Annamalai University

(Accredited with 'A' Grade by NAAC)

M.Sc. Mathematics (Two-Year) Programme

Regulations & Curriculum-2019

DST-FIST Assisted

Department of Mathematics

ANNAMALAI UNIVERSITY

REGULATIONS FOR THE TWO-YEAR POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

These Regulations are common to all the students admitted to the Two-Year Master's Programmes in the Faculties of Arts, Science, Indian Languages, Education, Marine Sciences, and Fine Arts from the academic year 2019-2020 onwards.

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.

1.17 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.

1.18 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.

1.19 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.

1.20 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

1.21 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.

1.22 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.

2. Programme Offered and Eligibility Criteria

The Department of Mathematics offers a Two Year M.Sc. Mathematics Programme.

Faculty of Science	
M.Sc. Mathematics	A pass in B.Sc. (Mathematics) with not less than 50% of marks in Part–III.

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

3. Reservation Policy

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

4. Programme Duration

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

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

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

5 Programme Structure

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

5.2 Core courses

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

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

5.3 Elective courses

5.3.1 **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:

	Credits
Core Courses	65-75
Elective Courses	15
Project	6-8
Total (Minimum requirement for award of Degree)	**90-95***

**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:

	Marks
Test-I & Test-II	15
Seminar	05
Assignment	05
Total	25

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

	Marks
Test-I	15
Test-II	15
Viva-voce and Record	10
Total	40

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:

Continuous Internal Assessment (25 Marks)		End Semester Examination (75 Marks)	
Review-I 10	Review-II: 15	Project / Dissertation Evaluation	Viva-voce
		50	25

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.

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

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.

m is the number of semesters

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

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

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)

Course Code	Course Title	Hours/ Week		C	Marks		
		L	P		CIA	ESE	Total
Semester-I							
19MATC101	Core 1: Advanced Abstract Algebra I	5		5	25	75	100
19MATC102	Core 2: Advanced Real Analysis	5		5	25	75	100
19MATC103	Core 3: Advanced Differential Equations	5		5	25	75	100
19MATC104	Core 4: Differential Geometry	5		5	25	75	100
	Elective 1: Interdepartmental Elective	3		3	25	75	100
				23			
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
				23			
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
				23			
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
				26			
	Total Credits			**95**			
	Value Added Courses						

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)

S. No.	Course Code	Course Title	hours/ week		C	Marks		
			L	P		CIA	ESE	Total
1.	19MAT206-1	Programming Language C++	3	0	3	25	75	100
2.	19MAT306-1	Number Theory	3	0	3	25	75	100
3.	19MAT306-2	Fuzzy Sets and their Applications	3	0	3	25	75	100

Interdepartmental Electives (IDE)

S. No.	Course Code	Course Title	Department	Hours/ week		C	Marks		
				L	P		CIA	ESE	Total
1.	19 SOSE 115.1	Soft Skills	English	3	0	3	25	75	100
2.	19 MATE 215.1	Discrete Mathematics	Mathematics	3	0	3	25	75	100
3.	19 MATE 215.2	Numerical Methods		3	0	3	25	75	100
4.	19 MATE 215.3	Statistical Computing		3	0	3	25	75	100
5.	19 MATE 315.1	Differential Equations		3	0	3	25	75	100
6.	19 STSE 215.1	Statistical Methods	Statistics	3	0	3	25	75	100
7.	19 STSE 215.2	Mathematical Statistics		3	0	3	25	75	100
8.	19 STSE 315.1	Bio-Statistics		3	0	3	25	75	100
9.	19 PHYE 215.1	Classical Mechanics and Special Theory of Relativity	Physics	3	0	3	25	75	100
10.	19 PHYE 215.2	Physics of the Earth		3	0	3	25	75	100
11.	19 PHYE 315.1	Bio-Medical Instrumentation		3	0	3	25	75	100
12.	19 PHYE 315.2	Energy Physics		3	0	3	25	75	100
13.	19 BOTE 215.1	Plant Tissue Culture	Botany	3	0	3	25	75	100
14.	19 BOTE 215.2	Plant Science – I		3	0	3	25	75	100
15.	19 BOTE 315.1	Gardening and Horticulture		3	0	3	25	75	100
16.	19 BOTE 315.2	Plant Science – II		3	0	3	25	75	100
17.	19 ZOOE 215.1	Animal Culture Techniques	Zoology	3	0	3	25	75	100
18.	19 ZOOE 315.1	Environmental Science		3	0	3	25	75	100
19.	19 GEOE 215.1	Environmental Geosciences	Earth Sciences	3	0	3	25	75	100
20.	19 GEOE 315.1	Applied Geophysics		3	0	3	25	75	100

21.	19 BIOE 215.1	Basic Biochemistry	Biochemistry & Biotechnology	3	0	3	25	75	100
22.	19 BIOE 215.2	Basic Biotechnology		3	0	3	25	75	100
23.	19 BIOE 315.1	Biochemical Techniques		3	0	3	25	75	100
24.	19 BIOE 315.2	Immunology		3	0	3	25	75	100
25.	19 MIBE 315.1	Microbiology	Microbiology	3	0	3	25	75	100
26.	19 CISE 215.1	R Programming	Computer & Information Science	3	0	3	25	75	100

Electives Offered to Other Departments

S. No.	Course Code	Course Title	Hours/ week		C	Marks		
			L	P		CIA	ESE	Total
1.	19 MATE 215.1	Discrete Mathematics	3	0	3	25	75	100
2.	19 MATE 215.2	Numerical Methods	3	0	3	25	75	100
3.	19 MATE 315.1	Differential Equations	3	0	3	25	75	100

Value Added Course

Course Code	Course Title	Hours/ week		C	Marks		
		L	P		CIA	ESE	Total
VAC	Mathematics for Competitive Examinations	3	0	3	25	75	100

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”.

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. Homomorphsims 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:
David S. Dummit and Richard M. Foote, Abstract Algebra (Third Edition), Wiley Student Edition, 2004.
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:
1. I.N. Herstein, John Wiley & Sons,Topics in Algebra (Second Edition), New Delhi, Third Reprint 2007.
2. N. Jacobson, D. Van Nostrand Co., Lectures in Abstract Algebra Vol. I, New York, 1951.
3. M. Anderson and T. Feil, A First Course in Abstract Algebra – Rings, Groups, and Fields, Chapman & Hall/CRC, 2005.
4. M. Artin, Algebra, Pearson, 2015.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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:
Tom. M. Apostol, Contents and treatment as in the book Mathematical Analysis, Narosa Publishing House, (Second Edition), New Delhi, 1974.

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:

1. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill International Book Company, New Delhi, 2013 Edition.
2. S.C. Malik and S. Arora, Mathematical Analysis, Wiley Eastern Ltd., New Delhi, 1991.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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:

1. E.A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1987.
   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]
2. S. Sankar Rao, Introduction to Partial Differential Equations, 2nd Edition, Prentice Hall of India, New Delhi, 2005.
   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:

1. George F. Simmons, Differential equations with applications and historical notes, Tata McGraw Hill Publishing Company, (second edition), 2004, New Delhi.
2. F.B. Hildebrand, Advanced calculus for applications, Prentice - Hall. Inc, 1976.
3. I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, New Delhi, 2006.
4. M.D. Raisinghania, Advanced Differential Equations, S.Chand & Company Ltd., New Delhi, 2001.
5. A.C.King, J.Billingham and S.R.Otto, Differential equations, Cambridge University Press, 2006.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

Semester-I **19MATC104: Differential Geometry** **Credits: 5**
Hours: 5

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:
T.J. Willmore, Content and treatment as in the book An Introduction to Differential Geometry, Oxford University Press, New Delhi, 1959.
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:
1. D.T. Struik, Lectures on Classical Differential Geometry, Addison-Wesley Press, 1950.
2. Andrew Pressley, Elementary Differential Geometry, Springer, 2001.
3. Heinrich W. Guggenheimer, Differential Geometry, Dover publications, Inc., New York, 1977.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

Semester-II **19MATC201: Advanced Abstract Algebra – II** **Credits: 5**
Hours: 5

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:

David S. Dummit and Richard M. Foote, Abstract Algebra, (Third Edition), Wiley Student Edition (2004).
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:
1. I.N. Herstein, Topics in Algebra, John Wiley & Sons (Second Edition), New Delhi, Third Reprint 2007.
2. N. Jacobson, Lectures in Abstract Algebra, Vol. I D. Van Nostrand Co., New York, 1951.
3. M. Anderson and T. Feil, A First Course in Abstract Algebra – Rings, Groups, and Fields, Chapman & Hall/CRC, 2005.
4. M. Artin, Algebra, Pearson, 2015.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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:
Lp spaces, Convex functions, Jensen's inequality, The inequalities of Holder and Minkowski, Completeness of Lp (μ).

Text Book:
G. de Barra , Contents and treatment as in the book Measure Theory and Integration, New Age International Publishers, 2005.
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:
1. Royden, Real Analysis, MacMillan Publishing Company, New York, 1968.
2. V. Ganapathy Iyer, Mathematical Analysis, Tata McGraw Hill Publication Co. Ltd., New Delhi,1977.
3. P.R. Halmos, Measure Theory, Van Nostrand Princeton, New Jersey, 1950.
4. Michael E. Taylor, Measure Theory and Integration by Graduate Studies in Mathematics, Volume 76, American Mathematical Society, Indian Edition, 2006.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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:
Removable Singularities, Taylor's theorem, Zeros and poles, The Local Mapping and The Maximum Principle.
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:
Weierstrass's Theorem, The Taylor series, The Laurent Series.
Unit–4: Partial Fractions and Factorization:
Partial fractions, Infinite products and Canonical products.
Normal Families:
Equicontinuity, Normality and Compactness, Arzela's Theorem, Families of Analytic Functions, The classical definition.
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:

L.V. Ahlfors, Content and treatment as in the book Complex Analysis, (Third edition), McGraw Hill Inc., New Delhi, 2014.

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:

1. J.B. Conway, Functions of One Complex Variable by Springer-Verlag, 1973.
2. H. Silverman, Complex Variables, Hughton Miffin Company,1975.
3. S. Ponnusamy, Foundations of Complex Analysis, (Second edition), Narosa, 2005.
4. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, McGraw Hill Education (India) Edition 2014.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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 Fibonocci 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:

1. Hamdy A. TAHA, Operations Research – An Introduction by Macmillan Publishing Company, New York, 2014.

2. Ivan Niven, Herbert S.Zuckerman and Hugh L. Montgomery, An Introduction to the theory of Numbers, Wiley, New Delhi, 2015.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, New Delhi, 40th Edition, 2014.

Supplementary Reading:
Premkumar Gupta and D.S.Hira S.Chand, Operations Research, New Delhi,2016.

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

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	✓	✓	-	-	-	✓	✓	✓	✓	✓

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 $X \times Y$.
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:
James R. Munkres, Content and treatment as in the book Topology, Prentice Hall of India, (Second edition), New Delhi, 2000.
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:

1. S.T. Hu, Elements of General topology, Holden-Day Inc, San Francisco, 1964.
2. J.G. Hocking and G.S. Young, Topology, Addison-Wesley Pub. Com, 1961.
3. G.F. Simmons, Introduction to Topology and Modern analysis, McGraw Hill International Edition, Singapore, 1963.
4. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing house, 2005.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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

Systems of linear Equations – Matrices and Elementary Row operations – Row-Reduced echelon Matrices – Matrix Multiplication – Invertible Matrices - Vector spaces – Subspaces – Bases and Dimension – Computations concerning Subspaces.

Unit-2: Linear Transformations

The algebra of linear transformations – Isomorphism of Vector Spaces – Representations of Linear Transformations by Matrices - Linear Functionals - The Double Dual – The Transpose of a Linear Transformation.

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)

Simultaneous triangulation and simultaneous Diagonalization – Direct-sum Decompositions - Invariant Direct sums – The Primary Decomposition Theorem.

Text Book:
Kenneth Hoffman and Ray Kunze, Linear Algebra, Second Edition, Prentice – Hall of India Private Limited, New Delhi ,1971.
Chapters 1 to 3, Chapter 5 (5.1 to 5.4) and Chapter 6.

Supplementary Reading:
1. I.N. Herstein,Topics in Algebra, John Wiley & Sons (Second Edition), New Delhi, Third Reprint, 2007.
2. Rao, A.R. and Bhimasankaram, P. , Linear Algebra, Second Edition, TRIM series 19, Hindustan Book Agency, 2000.
3. Charles W. Curtis, Linear Algebra – An Introductory Approach by Springer, 1984.
4. W. Keith Nicholson, Linear Algebra with Applications, Fifth Edition, Mc Graw Hill, 2006.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:
K.L. Chung, Content and treatment as in the book A Course in Probability Theory, Academic Press, Second Edition, 1974.

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:
1. B.R. Bhat, Modern Probability Theory, New Academic Science, UK, 2018.
2. Sheldon M. Ross, A first Course in probability, 8th Edition, Pearson Education, Ltd, London, 2010.
3. C.W. Burril, Measure, Integration and Probability, McGraw Hill. 1972.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:
i. Method of Bisection
ii. Method of Regula Falsi
iii. Newton's Method

2. Solution of Linear Equations:
i. Jacobi's Iterative Method
ii. Gauss-Seidal Iterative Method

3. Numerical Solution of Ordinary Differential Equations:
i. Euler's Method.
ii. Modified Euler's Method
iii. 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:

E.V. Krishnamoorthy and S.K. Sen, Content and treatment as in relevant sections of Numerical Algorithms, Affiliated East West Press Pvt. Ltd., (Second Edition), 1996.

Course Outcomes:

By the end of the course:

CO1: students will be able to gain knowledge between theory and practical.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	✓	✓	-	-	-	✓	✓	✓	✓	✓

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:

G.F. Simmons, Content and treatment as in the book Introduction to Topology and Modern Analysis, McGraw Hill Book Company, 2015.

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:

1. B.V. Limaye ,Functional Analysis, Prentice - Hall of India, New Delhi, 1996.
2. Bachmann and Narishi, Functional Analysis, Academic Press, 2000.
3. Karen Saxe, Beginning Functional Analysis, Springer, 2002.
4. C. Goffman and G. Padrick, A First Course in Functional Analysis by Chelsea Pub.,1974.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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 sophisticaition 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:

Introduction, Specification of Stochastic Processes, Stationary Process, Martingales.
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: Poisson Process and its Extensions:
Poisson Process, Poisson Process and Related Distributions, Generalization of Poisson Process, Birth and Death Process, Markov Process with Discrete State Space (Continuous Time Markov Chains).

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

Markov Chains with Continuous State Space, Introduction, Brownian Motion, Wiener Process, Differential Equations for a Wiener Process, Kolmogorov Equations, First Passage Time Distribution for Wiener Process.

Unit-5: Renewal Processes and Theory:

Renewal Process, Renewal Processes in Continuous Time, Renewal Equation, Stopping time: Wald's Equation, Renewal Theorems, Delayed and Equilibrium Renewal Processes.

Text Book:

J. Medhi, Content and treatment as in the book Stochastic Processes, New Age International (P) Limited, Publishers, New Delhi, (Second Edition), 1994.

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:

1. S. Karlin and H.M. Taylor, A First Course in Stochastic Processes, Academic Press (second edition), New York, 2011.

2. S.M. Ross, Stochastic Processes, Wiley India Pvt., Ltd., 2nd Edition, 2008.

Course Outcomes:

By the end of the course, students will be able to gains

CO1: working knowledge related to the problems of uncertainty.

CO2: a basic knowledge for doing research in this area.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:

Introduction – Sources – Sinks and doublets – Images in rigid infinite plane – Axis symmetric flows – Stokes stream function.

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:

Viscous flows – Stress components in a real fluid –Relation between Cartesian components of stress – Translation motion of fluid elements – The rate of strain quadric and principle stresses – Further properties of the rate of strain quadric – Stress analysis in fluid motion – Relation between stress and rate of strain – The coefficients of viscosity and Laminar flow – The Navier – Stokes equations of motion of a viscous fluid.

Text Book:

F. Chorlton, Content and treatment as in the book Fluid Dynamics, CBS Publication, New Delhi, 1985.

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:

1. G.K. Batchaelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.
2. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Pvt. Ltd., New Delhi, 1976.
3. R.K. Rathy, An Introduction to Fluid Dynamics, IBH Publ. Comp. New Delhi, 1976.
4. Pijush K. Kundu, Ira M. Cohen and David R. Dowling, Fluid Mechanics, Fifth Edition, 2010.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:

Graphs – Subgraphs – Degrees of vertices – Paths and connectedness – Automorphism of a simple graph, Line Graphs.

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:

Vertex Colorings – Critical Graphs – Brooks' Theorem.

Edge Colorings of Graphs – Vizing's Theorem – Chromatic Polynomials.

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:

R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory (Universitext), Second Edition, Springer, New York, 2012.

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:

1. J.A. Bondy and U.S.R. Murty, Graph Theory, Springer 2008.
2. Douglas B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi-2011.
3. G. Chartrand, Linda Lesniak and Ping Zhang, Graphs and Digraphs, Fifth Edition, CRC press 2011.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:

Calculus 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:

Integral Equations: Introduction – Relations between differential and integral equations – The Green's function – Alternative definition of the Green's function.

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: Sections3 .1 to 3.4
Unit IV: Chapter 3: Sections3.5 to 3.7
Unit V: Chapter 3: Sections3.8 to 3.9 and 3.11

Supplementary Reading:
1. Ram.P.Kanwal, Linear Integral Equations Theory and Practice, Academic Press 1971.
2. L.Elsgolts, Differential equations and the calculus of variations, University Press of the Pacific, 2003.
3. S.J.Mikhlin, Linear Integral Equations (translated from Russian), Hindustan Book Agency, 1960.
4. I.N.Snedden, Mixed Boundary Value Problems in Potential Theory, North Holland, 1966.
5. Lev D. Elsgole, Calculus of Variations, Dover Publications Inc, New York 2007.
6. Integral Equations and their Applications, M.Rahman WIT Press, Boston, 2007.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:
Basic Program Construction: Functions, Program Statements, White Space. Output Using Cout: String Constants. Preprocessor Directives: The # include Directive, Header Files. Comments: Comment Syntax, When to Use Comments, Alternative Comment Syntax. Integer variables: Defining Integer Variables, Declarations and Definitions, Variable Names, Assignment Statement, Integer Constants, Output variations. Character Variables: Character Constants, Initialization, Escape Sequences. Input with Cin: Variables Defined at Point of Use, Cascading, Expressions, Precedence. Type float: Floating-Point Constants, The Const Qualifier, The # define Directive. Manipulators: The end L Manipulator, The set W Manipulator, Type Long, Cascading the Insertion Operator, Multiple definitions, The IOMANIP.H Header File. Variable Type Summary: Unsigned data types. Type Conversion: Automatic Conversions, Casts. Arithmetic operators:

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:
Relational operators. Loops: The for Loop, Using Turbo C++ Debugging Features, for Loop Variations, The while Loop, Precedence: Arithmetic and Relational Operators, The do loop, When to Use Which Loop. Decisions: The if Statement, The if...else Statement, The else...if Construction, The Switch Statement. The Conditional Operator. Logical Operators: Logical OR Operator, Logical AND Operator, The Logical NOT Operator, Precedence Summary, Other Control Statements, The break Statement, The continue Statement, The GOTO Statement.

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

Functions:

Simple Functions: The Function Declaration, Calling the Function, The Function Definition, Comparison with Library Functions, Eliminating the Declaration. Passing Arguments to Functions: Passing Constants, Passing Variables, Passing by Value, Passing Structure Variables, Names in the Declaration. Returning Values from Functions: The return Statement, Returning structure Variables. Reference Arguments: Passing Simple Data Types by Reference. Overloaded Functions: Different Numbers of Arguments, Different Kinds of Arguments. Inline Functions: Default Arguments, Variables and Storage Classes: Automatic Variables, External Variables, Static Variables, Storage, Returning by Reference.

Unit-4: Arrays:
Array Fundamentals. Defining Arrays, Array Elements, Accessing Array Elements, Averaging Array Elements, Initializing Arrays, Multidimensional Arrays, Passing Arrays to Functions, Arrays of Structures. String: Variables, Avoiding Buffer Overflow, String Constants, Reading Embedded Blanks, Reading Multiple Lines, Copying a String the Hard Way, Copying a String the Easy Way, Arrays of Strings, Strings as Class Members, A User-Defined String Type.

Unit-5: Pointers:
Addresses and Pointers, The Address of Operator & Pointer Variables, Accessing the Variable Pointed To, Pointer to void. Pointers and Arrays: Pointer Constants and Pointer Variables. Pointers and Functions: Passing Simple Variables, Passing arrays, Sorting Array Elements. Pointers and Strings: Pointers to String Constants, Strings as Function Arguments, Copying a String Using Pointers, Library String Functions, Arrays of Pointers to Strings.

Text Book:
Robert Lafore, Content and treatment as in the book Object-Oriented Programming in TURBO C++, Galgotia Publications Pvt. Ltd., New Delhi, 1996.

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

Supplementary Reading:
1. E. Balagurusamy, Programming in ANSI C by Tata McGraw Hill Publishing Ltd., (Seventh Edition), New Delhi, 2006.
2. A. N. Kanthane, Object Oriented Programming in ANSI & Turbo C++, Peason Education, New Delhi, 2006.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	✓	✓	-	-	-	✓	✓	✓	✓	✓

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
Divisibility, Primes, Congruences, Solutions of Congruences, The Chinese Remainder Theorem.
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:
Ivan Niven, H.S. Zuckerman and Hugh L. Montgomery, Contents and treatment as in the book An Introduction to the Theory of Numbers, Fifth Edition, Wiley Eastern Limited, New Delhi, 1991.

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:
1. Tom M. Apostal, Introduction to Analytic Number Theory, Narosa Pub. Company, New Delhi, 2013.
2. C.Y. Hsiung, Elementary Theory of Numbers, World Scientific, Singapore, 1995.
3. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers, Clarendon Press, (Fourth edition), 1989.

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
- Algebric numbers.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	-

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 α**-** Cuts.
Unit-2: Fuzzy Sets Versus CRISP Sets:
Representation of Fuzzy sets – Extension principle of Fuzzy sets – Operation on Fuzzy Sets – Types of Operation – Fuzzy complements.
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:
G.J. Klir and Bo Yuan, Content and treatment as in the book Fuzzy Sets and fuzzy Logic: Theory and Applications, Prentice Hall of India Ltd., New Delhi, 2005.
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:
1. H.J. Zimmermann, Fuzzy Set Theory and its Applications, Allied Publishers, Chennai, 1996.
2. A. Kaufman, Introduction to the Theory of Fuzzy Subsets, Academic Press, New York, 1975.
3. V.Novak, Fuzzy Sets and Their Applications, Adam Hilger, Bristol, 1969.

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,
- α cuts,
- operations on fuzzy sets,
- extension principles,
- fuzzy norms,
- lattice of fuzzy numbers.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:
Partially Ordered Sets, Extremal Elements of Partially Ordered Sets, Lattice, Finite Boolean Algebras, Functions on Boolean Algebra, Circuit Designs.

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

Text Book:
Bernard Kolman, Robert C. Busby and Sharon Cutler Ross, Content and treatment as in the book Discrete Mathematical Structures, Prentice - Hall of India, Private Limited, New Delhi, 2002.

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:

1. E.G. Goodaire and M.M. Paramenter, Discrete Mathematics with Graph Theory, Prentice Hall International Editions, New Jersey (1998).
2. J. Matonsek and J. Nesetril, Invitation to Discrete Mathematics by Clarendon Press, Oxford (1998).
3. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill Publication Company, 1997.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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

Learning Objective (LO): The roll 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:

Introduction, The Bolzano's bisection method, Method of successive Approximations or the iteration method, The method of false position (Regula Falsi Method), Newton's iteration Method (Newton - Raphson method).

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:

Euler's method, improved Euler method, modified Euler method, Runge-Kutta methods, Second order Runge-Kutta Method, Higher order Runge - Kutta method.

Text Book:
M.K. Venkataraman, Content and treatment as in the book Numerical Methods in Science and Engineering, The National Publishing Company, Madras, 1991.
Chapters - III, IV, VI, IX, XI.

Supplementary Reading:
1. S.S. Sastry, Introductory Methods of Numerical Analysis by Prentice Hall of India (P) Ltd. 1994.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Ltd., Third Edition, 1993.

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:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:
Bernoulli Equation – Exact Differential Equations – Equations Reducible to Exact Equations – Equations of First order and Higher degree: Equations solvable for p, Equation solvable for x and Equations Solvable for y – Clairaut's Equation.
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:
1. P.R. Vittal, Differential Equations, Fourier and Laplace Transforms, Margham publications, Second Edition, 1999.

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.

2. George F. Simmons, Differential equations with applications and historical notes, Tata McGraw Hill Pub. Co., New Delhi, Second Edition, 2003.
Unit V - Chapter 5 Sections 26 – 29

Supplementary Reading:

1. M.D. Raisinghania and R.S. Aggarwal, Ordinary and partial Differential equations, Sultan Chand and Company Ltd., 1983.
2. M.D. Raisinghania, Ordinary and Partial Differntial Equations, S. Chand, 2006
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publishers, [2002], New Delhi.

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.

Outcome Mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓	✓	✓

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:

1. Abhijit Guha, Quantitative Aptitude for Competitive Examinations, Tata McGraw –Hill Pub. Co. Ltd. New Delhi, IV Edn., 2011.
2. Edgar Thorpe, Course in Mental Abilities and Quantitative Aptitude for Competitive Examinations, Tata McGraw Hill Pub. Co. Ltd. New Delhi, II Edn., 2008.
3. RSN Pillai and A. Bagavathi, Statistic, S.Chand & Co., 7th Revised Edition, 2008.

Course Outcome:

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