA Tests will be for two to three hours duration depending on the quantum of syllabus.

8.4.6 A student cannot repeat the CIA Test-I and CIA Test-II. However, if for any valid reason, the student is unable to attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

8.5 End Semester Examinations (ESE)
8.5.1 The ESE for the first/third semester will be conducted in November and for the second/fourth semester in May.

8.5.2 A candidate who does not pass the examination in any course(s) of the first, second and third semesters will be permitted to reappear in such course(s) that will be held in April and November in the subsequent semester/year.

8.5.3 The ESE will be of three hours duration and will cover the entire syllabus of the course.
9 Evaluation

9.1 Marks Distribution
9.1.1. Each course, both Theory and Practical as well as Project/Internship/Field work/In-plant training shall be evaluated for a maximum of 100 marks.

9.1.2 For the theory courses, CIA Tests will carry 25% and the ESE 75% of the marks.

9.1.3 For the Practical courses, the CIA Tests will constitute 40% and the ESE 60% of the marks.

9.2 Assessment of CIA Tests
9.2.1 For the CIA Tests, the assessment will be done by the Course Instructor
9.2.2 For the Theory Courses, the break-up of marks shall be as follows:

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test-I &amp; Test-II</td>
<td>15</td>
</tr>
<tr>
<td>Seminar</td>
<td>05</td>
</tr>
<tr>
<td>Assignment</td>
<td>05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

9.2.3 For the Practical Courses (wherever applicable), the break-up of marks shall be as follows:

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test-I</td>
<td>15</td>
</tr>
<tr>
<td>Test-II</td>
<td>15</td>
</tr>
<tr>
<td>Viva-voce and Record</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
</tr>
</tbody>
</table>

9.3 Assessment of End-Semester Examinations
9.3.1 Evaluation for the ESE is done by both External and Internal examiners (Double Evaluation).

9.3.2 In case of a discrepancy of more than 10% between the two examiners in awarding marks, third evaluation will be resorted to.

9.4 Assessment of Project/Dissertation
9.4.1 The Project Report/Dissertation shall be submitted as per the guidelines laid down by the University.

9.4.2 The Project Work/Dissertation shall carry a maximum of 100 marks.

9.4.3 CIA for Project will consist of a Review of literature survey, experimentation/field work, attendance etc.

9.4.4 The Project Report evaluation and viva-voce will be conducted by a committee constituted by the Head of the Department.

9.4.5 The Project Evaluation Committee will comprise the Head of the Department, Project Supervisor, and a senior faculty.

9.4.6 The marks shall be distributed as follows:
<table>
<thead>
<tr>
<th>Continuous Internal Assessment (25 Marks)</th>
<th>End Semester Examination (75 Marks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review-I: 10</td>
<td>Review-II: 15</td>
</tr>
<tr>
<td></td>
<td>Project / Dissertation Evaluation</td>
</tr>
<tr>
<td></td>
<td>Viva-voce</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

9.5 **Assessment of Value-added Courses**

9.5.1 Assessment of VACs shall be internal.

9.5.2 Two CIA Tests shall be conducted during the semester by the Department(s) offering VAC.

9.5.3 A committee consisting of the Head of the Department, faculty handling the course and a senior faculty member shall monitor the evaluation process.

9.5.4 The grades obtained in VACs will not be included for calculating the GPA.

9.6 **Passing Minimum**

9.6.1 A student is declared to have passed in each course if he/she secures not less than 40% marks in the ESE and not less than 50% marks in aggregate taking CIA and ESE marks together.

9.6.4 A candidate who has not secured a minimum of 50% of marks in a course (CIA + ESE) shall reappear for the course in the next semester/year.

10. **Conferment of the Master’s Degree**

A candidate who has secured a minimum of 50% marks in all courses prescribed in the programme and earned the minimum required credits shall be considered to have passed the Master’s Programme.

11. **Marks and Grading**

11.1 The performance of students in each course is evaluated in terms Grade Point (GP).

11.2 The sum total performance in each semester is rated by Grade Point Average (GPA) while Cumulative Grade Point Average (CGPA) indicates the Average Grade Point obtained for all the courses completed from the first semester to the current semester.

11.3 The GPA is calculated by the formula

\[ GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i} \]

where, \( C_i \) is the Credit earned for the Course \( i \) in any semester;

\( G_i \) is the Grade Point obtained by the student for the Course \( i \) and

\( n \) is the number of Courses passed in that semester.
11.4 **CGPA** is the Weighted Average Grade Point of all the Courses passed starting from the first semester to the current semester.

\[
CGPA = \frac{\sum_{i=1}^{m} \sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{m} C_i}
\]

where, \( C_i \) is the Credit earned for the Course \( i \) in any semester;

\( G_i \) is the Grade Point obtained by the student for the Course \( i \) and

\( n \) is the number of Courses passed in that semester.

\( m \) is the number of semesters

11.5 Evaluation of the performance of the student will be rated as shown in the Table.

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Grade Points</th>
<th>Marks %</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>10</td>
<td>90 and above</td>
</tr>
<tr>
<td>A</td>
<td>9</td>
<td>80-89</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>70-79</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>60-69</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>55-59</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>50-54</td>
</tr>
<tr>
<td>RA</td>
<td>0</td>
<td>Less than 50</td>
</tr>
<tr>
<td>W</td>
<td>0</td>
<td>Withdrawn from the examination</td>
</tr>
</tbody>
</table>

11.6 **Classification of Results.** The successful candidates are classified as follows:

11.6.1 **For First Class with Distinction:** Candidates who have passed all the courses prescribed in the Programme in the first attempt with a CGPA of 8.25 or above within the programme duration. Candidates who have withdrawn from the End Semester Examinations are still eligible for First Class with Distinction (See Section 12 for details).

11.6.2 **For First Class:** Candidates who have passed all the courses with a CGPA of 6.5 or above.

11.6.3 **For Second Class:** Candidates who have passed all the courses with a CGPA between 5.0 and less than 6.5.

11.6.4 Candidates who obtain highest marks in all examinations at the first appearance alone will be considered for University Rank.

11.7 **Course-Wise Letter Grades**

11.7.1 The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

11.7.2 A student is considered to have completed a course successfully and earned the credits if he/she secures an overall letter grade other than RA.

11.7.3 A course successfully completed cannot be repeated for the purpose of improving the Grade Point.

11.7.4 A letter grade RA indicates that the candidate shall reappear for that course. The RA Grade once awarded stays in the grade card of the student and is not deleted even when he/she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the Odd/Even semester in which the candidate has appeared for clearance of the arrears.
11.7.5 If a student secures RA grade in the Project Work/Field Work/Practical Work/Dissertation, he/she shall improve it and resubmit if it involves only rewriting/ incorporating the clarifications suggested by the evaluators or he/she can re-register and carry out the same in the subsequent semesters for evaluation.

12. Provision for Withdrawal from the End Semester Examination
12.1 The letter grade W indicates that a candidate has withdrawn from the examination.

12.2 A candidate is permitted to withdraw from appearing in the ESE for one course or courses in ANY ONE of the semesters ONLY for exigencies deemed valid by the University authorities.

12.3 Permission for withdrawal from the examination shall be granted only once during the entire duration of the programme.

12.3 Application for withdrawal shall be considered only if the student has registered for the course(s), and fulfilled the requirements for attendance and CIA tests.

12.4 The application for withdrawal shall be made ten days prior to the commencement of the examination and duly approved by the Controller of Examinations. Notwithstanding the mandatory prerequisite of ten days notice, due consideration will be given under extraordinary circumstances.

12.5 Withdrawal is not granted for arrear examinations of courses in previous semesters and for the final semester examinations.

12.6 Candidates who have been granted permission to withdraw from the examination shall reappear for the course(s) when the course(s) are offered next.

12.7 Withdrawal shall not be taken into account as an appearance for the examination when considering the eligibility of the candidate to qualify for First Class with Distinction.

13. Academic misconduct
Any action that results in an unfair academic advantage/interference with the functioning of the academic community constitutes academic misconduct. This includes but is not limited to cheating, plagiarism, altering academic documents, fabrication/falsification of data, submitting the work of another student, interfering with other students’ work, removing/defacing library or computer resources, stealing other students’ notes/assignments, and electronically interfering with other students'/University’s intellectual property. Since many of these acts may be committed unintentionally due to lack of awareness, students shall be sensitised on issues of academic integrity and ethics.

14. Transitory Regulations
Wherever there has been a change of syllabi, examinations based on the existing syllabus will be conducted for two consecutive years after implementation of the new syllabus in order to enable the students to clear the arrears. Beyond that, the students will have to take up their examinations in equivalent subjects, as per the new syllabus, on the recommendation of the Head of the Department concerned.

15. Notwithstanding anything contained in the above pages as Rules and Regulations governing the Two Year Master’s Programmes at Annamalai University, the Syndicate is vested with the powers to revise them from time to time on the recommendations of the Academic Council.
Programme Structure  
(For students admitted from the academic year 2019-2020)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td>Semester-I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19MATC101</td>
<td>Core 1: Advanced Abstract Algebra I</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>19MATC102</td>
<td>Core 2: Advanced Real Analysis</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>19MATC103</td>
<td>Core 3: Advanced Differential Equations</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>19MATC104</td>
<td>Core 4: Differential Geometry</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Elective 1:</td>
<td>Interdepartmental Elective</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

| Semester-II |                                       |   |   |   |     |     |   |
| 19MATC201   | Core 5: Advanced Abstract Algebra II  | 5 | 5 | 25 | 75  | 100 |
| 19MATC202   | Core 6: Measure Theory and Integration| 5 | 5 | 25 | 75  | 100 |
| 19MATC203   | Core 7: Advanced Complex Analysis     | 5 | 5 | 25 | 75  | 100 |
| 19MATP204   | Core 8: C++ Computer Practical        | 4 | 2 | 40 | 60  | 100 |
| Elective 2: | Interdepartmental Elective            | 3 | 3 | 25 | 75  | 100 |
| 19MAT206-1  | Elective 3: Department Elective       | 3 | 3 | 25 | 75  | 100 |

| Semester-III|                                      |   |   |   |     |     |   |
| 19MATC301   | Core 9: Topology                      | 5 | 5 | 25 | 75  | 100 |
| 19MATC302   | Core 10: Linear Algebra               | 5 | 5 | 25 | 75  | 100 |
| 19MATC303   | Core 11: Probability Theory           | 5 | 5 | 25 | 75  | 100 |
| 19MATP304   | Core 12: Numerical Methods Practical  | 4 | 2 | 40 | 60  | 100 |
| Elective 4: | Interdepartmental Elective            | 3 | 3 | 25 | 75  | 100 |
| 19MAT306    | Elective 5: Department Elective       | 3 | 3 | 25 | 75  | 100 |

| Semester-IV |                                      |   |   |   |     |     |   |
| 19MATC401   | Core 13: Functional Analysis          | 4 | 4 | 25 | 75  | 100 |
| 19MATC402   | Core 14: Stochastic Processes         | 4 | 4 | 25 | 75  | 100 |
| 19MATC403   | Core 15: Fluid Dynamics               | 4 | 4 | 25 | 75  | 100 |
| 19MATC404   | Core 16: Graph Theory                 | 4 | 4 | 25 | 75  | 100 |
| 19MATC405   | Core 17: Calculus of Variations & Integral Equations | 4 | 4 | 25 | 75  | 100 |
| 19MATPJ406  | Project (Dissertation & Viva-voce)    | 6 | 6 | 25 | 75  | 100 |

| Total Credits | 95 |

L- Lectures; P- Practical; C- Credits; CIA- Continuous Internal Assessment; ESE- End-Semester Examination

1. Students shall take both Department Electives (DEs) and Interdepartmental Electives (IDEs) from a range of choices available.
2. Students may opt for any Value-added Courses listed in the University website.
### Elective Courses

#### Department Elective (DE)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Department</th>
<th>hours/week</th>
<th>C</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>19MAT206-1</td>
<td>Programming Language C++</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>19MAT306-1</td>
<td>Number Theory</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>19MAT306-2</td>
<td>Fuzzy Sets and their Applications</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Interdepartmental Electives (IDE)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Department</th>
<th>hours/week</th>
<th>C</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>19 SOSE 115.1</td>
<td>Soft Skills</td>
<td>English</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>19 MATE 215.1</td>
<td>Discrete Mathematics</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>19 MATE 215.2</td>
<td>Numerical Methods</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>19 MATE 215.3</td>
<td>Statistical Computing</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>19 MATE 315.1</td>
<td>Differential Equations</td>
<td>Mathematics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>19 STSE 215.1</td>
<td>Statistical Methods</td>
<td>Statistics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
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**Value Added Course**

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19MATC - Core Course;
Elective Course (IDE) - Inter Department Elective Course;
Elective Course (DE) - Department Elective Course;
19MATP - Practical;
19MATPJ - Project (Dissertation & Viva-voce);
IA – Internal Assessment Evaluation Marks;
E - End Semester examination marks.
* - 75 Marks = 50 [Valuation of Dissertation] + 25 [Viva]

Students can take courses available in MOOC / SWAYAM portal and the marks obtained in the courses are added in the mark statement under the head “Extra Credit Courses”.

13
Programme Outcomes

PO1: Domain knowledge: Demonstrate knowledge of basic concepts, principles and applications of the specific science discipline.

PO2: Resource Utilisation. Cultivate the skills to acquire and use appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge-base and stay abreast of recent developments.

PO3: Analytical and Technical Skills: Ability to handle/use appropriate tools/techniques/equipment with an understanding of the standard operating procedures, safety aspects/limitations.

PO4: Critical thinking and Problem solving: Identify and critically analyse pertinent problems in the relevant discipline using appropriate tools and techniques as well as approaches to arrive at viable conclusions/solutions.

PO5: Project Management: Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyse and interpret data and provide solutions. Exhibit organisational skills and the ability to manage time and resources.

PO6: Individual and team work: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings.

PO7: Effective Communication: Communicate effectively in spoken and written form as well as through electronic media with the scientific community as well as with society at large. Demonstrate the ability to write dissertations, reports, make effective presentations and documentation.

PO8: Environment and Society: Analyse the impact of scientific and technological advances on the environment and society and the need for sustainable development.

PO9: Ethics: Commitment to professional ethics and responsibilities.

PO10: Life-long learning: Ability to engage in life-long learning in the context of the rapid developments in the discipline.

Programme Specific Outcomes

At the end of the programme, the student will be able to

PSO1: Improve the problems solving skills.

PSO2: Collaborate with the other related areas of science.

PSO3: Improve the theoretical knowledge of Mathematical concepts.

PSO4: Creatively applying the knowledge of Mathematics in selected real life situations.
Syllabus

Semester-I 19MATC101: Advanced Abstract Algebra – I  Credits: 5
Hours: 5

Learning Objective (LO): This course aims to provide a first approach to the subject of algebra, which is one of the basic pillars of modern mathematics. The focus of the course will be the study of certain structures called groups and some related structures. Some advanced concept of groups, Dihedral groups are introduced. Homomorphisms and Isomorphisms, cyclic groups, permutation groups, Sylow’s theorem, direct and semi-direct products are studied.

Unit-1: Introduction to groups:
Dihedral groups - Symmetric groups - Matrix groups - Homomorphisms and Isomorphisms - Group actions.
Subgroups: Definition and Examples - Centralizers and Normalizers, Stabilizers and Kernels.

Unit-2: Subgroups (Continued):
Cyclic groups and Cyclic subgroups of a group.
Quotient Groups and Homomorphisms: Definitions and Examples - More on cosets and Lagrange’s Theorem - The isomorphism theorems - Transpositions and the Alternating group.

Unit-3: Group Actions:
Group actions and permutation representations - Groups acting on themselves by left multiplication - Cayley’s theorem - Groups acting on themselves by conjugation - The class equation - Automorphisms.

Unit-4: Group Actions (Continued):
The Sylow theorems - The simplicity of An.
Further topics in group theory: p-groups, Nilpotent groups and Solvable groups.

Unit-5: Direct and semi-direct products and abelian groups: Direct Products - The fundamental theorem of finitely generated abelian groups - Table of groups of small order - semi direct products.

Text Book:

Unit I: Chapter 1: (Sections 1.2, 1.3, 1.4, 1.6, 1.7) and
        Chapter 2: (Sections 2.1, 2.2)
Unit II: Chapter 2: (Section 2.3) and
        Chapter 3: (Sections 3.1, 3.2, 3.3, 3.5)
Unit III: Chapter 4: (Sections 4.1, 4.2, 4.3, 4.4)
Unit IV: Chapter 4: (Sections 4.5, 4.6) and
        Chapter 6: (Section 6.1)
Unit V: Chapter 5: (Sections 5.1, 5.2, 5.3, 5.5)

Supplementary Reading:

Course Outcomes:
At the end of the course, the student will be able to:

CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving
of various concepts in:
- Groups,
- Quotient Groups,
- Homomorphism of Groups,
- Group Actions,
- Direct products of Groups.

Outcome Mapping:

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Semester-I 19MATC102: Advanced Real Analysis  Credits: 5
Hours: 5

Learning Objective (LO): The concept of derivatives of real valued functions and their properties are studied. Properties of monotonic functions, functions of bounded variations are also introduced. The concept of Riemann-Stieltjes integral and its properties are studied. The notion of convergence and uniform convergence of real valued functions and infinite series of functions are also studied.

Unit-1: Functions of Bounded Variation:
Properties of monotonic functions, Functions of bounded variation, Total variation, Additive property of total variation, Total variation on [a, x] as a function of x, Functions of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation. Riemann-Stieltjes Integral: The definition of the Riemann-Stieltjes integral, Linear properties, Integration by parts.

Unit-2: Riemann-Stieltjes Integral (Continued):
Change of variable in a Riemann-Stieltjes integral, Reduction to a Riemann integral, Step functions as integrators, Reduction of a Riemann-Stieljes integral to a finite sum, Euler's summation formula, Monotonically increasing integrators, Upper and lower integrals, Additive and linearity properties of upper and lower integrals, Reimann's condition, Comparison theorems, Integrators of bounded variation.

Unit-3: Riemann-Stieltjes Integral (Continued):
Sufficient conditions for existence of Riemann-Stieltjes integrals, Necessary conditions for existence of Riemann-Stieltjes integrals, Mean value theorems for Riemann-Stieltjes integrals, The integral as a function of the interval, Second fundamental theorem of integral calculus, Change of variable in a Riemann integral, Second mean-value theorem for Riemann integrals, Riemann-Stieltjes integrals depending on a parameter, Differentiation under the integral sign, Interchanging the order of integration.

Unit-4: Sequence of functions:
The Taylor’s series generated by a function, Bernstein’s theorem, Abel’s limit theorem, Tauber’s theorem.
Multivariable differential calculus: The directional derivative, directional derivatives and continuity, the total derivative, the total derivative expressed in terms of partial derivatives.

Unit-5: Multivariable differential calculus (Continued):
The Jacobian matrix.
Implicit functions: Functions with non-zero Jacobian determinant, the inverse function theorem, the implicit function theorem.

Text Book:
Unit – I  Chapter 6 Sections 6.1 to 6.8;
Chapter 7 Sections 7.1 to 7.5;
Unit – II  Chapter 7 Sections 7.6 to 7.15;
Unit – III  Chapter 7 Sections 7.16 to 7.25;
Unit – IV  Chapter 9 Sections 9.19; 9.20, 9.22, and 9.23;
Chapter 12 Sections 12.1 to 12.5;
Unit – V  Chapter 12: Section 12.8;
Chapter 13 Sections 13.1 to 13.4.

Supplementary Reading:

Course Outcomes:
At the end of the course, the student will be able to introduced to and have knowledge of many mathematical concepts

CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving

studied in real analysis such as
• Functions of bounded variations,
• Riemann –Stieltjes Integral,
• Sequence of functions,
• Multivariate Differential Calculus.

Outcome Mapping:

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Semester-I  19MATC103: Advanced Differential Equations  Credits: 5  Hours: 5

Learning Objective (LO): This Course aims to provide problem solving techniques in ordinary differential equations with variable coefficients and some special partial differential equations of Mathematical Physics such as Elliptic and Parabolic equations.

Unit-1: Linear Equation with Variable Coefficients
Initial value problems - Existence and uniqueness theorems - Solutions to solve a non-homogeneous equation - Wronskian and linear dependence - reduction of the order of a homogeneous equation - homogeneous equation with analytic coefficients -The Legendre equation.

Unit-2: Linear Equation with Regular Singular Points
Euler equation - Second order equations with regular singular points - Exceptional cases - Bessel Equation.

Unit-3: Existence and Uniqueness of Solutions to First Order Equations
Equation with variable separated - Exact equations - method of successive approximations - the Lipschitz condition - convergence of the successive approximations and the existence theorem.
Unit-4: Elliptic Differential Equations
Derivation of Laplace and Poisson equation - BVP - Separation of Variables - Dirichlet Problem and Newmann Problem for a rectangle - Interior and Exterior Dirichlet problems for a circle - Interior Newmann problem for a circle - Solution of Laplace equation in Cylindrical and spherical coordinates - Examples.

Unit-5: Parabolic Differential Equations
Formation and solution of Diffusion equation - Dirac-Delta function - Separation of variables method - Solution of Diffusion Equation in Cylindrical and spherical coordinates - Examples.

Text Books:
   Unit-I Chapter 3: Sections 1 to 8 [Omit Section 9]
   Unit-II Chapter 4: Sections 1 to 4 and 6 to 8 [Omit Sections 5 and 9]
   Unit-III Chapter 5: Sections 1 to 6 [Omit Sections 7 to 9]
   Unit-IV Chapter 2: Sections 2.1, 2.2, 2.5 to 2.13 (omit Sections 2.3 and 2.4)
   Unit-V Chapter 3: Sections 3.1 to 3.7 and 3.9 (omit Section 3.8)

Supplementary Reading:

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Apply the fundamental concept of ordinary and partial differential equation to
   a. demonstrate their understanding of how physical phenomena are modeled by second order differential equations and dynamical systems;
   b. perform operations with Bessel, Hermite and Legendre differential equations along with the corresponding recurrence formulas of different functions.
CO2: Solve various first order and higher orders differential equations with their applications.
CO3: Illustrate the mathematical aspects that contribute to the solution of heat, wave and diffusion equations.

Outcome Mapping:

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Learning Objective (LO): To introduce space curves, surfaces, curves on surfaces and study some of their properties. To study the notion of geodesic and its properties. To understand some type of special surfaces such as developables and minimal surfaces.

Unit–1: Space curves
Space curves, Arc length, Tangent, normal and binormal, Curvature and torsion of a curve given as the intersection of two surfaces.

Unit–2: Space curves (continued)
Contact between curves and surfaces, Tangent surface, involutes and evolutes, Intrinsic equations, Fundamental existence theorem for space curves, Helices.

Unit–3: Metric
Surface, Curves on a surface, Metric, Direction coefficients, Geodesics, Canonical geodesic equations, Normal property of geodesics, Geodesic curvature.

Unit–4: Metric (continued)
Gauss-Bonnet theorem, Gaussian curvature, Surfaces of constant curvature, Conformal mapping, Only statements of Dini’s theorem and Tissot’s theorem.

Unit–5: Second Fundamental form
Second fundamental form, Developables, Developables associated with space curves, Developables associated with curves on surfaces, Minimal surfaces.

Text Book:

Unit-I Chapter 1 Sections 1 to 5
Unit-II Chapter 1 Sections 6 to 9
Unit-III Chapter 2 Sections 1, 2, 5, 6, 10, 11, 12 and 15
Unit-IV Chapter 2 Sections 16 to 20
Unit-V Chapter 3 Sections 1, 4, 5, 6, 7.

Supplementary Reading:

Course Outcomes:
After successful completion of the course the student will be able to:
CO1: understand the concept of a space curve in 3D and compute the curvature and torsion of space curves;
CO2: understand the fundamental existence theorem for space curves;
CO3: find geodesics equations on a surface;
CO4: understand surfaces of constant curvature (Minding’s theorem) and Gaussian curvature;
CO5: determine the second fundamental form and developables associated with space curves.

Outcome Mapping:
Learning Objective (LO): This course aims to provide a continuation of Advanced Abstract Algebra-I. The focus of the course will be the study of Rings, Polynomial rings, Euclidean ring, Unique factorization domains, Module Theory, Field theory and Splitting fields.

Unit-1: Introduction to Rings:
Examples: Polynomial rings - Matrix rings and group rings - Ring Homomorphisms and quotient rings - Properties of Ideals - Rings of fractions - The Chinese remainder theorem.

Unit-2: Rings (continued):
Euclidean domains, principal ideal domains and unique factorization domains.
Polynomial rings: Definitions and basic properties – Polynomial rings over fields.

Unit-3: Polynomial rings (continued):
Polynomial rings that are unique factorization domains – Irreducibility criteria – Polynomial ring over fields.
Introduction to Module Theory: Basics definitions and examples – Quotient modules and Module homomorphism.

Unit-4: Field theory:
Basic Theory of field extensions - Algebraic Extensions.

Unit-5: Field theory (continued):
Splitting fields and Algebraic closures - Separable and inseparable extensions - Cyclotomic polynomials and extensions.

Text Book:
Unit I: Chapter 7: (Sections 7.2,7.3,7.4,7.5,7.6)
Unit II: Chapter 8: (Sections 8.1,8.2,8.3) and
Chapter 9: (Sections 9.1,9.2)
Unit III: Chapter 9: (Sections 9.3,9.4,9.5),
Chapter 10: (Sections 10.1,10.2)
Unit IV: Chapter 13: (Sections 13.1,13.2)
Unit V: Chapter 13: (Sections 13.4,13.5,13.6)

Supplementary Reading:

Course Outcomes:
Students will be introduced to and have knowledge of many mathematical concepts
- CO1: examples and counter examples
- CO2: proof techniques
- CO3: problem solving

studied in Abstract Algebra such as
- Rings,
- Irreducibility,
- Modules, a generalization of vector spaces,
- Fields.
Outcome Mapping:

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Semester-II 19MATC202: Measure Theory and Integration

Credits: 5
Hours: 5

Learning Objective (LO): The concept of Lebesgue measure is introduced. Measure space and integration with respect to a measure are introduced. Convergence in measure and properties of $L^p$ space are discussed.

Unit-1:
Lebesgue Outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability.

Unit-2:
Integration of nonnegative functions, General integral, Integration of series, Riemann and Lebesgue integrals.

Unit-3:
Continuous non-differentiable functions, Lebesgue differential theorem (statement only), Differentiation and Integration, Lebesgue set, Convergence in measure, Almost uniform convergence.

Unit-4:
Measures and outer measures, Extension of a measure, Uniqueness of the extension, Completion of a measure, Measure spaces, Integration with respect to a measure.

Unit-5:

Text Book:

Unit – I Chapter 2: Sections 2.1 to 2.5
Unit – II Chapter 3: Sections 3.1 to 3.4
Unit – III Chapter 4: Sections 4.2, 4.4 to 4.6 and Chapter 7: Sections 7.1, 7.2
Unit – IV Chapter 5: Sections 5.1 to 5.6
Unit – V Chapter 6: Sections 6.1 to 6.5.

Supplementary Reading:

Course Outcomes:
Students will be introduced to and have knowledge of many mathematical concepts
CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving
studied in Measure theory & Integration such as
- Measurable sets and Measurable functions,
- Integration with respect to Measure,
- Convergence in Measure.

Outcome Mapping:

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Semester-II 19MATC203: Advanced Complex Analysis Credits: 5 Hours: 5

Learning Objective (LO): This course aims to train the students to get essential knowledge in functions of a complex variable. Analytic functions and their properties, Residue theorem and its applications, Riemann mapping theorem are discussed in detail.

Unit–1: Complex integration:
Line integrals, Rectifiable arcs, Line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a Disc.
Cauchy's integral Formula:
The index of a point with respect to a closed curve, The integral formula, Higher derivatives.

Unit–2: Local Properties of Analytic Functions:
The General Form of Cauchy's Theorem:
Chains and cycles, Simple connectivity, Locally exact differentials, Multiply connected regions.

Unit–3: Harmonic Functions:
Definition and basic properties, The mean-value property, Poisson's Formula, Schwarz’s theorem, The Reflection principle.
Power Series Expansions:

Unit–4: Partial Fractions and Factorization:
Partial fractions, Infinite products and Canonical products.
Normal Families:

Unit–5: The Riemann Mapping Theorem:
Statement and Proof
Conformal mapping of Polygons:
The behavior at an angle, The Schwarz-Christoffel formula, Mapping on a rectangle, The triangle functions of Schwarz.
A Closer look at Harmonic Functions:
Functions with the Mean-value Property, Harmack’s Principle.

Text Book:

Unit-I Chapter 4 Sections 1 & 2.
Unit-II Chapter 4 Sections 3, 4 (4.1, 4.2, 4.6 and 4.7 only).
Unit-III Chapter 4 Section 6; Chapter 5 Section 1.
Unit-IV Chapter 5 Section 2 (2.1, 2.2 and 2.3 only).
Chapter 5 Section 5.
Unit-V Chapter 6 Sections 1 (1.1 only), 2 and 3.
Supplementary Reading:

Course Outcomes:
After successful completion of the course the student will be able to
CO1: use Cauchy’s integral theorem or formula to compute complex line integrals;
CO2: compute the Taylor’s theorem, to determine the nature of the removable singularities;
CO3: explain the convergence of power series and develop analytical capabilities in Taylor or Laurent series in a given domain;
CO4: determine the concept of conformal mapping of polygons, to find Schwarz – Christoffel formula.

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Semester-II 19MATP204: C++ Computer Practical Credits: 2
Hours: 4

Learning Objective (LO): The objective are acquire the practical knowledge to solve problems including the fields of optimization, number theory and matrix theory.

1. Solution of Linear Programming Problem.

2. Deterministic Inventory Models.
   i. Single-item Static Model.
   ii. Single-item Static Model with Price Breaks.
   iii. Multi-item Static Model with Storage Limitation.

3. Number Theory:
   i. Reversing of an integer series.
   ii. Generating Fibonacci series.
   iii. Average and Standard Deviation of numbers.
   iv. Identification of Prime, Even and Odd integers.

4. Matrix Theory
   i. Determinant of a matrix.
   ii. Rank of a matrix.
   iii. Inverse of a matrix.
   iv. Product of matrices.

Text Books:
Content and treatment as in relevant sections of the following books:

Supplementary Reading:

Course Outcome:
By the end of the course,
CO1: the students will be able to gain knowledge between theory and practical.

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Semester-III 19MATC301: Topology

Credits: 5
Hours: 5

Learning Objective (LO): The idea and method of topology have transformed large parts of geometry and analysis. This subject is of interest in its own right, and it also serves to lay the foundations for future studies in analysis and geometry. In this course we teach the basics of topology including connectedness, compactness, countability, separation axioms, Tychonoff theorem and complete metric spaces.

Unit-1:
Topological spaces, Basis for a topology, The order topology, The product topology on X × Y.

Unit-2:
The subspace topology, Closed sets and limit points, Continuous function, The product topology. The metric topology, Connected spaces, Connected subspaces of the real line, Components and Local connectedness.

Unit-3:
Compact spaces, Compact subspaces of the real line, Limit point compactness, Local compactness.

Unit-4:
Countability axioms, The separation axioms, Normal spaces, Urysohn Lemma, Urysohn metrization theorem, Tietze extension theorem.

Unit-5:
The Tychonoff Theorem, Stone-Cech compactification, Complete metric spaces, Compactness in metric spaces.

Text Book:

Unit – I Chapter 2: Sections 12 to 15.
Unit – II Chapter 2: Sections 16 to 21 and
Chapter 3: Sections 23 to 25.
Unit - III Chapter 3: Sections 26 to 29.
Unit - IV Chapter 4: Sections 30 to 35.
Unit - V Chapter 5: Sections 37 and 38;
Chapter 7: Sections 43 and 45 only.
Supplementary Reading:

Course Outcomes:
Students will be introduced to and have knowledge of many mathematical concepts

CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving

studied in Topology such as
• Connectedness
• Compactness
• Completeness

which are studied in Real Numbers.

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Semester-III 19MATC302: Linear Algebra Credits: 5 Hours: 5

Learning Objective (LO): This course aims learning the students to solve systems of linear equations using multiple methods, echelon Matrices, matrix operations, including inverses and invertible matrix using determinants. Applying principles of matrix algebra to linear transformations, double dual, commutative rings, Characteristic values, Annihilating polynomials and Decompositions of Invariant Direct sums are studied.

Unit-1: Linear Equations and Vector spaces

Unit-2: Linear Transformations

Unit-3: Determinants
Commutative rings – Determinant functions – Permutations and the uniqueness of determinants – Classical Adjoint of a (Square) matrix – Inverse of an invertible matrix using determinants.

Unit-4: Canonical Forms
Characteristic values – Annihilating polynomials, Invariant subspaces.

Unit-5: Canonical Forms (continued)
Text Book:
Chapters 1 to 3, Chapter 5 (5.1 to 5.4) and Chapter 6.

Supplementary Reading:

Course Outcomes:
Students will be introduced to and have the knowledge of many mathematical concepts
CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving

studied in Linear Algebra such as
• Systems of linear Equations,
• The algebra of linear transformations,
• Determinant functions,
• Diagonalization,
• Decompositions.

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Semester-III 19MATC303: Probability Theory  Credits: 5
Hours: 5

Learning Objective (LO): The objective are (i) acquire quantative skills and an understanding of rigorous concepts and methods in probability theory through measure theoretic approach (ii) acquire understanding of diverse characteristics like convergence, law of large numbers and central limit theorems. (iii) Acquire the ability to solve widely varied problems.

Unit-1: Distribution Function:
Monotone functions, Distribution functions, Absolutely continuous and Singular distributions.
Measure Theory:
Classes of sets, Probability measures and their distribution functions.
Random variable, Expectation, Independence:
General definitions, Properties of mathematical expectation, Independence.

Unit-2: Convergence Concepts:
Various modes of convergence, Almost sure Convergence; Borel-Cantelli lemma, Vague Convergence, Continuation.

Unit-3: Law of Large Numbers. Random series:
Simple limit theorems, Weak law of large numbers, Convergence of series, Strong law of large numbers.

Unit-4: Characteristic Function:
General properties; Convolutions, Uniqueness and inversion, Convergence theorems, Simple applications.
**Unit-5: Central limit theorem and its Ramifications:**

Liapounov's theorem, Lindeberg-Feller theorem, Ramification of the central limit theorem.

**Text Book:**

Unit - I
- Chapter 1 (Sections 1 to 3).
- Chapter 2 (Sections 1 and 2).
- Chapter 3 (Sections 1 to 3).

Unit – II
- Chapter 4 (Sections 1 to 4).

Unit - III
- Chapter 5 (Sections 1 to 4).

Unit – IV
- Chapter 6 (Sections 1 to 4).

Unit - V
- Chapter 7 (Sections 1 to 3).

**Supplementary Reading:**

**Course Outcomes:**
By the end of the course, students will be able to gains

- CO1: knowledge related to probability problems
- CO2: a basic knowledge for studying advanced courses in
  this area like stochastic processes.

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**Semester-III**

19MATP304: Numerical Methods Practical (Using C++ language) Credits: 2 Hours: 4

**Learning Objective (LO):** The objectives are acquire the practical applicability of C++ Programming to some of the problems in numerical mathematics.

1. **Solution of transcendental and polynomial equations in one variable:**
   - Method of Bisection
   - Method of Regula Falsi
   - Newton's Method

2. **Solution of Linear Equations:**
   - Jacobi’s Iterative Method
   - Gauss-Seidal Iterative Method

3. **Numerical Solution of Ordinary Differential Equations:**
   - Euler’s Method.
   - Modified Euler's Method
   - Runge-Kutta Method of order four
4. Numerical Integration:
   i. Simpson's one third rule
   ii. Simpson's three eighth rule
   iii. Weddle's rule.

Text Book:

Course Outcomes:
By the end of the course:
CO1: students will be able to gain knowledge between theory and practical.

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Semester-IV 19MATC401: Functional Analysis Credits: 4
Hours: 4

Learning Objective (LO): There are many domains in the broad field of topology. The following are the few viz, the theory of Banach and Hilbert Spaces and their operators and Banach algebras. In this course we teach some results on Banach spaces, Hilbert spaces, operator theory and Banach algebras. Each of these subjects starts from the fundamental knowledge and develops its own methods of dealing with its own characteristic problems.

Unit–1: Linear transformations and Banach spaces
Linear transformations, Banach spaces, Continuous linear transformations, The Hahn-Banach theorem.

Unit–2: Banach spaces (continued)
The natural embedding of N into N**, The open mapping theorem, The conjugate of an operator.

Unit–3: Hilbert spaces
Hilbert space, Orthogonal complements, Orthonormal sets, The Conjugate space H*, The adjoint of an operator, Self adjoint operators, Normal and Unitary operators.

Unit–4: Finite dimensional Spectral theory
Matrices, Determinants and Spectrum of an operator, The spectral theorem.

Unit–5: Banach algebras
Definition and some examples, Regular and singular elements, Topological divisors of zero, The spectrum, The formula for the spectral radius.

Text Book:

Unit-I Chapter 8: Section 44 only and
   Chapter 9: Sections 46, 47 and 48.
Unit-II Chapter 9: Sections 49, 50 and 51.
Unit-III Chapter 10: Sections 52 to 58.
Unit-IV Chapter 11: Sections 60, 61 and 62.
Unit-V Chapter 12: Sections 64 to 68.

Supplementary Reading:
Course Outcomes:
In the board field of topology, students gaining knowledge related to
CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving
in Banach space, Hilbert space and spectral operator theory.

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Semester-IV 19MATC402: Stochastic Processes  Credits: 4
Hours: 4

Learning Objective (LO): The objectives are to (i) acquire the skill of advanced level of mathematical sophistication and enhancing the horizons of knowledge. (ii) acquire understanding of applicability of different concepts of stochastic processes on some physical situation. (iii) to familiarize the students with the use of stochastic models in different areas.

Unit-1: Stochastic Processes:
Markov Chains:
Definition and Examples, Higher Transition Probabilities, Generalization of independent Bernoulli Trials: Sequence of Chain Dependent Trials, Classification of States and Chains.

Unit-2: More on Markov Chains:
Determination of Higher Transition Probabilities, Stability of a Markov System, Markov Chain with Denumerable Number of States, Reducible Chains.

Unit-3: Markov Processes with Discrete State Space:

Unit-4: Markov Chains and Markov Processes with Continuous State Space:

Unit-5: Renewal Processes and Theory:

Text Book:

Unit-I Chapter 2: Sections 1 to 4 and
   Chapter 3: Sections 1 to 4.
Unit-II Chapter 3: Sections 5, 6, 8 and 9.
Unit-III Chapter 4: Sections 1 to 5.
Unit-IV Chapter 3: Section 11
   Chapter 5: Sections 1 to 5.
Unit-V Chapter 6: Sections 1 to 6.

Supplementary Reading:

**Course Outcomes:**
By the end of the course, students will be able to gain:

- **CO1:** working knowledge related to the problems of uncertainty.
- **CO2:** a basic knowledge for doing research in this area.

**Outcome Mapping:**

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**Semester-IV**

19MATC403: Fluid Dynamics

**Credits:** 4

**Hours:** 4

**Learning Objective (LO):** This course aims to discuss kinematics of fluids in motion, Equations of motion of a fluid, three dimensional flows, two dimensional flows and viscous flows.

**Unit-1: Kinematics of Fluids in Motion:**
Real fluids and ideal fluids – Velocity of a fluid at a point stream lines – path lines – Steady and unsteady flows – Velocity potential – The velocity vector – Local and particle rates of changes – Equations of continuity – Examples.

**Unit-2: Equation of Motion of a fluid:**
Pressure at a point in a fluid at rest – Pressure at a point in a moving fluid – Condition at a boundary of two invicid immersible fluids. Euler’s equation of motion – Discussion of the case of steady motion under conservative body forces.

**Unit-3: Some three dimensional flows:**

**Unit-4: Some two-dimensional flows:**
Two dimensional flows – Meaning of two dimensional flow – Use of cylindrical polar co-ordinates – The stream function – Complex potential for two dimensional – Irrational incompressible flow – Complex velocity potential for standard two dimensional flows – Examples.

**Unit-5: Viscous flows:**

**Text Book:**

- Unit – I Chapter 2: Sections 2.1 to 2.8
- Unit – II Chapter 3: Sections 3.1 to 3.7
- Unit – III Chapter 4: Sections 4.1 to 4.3 and 4.5
- Unit – IV Chapter 5: Sections 5.1 to 5.6
- Unit – V Chapter 8: Sections 8.1 to 8.9.

**Supplementary Reading:**
Course Outcomes:
On successful completion of the course, the student will be able to,
CO1: Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.
CO2: Recognize these principles written in form of mathematical equations.
CO3: Apply dimensional analysis to predict physical parameters that influence the flow in fluid dynamics.

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Semester-IV  19MATC404: Graph Theory  Credits: 4  Hours: 4

Learning Objective (LO): Graph Theory is an integral part of Discrete Mathematics. It has applications to many fields, including Computer Science, Physics, Chemistry, Psychology and Sociology. In this course we teach basic topics in graph theory such as Trees, Connectivity, Euler tours, Hamilton cycles, Matchings, Colourings, Planar graphs.

Note: Theorems, Propositions and results which are starred are to be omitted.

Unit–1: Basic Concepts:
Connectivity:
Vertex cuts and Edge cuts – Connectivity and edge-connectivity, Blocks.

Unit–2: Trees:
Trees – Characterization and Simple properties. Independent sets and Matchings:
Vertex Independent sets and Vertex Coverings – Edge-Independent Sets – Matchings and Factors, Matchings in Bipartite Graphs (except the proof of Tutte's 1-factor theorem).

Unit–3:
Eulerian Graphs. Hamiltonian Graphs.

Unit–4 : Graph Colorings:

Unit–5: Planarity:
Planar and Nonplanar Graphs – Euler’s Formula and its Consequences – $K_5$ and $K_{3,3}$ are Nonplanar graphs – Dual of a Plane Graph – The Four Color Theorem and the Heawood Five-Color Theorem – Hamiltonian plane graphs.

Text Book:
Unit - I  Chapter 1: 1.1 to1.6; Chapter 3: 3.1 to 3.3;
Unit - II  Chapter 4: 4.1, 4.2; Chapter 5: 5.1 to 5.5;
Unit - III  Chapter 6: 6.2, 6.3;
Unit - IV  Chapter 7: 7.1, 7.2, 7.3 (except 7.3.2 and 7.3.3), 7.6, 7.9;
Unit - V  Chapter 8: 8.1 to 8.6; 8.8.
Supplementary Reading:

Course Outcomes:
Students will be introduced to and have knowledge of many mathematical concepts
CO1: examples and counter examples
CO2: proof techniques
CO3: problem solving
CO4: applications

studied in Graph Theory such as
• Trees,
• Connectivity,
• Euler tours,
• Hamilton cycles,
• Matchings,
• Colourings,
• Planar graphs

Students will be able to solve problems that can be modeled as graphs.

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Semester-IV 19MATC405: Calculus of Variations and Integral Equations Credits: 4
Hours: 4

Learning Objective (LO): The aim of the course is to introduce to the students the concept of calculus of variations and its applications. Various types of integral equations have been introduced and method of solving these equations are given.

Unit-1:
Calculation of Variations and Applications:
Maxima and Minima - The Simplest case-Illustrative examples-Natural boundary conditions and transition conditions – The variational notation-The more general case.

Unit-2:
Constraints and Lagrange multipliers-Variable end points - Sturm- Liouville problems-Hamilton’s principle-Lagrange’s equations.

Unit-3:

Unit-4:
Linear equation in cause and effect: The influence function – Fredholm equations with separable kernels – Illustrative example.
Unit-5:
Hilbert – Schmidt theory – Iterative methods for solving equations of the second kind – Fredholm theory.

Text Book:
Francis B. Hildebrand, Methods of Applied Mathematics, (Second Edition)
Unit I: Chapter 2: Sections 2.1 to 2.6
Unit II: Chapter 2: Sections 2.7 to 2.11
Unit III: Chapter 3: Sections 3.1 to 3.4
Unit IV: Chapter 3: Sections 3.5 to 3.7
Unit V: Chapter 3: Sections 3.8 to 3.9 and 3.11

Supplementary Reading:

Course Outcomes:
On Successful completion of the course student will be able to
CO1: Recognize the difference between Volterra & Fredholm integral equations, First kind & second kind, homogeneous and inhomogeneous etc.
CO2: They will have a much better understanding of the fundamental concepts related to the space of admissible variations and concepts of a weak and a strong relative minimum of an integral.

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Elective Courses (DE):

Semester-II 19MAT206-1: Programming Language C++ Credits: 3
Hours: 3

Learning Objective (LO): The language C++ is a Object Oriented Programming Language. First the syntax of the language C++ is introduced. This is followed by Control statement, Arrays, Functions, Pointers, Structures and Classes. Many problems are solved after writing algorithms and programs in C++.

Unit-1: C++ Programming Basics:
The Remainder Operator, Arithmetic Assignment operators, Increment Operators. Library Functions: Header Files, Library Files, Header Files and Library Files, Two Ways to Use # include.

**Unit-2: Loops and Decisions:**

**Unit-3: Structures:**
A simple structure, Specifying the structure, Defining a structure variable, Accessing structure members.

Functions:

**Unit-4: Arrays:**

**Unit-5: Pointers:**

**Text Book:**

**Unit-I**  Chapter 3
**Unit-II**  Chapter 4
**Unit-III**  Chapters 5 and 6
**Unit-IV**  Chapter 8
**Unit-V**  Chapter 12

**Supplementary Reading:**

**Course Outcomes:**
CO1: On Successful completion of C++ course, the students gathered computer knowledge in C++ to write programmes for various types of mathematical problems.
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Semester-III 19MAT306-1: Number Theory Credits: 3

Hours: 3

Learning Objective (LO): The prime aim of this paper is to enrich the knowledge of Number Theory. The concepts of primes, congruences, prime power moduli, power residues, quadratic residues, greatest integer function, Mobius inversion formula are introduced. Diophantine equations and their positive solutions are discussed. Simple continued functions are also considered.

Unit-1: Divisibility and Congruences

Unit-2: Congruences (continued)
Prime power moduli, Prime modulus, Primitive Roots and Power Residues, Congruences of degree two, Prime Modulus.
Quadratic Reciprocity and Quadratic Forms:
Quadratic Residues, Quadratic reciprocity and the Jacobi symbol.

Unit-3: Some functions of Number Theory
Greatest integer function, Arithmetic functions, The Mobius inversion formula, Recurrence Functions, Combinatorial Number Theory.

Unit-4: Some Diophantine Equations
The equation ax+by=c, Simultaneous Linear Equations, Pythagorean Triangles, Assorted Examples, Ternary Quadratic Forms.

Unit-5: Simple Continued Fractions
The Euclidean Algorithm, Uniqueness, Infinite Continued Fractions, Irrational Numbers, Approximations to Irrational Numbers.

Text Book:

Unit - I Chapter 1 Sections 1 to 3 and
Chapter 2 Sections 1 to 3

Unit – II Chapter 2 Sections 6 to 9 and
Chapter 3 Sections 1 to 3

Unit – III Chapter 4 Sections 1 to 5

Unit - IV Chapter 5 Sections 1 to 5

Unit - V Chapter 7 Sections 1 to 5

Supplementary Reading:

Course Outcomes:
On successful completion of the course, the student will be able to understand the concepts

CO1: examples and counter examples

CO2: Proof techniques

CO3: problem solving of
  - Divisibility relation,
  - Congruence relation,
• Special number theoretic functions,
• Diophantine equations and
• Algebraic numbers.

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Semester-III 19MAT306-2: Fuzzy Sets and their Applications Credits: 3
Hours: 3

Learning Objective (LO): This course aims to offer fuzzy sets, fuzzy relations, fuzzy logic, fuzzy composition and applications.

Unit-1: Fuzzy sets:
Fuzzy sets – Basic types – Basic concepts - Characteristics – Significance of the paradigm shift – Additional properties of $\alpha$-Cuts.

Unit-2: Fuzzy Sets Versus CRISP Sets:

Unit-3: Operations on Fuzzy Sets:
Fuzzy intersection – t-norms, Fuzzy unions – t conorms – Combinations of operations – Aggregation operations.

Unit-4: Fuzzy Arithmetic:
Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of Fuzzy numbers.

Unit-5: Constructing Fuzzy Sets:
Methods of construction: An overview – Direct methods with one expert – Direct method with multiple experts – indirect method with multiple experts and one expert – Construction from sample data.

Text Book:

Unit – I Chapter 1: Sections 1.3 to 1.5 and
Chapter 2: Sections 2.1
Unit – II Chapter 2: Sections 2.2 to 2.3 and
Chapter 3: Sections 3.1 to 3.2
Unit – III Chapter 3: Sections 3.3 to 3.6
Unit – IV Chapter 4: Sections 4.1 to 4.4
Unit – V Chapter 10: Sections 10.1 to 10.7

Supplementary Reading:

Course Outcomes:
On successful completion of the course, the student will be able to identify the basic concepts
CO1: examples and counter examples
CO2: Proof techniques
CO3: problem solving
on
• characteristics of fuzzy logic,
• \( \alpha \) cuts,
• operations on fuzzy sets,
• extension principles,
• fuzzy norms,
• lattice of fuzzy numbers.

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Electives for other Department students:

Semester- II 19MATE215.1: Discrete Mathematics Credits: 3 Hours: 3

Learning Objective (LO): Students must understand mathematical reasoning in order to read, comprehend and construct mathematical arguments. Mathematical logic, which serves as foundation for subsequent discussion is discussed. Discrete structures such as sets and permutations are studied. Discrete probability, recurrence relations, conquer relations and principles of inclusion and exclusion are studied.

Unit-1: Logic and Counting:
Propositions and logical operations, Conditional statements, Methods of Proof, Mathematical Induction. Permutations, Combinations, Pigeonhole Principle, Elements of Probability, Recurrence Relations.

Unit-2: Relations and Digraphs:
Product sets and partitions, Relations and Digraphs, Paths in Relations and Digraphs, Properties of relations, Equivalence Relations, Computer Representation of Relations and Digraphs, Operations on Relations, Transitive Closure and Warshall's Algorithm.

Unit-3: Functions:
Functions, Functions for Computer Science, Growth of Functions, Permutation Functions.

Unit-4: Order Relations and Structures:

Unit-5: Semigroups and Groups:
Semigroups, Product and Quotient of Semigroups, Groups, Product and Quotient of Groups.

Text Book:

Unit I Chapter 2 Sections 1 to 4,
Chapter 3 Sections 1 to 5.

Unit II Chapter 4 Sections 1 to 8.

Unit III Chapter 5 Sections 1 to 4.

Unit IV Chapter 6 Sections 1 to 6.

Unit V Chapter 9 Sections 1 to 4.
Supplementary Reading:

Course Outcomes:
Every student shall get a good exposure in
CO1: examples and counter examples
CO2: Proof techniques
CO3: problem solving
CO4: applications
of various concepts in: Logic and Counting, Relations and Digraphs, Functions, Order Relations and Structures and Semigroups and Groups.

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Semester-II 19MATE215.2: Numerical Methods Credits: 3 Hours: 3

Learning Objective (LO): The role of numerical analysis is to develop and analyze the numerical techniques. In this paper, different methods for finding the roots of algebraic and transcendental equations, solutions of simultaneous equations, solutions of differential equations are concentrated. Numerical differentiation and integration are also evaluated.

Unit-1: The solution of Numerical Algebraic and Transcendental Equations:

Unit-2: Simultaneous Linear Algebraic Equations:
Gauss Elimination method, Computation of the inverse of a matrix using Gauss elimination method, Method of Triangularisation (Method of Factorization), Crout's method, Iterative methods, Jacobi method of iteration (Gauss-Jacobi Method), Gauss Seidal method of iteration.

Unit-3: Interpolation:
Introduction, Linear interpolation, Gregory Newton Forward and Backward interpolation Formula, Equidistant terms with one or more missing values.

Interpolation with unequal intervals:
Divided Differences, Properties of Divided differences, Newton's interpolation formula for unequal intervals, Lagrange's interpolation formula, Inverse interpolation.

Unit-4: Numerical Differentiation and Integration:
Introduction, Newton's forward difference formula to compute the derivatives, Newton's backward difference formula to compute the derivatives, Derivatives using Stirling's formula. Trapezoidal rule, Simpson's rule, Practical applications of Simpson's rule, Trapezoidal rules.

Unit-5: Numerical Solution of Ordinary Differential Equations:
Text Book:
Chapters - III, IV, VI, IX, XI.

Supplementary Reading:

Course Outcomes:
Every student shall get a good exposure in
CO1: examples and counter examples
CO2: problem solving
CO3: applications
of various concepts in: obtaining numerical solutions of Algebraic, Transcendental and Ordinary Differential Equations.

Outcome Mapping:

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Semester-III 19MATE315.1: Differential Equations Credits: 3 Hours: 3

Learning Objective (LO): This course aims to provide logical skills in the formation of differential equations, to expose to different techniques of finding solutions to these equations and in addition stress is laid on the application of these equations in geometrical and physical problems. It also aims to provide logical skills in the formation and solutions techniques of partial differential equations.

Unit-1: Ordinary Differential Equations:
Unit-2: Ordinary Differential Equations [Contd...]:
Method of Variation of Parameters – 2nd order Differential Equations with Constant Coefficients for finding the P.I’s of the form eax V, where V is sin(mx) or cos(mx) and xn.
Unit-3: Laplace Transform:
Laplace Transform, Inverse Laplace transform, Application to the first and second order linear differential equations.
Unit-4: Partial Differential Equations:
Partial differential equations: Formation of P.D.E. by eliminating arbitrary constants and arbitrary functions, Complete, Singular and General integral. Solution of equations of standard types: f(p,q)=0, f(x,p,q)=0, f(y,p,q)=0, f(z,p,q)=0, f(x,p)=f(y,q), and Clairaut's form. Lagrange's equation Pp+Qq=R, Simple problems.
Unit-5: Series Solution:
Series solutions of first order equations, Second order linear equations, Ordinary points, Regular Singular Points

Text Books:
Content and treatment as in the following books:
Unit I - Chapter 1 1(A) & 1 (B)
Unit II - Chapter 2 2.10 to 2.32
   - Chapter 3 3.15 to 3.23
Unit III - Chapter 7 except simultaneous equations
Unit IV - Chapter 5.

Unit V - Chapter 5 Sections 26 – 29

Supplementary Reading:
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand, 2006

Course Outcomes:
At the end of the course the students will able to get
CO1: the skill of the formation of differential equations and partial differential equations.
CO2: the skill to expose different techniques of finding solution of differential equations and partial differential equations.

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Value Added Course:

Semester- VAC: Mathematics For Competitive Examinations Credits: 3
          Hours:  3

Learning Objective (LO): To introduce concepts of mathematics with emphasis on analytical ability and computational skill needed in competitive examinations.

Unit-1: Problems on General Arithmetic:
Problems of ages – Ratio and proportions -Inverse ratio-properties (Addendo, subtrahendo, componendo & dividendo) -ratio of four numbers -increasing and decreasing order of fractions.
Unit-2:
Percentages - Gain and loss percents - Partnership problems.
Unit-3: Time, Distance and Work:
Time and work – Time and distance.
Unit-4: Commercial Arithmetic:
Simple interest - Compound interest – Stocks and Shares.
Unit -5: Data Interpretation:
Tabulation – Bar graphs and Pie charts – Line Graphs.

Text Book:
R.S. Agarwal, Content and treatment as in the book Quantitative Aptitude, S. Chand & Co, New Delhi, 2015.

  Unit – I  Sections 1.8 and 1.12
  Unit – II Sections 1.10, 1.11 and 1.13
  Unit – III Sections 1.15 and 1.17
  Unit – IV Sections 1.21, 1.22 and 1.29
  Unit – V  Sections 2.36 to 2.38
Supplementary Reading:

Course Outcome:
By the end of the course, students will be able to face the Mathematics part of competitive examinations easily.