SACRED HEART COLLEGE (AUTONOMOUS), THEVARA

KOCHI, KERALA, 682013

Syllabus of Courses

Under the discipline

MATHEMATICS

(For Undergraduate(Honours) Degree Programmes)

Introduced from 2024-25 admission onwards

Prepared by

Board of Studies in Mathematics

Sacred Heart College (Autonomous), Thevara, Kochi.

BOARD OF STUDIES IN MATHEMATICS
Sacred Heart College (Autonomous)
Thevara, Kochi, Kerala

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1. INTRODUCTION

The National Education Policy (NEP) 2020 envisages the revision of the Choice Based Credit System (CBCS) for instilling innovation and flexibility. It emphasizes on promoting interdisciplinary studies, introducing new subjects, and providing flexibility in courses and fresh opportunities for students. It also envisages setting up of facilitative norms for issues, such as credit transfer, equivalence etc., and a criterion-based grading system that assesses student achievement based on the learning goals for each programme.

The NEP document suggests several transformative initiatives in higher education. These include:

- Introduction of holistic and multidisciplinary undergraduate education that would help develop all capacities of human beings - intellectual, aesthetic, social, physical, emotional, ethical and moral - in an integrated manner; soft skills, such as complex problem solving, critical thinking, creative thinking, communication skills; and rigorous specialization in a chosen field(s) of learning.
- Adoption of flexible curricular structures in order to enable creative combinations of disciplinary areas for study in multidisciplinary contexts in addition to rigorous specialization in a subject
- Undergraduate degree programmes of either 3 or 4-year duration.
- The students are getting a chance to determine his/her own semester-wise academic load and will be allowed to learn at his/her pace, to the extent possible.
- Increase in the number of choices of courses available to students and the students are getting an opportunity to choose the courses of their interest from all disciplines.
- Multidisciplinary and holistic education with emphasizes on research, skill development and higher order thinking,
- Promotion of innovation and employability of the student.
- Flexibility for the students to move from one institution to another as per their choice.
- Flexibility to switch to alternative modes of learning (offline, ODL, and online learning, and hybrid modes of learning).

Outcome Based Education (OBE)

Undergraduate courses in Mathematics follow the Outcome-based Education (OBE) framework. OBE is a system where all the parts and aspects of education are focused on the outcomes of the course. The students take up courses with a certain goal of developing skills or gaining knowledge and they have to complete the goal by the end of the course. Outcome-based education affirms teachers as facilitators, rather than lecturers. In this model, teachers guide the students and encourage them to develop their knowledge and skills. The undergraduate courses at the Department of Mathematics, Sacred Heart College (Autonomous), Thevara provide a learning approach in which students develop analytical ability, critical thinking and research acumen over different situations.

Programme Outcomes:

The Undergraduate Programme Outcomes (POs) are as follows:

PO 1: Critical thinking and Analytical reasoning

- Critical thinking guides the assessment and judgment of information, while analytical reasoning involves specific methods for analysis and conclusion drawing. It includes the ability to assess evidence, identify assumptions, formulate coherent arguments, understand complex relationships, and evaluate practices and theories critically. Additionally, critical sensibility involves self-awareness and reflection on personal and societal experiences.

PO 2: Scientific reasoning and Problem solving

- Capacity to interpret and draw conclusions from data, critically evaluate ideas and evidence with an open-minded perspective; ability to apply learned competencies to solve unfamiliar problems and apply knowledge to real-life situations, avoiding mere replication of curriculum content.

PO 3: Effective communication and leadership skill

- Proficiency in expressing thoughts verbally and non-verbally, utilizing appropriate communication media. Confidently sharing ideas, active listening, analytical reading and writing and presenting complex information clearly to diverse groups. Effective teamwork and leadership skills, including setting direction, inspiring vision, building and motivating teams, and guiding them efficiently towards common goals.

PO 4: Social consciousness and responsible citizenship

- Social consciousness involves an empathetic and informed perspective, extending beyond personal concerns to embrace a responsibility for the collective good in nation-building. It includes reflecting on the impact of research on conventional practices and a clear understanding of societal needs for inclusive and sustainable development. Responsible citizens contribute positively through civic engagement, environmental stewardship, and a commitment to social justice, abiding by laws and working for the advancement of society.

PO 5: Equity, Inclusiveness and Sustainability

- Promoting equity, inclusiveness, sustainability, and diversity appreciation. Developing ethical and moral reasoning with values of unity, secularism, and national integration for dignified citizenship. Understanding and appreciating diversity, managing differences, and using an inclusive approach. Emphasizing creating environments where diverse individuals feel valued, addressing present needs without compromising future generations' ability to meet their own needs, considering environmental, economic, and social factors.

PO 6: Moral and Ethical Reasoning

- Possessing the capacity to embody moral and ethical values in personal conduct, articulating positions and arguments on ethical matters from diverse perspectives, and consistently applying ethical practices in all endeavours. Proficient in recognizing and addressing ethical issues pertinent to one's work, steadfastly steering clear of any unethical behaviour.

PO 7: Networking and Collaboration

- Cultivating networking skills in education entails establishing meaningful professional connections and relationships among educators, administrators, and stakeholders. It also involves fostering cooperative efforts among individuals, institutions, and research organizations within the educational realm. These practices are indispensable for nurturing a supportive, innovative, and dynamic learning environment.

PO 8: Lifelong Learning

- Cultivating the ability to continually acquire knowledge and skills, including the art of "learning how to learn," becomes paramount for lifelong learning. This self-paced and self-directed approach serves personal development, aligns with economic, social, and cultural objectives, and facilitates adaptation to evolving workplace demands through skill development and reskilling. It equips individuals with competencies and insights, allowing them to adeptly respond to society's changing landscape and enhance their overall quality of life. Lifelong learning extends beyond formal education, embracing diverse informal and non-traditional learning experiences.

2. REGULATIONS FOR UNDERGRADUATE (HONOURS) DEGREE PROGRAMMES

PREAMBLE

Sacred Heart College (Autonomous), Thevara, Kochi is a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala. The College was established in 1944 as a higher educational institute for men on the basis of minority rights. It started admitting girls in 1975 and currently serves all sections of society without any discrimination of caste or creed.

The College was granted Autonomous Status by the University Grants Commission (UGC) in 2014.

Vision and Mission of the Institution

The vision of the College aims at the formation of holistic individuals who would champion the cause of justice, love, truth and peace. To this effect, Sacred Heart College envisions the **"Fashioning of an enlightened society founded on a relentless pursuit of excellence, a secular outlook on life, a thirst for moral values as well as an unflinching faith in God."** It seeks the creation of a world, guided by divine wisdom, governed by moral principles, inclusive by secular outlook and united by the principle of equity.

The Mission of the Institution is to provide an environment that

- facilitates the holistic development of the individual
- enables the students to play a vital role in the nation-building process and contribute to the progress of humanity
- disseminates knowledge even beyond academia
- instils in the students a feel for the frontier disciplines, and
- cultivates a concern for the environment

by setting lofty standards in the ever-evolving teacher-learner interface.

Framing of the Regulations

As part of the implementation of the National Education Policy 2020 (NEP 2020), the University Grants Commission (UGC) has issued the Curriculum and Credit Framework for Undergraduate Programmes 2023 (CCFUP) which would provide a flexible choice-based credit system, multidisciplinary approach, multiple entry and exit options, and establish three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

The Kerala Higher Education Reforms Commission has recommended a comprehensive reform in the undergraduate curriculum for the 2023-24 academic year, adopting 4-year undergraduate programmes to bring Kerala's undergraduate education at par with well acclaimed universities across the globe.

The Kerala State Curriculum Committee for Higher Education has been constituted, and have proposed a model Kerala State Higher Education Curriculum Framework (KSHECF) for Undergraduate Education.

Further, an Academic Committee and various sub committees were constituted for the implementation of the Regulations. The Academic Committee submitted the draft regulations on 15-03-2024, namely**: THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)}** under the New Curriculum and Credit Framework, 2024.

REGULATIONS

Short Title and Commencement

i. These Regulations may be called THE SACRED HEART COLLEGE (AUTONOMOUS) UNDERGRADUATE PROGRAMMES (HONOURS) REGULATIONS, 2024 {SHC-UGP (Honours)} under the New Curriculum and Credit Framework 2024.
ii. These Regulations will come into effect from the academic year 2024-2025 and will have prospective effect.

Scope and Application

i. These Regulations shall apply to all Undergraduate programmes under various Faculties conducted by THE SACRED HEART COLLEGE (AUTONOMOUS) for the admissions commencing in the academic year 2024-2025.
ii. Every programme conducted under the SHC-UGP shall be monitored by an SHC-UGP Academic Committee comprising members nominated by the Principal.

Definitions

Unless used in a context otherwise specified,

i. College means THE SACRED HEART COLLEGE (Autonomous), a grant-in-aid private college affiliated to Mahatma Gandhi University, Kottayam, Kerala.
ii. 'University' means the MAHATMA GANDHI University which is the affiliating University of Sacred Heart College (Autonomous).
iii. FYUGP means Four Year Undergraduate Programme.
iv. Academic Year: Two consecutive (one odd and one even) semesters followed by a vacation in one academic year.
v. Academic Coordinator/Nodal Officer: Academic Coordinator/Nodal Officer is a faculty nominated by the college council to co-ordinate the effective conduct of the FYUGP including Continuous Comprehensive Assessment (CCA) undertaken by various departments within the college. She/ he/ they shall be the convenor for the College level Academic Committee.
vi. Academic Week: A unit of five working days in which the distribution of work is organized, with at least five contact hours of one-hour duration on each day.
vii. Academic Credit: A unit by which the course work is measured. It determines the number of hours of instructions required per week in a semester. It is defined both in terms of student efforts and teacher's efforts. A course which includes one hour of lecture or tutorial or minimum 2 hours of lab work/ practical work/ field work per week is given one credit hour. Accordingly, one credit is equivalent to one hour of lecture or tutorial or two hours of lab work/ practical work/ field work/ practicum and learner engagement in terms of

course related activities (such as seminars preparation, submitting assignments, group discussion, recognized club-related activities etc.) per week. Generally, a one credit course in a semester should be designed for 15 hours Lecture/ tutorials or 30 hours of practical/ field work/ practicum and 30 hours learner engagement.

viii. Academic Bank of Credits (ABC): An academic service mechanism as a digital/ virtual entity established and managed by Government of India to facilitate the learner to become its academic account holder and facilitating seamless learner mobility, between or within degree-granting Higher Education Institutions (HEIs) through a formal system of credit recognition, credit accumulation, credit transfers and credit redemption to promote distributed and flexible process of teaching and learning. This will facilitate the learner to choose their own learning path to attain a Degree/ Diploma/ Certificate, working on the principle of multiple entry and exit, keeping to the doctrine of anytime, anywhere, and any level of learning.

ix. Credit Accumulation: The facility created by ABC in the Academic Credit Bank Account (ABA) opened by the learner across the country in order to transfer and consolidate the credits earned by them by undergoing courses in any of the eligible HEIs.

x. Credit Recognition: The credits earned through eligible/ partnering HEIs and transferred directly to the ABC by the HEIs concerned.

xi. Credit Redemption: The process of commuting the accrued credits in the ABC of the learner for the purpose of fulfilling the credits requirements for the award of various degrees. Total credits necessary to fulfil the criteria to get a degree shall be debited and deleted from the account concerned upon collecting a degree by the learner.

xii. Credit Transfer: The mechanism by which the eligible HEIs registered with ABC are able to receive or provide prescribed credits to individual's registered with ABA in adherence to the UGC credit norms for the course(s) registered by the learner in any HEIs within India.

xiii. Credit Cap: Maximum number of credits that a student can take per semester, which is restricted to 30.

xiv. Continuous Comprehensive Assessment (CCA): The mechanism of evaluating the learner by the course faculty at the institutional level.

xv. End Semester Evaluation (ESE): The mechanism of evaluating the learner at the end of each semester.

xvi. Audit Course: a course that the learner can register without earning credits, and is not mandatory for completing the SHC-UGP. The student has the option not to take part in the CCA and ESE of the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is eligible for a pass in that course, without any credit (zero-credit).

xvii. Courses: refer to the papers which are taught and evaluated within a programme, which include lectures, tutorials, laboratory work, studio activity, field work, project work, vocational training, viva, seminars, term papers, presentations, assignments, self-study, group discussion, internship, etc., or a combination of some of these elements.

xviii. Choice Based Credit System (CBCS) means the system wherein students have the option to select courses from the prescribed list of courses.

xix. College-level Academic Committee: Is a committee constituted for the FYUGP at the college level comprising the Principal as the Chairperson, the Academic Co-ordinator/ Nodal Officer as its convenor.

xx. Academic Co-ordinator/ Nodal Officer: A senior faculty member nominated by the college council.

xxi. Course Faculty: A faculty member nominated by the Head of the Department shall be in charge of offering a particular course in a particular semester of FYUGP.

xxii. Department means any teaching department in a college offering a course of study approved by the College as per the regulations of the college and it includes a Department, Centre, or School of Teaching and Research conducted directly by the College.

xxiii. Board of Studies (BoS) means the academic body duly constituted to frame the syllabus of each department.

xxiv. Senior Faculty Advisor (SFA) is a faculty nominated by a Department Council to co-ordinate all the necessary work related to FYUGP undertaken in that department, including the continuous comprehensive assessment.

xxv. Department Council means the body of all teachers of a department in a college.

xxvi. Faculty Adviser (FA) means a teacher from the parent department nominated by the Department Council to advise students in academic matters.

xxvii. Graduate Attributes means the qualities and characteristics to be obtained by the graduates of a programme of study at the College, which include the learning outcomes related to the disciplinary areas in the chosen field of learning and generic learning outcomes. The College will specify graduate attributes for its programmes.

xxviii. Programme means the entire duration of the educational process including the evaluation leading to the award of a degree.

xxix. Programme Pathway: Combination of courses that can be chosen by a student that give options to pursue interesting and unconventional combinations of courses drawn from different disciplinary areas, like the sciences and the social sciences/ humanities. The pathways could be in terms of major- minor options with different complementary/ allied disciplines.

xxx. Regulatory Body means University Grants Commission (UGC), All India Council for Technical Education (AICTE), National Assessment and Accreditation Council (NAAC) and National Board of Accreditation (NBA) etc.

xxxi. Signature Courses: Signature courses are the specialized Discipline Specific Elective courses or skill-based courses designed and offered by the regular/ ad hoc/ visiting/ emeritus/ adjunct faculty member of a particular college with the prior recommendation of the BoS and the approval of Academic Council of the College.

xxxii. Letter Grade or simply 'Grade' in a course is a letter symbol (O, A+, A, B+, B, C, P, F, and Ab). Grade shall mean the prescribed alphabetical grade awarded to a student based on their performance in various examinations. The Letter grade that corresponds to a range of CGPA.

xxxiii. Grade Point: Each letter grade is assigned a 'Grade point' (G) which is an integer indicating the numerical equivalent of the broad level of performance of a student in each course. Grade Point means point given to a letter grade on 10-point scale.

xxxiv. Semester Grade Point Average (SGPA) is the value obtained by dividing the sum of credit points obtained by a student in the various courses taken in a semester by the total number of credits in that semester. SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

xxxv. Credit Point (P) of a course is the value obtained by multiplying the grade point (G) by the credit (C) of the course: P = G x C

xxxvi. Cumulative Grade Point Average (CGPA) is the value obtained by dividing the sum of credit points in all the semesters earned by the student for the entire programme by the total number of credits in the entire programme and shall be rounded off to two decimal places.

xxxvii. Grade Card means the printed record of students' performance, awarded to them.

xxxviii. Words and expressions used and not defined in this regulation, but defined in the Mahatma Gandhi University Act and Statutes, being the Act and Statues of Sacred Heart College (Autonomous)'s affiliating University shall have the meaning assigned to them in the Act and Statutes.

Features and Objectives of SHC-UGP

The features and objectives of the SHC-UGP shall be:

i. The features, meaning, and purpose of FYUGP shall be as stipulated by the UGC and as adapted by the Kerala State Higher Education Curriculum Framework (KSHECF) for undergraduate education.

ii. The practice of lateral entry of students to various semesters exists, but an exit with a Degree shall be awarded only upon successful completion of 133 credits as per the conditions stipulated in this regulation.

iii. FYUGP shall have three Broad Pathways, (a) 3-year UG Degree, (b) 4-year UG Degree (Honours), and (c) 4-year UG Degree (Honours with Research).

iv. Students who choose to exit after 3 years shall be awarded UG Degree in their respective Discipline/ Disciplines after the successful completion of the required minimum Courses with 133 credits.

v. A 4-year UG Degree (Honours) in the Discipline/ Disciplines shall be awarded to those who complete the FYUGP with a specific number of Courses with 177 credits including 8 credits from a graduate project/ dissertation in their major discipline.

vi. Students who acquire minimum 75% in their graduation (upto 6th semester) are eligible for Honours with Research Programme. However if necessary, College may conduct screening test for the honours with research programme in accordance with College Regulations from time to time.

vii. 4-year UG Degree (Honours with Research): Students who aspire to pursue research as a career may opt for 4-year UG Degree Honours with Research stream under FYUGP with a specific number of Courses with 177 credits including 12 credits from a research project in their major discipline.

viii. The recognized research departments or departments with at least two faculty members having PhD shall offer the Honours with Research programme. Minimum 2 students (mentees) should be allotted to a faculty member (Mentor).

ix. Students who have chosen the honours with research stream shall do their entire fourth year under the mentorship of a mentor.

x. The mentor shall prescribe suitable advanced level/capstone level courses for a minimum of 20 credits to be taken within the institutions along with the courses on research methodology, research ethics, and research topic-specific courses for a minimum of 12 credits which may be obtained either within the institution or from other recognized institutions, including online and blended modes.

xi. Students who have opted for the honours with research should successfully complete a research project under the guidance of the mentor and should submit a research report for evaluation. They need to defend successfully the research project to obtain 12 credits under a faculty member of the College. The research shall be in the Major/ allied discipline.

xii. The research outcomes of their project work may be published in peer-reviewed journals or presented at conferences or seminars or patented.

xiii. The proposed FYUGP curriculum comprises Three Broad Parts: a) Foundation Components, b) Discipline Specific Pathway components (Major/ Minor), and c) Discipline Specific Capstone Components.

xiv. The Foundation component of the FYUGP shall consist of a Set of General Foundation Courses and a Set of Discipline Specific Foundation Courses.

xv. General Foundation Courses shall be grouped into 4 major baskets as Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC), Value Addition Courses (VAC), and Multi-Disciplinary Courses (MDC).

xvi. Ability Enhancement Courses shall be designed specifically to achieve competency in English, other languages as per the student's choice with special emphasis on language and communication skills.

xvii. English or other language courses shall be designed to enable the students to acquire and demonstrate the core linguistic skills, including critical reading, academic and expository writing skills as well as the cultural and intellectual heritage of the language chosen. Separate courses will be designed for Science, Humanities and Commerce streams.

xviii. Multi-Disciplinary Courses (MDC) shall be so designed as to enable the students to broaden their intellectual experience by understanding the conceptual foundations of Science, Social Sciences, Humanities, and Liberal Arts. Students shall not be eligible to take the MDC in the same discipline that they have studied during their +2. Third semester MDC can be Kerala specific content.

xix. Skill Enhancement Courses (SEC) shall be designed to enhance 21st century workplace skills such as creativity, critical thinking, communication, and collaboration.

xx. Discipline Specific Courses shall include Discipline Specific Pathway Courses, both Major and Minor streams, enabling students to gain basic knowledge in the chosen discipline.

xxi. Discipline Specific Foundation Courses shall focus on foundational theories, concepts, perspectives, principles, methods, and critical thinking essential for taking up advanced/ Capstone Courses. Practical courses shall be included in discipline specific foundation courses.

xxii. The curriculum of the SEC should be designed in a manner that at the end of year- 1, year-2, year-3, and year-4 students are able to meet the level descriptors for levels 5, 6, 7, and 8 of the UGC Guidelines on National Skills Qualifications Framework (NSQF). The detailed descriptors of the NSQF levels is provided as **Appendix I** below.

xxiii. Value Addition Courses (VAC) shall be so designed as to empower the students with personality development, perspective building, and self-awareness.

xxiv. Discipline Specific Pathway Components (Major/ Minor) shall provide the students with an opportunity to pursue in-depth study of a particular subject or discipline and develop competency in that chosen area, which includes Discipline Specific Core (DSC) courses and Discipline Specific Elective (DSE) courses as Major and Minor courses.

xxv. Major components consist of three types: Discipline Specific Core or the Discipline Specific Elective Courses, and the research /laboratory/ fieldwork.

xxvi. Minor Courses can be selected from any discipline that may supplement or complement the Major Courses.

xxvii. Students who complete a sufficient number of Courses in a discipline or an interdisciplinary area of study other than their chosen Major shall qualify for a Minor in that discipline or in a chosen interdisciplinary area of study.

xxviii. Major Components shall be the main focus of study. By selecting a Major, the student shall be provided with an opportunity to pursue an in-depth study of a particular discipline.

xxix. Each Board of Studies (BoS) shall identify specific Courses or baskets of Courses towards Minor Course credits. Students shall have the option to choose Courses from disciplinary/ interdisciplinary minors and skill-based courses related to a chosen programme.

xxx. Students can opt for a change of Major at the end of the second semester to any Minor discipline studied among the foundation level courses. Students also can opt for a change of Major at the end of the second semester to any MDC.

xxxi. Students should opt their 5th and 6th semester VAC and SEC from their Major disciplines only.

xxxii. Course cum Credits Certificate: After the successful completion of a semester as proof for re-entry to another institution this certificate is essential. This will help the learner for preserving the credits in the Academic Bank of Credits.

xxxiii. The Advanced Level/ Capstone Level Courses shall be designed in such a manner as to enable students to demonstrate their cumulative knowledge in their main field of study, which shall include advanced thematic specialization or internships or community engagement or services, vocational or professional training, or other kinds of work experience.

xxxiv. Advanced/ Capstone level Major Specialization shall include Courses focused on a specific area of study attached to a specific Major, which could be an Elective Course. They shall include research methodology as well.

xxxv. The student has the option to register for and attend a course without taking part in the CCA and ESE of that course. Such a course is called the Audit Course. If the student has 75% attendance in an Audit Course, he/she/they is/are eligible for a pass in that course, without any credit (zero-credit). The Audit Course will be recorded in the final grade card of the student.

xxxvi. All students shall undergo Summer Internship or Apprenticeship in a Firm, Industry or Organization; or Training in labs with faculty and researchers or other Higher Education Institutions (HEIs) or Research Institutions. The College will adhere to the guidelines on internship published by the University.

xxxvii. Students will be provided the opportunities for internships with local industries, business organizations, agriculture, health and allied sectors, Local Government institutions (such as panchayats, municipalities), State Planning Board, State Councils/ Boards, Research Institutions, Research Labs, Library, elected representatives to the parliament/ state assembly/ panchayat, media organizations, artists, crafts persons etc. These opportunities will enable the students to actively engage with the practical aspects of their learning and to improve their employability.

xxxviii. The College will provide opportunities for field-based learning/minor projects enabling them to understand the different socio-economic and development-related issues in rural and urban settings. The College will provide the students with opportunities for Community engagement and services, exposing them to socio-economic issues to facilitate theoretical learning in real-life contexts.

xxxix. Additional Credits will be awarded for those who actively participating in Social Activities, which may include participation in National Service Scheme (NSS), Sports and Games, Arts, participation in College union related activities (for respective elected/ nominated members), National Cadet Corps (NCC), adult education/ literacy initiatives, mentoring school students, and engaging in similar social service organizations that deemed appropriate to the College.

xl. Grace marks shall be awarded to a student for meritorious achievements in co-curricular activities (in Sports/ Arts/ NSS/ NCC etc.). Such a benefit is applicable in the same academic year spreading over two semesters, in which the said meritorious achievements are earned. The Academic Council will decide from time to time the eligibility and other rules of awarding the grace marks.

xli. Options will be made available for students to earn credit by completing quality- assured remote learning modes, including Online programmes offered on the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) or other Online Educational Platforms approved by the competent body/university from time to time.

xlii. Students shall be entitled to gain credits from courses offered by other recognized institutions directly as well as through distance learning.

xliii. For the effective operation of the FYUGP, a system of flexible academic transaction timings shall be implemented for the students and teachers.

Eligibility for Admission and Reservation of Seats

i. The eligibility for admissions and reservation of seats for various FYUG Degree Programmes shall be in accordance with the norms/ rules made by the Government/ University from time to time.

ii. No student shall be eligible for admission to FYUG Degree Programmes in any of the disciplines unless he/she/they has successfully completed the examination conducted by a Board/University at the +2 level of schooling or its equivalent.

iii. Students shall be admitted and enrolled in the respective programmes solely based on the availability of the academic and physical facilities within the institution. The College shall provide all students with a brochure detailing the Courses offered by the various departments under the various Programmes and the number of seats sanctioned by the University for each Programme.

iv. During the time of admission each student may be provided with a unique higher education student ID which may be linked with the Aadhar number of the student so that this ID can be transferred if required to other higher education institutions as well.

v. The students at the end of second semester may be permitted to change their major programme of study to any course/ institution/ university across the state. Based on the availability of seats and other facilities, the students may be permitted to opt any discipline which he/she/they had studied during the first two semesters as Discipline Specific

Foundation courses/ Multidisciplinary Foundation courses. If ranking is required it will be in the order of the highest-grade points secured in the discipline to which the switching of Major is sought.

vi. Students shall be allowed to change their major programmes, if required, to a maximum of 10% of the sanctioned strength of that particular programmes depending upon the academic and infrastructural facilities available in the Institution.

vii. Depending upon the availability of academic and infrastructural facilities, the College may also admit a certain number of students who are registered for particular programmes in each semester by transfer method, if required, from other Institutions subject to conditions as may be issued by the University.

viii. A student who has already successfully completed a First-Degree Programme and is desirous of and academically capable of pursuing another First-Degree Programme may also be admitted with the prior approval of the University as per the conditions regarding programme requirements specified by the University.

ix. A Student can also be admitted for an additional major/ second major/ additional minor and on completion of the required credits he/she/they can be awarded a second major/ additional major/ minor. He/she/they may be exempted from minor pathway and general foundation course requirement.

x. The College can also enroll students in certain courses as per their choice depending upon the availability of infrastructure and other academic facilities from other recognized HEIs who are already registered for a particular programme there either through regular/ online/ distance mode irrespective of the nature of programme (Govt./ Aided/ Self- finance/ Autonomous). On successful completion of the course the credits may be transferred through the Academic Bank of Credit.

Academic Monitoring and Student Support

The academic monitoring and student support shall be in the following manner, namely

i. The College shall appoint a Senior Faculty member as Academic Co-ordinator/ Nodal officer for the smooth conduct of FYUGP.

ii. Advisory System: There shall be one Senior Faculty Advisor (SFA) for each department and one Faculty Advisor (FA) for 20 to 30 students of the class to provide advice in all relevant matters. The Head of the Department, in consultation with the SFA, shall assign FA for each student.

iii. The documents regarding all academic activities of students in a class shall be kept under the custody of the FA/ SFA.

iv. All requests/ applications from a student or parent to higher offices are to be forwarded/ recommended by FA/ SFA.

v. Students shall first approach their FA/ SFA for all kinds of advice, clarifications, and permissions on academic matters.

vi. It is the official responsibility of the institution to provide the required guidance, clarifications, and advice to the students and parents strictly based on the prevailing academic regulations.

vii. The SFA shall arrange separate or combined meetings with FA, faculty members, parents, and students as and when required and discuss the academic progress of students.

viii. The FA/ SFA shall also offer guidance and help to solve the issues on academic and non-academic matters, including personal issues of the students.

ix. Regular advisory meetings shall be convened immediately after the commencement of the semester and immediately after announcing the marks of the Continuous Comprehensive Assessment (CCA).

x. The CCA related results shall be displayed on the department notice board/ other official digital platforms of the college at least for two working days.

a. Any concern raised by the students regarding CCA shall be looked into in the combined meetings of advisors, HOD, course faculty, and the students concerned.

b. If the concerns are not resolved at the advisor's level, the same can be referred to the properly constituted college-level grievance redressal committees as per the existing UGC/ University/ Government norms.

c. The Principal/ HOD shall ensure the proper redressal of the concerns raised by the students regarding CCA.

d. If the students raise further concerns about the issue, the principal shall refer the issue to the appropriate authorities with proper documents and minutes of all the committees.

xi. The FA/ SFA shall be the custodian of the minutes and action taken reports of the advisory meetings. The SFA shall get the minutes and action taken reports of advisory meetings approved by the Head of Department and the Principal.

xii. The Principal shall inform/forward all regulations, guidelines, communications, announcements, etc. regarding student academic and other matters to the HODs/ SFA for information and timely action.

xiii. It shall be the official responsibility of the Principal to extend the required administrative and financial support to the HODs, SFAs and FAs to arrange necessary orientation programmes for students regarding student counselling, the prevailing norms, regulations, guidelines and procedures on all academic and other related matters.

xiv. An integrated educational planning and administration software will be made available by the College to manage the academic information of all students including student admissions and registration, managing students' personal and academic information, course registrations, attendance management, all process related to assessments including regular & online examinations, grading, publishing of results, supplementary examinations, LMS, stakeholders' feedback, etc.

xv. Faculty, staff, students, and parents shall be allowed to access this software system over a highly secure authenticated mechanism from within the campus.

Course Registration

i. Each department shall publish well in advance the relevant details of courses offered, such as the name, academic level, expected outcomes, time slot, and course faculty members.

ii. Students shall be allowed to visit and interact with respective faculty members during the first week of each semester, to gather more information about the courses and the availability of seats.

iii. Based on consultations and advice from the faculty adviser, each student shall complete course registration within one week from the commencement of each semester.

iv. The number of credits that a student can take in a semester is governed by the provisions in these Regulations, subject to a minimum of 16 and a maximum of 30 Credits.

v. A student can opt out of a Course or Courses registered, subject to the minimum Credit/ Course requirement, if he/she/they feels that he/she/they has registered for more Courses than he/she/they can handle, within 30 days from the commencement of the semester.
vi. The college shall publish a list of the students registered for each course including audit course, if any, along with the chosen Programmes, repeat/ reappearance courses, if any.
vii. The higher education institutions shall admit candidates not only for programmes, but also for courses.

Re-admission and Scheme Migration

i. Students who opt out before the completion of the third year shall be provided with a 'Course cum Credits Certificate' after the successful completion of a semester as proof for re-entry to another institution.
ii. Students who have successfully completed a particular programme pathway may be permitted to take an additional minor or second major.
iii. Those students who are opting for a second major are eligible for getting certain credit transfer/ credit exemption from their previous minor programs of study, subject to the prior recommendation of the BoS that, those credits are relevant for the present major programme of study.

Duration of Programme, Credits, Requirements and Options

i. Students will be offered the opportunity to take breaks during the programme and resume after the break, but the total duration for completing the FYUG programme shall not exceed 7 years.
ii. Students who wish to complete the undergraduate programmes faster may do so by completing different courses equivalent to the required number of credits and fulfilling all other requirements in N-1 semesters, where N is the number of semesters in the FYUGP.
iii. Provided further that the students may complete the undergraduate programme in slower pace, they may pursue the three years or six semester programme in 4 to 5 years (8 to 10 semesters), and four years, or eight semester programme in 5 to 6 years (10 to 12 semesters) without obtaining readmission.
iv. For students who crossed 6 semesters at a slower space, the requirement of 16 credits per semester from the institutions where they enrolled may be relaxed.

Credit Structure

The proposed number of credits per course and the credit distribution of them for the FYUG Programmes are given below:

i. An academic year shall consist of 200 working days; one semester consists of 90 working days; and an academic year consists of two semesters.
ii. Ten working days in a semester shall be used for extracurricular activities. One semester consists of 18 weeks with 5 working days per week. In each semester, 15 days (3 weeks) should be kept aside for End Semester Evaluation (ESE) and CCA.
iii. The maximum number of available weeks for curriculum transactions should be fixed at 15 in each semester. A minimum of 5 teaching or tutorial hours could be made available for a day in a 5-day week.
iv. A course that includes one hour of lecture/ tutorial or two hours of lab work/ practical work/ field work/ practicum per week is given one credit hour.
v. One credit in a semester should be designed for 15 hours of lectures/ tutorials or 30 hours of lab work/ practical work/ field work/ practicum and 30 hours of learner engagement in terms of course-related activities such as seminar preparation, submitting assignments, etc.
vi. A one-credit seminar or internship or studio activities or field work/ projects or community engagement and service will have two-hour engagements per week (30 hours of engagement per semester).
vii. A course can have a combination of lecture credits, tutorial credits, and practicum credits.

viii. Minimum credit for one Course should be 2 (Two), and the maximum credit should be 4 (Four).
ix. All Discipline Specific Major/ Minor Courses shall be of 4 (Four) credits.
x. For all Discipline Specific Major/ Minor Courses, there may be practical/ practicum of two or four hours per week.
xi. All Courses under the Multi-Disciplinary, Ability Enhancement, Value Addition and Skill Enhancement categories are of 3 credits.
xii. Summer Internship, Apprenticeship, Community outreach activities, etc. may require sixty hours (or as appropriate) of engagement for acquiring one credit.
xiii. A student shall be able to opt for a certain number of extra credits over and above the requirements for the award of a degree.
xiv. Maximum number of credits that a student can earn per semester shall be restricted to 30. Hence, a student shall have the option of acquiring credits to a maximum of 180 credits for a 6-semester UG programmes and 240 credits for a 4-year (8-semester) programmes.
xv. Each faculty member shall offer a maximum of 16 credits per semester. However, those who are offering both practical and theory courses shall offer a maximum of 12-16 credits per semester.
xvi. For a four-credit theory course, 60 hours of lecture/ tutorial class shall be assured as a mandatory requirement for the completion of that course.

Course Structure of the SHC-UGP Programme

The SHC-UGP consists of the following categories of courses and the minimum credit requirements for pathway option-one shall be as follows;

Sl. No.	Categorization of Courses for all Programme	Minimum Number of Credit Required	
1.	Major	68	88
2.	Minor	24	24+12*
3.	Multi-Disciplinary Courses (MDC)	9	9
4.	Skill Enhancement Courses (SEC)	9	9
5.	Ability Enhancement Courses (AEC)	12	12
6.	Value Addition Courses (VAC)	9	9
7.	Summer Internship, field basedlearning etc.	2	2
8.	Research Project / Dissertation		12/8**

* The students can acquire advanced/ capstone level courses with 12 credits from their DSC/ DSE/ Minor courses depending up on their pathway choice. The Minor courses can be of level 300 or above.

** The students pursuing the 4-year honours with research have to complete a project with 12 credits and for the 4-year honours degree students have to complete a project with 8 credits and DSC/ DSE capstone/ advanced level course in the 8th semester.

i. 20% syllabus of each course will be prepared by the teacher as 'Teacher Specific Content' and will be evaluated under CCA.
ii. In case of MDC, SEC, VAC courses coming under 3rd & 4th semester, college should make necessary arrangements to give adequate preference to courses designed by language departments. MDC in the 3rd semester can be Kerala Specific Content.

Academic Levels of Pathway Courses

Semester	Difficulty level	Nature of Course
1 & 2	100-199	Foundation-level or introductory courses
3 & 4	200-299	Intermediate level courses
5 & 6	300-399	Higher level courses
7 & 8	400-499	Advanced/Capstone level courses

Signature Courses

i. With a prior recommendation of BoS and the approval of academic council, each faculty member can design and offer at least one signature course in every semester, which may be offered as DSE /SEC/ VAC.
ii. The College will publish a list of signature courses in DSE/ SEC/ VAC offered by the faculty members with a prior recommendation of BoS and the approval of academic council.
iii. The College may empanel distinguished individuals who have excelled in their field of specialization like science and technology, industry, commerce, social research, media, literature, fine arts, civil services etc. as adjunct faculty as per the UGC guidelines with the approval of the College. With a prior recommendation of BoS and the approval of academic council, the adjunct faculty can offer SEC/VAC as signature course.
iv. Ad hoc/ Guest faculty/ Visiting faculty/ Visiting Scholars can also offer DSE/ SEC/ VAC as signature courses with a prior recommendation of BoS and the approval of academic council.
v. The faculty concerned may design the particular course and it should be forwarded to the concerned BoS after the approval of the Academic Committees formed as part of this regulations.
vi. The examinations and evaluation of the signature courses designed by the faculty shall be conducted by the faculty themselves and an external expert faculty chosen by the college from a panel of experts submitted by the faculty and recommend by the BoS concerned.

Programme Pathways and Curriculum Structure

Students who have joined for any programme under these regulations shall have the option to choose the following pathways for their UG degree and Honours programme.

i. **Degree with single Major**: A student pursuing the FYUG programme in a specific discipline shall be awarded a Major degree if he secures at least 50% of the total credits in the specific discipline required for the award of the Degree in that Discipline. Example: Physics Major/ Economics Major/ Commerce Major
ii. **Degree Major with Minor**: If a student pursuing the FYUG Programme is awarded a Major Degree in a particular discipline, he/she/they are eligible to be awarded a Minor in another discipline of his choice, if he earns a minimum of 32 credits (approximately 25% of credit required for the three-year programme) from 8 pathway courses in that discipline. Example: Physics Major with Chemistry Minor/ Chemistry Major with English Minor/ Commerce Major with Economics Minor/ English Major with Functional English Minor/ Hindi Major with Malayalam Minor etc.

iii. **Major with Multiple Disciplines** of Study: This pathway is recommended for students who wish to develop core competencies in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/ subjects. If a student pursuing FYUG Degree Programme is awarded a major Degree in a particular discipline, he/she/they are eligible to get mentioned his core competencies in other disciplines of his choice if he has earned 12 credits from the pathway courses of that discipline. Example: Physics Major with Minors in Chemistry and Mathematics, Economics Major with Minors in History and English, Commerce Major with Minors in Economics and Statistics.

iv. **Interdisciplinary Major**: For these programme pathways, the credits for the major and minor pathways shall be distributed among the constituent disciplines/subjects to attain core competence in the interdisciplinary programme. Example: Econometrics Major, Global Studies Major, Biostatistics Major.

v. **Multi-Disciplinary Major**: For multidisciplinary major pathways, the credits for the major and minor pathways will be distributed among the broad disciplines such as Life Sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc. Example: Life Science, Data Science, Nano Science.

vi. **Degree with Double Major**: A student who secures a minimum of 50% credits from the first major will be awarded a second major in another discipline if he could secure 40% of credit from that discipline for the 3-year/ 4-year UG degree to be awarded a double major degree. Example: Physics and Chemistry Major, Economics and History Major, Economics and History Major, Commerce and Management Major.

Pathway Option 1 - Degree Major or Major with Multiple Disciplines of Study

Course Components	No. of Courses											
	Semester 1	**Semester 2**	**Semester 3**	**Semester 4**		**Semester 5#**	**Semester 6#**	**Total**	**Remarks**	**Semester 7**	**Semester 8**	**Total**
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		5	4	17	7 Out of 17 can be opted as DSE	3	2	22
DSC B & C (4 Credit /Course)	2(P)	2(P)	1(P) (B or C)	1(P) (C or B)				6		3		9
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC Aonly			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department ** From DSC Aonly			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC / DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

Internship of 2 Credits

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 2 - Major with Minor

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4	Internship of 2 Credits	Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1(P)	3 (2P)	3 (2P)		4	3	15	7 Out of 15 can be opted as DSE	3	2	20
DSC B (4 Credit /Course)	2(P)	2(P)	1(P)	1(P)		1	1	8	1 Out of 8 can be opted as DSE	3		11
Multidisciplinary Courses (MDC)/ (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1**	1**	3	*Recommended that the course may be offered by the English Department ** From DSC A only			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1**	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department ** From DSC Aonly			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC/ DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Pathway Option 3 - Double Major

Course Components	No. of Courses											
	Semester 1	Semester 2	Semester 3	Semester 4	Internship of 2 Credits	Semester 5#	Semester 6#	Total	Remarks	Semester 7	Semester 8	Total
DSC A (4 Credit /Course)	1(P)	1 (P)	2(2P)	2(1P)		4	3	13	7 Out of 13 can be opted as DSE	3	2	18
DSC B (4 Credit /Course)	2(P)	2(P)	2(1P)	2(2P)		1	1	10	2 Out of 10 can be opted as DSE	3		13
Multidisciplinary Courses (MDC) (3 Credit /Course)	1(P)	1(P)	1*					3	*Recommended that the course offered be related to Indian Knowledge Systems or allied areas.			3
Ability Enhancement Courses (AEC) (3 Credit /Course)	1 (English) 1 (OL)	1 (English) 1 (OL)						4				4
Skill Enhancement Courses (SEC) (3 Credit /Course)				1*		1	1	3	*Recommended that the course may be offered by the English Department			3
Value Addition Courses (VAC) (3 Credit /Course)			1*	1*			1	3	*Recommended that one VAC be offered by the English Department and one by Other Languages Department			3
Project/ Dissertation 12 credits for Honours with Research & 8 for Honours											**12/8 (1 DSC/ DSE for Honours**	
Total Courses	**6**	**6**	**6**	**6**		**6**	**6**	**36**		**6**	**2+1**	
Total Credits	**21**	**21**	**22**	**22**	**2**	**23**	**22**		**Total Credits 133**	**24**	**20**	**Total Credits 177**
Total Hours per Week	**25**	**25**	**25**	**25**		**25**	**25**		**Exit option available**	**25**	**25**	

BoS can include 2 practical courses in 5th semester and 3 practical courses in 6th semester in any of the 6 courses distributed in each semester.

Note: In all the above 3 tables "(P)" means courses with practical

Guidelines for Acquiring Credit from Other Institutions/Online/Distance Mode

i. A student shall register to a minimum of 16 credit per semester from the college/ department where he/she/they officially admitted for a particular programme. However, students enrolled for a particular programme in one institution can simultaneously enroll for additional credits from other HEIs within the University or outside University subject to a maximum of 30 credits per semester including the 16 institutional credits.
ii. The College shall publish a list of courses that are open for admission for students from other institutions well in advance before the commencement of each semester.
iii. Each BoS shall prepare and publish a list of online courses at different levels before the commencement of each semester offered in various online educational platforms recognized by the Academic Council of the college, which can be opted by the students for acquiring additional credits.
iv. BoS shall prepare and publish a list of allied/ relevant pathway courses before the commencement of each semester offered by other Board of Studies that can be considered as pathway course for major/ minor for their disciplines at different levels.
v. At the end of each semester the college will include the credit acquired by the student through online courses in their semester grade card subject to a maximum of 30 credits.

Attendance

i. A student shall be permitted to register for the end-semester evaluation of a specific course to acquire the credits only if he has completed 75% of the prescribed classroom activities in physical, online, or blended modes, including any makeup activities as specified by the course faculty of that particular course.
ii. A student is eligible for attendance as per the existing university and government orders which includes participation in a meeting, or events organized by the college or the university, a regularly scheduled curricular or extracurricular activity prescribed by the college or the university. Due to unavoidable or other legitimate circumstances such as illness, injury, family emergency, care-related responsibilities, bad or severe weather conditions, academic or career-related interviews students are eligible for authorized absence. Apart from this, all other eligible leaves such as maternity leave, and menstrual leave shall also be treated as authorized absences.
iii. The condonation facility can be availed as per the university norms.

Workload

i. The workload of a faculty who offers only lecture courses during an academic year shall be 32 credits.
ii. The workload of a faculty offering both practical courses and theory courses may be between 24-32 credits per academic year.
iii. An academic year shall consist of two semesters.
iv. To protect the existing language workload, college should make necessary arrangements to give adequate preference to those courses designed by language departments coming under MDC, SEC and VAC of 3rd & 4th semester. It is recommended that the MDC offered in the third semester shall be based on Indian Knowledge Systems or Nation-specific topics and may be offered by the Other Languages department or any other department as may be seen fit. Additionally, the SEC in the fourth semester may be offered by the English Department and of the VACs in the third and fourth semesters, one may be offered by the Other Languages Department and the other may be offered by the English Department. These recommendations may be modified as per the recommendations of the SHC-UGP Academic Monitoring Committee.
v. Programme wise workload calculation will be as per the FYUGP workload ordinance 2024.

vi. The teachers given the administrative responsibilities in the department and college level may give a relaxation in their work load as specified in the UGC regulations 2018.

Credit Transfer and Credit Accumulation

i. The college will establish a digital storage (DIGILOCKER) of academic credits for the credit accumulation and transfer in line with ABC.

ii. The validity of credits earned shall be for a maximum period of seven (7) years or as specified in the university/ UGC regulations.The students shall be required to earn at least 50% of the credits from the College.

iii. Students shall be required to earn the required number of credits as per any of the pathway structure specified in this regulation for the award of the degree.

Outcome Based Approach

The curriculum will be designed based on Outcome Based Education (OBE) practices. The Graduate Attributes (GA) and Programme Outcomes (PO) will be defined and specified in the syllabus of each programme.

Assessment and Evaluation

i. The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE).

ii. 30% weightage shall be given for CCA. The remaining 70% weight shall be for the ESE.

iii. Teacher Specific Content will be evaluated under CCA.

iv. CCA will have two subcomponents Formative Assessment (FA) and Summative Assessment (SA). Each of these components will have equal weightage and to be conducted by the course faculty/ course coordinator offering the course.

v. FA refers to a wide variety of methods that teachers use to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, module or course. FA is to encourage students to build on their strengths rather than fixate or dwell on their deficits. FA can help to clarify and calibrate learning expectations for both students. FA will help students become more aware of their learning needs, strengths, and interests so they can take greater responsibility over their own educational growth. FA will be prerogative of the course faculty/ course coordinator based on specific requirement of the student.

vi. Suggestive methods of FA are as follows: (anyone or in combinations as decided by the course faculty/ course coordinator)

a. Practical assignment
b. Observation of practical skills
c. Viva voce
d. Quiz
e. Interview
f. Oral presentations
g. Computerized adaptive testing
h. In-class discussions
i. Group tutorial work
j. Reflection writing assignments

k. Home assignments
l. Self and peer Assessments
m. Any other method as may be required for specific course/ student by the course faculty/ course coordinator.

vii. Summative Assessments (SA) are used to evaluate student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period- typically at the end of a project, unit, module, course or semester. SA may be a class tests, assignments, or project, used to determine whether students have learned what they were expected to learn. It will be based on evidence, collected using single or multiple ways of assessment. The systematically collected evidences should be kept in record by course faculty/ course coordinator and the marks should be displayed on the college notice board/ other official digital platforms of the college before the End Semester Evaluations.

viii. The method of SA will be as follows: (any one as decided by the course faculty/ course coordinator)

a. Written test
b. Open book test
c. Laboratory report
d. Problem based assignments
e. Individual project report
f. Case study report
g. Team project report
h. Literature survey
i. Standardized test
j. Any other pedagogic approach specifically designed for a particular course by the course faculty/ course coordinator.

ix. A student may repeat SA only if for any compulsive reason due to which the student could not attend the assessment.

x. The prerogative of arranging a CCA lies with the course faculty/ course coordinator with the approval of SHC-UGP Academic Committee based on justified reasons.

xi. The course faculty/ course coordinator shall be responsible for evaluating all the components of CCA. However, the college may involve any other person (External or Internal) for evaluation of any or all the components as decided by the Principal/Controller of Examinations from time to time in case any grievances are raised.

xii. Written tests shall be precisely designed using a variety of tools and processes (e.g., constructed responses, open-ended items, multiple-choice), and the students should be informed about the evaluation modalities before the commencement of the course.

xiii. The course faculty may provide options for students to improve their performance through continuous assessment mechanism.

xiv. There shall be theory and practical examinations at the end of each semester.

xv. Regarding evaluation, one credit may be evaluated for 25 marks in a semester; thus, a 4-credit course will be evaluated for 100 marks; 3-credit courses for 75 marks and 2-credit courses for 50 marks.

xvi. All examinations will be conducted by the College and will be evaluated at the College itself.

xvii. Individual Learning Plans (ILPs) and/ or specific assessment arrangements may be put in place for differently abled students. Suitable evaluation strategies including technology assisted examinations/ alternate examination strategies will be designed and implemented for differently abled students.

Practical Examination

i. The end semester practical examination will be conducted and evaluated by the institution.
ii. There shall be a CCA for practical courses conducted by the course faculty/ course coordinator.
iii. The scheme of evaluation of practical courses will be as given below:

Components for the Evaluation of Practical Courses	Weightage
CCA of practical/practicum.	30%
ESE of practical/practicum.	70%

iv. Those who have completed the CCA alone will be permitted to appear for the ESE.
v. For grievance redressal purpose, the university shall have the right to call for all the records of CCA.
vi. Duration of Examination: Questions shall be set as per the defined Outcome .The duration of the examinations shall be as follows.

Mode	Time (in Hours)
Written Examination	2
Multiple Choice	1.5
Open Book	2
Any Other Mode	2

Evaluation of Project/Dissertation

The evaluation of project work shall be CCA with 30% and ESE 70%. The scheme of evaluation of the Project is given below:

Project type	Maximum Marks	CCA	ESE
Research Project of Honours with Research (12 credits)	200	60	140
Project of Honours (8 credits)	100	30	70

Evaluation of Internship

The evaluation of internship shall be done by a committee constituted by the Department Council. The scheme of CCA and ESE is given below:

Components of Evaluation of Internship	Weightage	Marks for Internship2 Credits/ 50 Marks
CCA	30%	15
ESE	70%	35

The department council may decide any mode for the completion of the Internship. If in case evaluation is not specified in any of the selected internship programme, institution can adopt a proper evaluation method as per the weightage specified in the table above.

Letter Grades and Grade Points

Mark system is followed for evaluating each question. For each course in the semester, letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below,

i. The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the

current term, while the Cumulative Grade Point Average (CGPA) is based on the grades in all courses taken after joining the programme of study.

ii. Based on the marks obtained, the weighted grade point will be mentioned in the student's grade cards.

Letter Grade	Grade Point	Percentage of Marks (Both Internal & External Marks put together)	Class
O (Outstanding)	10	95% and above	First Class with Distinction
A+ (Excellent)	9	85% and above but below 95%	
A (Very good)	8	75% and above but below 85%	
B+ (Good)	7	65% and above but below 75%	First Class
B (Above average)	6	55% and above but below 65%	
C (Average)	5	45% and above but below 55%	Second Class
P (Pass)	4	35% and above below 45% Aggregate (external and internal put together) with a minimum of 30% in external	Third Class
F (Fail)	0	Below an aggregate of 35%or below 30% in external evaluation	Fail
Ab (Absent)	0		Fail

iii. When students take audit courses, they may be given pass (P) or fail (F) grade without any credits.

Computation of SGPA and CGPA

The following method is recommended to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

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

SGPA (Si) = Σ(Ci x Gi) / ΣCi

Where Si is the SGPA in the i^{th} semester, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

$$\textbf{SGPA} = \frac{\text{Sum of the credit points of all courses in a semester}}{\text{Total Credits in that Semester}}$$

Illustration – Computation of SGPA

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	DSC A	4	A	8	4 x 8 = 32
I	DSC B	4	B+	7	4 x 7 = 28
I	DSC C	4	B	6	4 x 6 = 24
I	MDC	3	B	6	3 x 6 = 18
I	AEC 1	3	O	10	3 x 10 = 30

I	AEC 2	3	C	5	3 x 5 = 15
	Total	21			147
	SGPA				147/21 = 7

The CGPA is also calculated in the same manner considering all the courses undergone by a student over all the semesters of a programme, i.e.

$$\textbf{CGPA} = \frac{\text{Sum of the credit points of all courses in six or eight semesters}}{\text{Total Credits in Six (133) or Eight (177) semesters}}$$

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

Implementation and Monitoring of SHC-UGP

i. The implementation and monitoring of SHC-UGP will be carried out by duly appointed bodies/committees of the college such as the Academic Council, the various Boards of Studies and the Academic Monitoring Committee.

ii. Academic Council

Among its other functions, the Academic Council of the College shall:

i. Scrutinize and approve all the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP details such as, academic pathways, allowed syllabi enrichment/ updating, details of elective courses, Online courses, blended teaching, courses offering to the students of other HEIs, panel of examiners, summative and formative evaluation tools proposed by the course faculty concerned, new courses and syllabus proposed by the faculty members as signature courses etc.
ii. The Academic Council can differ on any proposal and it shall have the right to return the matter for reconsideration to the Board of Studies concerned or reject it, after giving sufficient reasons to do so.
iii. Undertake the scrutiny of all documents related to Teacher Specific Content.
iv. Recommend to the College Governing Council for starting innovative programmes using the flexibility and holistic nature of the SHC-UGP curriculum frame work.

iii. Board of Studies

Among its other functions, the Board of Studies of each Department shall:

i. Prepare teacher specific content of syllabi for various courses keeping in view the objectives of the SHC-UGP and submit the same for the approval of the Academic Council.
ii. Scrutinize the signature course content and its evaluation techniques.
iii. Suggest methodologies for innovative teaching and evaluation techniques.
iv. Suggest panel of examiners to the Office of the Controller of Examinations.
v. Coordinate research, teaching, extension and other academic activities in the department.

iv. SHC-UGP Academic Monitoring Committee

The SHC-UGP Academic Monitoring Committee shall be constituted under the Chairmanship of the Principal, with the Academic Coordinator as the Convenor, shall be entrusted to oversee the implementation and monitoring of the SHC-UG programme.

i. The Academic Monitoring Committee will collect and whet the proposals submitted by the Board of Studies of each Department with regard to the SHC-UGP and duly forward them to the Academic Council.
ii. It will oversee and coordinate the activities undertaken for the successful implementation of SHC-UGP in the College and will function as an advisory body in such matters.

Power to Remove Difficulties

If any difficulty arises in giving effect to the provisions of these Regulations, the Principal may by order make such provisions which appears to him/her to be necessary or expedient for removing the difficulty. Every order made under this rule shall be subject to ratification by the appropriate authorities.

Modifications to the Regulations

Notwithstanding anything contained in these Regulations, any amendments or modifications issued or notified by the University Grants Commission or the State Government or the Mahatma Gandhi University from time to time, shall be incorporated into these Regulations by the appropriate regulatory bodies of the College and shall constitute an integral part thereof.

3. SYLLABUS INDEX

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
DISCIPLINE SPECIFIC COURSES (DSC)						
I	24UMATDSC101	Ground Roots of Mathematics	100-199	4	3	2
II	24UMATDSC102	Gateway to Mathematics	100-199	4	3	2
III	24UMATDSC201	Building Blocks for Higher Mathematics	200-299	4	3	2
	24UMATDSC202	Differential Equations	200-299	4	3	2
IV	24UMATDSC203	Foundations of Analysis and Algebra	200-299	4	3	2
V	24UMATDSC301	Algebra -I	300-399	4	3	2
	24UMATDSC302	Real Analysis- I	300-399	4	3	2
	24UMATDSC303	Linear Algebra- I	300-399	4	4	0
VI	24UMATDSC304	Real Analysis -II	300-399	4	3	2
	24UMATDSC305	Linear Algebra -II	300-399	4	4	0
VII	24UMATDSC401	Complex Analysis -II	400-499	4	4	0
	24UMATDSC402	Real Analysis -III	400-499	4	3	2
	24UMATDSC403	Algebra -III	400-499	4	4	0
	24UMATDSC404	Metric Space and Topology	400-499	4	4	0
	24UMATDSC405	Ordinary Differential equations	400-499	4	4	0
	24UMATDSC406	Combinatorics	400-499	4	4	0
VIII	24UMATDSC407	Complex Analysis 3	400-499	4	3	2
	24UMATDSC408	Basic Topology	400-499	4	3	2
	24UMATDSC409	Measure Theory and Integration	400-499	4	3	2
	24UMATDSC410	A First Course in Chaotic Dynamical Systems	400-499	4	3	2
	24UMATDSC411	Functional Analysis	400-499	4	3	2
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)						
III	24UMATDSE201	Numerical Analysis	200-299	4	4	0
IV	24UMATDSE202	Vector Calculus	200-299	4	3	2
IV	24UMATDSE203	Special Functions and Integral Transforms	200-299	4	4	0
V	24UMATDSE301	Operations Research	300-399	4	4	0
V	24UMATDSE302	Graph Theory	300-399	4	4	0
VI	24UMATDSE303	Complex Analysis -I	300-399	4	3	2
VI	24UMATDSE304	Algebra -II	300-399	4	3	2
DISCIPLINE SPECIFIC COURSES (DSC) - *Minor Pathway*						
I	24UMATDSC101	Ground Roots of Mathematics	101-199	4	3	2
II	24UMATDSC102	Gateway to Mathematics	101-199	4	3	2

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
III	24UMATDSC203	Differential Equations and Vector Calculus	200-299	4	3	2
III/IV	24UMATDSE205	Mathematics for Business and Economics	200-299	4	3	2
I	24UMATDSC111	Foundation of Mathematics	100-199	4	3	2
II	24UMATDSC112	Discrete Mathematics	100-199	4	3	2
IV	24UMATDSC211	Calculus and Numerical Analysis	200-299	4	3	2
IV	24UMATDSC212	Mathematics for Data Science	200-299	4	3	2
MULTIDISCIPLINARY COURSES (MDC)						
I	24UMATMDC101	Mathematics for Competitive Examinations	101-199	3	2	2
II	24UMATMDC102	Applicable Mathematics	101-199	3	2	2
III	24UMATDSE201	Mathematics in Nature	200-299	3	3	0
SKILL ENHANCEMENT COURSES (SEC)						
IV	24UMATSEC201	Document preparation using LaTeX	200-299	3	3	0
V	24UMATSEC301	Introduction to Python for Mathematical Computation	300-399	3	3	0
VI	24UMATSEC401	Computations and Graphics Using SageMath	300-399	3	3	0
VALUE ADDITION COURSES (VAC)						
III	24UMATVAC201	Mastering Problem Solving through Vedic Mathematics	200-299	3	3	0
IV	24UMATVAC202	Business Mathematics	200-299	3	3	0
VI	24UMATVAC401	Mathematical Computation and Visualization with R	300-399	3	3	0

PROPOSED PROGRAMME STRUCTURE FOR B.Sc. (HONS.) MATHEMATICS

(*with Mathematics as Major and Minors B and C*)

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
I	24UMATDSC101	Ground Roots of Mathematics	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
II	24UMATDSC102	Gateway to Mathematics	100-199	4	3	2
	-	DSC – Minor (B)	100-199	4	3	2
	-	DSC – Minor (C)	100-199	4	3	2
	-	AEC - English	100-199	3	3	0
	-	AEC – Other Languages	100-199	3	3	0
	-	MDC	100-199	3	2	2
				21	**17**	**8**
III	24UMATDSC201	Building Blocks for Higher Mathematics	200-299	4	3	2
	24UMATDSC202	Differential Equations	200-299	4	3	2
	24UMATDSE201	Numerical Analysis	200-299	4	4	0
	-	DSC – Minor (B) / (C)	200-299	4	3	2
	-	MDC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
IV	24UMATDSC203	Foundations of Analysis and Algebra	200-299	4	3	2
	24UMATDSE202	Vector Calculus	200-299	4	3	2
	24UMATDSE203	Special Functions and Integral Transforms	200-299	4	4	0
	-	DSC – Minor (C) / (B)	200-299	4	3	2
	-	SEC	200-299	3	3	0
	-	VAC	200-299	3	3	0
				22	**19**	**6**
Summer Internship				**2**	**-**	**60**
V	24UMATDSC301	Algebra -I	300-399	4	3	2
	24UMATDSC302	Real Analysis- I	300-399	4	3	2
	24UMATDSC303	Linear Algebra- I	300-399	4	4	0

SEM	Course Code	Course Title	Course Level	Credit	Hours per Week	
					Theory	*Practical*
	24UMATDSE301	Operations Research	300-399	4	4	0
	24UMATDSE302	Graph Theory	300-399	4	4	0
	24UMATSEC301	Introduction to Python for Mathematical Computation	300-399	3	3	0
				23	**21**	**4**
VI	24UMATDSC304	Real Analysis -II	300-399	4	3	2
	24UMATDSC305	Linear Algebra -II	300-399	4	4	0
	24UMATDSE303	Complex Analysis -I	300-399	4	3	2
	24UMATDSE304	Algebra -II	300-399	4	3	2
	24UMATSEC401	Computations and Graphics Using SageMath	300-399	3	3	0
	24UMATVAC401	Mathematical Computation and Visualization with R	300-399	3	3	0
				22	**19**	**6**
Exit at 3rd Year with 133 Credits – BSc Degree						
VII*	24UMATDSC401	Complex Analysis -II	400-499	4	4	0
	24UMATDSC402	Real Analysis -III	400-499	4	3	2
	24UMATDSC403	Algebra -III	400-499	4	4	0
	24UMATDSC404	Metric Space and Topology	400-499	4	4	0
	24UMATDSC405	Ordinary Differential equations	400-499	4	4	0
	24UMATDSC406	Combinatorics	400-499	4	4	0
** 3 Courses in Sem 7 can be taken from minor pathway at 300-399 level (for single minor pathway)*				**24**	**23**	**2**
VIII	24UMATDSC407	Complex Analysis 3	400-499	4	3	2
	24UMATDSC408	Basic Topology	400-499	4	3	2
	24UMATDSC409	Measure Theory and Integration	400-499	4	3	2
	24UMATDSC410	A First Course in Chaotic Dynamical Systems	400-499	4	3	2
	24UMATDSC411	Functional Analysis	400-499	4	3	2
	-	12 Credit Project or 8 Credit Project + DSE	-	12	-	-
				20	-	-
Completion of the Programme at 4th Year with 177 Credits – BSc Honours Degree						

4. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES IN MATHEMATICS

Course 01

Discipline	Mathematics
Semester	I
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC101
Course Title	Ground Roots of Mathematics
Course Level	100-199
Course Summary	This course provides a solid foundation in both mathematical logic and the principles of calculus. Beginning with "Basic Logic," students explore propositional logic, propositional equivalence, predicates, and quantifiers.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PO
1	Explain the language of Mathematics and communicate in a proper way.	Understand	1, 2, 3
2	Apply matrices to solve systems of linear equations using methods of Gaussian elimination and matrix inversion	Apply	1, 2
3	Explain and apply the process of differentiation	Apply	1, 2
4	Characterize increasing/decreasing functions using their derivatives	Apply	1, 2
5	Apply L'Hospital's rule to evaluate indeterminate forms	Apply	1, 2

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Basic Logic (15 Hours)**			
	1.1	Propositional Logic (1.1, Text 1)	8	CO 1
	1.2	Propositional Equivalence (1.3, Text 1)		CO 1
	1.3	Predicates and Quantifiers (1.4, Text 1)		CO 1

	1.4	Practicum	7	CO 1
2	**Matrices (20 Hours)**			
	2.1	Linear System, Coefficient Matrix, Augmented Matrix	12	CO 2
	2.2	Gauss Elimination and Back Substitution		CO 2
	2.3	Elementary Row Operations, Row-Equivalent Systems		CO 2
	2.4	Gauss Elimination: The three Cases of systems		CO 2
	2.5	Row Echelon Form and Information from It (**Text 2: Chapter 7 - Section:7.3)**		CO 2
	2.6	Practicum	8	CO 2
3	**Derivatives (15 Hours)**			
	3.1	Introduction to Techniques of Differentiation (without proof) (2.3, Text 3)	8	CO 3
	3.2	Higher derivatives, The product and quotient rules (Without Proof) (2.4, Text 3)		CO 3
	3.3	Derivatives of trigonometric functions (Using formulas only) (2.5, Text 3)		CO 3
	3.4	Chain Rule (2.6, Text 3)		CO 3
	3.5	Implicit Differentiation (2.7, Text 3)		CO 3
	3.6	Practicum	7	CO 3
4	**Applications of Derivatives (20 Hours)**			
	4.1	Analysis of Functions I: Increase, decrease and Concavity (3.1 Text 3)	12	CO 4
	4.2	Analysis of Functions II: Relative extrema (3.2 Text 3) (Excluding - Geometric implications of multiplicity, Analysis of polynomials)		CO 4
	4.3	L'Hôpital's Rule (6.5 Text 3)		CO 5
	4.5	Indeterminate forms (6.5 Text 3)		CO 5
	4.6	Practicum	8	CO 4, CO 5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS: ➢ Determine the output of a combinatorial circuit constructed using basic logic gates. Also, building a digital circuit produces the required output. (Eg: Build a digital circuit that produces the output $(p \vee \neg r) \wedge (\neg p \vee (q \vee \neg r))$ with input bits p, q and r . ➢ Using a graphing calculator, visualize the effect of stretching and scaling (horizontal & vertical) of functions. ➢ Match the graphs of functions with the graphs of their derivatives. ➢ Use a graphing utility to make rough estimates of the locations of all horizontal tangent lines			

	➢ Use the implicit plotting capability of a CAS to graph a curve. Suggested software: Desmos, GeoGebra etc.

The practicum component is to be done in the classroom under the strict guidance of the teachers. A minimum of 30 problems is to be solved, and a handwritten copy of the solutions should be kept in the department.

Textbooks:

1. Discrete Mathematics and its application, Kenneth H Rosen, 7th Ed McGraw Hill Publishing.
2. Advanced Engineering Mathematics, Kreyszig, Erwin, 9th edition Wiley International Edition.
3. Calculus, 10th Edition, Howard Anton, Irl Bivens and Stephen Davis John Wiley and Sons, Inc.

References:

1. Hofstadter, Douglas R. Gödel, Escher, Bach: An Eternal Golden Braid. Expanded ed. Basic Books, 2007.
2. Copi, Irving M., Carl Cohen. Introduction to Logic. 5th ed. Routledge, 2018.
3. Stewart, James. Calculus: Early Transcendentals. 10th ed. Cengage Learning, 2023.
4. Thompson, Silvanus P. Calculus Made Easy. 5th ed. Dover Publications, 2014.
5. Thomas, George B., Jr., and Maurice D. Weir. Thomas' Calculus. 15th ed. Pearson, 2023.

Course 02

Discipline	Mathematics
Semester	II
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC102
Course Title	Gateway to Mathematics
Course Level	100-199
Course Summary	This course offers a comprehensive exploration of integral and partial differentiation calculus. Topics include integration methods, the definite integral, and the Fundamental Theorem of Calculus. Practical sessions cover integration applications like area between curves and double integrals. In partial differentiation, functions of several variables, partial derivatives, and the Chain rule are studied, with practical exercises reinforcing concepts. Applications of partial derivatives include directional derivatives, gradients, tangent planes, and identifying extreme values and saddle points. Through theory, practice, and real-world examples, students gain a deep understanding of integral and partial differentiation calculus principles and their practical applications.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	The Course 'Ground Roots of Mathematics'

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO
1	Compute definite integrals of single-variable functions	A	1,2,3,7,8
2	Explain the geometric interpretation integrals and finding areas	U & A	1,2,3,7,8
3	Explain the concept of partial derivatives and experience its applications	U	1,2,3,7,8
4	Explore vector functions and directional derivatives	A	1,2,3,7,8

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Integration			
	1.1	Integrals and Integration methods (Review)	9	1

1	1.2	The Definite Integral 2		1
	1.3	The Fundamental Theorem of Calculus (Proof of theorems excluded)		1
	1.5	Practicum: 4.1, 4.5(excluding discontinuity and integrability), 4.6 (excluding dummy variables, mean value theorem for integrals and integrating rate of changes)	6	1
2	**Applications of Integration**			
	2.1	Area between two curves (5.1)	12	2
	2.2	Length of plane curve (5.2)		2
	2.3	Double Integrals over rectangular regions (14.1)		2
	2.5	Practicum	8	2
3	**Partial Differentiation**			
	3.1	Functions of several variables (13.1)	12	3
	3.2	Partial Derivatives(13.3)		3
	3.3	The Chain Rule(13.5)		3
	3.6	Practicum	8	3
4	**Applications of Partial Derivatives**			
	4.1	Directional Derivative and Gradient (13.6)	12	4
	4.2	Tangent plane and normal line(13.7)		4
	4.3	Extreme values and saddle points(13.8)		4
	4.6	Practicum	8	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Real life application of Integration and partial differentiation			

Textbook:

Calculus, 10th Edition, Howard Anton, Irl Bivens and Stephen Davis John Wiley and Sons, Inc.

References:

1. Thomas' Calculus, 11th Edition, Maurice D Weir, Joel Hass, Frank.R. Giordano, Pearson Education.
2. Calculus and Analytic Geometry, George B Thomas Jr, Ross L Finney, Pearson Education.

Course 03

Discipline	Mathematics
Semester	III
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC201
Course Title	Building Blocks for Higher Mathematics
Course Level	200-299
Course Summary	This course serves as an essential bridge to advanced mathematical concepts, focusing on the development of proof techniques, and an in-depth exploration of number theory, including congruence, divisibility, GCD, etc. The second segment delves into the relationship between roots and coefficients in equations. Various methods to find the roots of the equations are explored.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Demonstrate understanding of fundamental concepts in number theory, including congruence, divisibility, GCD etc	U	1,2,3,7,8
2	Analyze Fermat's Little Theorem, understanding its significance and implications	An	1,2,3,7,8
3	Explain Wilson's Theorem and its applications in determining the primality	U	1,2,3,7,8
4	Analyze the relationship between roots and coefficients in equations.	An	1,2,3,7,8
5	Apply various methods to find the roots of the equation	A	1,2,3,7,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Divisibility			
	1.1	Division Algorithm Arithmetic (Statement and applications) (2.2-Text -1)	16	1

1	1.2	GCD (2.3 Text-1)		1
	1.3	Euclidean Algorithm (2.4 Text-1)		1
	1.4	Fundamental Theorem of Arithmetic (Statement and applications) (3.1 Text-1)		1
	1.5	Practicum	4	1
2	**Congruence**			
	2.1	Basic Properties of Congruence (4.2-Text -1)	16	1
	2.2	Fermat's Little Theorem and Pseudo primes (5.2 Text-1)		2
	2.3	Wilson's Theorem (5.3 Text-1)		3
	2.4	Euler's Theorem (7.2 Text-1)		3
	2.5	Practicum	4	2, 3
3	**Theory of Equations**			
	3.1	Zero of Polynomials (2.1-2.8 Text-2)	17	4
	3.2	Synthetic Division (2.9 Text-2)		4
	3.3	Fundamental Theorem of Algebra (2.10 Text-2)		4
	3.4	Multiplication of Roots (2.11 Text-2)		4
	3.5	Diminishing and Increasing the Roots (2.12 Text-2)		4
	3.6	Practicum	3	4
4	**Number Theory**			
	4.1	Removal of Terms (2.13 Text-2)	12	5
	4.2	Reciprocal Equations (2.14 Text-2)		5
	4.3	Sum of the Integral Powers of the Roots and Symmetric Functions of the Roots (2.15,2.16 Text-2)		5
	4.4	Descartes rule of signs		5
	4.5	Cardon's Method		5
	4.6	Practicum: Ferrari's Methods and Problems	3	5
5	**Teacher-Specific Contents** (This can be either classroom teaching, practical session, field visit, etc. as specified by the teacher concerned) This content will be evaluated internally			

	Converse of Wilson Theorem and problems related to the applications of number theory

Textbooks:

1. Elementary Number Theory, David M. Burton, 7th Edn, McGraw Hill Education.
2. A Textbook of Engineering Mathematics, N.P.Bali, Manish Goyal, 9th Edn, Laxmi Publications.

References:

1. Elementary Number Theory (Dover Books on Mathematics), Underwood Dudley, Second Edition, Dover Publications, 2008
2. A Friendly Introduction to Number Theory, Joseph H. Silverman, Fourth Edition, Brown University, 2019.

Course 04

Discipline	Mathematics
Semester	III
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC202
Course Title	Differential Equations
Course Level	200-299
Course Summary	This mathematics course covers topics to solve an ordinary differential equation of first degree and higher. Various methods to solve them are discussed.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	Differentiation, Integration and partial differentiation

COURSE OUTCOME

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain and solve a first order differential equation	U	1, 2
2	Differentiate homogeneous and non - homogeneous equation and find the solution of homogeneous equation	U	2
3	Apply different techniques to solve non - homogeneous equation	A	2
4	Study power series and Frobenius series to solve second order differential equation	A	2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**First Order Differential Equations**			
	1.1	Exact Differential Equations (Sec 2.1 of text 1) (Proofs of all theorems of this section are excluded)	13	1
	1.2	Separable Equations and Equations Reducible to those forms. (Sec 2.2of text 1)		1
	1.3	Linear Equations and Bernoulli's Equations (Sec 2.3of text 1)		1
	1.4	Practicum: Special Integrating factor and transformations (Sec 2.4of text 1)	5	1

2	**Basic Theory of Linear Differential Equations**			
	2.1	Definitions and Basic Existence Theorem (Sec 4.1.a of text 1)	10	2
	2.2	Homogeneous Equations (4.1.b of text 1)		2
	2.3	Reduction of Order (4.1.c of text 1)		2
	2.4	Non-Homogenous Equations (4.1.d of text 1)		2
	2.5	Homogenous Linear Differential Equations with constant coefficients (4.2 of text 1)		2
	2.5	Practicum (Problems on Solutions of Homogeneous equations - section 4 of text 1)	10	2
3	**General Solutions of Non homogeneous Differential Equations**			
	3.1	Method of undetermined coefficients (Sec 4.3 of text 1)	10	3
	3.2	Variation of Parameters (4.4 of text 1)		3
	3.3	Cauchy-Euler Equations (4.5 of text 1)		3
	3.4	Differential Operators and Operator Method (7.1 of Text 1)		3
	3.5	Practicum: Problems (4.3,4.4 of text 1)	10	3
4	**Series Solutions of Linear Differential Equations**			
	4.1	Power Series solution about an ordinary point (Sec 6.1 of text 1)	12	4
	4.2	Solution about a singular point; Method of Frobenius (Sec 6.2 of text 1)		4
	4.3	Practicum: Problems (Sec 6.1,6.2 of text 1)	5	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** ➢ Applications of Ordinary Differential Equations of First Order in Simple Electric Circuits ➢ Rate of Decay of Radioactive Materials ➢ Chemical Reactions and Solutions (Text 2: Chapter 12-Section 12.5, 12.8, 12.9)			

Textbook

1. Differential Equations, Shepley L. Ross, 3rd Edn, Wiley Student Edition.

References

1. Simmons, George F and Steven G Krantz. Differential equations -Theory, Technique, and Practice. Tata McGraw Hill (Walter Rudin Student Series).
2. Amarnath.T, An Elementary Course in Partial Differential Equations, 2nd Edition. Jones and Bartlett .
3. Grewal, B. S. Higher Engineering Mathematics. 42nd ed. Khanna Publications. 2012

Course 05

Discipline	Mathematics
Semester	IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC203
Course Title	Foundations of Analysis and Algebra
Course Level	200-299
Course Summary	This course navigates through foundational topics in set theory and real numbers, exploring Finite and Infinite Sets, Countable Sets, and Algebraic Properties of R. It delves into Rational and Irrational Numbers, Order Properties of R, and Absolute Value on the Real Line, with practical exercises enhancing comprehension. Introduction to Complex Numbers encompasses Vectors, Moduli, Conjugates, and Exponential Form, progressing to Products, Powers, Roots, and Regions in the Complex Plane. It culminates in an introduction to Groups, Rings, and Fields, elucidating their structures, operations, and relationships.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning Domain*	PO
1	Discuss the concept of cardinality of sets.	An	1, 2, 3, 7, 8
2	Analyse the algebraic and order, and other properties of the real line.	An	1, 2, 3, 7, 8
3	Discuss the elementary properties of complex numbers and their geometric representation.	A	1, 2, 3, 7, 8
4	Discuss the basic concepts of binary operations and groups.	An	1, 2, 3, 7, 8
5	Analyse the definition and basic properties of rings and fields.	An	1, 2, 3, 7, 8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**An introduction to Real Numbers (Sections 1.3 and Sections 2.1-2.2 of Text 1)**			
	1.1	Finite and Infinite Sets	10	1
	1.2	Countable Sets		1
	1.3	Algebraic Properties of R		2
	1.4	Rational and Irrational Numbers		2
	1.5	Order Properties Of R		2
	1.6	Absolute Value and the Real Line		2
	1.7	Practicum:	7	
2	**An introduction to Complex Numbers (Sections 4,5,6,7,8,9,10 and 11 of text 2)**			
	2.1	Vectors and Moduli	12	3
	2.2	Complex Conjugates		3
	2.3	Exponential Form		3
	2.4	Products and Powers in Exponential Form		3
	2.5	Arguments of Products and Quotients		3
	2.6	Roots of Complex Numbers		3
	2.7	Regions in the Complex Plane		3
	2.8	Practicum: Exercises in sections 4-11 of text 2.	8	
3	**Introduction to Groups (Sections 0.16 to 0.22, Sections 2,4 and 5 of text 3)**			
	3.1	Partitions and Equivalence Relations.	12	4
	3.2	Binary Operations		4
	3.3	Definition of a Group		4

	3.4	Abelian group and Examples		4
	3.5	Non-Abelian group and Examples		4
	3.6	Subgroups		4
	3.7	Practicum: Exercises in sections 2,4 and 5 of text 3	7	
4	**Introduction to Rings and Fields** **(Sections 18 and 19 of text 3)**			
	4.1	Definition and Basic Properties of Rings	11	5
	4.2	Homomorphisms and Isomorphisms; Definition and Examples		5
	4.3	Commutative Ring, Ring with Unity; Definitions and Examples		5
	4.4	Division Rings and Fields: Definition and Examples		5
	4.5	Divisors of Zero, Integral Domains and Properties		5
	4.6	Relationship between Fields and Integral Domains.		5
	4.7	Practicum: Exercises in sections 18 and 19 of Text 3	8	
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally			

Textbooks

1. Introduction to Real Analysis, Bartle,Robert G and Sherbert, Donald Wiley Student Edition, 2011, 3rd Edition.
2. Complex Variables and Applications. Brown, James Ward and Churchill, Ruel V. McGraw Hill Education, 2014, 8th Edition.
3. A First Course in Abstract Algebra. John B Fraleigh, 7th Edition, Pearson Education.

References

1. Methods of Real Analysis, Richard R Goldberg, Oxford & IBH Publishing Company Pvt. Ltd.
2. Principles of Mathematical Analysis, Walter Rudin, McGraw Hill .
3. Contemporary Abstract Algebra, Joseph A Gallian.

Course 06

Discipline	Mathematics
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC301
Course Title	Algebra I
Course Level	300-399
Course Summary	The objective of the course is to introduce group and ring theory for a beginner. The basic algebraic structure group, its subgroups, cyclic groups, permutations, cosets, homomorphisms, and normal subgroups are covered in the first three modules. Rings and Fields are introduced in the fourth module.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	Sets and Functions

CO No.	Expected Course outcomes	Learning domain*	PO No.
1	Comprehend binary operations, isomorphic structures, groups, and subgroups.	U	1, 2, 3, 6, 7
2	Analyse cyclic groups and permutation groups and apply these concepts to solve problems in group theory	A	1, 2, 3, 6, 7
3	Use cosets to prove Lagrange's theorem, analyse homomorphisms, and understand Cayley's Theorem	A	1, 2, 3, 6, 7
4	Analyse rings, fields, and integral domains, and become adept in algebraic structures.	An	1, 2, 3, 6, 7
5	Apply the ideas of Groups and Permutations in practical situations.	S	1, 2, 3, 6, 7
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Group: Definition and Examples (2-6 Text 1)			
	1.1	Binary Operations – Definitions and Examples		

1	1.2	Groups – Definition, Examples	16	1, 2
	1.3	Groups - Elementary Properties		
	1.4	Group Isomorphism, Group Tables and Examples of Abelian Groups		
	1.5	Practicum	4	
2	**Group of Permutations and cyclic groups (7, 9 of Text 1)**			
	2.1	Examples of non-abelian groups and Permutation Group	15	3
	2.2	Symmetric Groups and Disjoint Cycles		
	2.3	Subgroups, Cyclic Groups and Cyclic Subgroups		
	2.4	Practicum	5	3
3	**Homomorphisms (14 ,15 ,16 of text 1)**			
	3.1	Generating Sets	16	4
	3.2	Group Homomorphism and Group of Permutation		
	3.3	Kernel, Cayley's Theorem, Even and Odd Permutation		
	3.4	Costs and Theorem of Lagrange		
	3.5	Practicum	4	
4	**Rings and Fields (19, 20, 22 of text 1)**			
	4.1	Rings and Fields	12	5
	4.2	Integral Domain, Characteristic of a Ring.		
	4.3	Field of Quotients of an Integral Domain (Statement only)		
	4.4	Practicum: Problems of section 13-18 of Text 1	3	

5	**Teacher-Specific Contents** (This can be either classroom teaching, practical session, field visit, etc. as specified by the teacher concerned) This content will be evaluated internally **Some suggestions for Teacher Specific Content** Problems of chapter 2-7 of Text 2

Textbook:

1. A First Course in Abstract Algebra, John B. Fraleigh and Neal E Brand,8th edition.
2. Contemporary Abstract Algebra, Joseph A. Gallian, 10th edition**.**

References:

1. Abstract Algebra – D. S. Dummit and R. M. Foote, 3rd Edition
2. Algebra – M. Artin, 2nd Edition
3. Topics in Algebra – I. N. Herstein, 2nd Edition
4. Rings and Modules – C. Musili, 2nd revised Edition

Course 07

Discipline	Mathematics
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC302
Course Title	Real Analysis - I
Course Level	300-399
Course Summary	This course covers essential concepts in sequences and series. Topics include Sequences with their Limits and Limit Theorems, exploring Monotone Sequences and Sub sequences with the Bolzano-Weierstrass Theorem. The Cauchy Criterion and Properly Divergent Sequences are discussed. The study progresses to Series, including the nth Term Test, Cauchy Criterion, Comparison Tests, Absolute Convergence, and Tests for Non-Absolute Convergence, reinforced with practical exercises.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO No.
1	Analyse the convergence of sequences and determine their limits.	E	1, 2, 3, 7, 8
2	Investigate the properties of monotone sequences.	An	1, 2, 3, 7, 8
3	Discuss the concept of subsequences and their applications	A	1, 2, 3, 7, 8
4	Comprehend the concept of convergence of series and the various convergence tests.	E	1, 2, 3, 7, 8
5	Analyse absolute and conditional convergence of series.	A	1, 2, 3, 7, 8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Sequences Part I (Sections 3.1, 3.2 and 3.3 of the text)			
	1.1	Sequences and their Limits	10	1
	1.2	Limit Theorems		1

1	1.3	Monotone Sequences		2
	1.4	Practicum: Exercises for sections 3.1, 3.2 and 3.3 of the text.	8	1, 2
2	**Sequences Part II** **(**Sections 3.4, 3.5 and 3.6 of the text)			
	2.1	Sub sequences and the Bolzano- Weierstrass Theorem.	15	3
	2.2	The Cauchy Criterion.		1
	2.3	Properly Divergent Sequences.		1
	2.4	Practicum: Exercises for sections 3.4, 3.5 and 3.6 of the text.	7	1, 2, 3
3	**Series Part I** **(**Section 3.7 of the text)			
	3.1	Introduction to Series	10	4
	3.2	The nth term test		4
	3.3	Cauchy criterion for Serie		4
	3.4	Comparison Tests		4
	3.5	Practicum: Exercises for section 3.7 of the text	7	4
4	**Series Part II** Chapter 9: Sections 9.1,9.2,9.3			
	4.1	Absolute Convergence, Tests for Absolute convergence, Tests for non-absolute Convergence.	10	5
	4.2	Practicum: Exercises for sections 9.1,9.2 and 9.3 of the text	8	5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Convergence of power series Problems on continuity and differentiation Well ordering property			

Text Book:

1. Introduction to Real Analysis – Robert G Bartle and Donald R Sherbert (3rd Edition) John Wiley & Sons, Inc. 2007

References:

1. 1.Richard.R. Goldberg, Methods of Real Analysis, 3rd Edition, Oxford and IBM publishing co. 1964
2. J. M. Howie, Real Analysis, Springer, 2007
3. K.A. Ross, Elementary Real analysis, Springer, Indian reprint

Course 08

Discipline	Mathematics
Semester	V
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC303
Course Title	Linear Algebra - I
Course Level	300-399
Course Summary	Linear Algebra is a fundamental tool in many areas of mathematics, science, engineering, economics, and data science. It also has applications in machine learning, providing the mathematical foundation for many algorithms and techniques. This course on Linear Algebra deals with the basic concepts like vector spaces, linear transformations, determinants, Eigen values and Eigen vectors.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Groups and Rings

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO No.
1	Analyse the basic concepts of vector spaces	An	1,2,3,7,8
2	Illustrate the fundamental properties of linear transformations	A	1,2,3,7,8
3	Compute the eigen values and eigenvectors	A	1,2,3,7,8
4	Deduce the connections between determinants and other linear algebra concepts	An	1,2,3,7,8
5	Apply computational software and tools in linear algebra computations.	A	1,2,3,7,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Vector Space			
	1.1	Vector Spaces: Definition and examples	15	1
	1.2	Subspaces		

1	1.3	Linear Combination of Vectors, Spanning Set, Linear Dependence and Independence of Vectors		
	1.4	Basis of a Vector Space		
	1.5	Dimension of a Vector Space		
2	**Linear Map**			
	2.1	Linear Mappings	15	2
	2.2	Kernel and Range of a Linear Mapping		
	2.3	Bijective Linear Mappings		
3	**Rank and Nullity**			
	3.1	Dimension Theorem	15	3,4
	3.2	Linear Isomorphism		
4	**Eigen values and Eigen vectors**			
	4.1	Eigen Values and Eigenvectors	15	5
	4.2	Characteristic Polynomial, Characteristic Equation and Algebraic Multiplicity		
	4.3	Eigen Space and Geometric Multiplicity (up to theorem 9.3)		

Module 1: Chapter 5 Module 2: Chapter 6 Module 3: Chapter 9 Module 4: Chapter 8 (Concept and Problem Oriented - Proofs excluded)

5	**Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally**
	Determinant of a Matrix as a Mapping (Excluded proofs of all theorems) Adjoint and Inverse of a Matrix (Excluded proofs of all theorems)

Text Book:

1. T. S. Blyth & E. F. Robertson. (2007). Basic linear algebra. Springer.

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.

2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.

3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.

4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

5. S. Kumaresan, Linear Algebra -A Geometric Approach, Prentice Hall of India, 2000.

Course 09

Discipline	Mathematics
Semester	VI
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC304
Course Title	Real Analysis - II
Course Level	300-399
Course Summary	This course is a comprehensive journey through fundamental topics in calculus. Module 1 explores Limits of Functions, Limit Theorems, and Extensions of the Limit Concept. Module 2 delves into Continuous Functions, including combinations, intervals, uniform continuity, and monotone functions. Module 3 focuses on The Derivative, Mean Value Theorem, and L'Hospital Rules. Module 4 concludes with the Riemann Integral, Riemann Integrable Functions, and the Fundamental Theorem of Calculus. Each module is structured around specific chapters, providing a systematic approach to understanding key calculus concepts
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO No.
1	Comprehend the concept of limit of a function,	A	1,2,3,7,8
2	Discuss the concepts of continuity and uniform continuity of a function.	An	1,2,3,7,8
3	Analyse the concept of differentiation of a function	An	1,2,3,7,8
4	Analyse the concepts of Mean Value theorem, L'Hopital's rule and Taylor's theorem.	An	1,2,3,7,8
5	Comprehend the concept of Riemann integration and its applications.	E	1,2,3,7,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Limits of functions**			

	(Chapter 4: Sections 4.1,4.2,4.3)			
	1.1	Limits of Functions	3	1
	1.2	Limit Theorems	4	1
	1.3	Some Extensions of the Limit Concept.	3	1
	1.4	Practicum: Exercises for sections 4.1,4.2 and 4.3	7	1
2	**Continuous Functions** **Chapter 5: Sections 5.1,5.2,5.3,5.4,5.6**			
	2.1	Continuous Functions.	3	2
	2.2	Combinations of Continuous Functions	3	2
	2.3	Continuous Functions on Intervals	2	2
	2.4	Uniform continuity	2	2
	2.5	Monotone and Inverse Functions.	2	2
	2.6	Practicum: Exercises for sections 5.1,5.2,5.3,5.4 and 5.6	8	2
3	**The Derivative, Mean value theorem and L'Hospital's rules** **(Chapter 6 -6.1,6.2,6.3)**			
	3.1	The Derivative	3	3,4
	3.2	The Mean Value Theorem.	3	3,4
	3.3	L' Hospital Rules (Proof Excluded)	4	3,4
	3.4	Practicum: Exercises for sections 6.1,6.2 and 6.3	7	3,4
4	**The Riemann Integral** **(Chapter 7: Sections 7.1,7.2,7.3)**			
	4.1	The Riemann Integral	3	5
	4.2	Riemann Integrable Functions	6	5
	4.3	The Fundamental Theorem	4	5
	4.4	Practicum: Exercises for sections 7.1,7.2 and 7.3	8	5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally 1) The n^{th} root function 2) Further applications of the mean value theorem 3) Proof of L Hospitals rule.			

Text Book:

1. Introduction to Real Analysis – Robert G Bartle and Donald R Sherbert (3rd Edition) John Wiley & Sons, Inc. 2007

References:

1. Richard R. Goldberg, Methods of Real Analysis, 3rd Edition, Oxford and IBM publishing co. 1964
2. J. M. Howie, Real Analysis, Springer, 2007
3. K.A. Ross, Elementary Real analysis, Springer, Indian reprint

Course 10

Discipline	Mathematics
Semester	VI
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC305
Course Title	Linear Algebra - II
Course Level	300-399
Course Summary	This course on linear algebra provides a comprehensive introduction to the fundamental concepts and techniques of linear algebra. The course covers a wide range of topics, including vector spaces, coordinates, linear transformations, linear functionals, matrix of linear transformations, dual spaces, characteristic values, annihilating polynomials, invariant subspaces, simultaneous triangulization and diagonalisation, direct sum decomposition, and invariant direct sums.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Fields, Vector spaces, subspaces, basis and dimension

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO No.
1	Analyse finite and infinite dimensional vector spaces and subspaces over a field and their properties including basis structure of vector spaces	An	1,2,3,7
2	Use the definition and properties of linear transformations and matrices of linear transformations and change of basis, including kernel, range and isomorphism	A	1,2,3,7
3	Compute the characteristic polynomial, eigenvectors, eigenvalues and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result	A	1,2,3,7
4	Explain the basic theory of Simultaneous triangulations, Direct sum decompositions and Invariant direct sums	An	1,2,3,7
5	Utilize Python to perform computations efficiently in linear algebra	A	1,2,3,7
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Module 1: Chapter 1 (Section 1.1), Chapter 2 (Section 2.1 to 2.4)
Chapter 3 (Section 3.1 to 3.3)
Module 2: Chapter 3 (Section 3.4 to 3.6)

Module 3: Chapter 6 (Section 6.1 to 6.4)

Module 4: Chapter 6 (Section 6.5 to 6.7)

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
	Linear Transformations			
1	1.1	Review on Fields, Vector spaces, subspaces, basis and dimension (proofs of all theorems are excluded)	20	1
	1.2	Coordinates		
	1.3	Linear transformations and Algebra of Linear Transformations		
	1.4	Isomorphism		
2	**Matrix Representations**			
	2.1	Representation of transformations by matrices	20	2
	2.2	Linear functionals and dual space		
	2.3	Double dual		
3	**Characteristic values and vectors**			
	3.1	Characteristic Values	12	3,4,5
	3.2	Diagonalizable linear operators		
	3.3	Annihilating polynomials		
4	**Invariant Subspaces**			
	4.1	Cayley Hamilton Theorem	8	4,5

	4.2	Invariant subspaces		

5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Simultaneous triangulation; simultaneous diagonalization Direct sum Decompositions Invariant Direct Sums

Text Book:

1. Hoffman, K., & Kunze, R. (1992). Linear algebra: Second edition. Prentice-Hall of India Pvt. Ltd.

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.

2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.

3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.

4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

5. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 2000.

Course 11

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC401
Course Title	Complex Analysis - II
Course Level	400-499
Course Summary	This course provides an introduction to complex analysis which is the theory of complex functions of a complex variable. We will start by introducing the complex plane, along with the algebra and geometry of complex numbers, and then we will make our way via differentiation, integration, complex dynamics, power series representation and Laurent series into territories at the edge of what is known today.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	A good course in Real Analysis, Metric Spaces and Complex Numbers

COURSE CONTENT

CO	Expected Outcomes	Learning Domain	PO No.
1	Understand analytic function as a mapping on the plane, Mobius transformation and branch of logarithm.	U	1
2	Understand Cauchy's theorems and integral formulas on open subsets of the plane.	U & A	1,2
3	Understand the concept of homotopy and homotopic version of Cauchy's theorem and simply connectivity.	U	1
4	understand how to count the number of zeros of analytic function giving rise to open mapping theorem and Goursat theorem as a converse of Cauchy's theorem.	U & A	1
5	Analyse different versions of the maximum principle as well as the Schwarz's lemma representing analytic function on a disk as fractional mappings.	An	1,2

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Analytic functions**			
	1.1	The extended plane and its spherical representation Chapter 1 section 6	15	1
	1.2	Power series Chapter 3 section 1		1
	1.3	Analytic functions Chapter 3 section 2		1
	1.4	Analytic functions as mappings, Chapter 3 section 3		1
	1.5	Mobius transformations, Chapter 3 section 3		1
2	**Complex Integration - I**			
	2.1	Power series representation of analytic functions, Chapter 4 section 2	15	2
	2.2	Zeros of an analytic function Chapter 4 section 3		2
	2.3	The index of a closed curve, Chapter 4 section 4		2
	2.4	Cauchy's Theorem and Integral Formula Chapter 4 section 5		2
3	**Complex Integration - II**			
	3.1	The Homotopic version of Cauchy's Theorem and simple connectivity Chapter 4 section 6	15	3
	3.2	Counting zeros, the Open Mapping Theorem Chapter 4 section 7		3, 4
	3.3	Goursat's Theorem Chapter 4 section 8		3, 4
4	**Residues**			
	4.1	Classification of singularities Chapter 5 section 1	15	5
	4.2	Residues Chapter 5 section 2		5
	4.3	The Argument Principle Chapter 5 section 3		5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally			

Text Book

- John B. Conway, Functions of One Complex Variable, Second Edition.

References:

1. H. Cartan: Elementary Theory of analytic functions of one or several variables; Addison - Wesley Pub. Co.; 1973
2. B. Chaudhary, The elements of Complex Analysis, Wiley Eastern
3. T.W. Gamelin: Complex Analysis; Springer-Verlag, NY Inc.; 2001
4. S. Lang, Complex Analysis, Springer
5. T.O. Moore and E.H. Hadlock: Complex Analysis, Series in Pure Mathematics-Vol. 9; World Scientific; 1991
6. L. Pennisi: Elements of Complex Variables (2nd Edn.); Holf, Rinehart & Winston 1976

Course 12

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC402
Course Title	Real Analysis - II
Course Level	400-499
Course Summary	This course provides a thorough exploration of real analysis topics. Module 1 delves into Functions of Bounded Variation and Rectifiable Curves, emphasizing monotonic functions, bounded variation, and rectifiable paths. Module 2 introduces the Riemann-Stieltjes Integral, discussing its definition, properties, and relations with differentiation. Module 3 covers Uniform Convergence, discussing its implications on continuity, integration, and differentiation. Module 4 concludes with Equicontinuous Families, Power Series, and the Completeness of the Complex Field, accompanied by practical exercises.
Hours	75 (Lecture/Tutorial – 45, Practicum-30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO No.
1	Analyse functions of bounded variations and their properties.	An	1,2,3,7,8
2	Analyse properties of the Riemann Stieltjes integral	An	1,2,3,7,8
3	Discuss the concept of uniform convergence.	E	1,2,3,7,8
4	Understand equicontinuous family of functions and the Stone-Weierstrass theorem.	E	1,2,3,7,8
5	Discuss the algebraic completeness of the complex field.	An	1,2,3,7,8

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Functions of Bounded Variation			

1	1.1	Functions of bounded variation and rectifiable curves Introduction, properties of monotonic functions, functions of bounded variation,	4	1
	1.2	total variation, additive property of total variation, total variation on (a, x) as a function of x,	4	1
	1.3	functions of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation,	3	1
	1.4	curves and paths, rectifiable path and arc length, additive and continuity properties of arc length, equivalence of paths, change of parameter. (Chapter 6, Section: 6.1 - 6.12. of Text 1)	3	1
	1.5	Practicum: Exercises in the relevant sections of the prescribed text	8	1
2	**The Riemann-Stieltjes Integral.**			
	2.1	The Riemann-Stieltjes Integral. Definition and existence of the integral	8	2
	2.2	properties of the integral, integration and differentiation. (Chapter 6 - Section 6.1 to 6.22 of Text 2)		2
	2.3	Practicum: Exercises in the relevant sections of the prescribed text	7	2
3	**Uniform Convergence**			
	3.1	Discussion of main problem, Uniform convergence, Uniform convergence and Continuity,	4	3
	3.2	Uniform convergence and Integration, Uniform convergence and Differentiation (Chapter 7 Section. 7.1 to 7.18 of Text 2)	5	3
	3.3	Practicum: Exercises in the relevant sections of the prescribed text	7	3
4	**Equicontinuity, Power Series and Algebraic Completeness**			
	4.1	Equicontinuous families of functions, the Stone - Weierstrass theorem, Power series, the exponential and logarithmic functions,	5	4
	4.2	the trigonometric functions,	5	4
	4.3	the algebraic completeness of complex field. (Chapter 7 – Sections 7.19 to 7.27, Chapter 8 - Section 8.1 to 8.8 of Text 2)	4	5

	4.4	Practicum: Exercises in the relevant sections of the prescribed text	8	1,2,3,4,5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally 1) Equivalence of Paths, Change of parameter 2) Linear space of functions 3) Absolutely continuous functions and bounded variation 4) The exponential and logarithmic functions 5) The algebraic completeness of the complex field.			

Text Book

- Mathematical Analysis, Tom M Apostol, 2th Edition.

References

1) Principles of Mathematical Analysis, Walter Rudin, 3rd Edition, McGraw Hill Pvt. Ltd.

2) Real Analysis, Barry Simon, Indian Edition, American Mathematical Society

3) Introduction to Real Analysis, R.G. Bartle and D.R. Sherbert, Third Edition, Wiley India.

4) Methods of Real Analysis, Richard R Goldberg, Oxford & IBH Publishing Co. Pvt Ltd.

5) A first course in Real Analysis, M.H. Protter and C.B. Murray, 2nd Edition, Springer.

6) A First Course in Analysis, George Pedrick, Springer.

Course 13

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC403
Course Title	Algebra - III
Course Level	400-499
Course Summary	The objective of the course is to learn more about field theory. The first module covers topics on ring of polynomials, factorization of polynomials etc. The second module covers concepts on extension fields, finite fields etc. The third module includes automorphisms of fields, splitting fields etc. Topics on separable extensions, Galois theory etc. are covered in the fourth module.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Concepts from Fundamentals of Groups and Rings and Advanced Theory of Groups and Rings

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Ring of Polynomials**			
	1.1	Rings of polynomials, The evaluation homomorphisms	5	1,2
	1.2	Factorization of polynomials over a field, The division algorithm in F[x]	4	1,2
	1.3	Irreducible polynomials, Uniqueness of factorization in F[x]	5	1,2
	1.4	Ideal Structure in F[x], Application to unique factorization in F[x]	3	1,2
2	**Field Extensions**			
	2.1	Introduction to Extension fields, Algebraic and transcendental elements, The irreducible polynomial for α over F	5	3
	2.2	Simple extensions	3	3
	2.3	Algebraic extensions, Algebraically closed fields and algebraic closures	7	3
	2.4	Finite fields, The existence of GF(p^n)	5	3
	Isomorphism Theorems			

3	3.1	Introduction to Galois theory	6	4
	3.2	Conjugation isomorphism	4	4
	3.3	Splitting fields, The isomorphism extension theorem	4	4
	3.4	Properties of splitting fields	6	4
4	**Galois Theory**			
	4.1	Separable extensions	7	5
	4.2	The primitive element theorem, Normal extensions	4	5
	4.3	Galois Theory, The Galois theorems	7	5
5	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally			
	Problems of section 48-51 of the Text			

Text book:

1. A First Course in Abstract Algebra, John B. Fraleigh, Neal E Brand, 8th edition

References:

1. Contemporary Abstract Algebra - Joseph A. Gallian, 10th Edition
2. Abstract Algebra – D. S. Dummit and R. M. Foote, 3rd Edition
3. Algebra – M. Artin, 2nd Edition
4. Topics in Algebra – I. N. Herstein, 2nd Edition
5. Rings and Modules – C. Musili, 2nd revised Edition

Course 14

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC404
Course Title	Metric Space and Topology
Course Level	400-499
Course Summary	This undergraduate course in mathematics introduces fundamental concepts in Metric Space and General Topology.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Set and Functions, Fundamentals of Analysis.

COURSE OUTCOME

CO No.	Expected Course Outcome	Learning Domains *	PO No.
1	Visualize the concept of distance as a mathematical function in various spaces	**U**	**1**
2	Explain the concept of continuity	**U**	**1,2**
3	Understand the concept of compactness	**U**	**1**
4	Classify and compare different topological spaces	**An**	**1,2**

Course Content

Module	Units	Course description	Hrs	CO Nos
1	**Metric spaces**			
	1.1	Definition and examples (Chapter 2 section 9 of Text 1)	5	1
	1.2	Open sets (Chapter 2 section 10 of Text 1)	5	1
	1.3	Closed sets (Chapter 2 section 11 of Text 1)	5	1
2	**Continuity and Completeness**			
	2.1	Convergence, completeness and Baire's theorem (Chapter 2 section 12 of Text 1)	5	2

	2.2	Continuous mappings (Chapter 2 section 13 of Text 1)	5	2
	2.3	Problems (Chapter 2 and 3 of Text 1)	5	2
3	**Compactness**			
	3.1	Definition and some examples (Chapter 3 section 16 of Text 1)	5	3
	3.2	Elementary concepts (Chapter 3 section 17)	5	3
	3.3	Open bases and open sub bases (Chapter 3 section 18 Theorem A, B, E of Text 1)	5	3
4	**Topological spaces**			
	4.1	Compact spaces and their properties (Chapter 4 section 21 Text 1)	8	4
	4.2	Compactness for metric space (section 24 excluding theorem B, C, D of Text 1)	7	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** 1. Problems from Chapter 2, 3 and 4 of Text 2 2. Section 1.1 and 1.2 of Text 2			

Text Book:

- Text-1: Introduction to Topology and Modern Analysis, GF Simmons, McGraw- HILL Book Company

References:

1. Munkres J.R, Topology-A First Course, Prentice Hall of India Pvt. Ltd., New Delhi,2000.

2. Stephen Willard, General Topology, Addison-Wesley, 2004.

3. Dugundji, Topology, Universal Book Stall, New Delhi, 1989.

4. Topology of Metric Spaces, S Kumaresan, 2nd edition, Narosa Publication House

Course 15

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC405
Course Title	Ordinary Differential equations
Course Level	400-499
Course Summary	This course provides a solid foundation in concepts of Sturm Separation theorem and Sturm Liouville problems. This course also explains the properties of Legendre and Bessel's polynomials. The course also analyses the concept of linear and nonlinear systems and their stability.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Course in Differential equations

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO No.
1	Summarize the concepts of Sturm Separation theorem and Sturm Liouville problems	**A**	**1,2**
2	Explain the properties of Legendre and Bessel's polynomials	**A**	**1,2**
3	Analyse the concept of linear and nonlinear systems and their stability	**E**	**1,3**
4	Illustrate the ideas of existence and uniqueness of solutions	**An**	**1,2**

COURSE CONTENTS

Module	Units	Course description	Hrs	CO Nos
1	**Qualitative properties of Solutions**			
	1.1	Oscillations and Sturm Separation theorem (Chapter 4 section 24)	5	1
	1.2	Sturm Comparison theorem (Chapter 4 section 25)	5	1
	1.3	Eigenvalues, Eigen functions and the Vibrating string (Chapter 7 section 40)	5	1
2	**Legendre and Bessel polynomials**			
	2.1	Legendre polynomials	5	2

	2.2	Properties of Legendre polynomials	5	2
	2.3	Bessel functions	5	2
3	**Nonlinear systems**			
	3.1	System of first order equations	3	3
	3.2	Nonlinear systems	3	3
	3.3	Autonomous systems	3	3
	3.4	Critical points and stability	3	3
	3.5	problems	3	3
4	**Picard's Theorem**			
	4.1	Method of successive approximates	8	4
	4.2	Existence and uniqueness theorems	7	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENT Sturm Liouville problems (Chapter 1 section 43) Properties of Bessel functions Existence and uniqueness theorems Problems from module 3			

Text Book:

- George F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, Tata McGraw Hill Publishing Company Limited

References:

1. Shepley L. Ross - Differential Equations, 3rd ed., (Wiley India).
2. E.A. Coddington - An Introduction to Ordinary Differential Equations, PHI.
3. W.E. Boyce & R.C. Diprima - Elementary Differential Equations and boundary value Problems, (Wiley India)
4. S. Balachandra Rao & H. Ranuradha – Differential Equation with Applications and Programs (Universities Press)

Course 16

Discipline	Mathematics
Semester	VII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC406
Course Title	Combinatorics
Course Level	400-499
Course Summary	This course is a dynamic exploration of fundamental combinatorial concepts, focusing more on problems than theory. This approach aims to help students excel in competitive examinations by thoroughly covering exercise problems.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Elementary Algebra, Basic Set theory, Basic understanding of Probability

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO No.
1	Provides a valuable toolkit for students preparing for competitive exams, offering a wealth of problems that sharpen logical reasoning and problem-solving skills	U	2,3,4
2	Apply combinatorial methods to model and analyse real-world problems, emphasizing the translation of problems into mathematical language	A	1,2,3
3	Demonstrate a deep understanding of basic combinatorial concepts, such as permutations, combinations, and the multiplication principle	E	1,2
4	Develop critical thinking skills by analysing and synthesizing complex combinatorial problems, evaluating different approaches, and selecting the most suitable strategies.	An	2,7,8

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Permutations and Combinations			
	1.1	Two basic counting principles (Chapter 1 section 1.1)	3	1
	1.2	Permutations (Chapter 1 section 1.2)	3	1

1	1.3	Circular Permutations (Chapter 1 section 1.3)	3	1
	1.4	Combinations (Chapter 1 section 1.4)	3	1
	1.5	Injection and bijection principle (Chapter 1 section 1.5)	3	1
2	**Pigeonhole principle and Ramsey Numbers**			
	2.1	Pigeonhole principle (Chapter 3 section 3.2, 3.3)	4	2
	2.2	Ramsey type problems and Ramsey numbers (Chapter 3 section 3.4)	4	2
	2.3	Bounds for Ramsey numbers (Chapter 3 section 3.5)	4	2
	2.4	problems	3	2
3	**The principle of Inclusion and Exclusion**			
	3.1	Introduction and the Principle (Chapter 4 section 4.1, 4.2)	4	3
	3.2	Generalization (Chapter 4 section 4.3)	4	3
	3.3	Integer Solutions and Shortest Routes (Chapter 4 section 4.4)	4	3
	3.4	Surjective mappings and Stirling numbers of the second kind (Chapter 4 section 4.5)	3	3
4	**Generating Functions**			
	4.1	Ordinary generating functions (Chapter 5 section 5.1)	3	4
	4.2	Some modelling problems (Chapter 5 section 5.2)	3	4
	4.3	Exponential generating functions	3	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENT Arrangements and selections with repetitions (Chapter 1 section 1.6) Derangements and a generalization Distribution problems			

Textbook:

- Chen, Chuan-Chong, Khee Meng Koh, and Koh Khee-Meng. Principles and techniques in combinatorics. World Scientific, 1992.

References:

1. Krishnamoorthy, V., Hoewood, E. Combinatorics theory and applications, 1986.
2. Hall, Jr. Combinatorial Theory, Wiley-Interscinice,1998.
3. Brualdi, RA. Introductory Combinatorics, PrenticeHall,1992
4. Bona Miklos. A Walk Through Combinatorics – An Introduction to Enumeration and Graph Theory, Second Edition, World Scientific, 2006.

Course 17

Discipline	Mathematics
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC407
Course Title	Complex Analysis III
Course Level	400-499
Course Summary	To understand the applications of residues for evaluation of definite and improper integrals occurring in real analysis and applied mathematics. To know about special functions like Riemann Zeta function which plays a pivotal role in analytic number theory and has applications in physics, probability theory, and applied statistics.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Foundation course in Complex Analysis

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcomes	Learning domain	PO No.
1	Understand the metric on spaces of analytic, meromorphic and analytic functions, equi-continuity and normal families leading to ArzelaAscoli and related theorems.	U	1
2	Factorize Complex functions using Weierstrass factorization theorem	A	1, 2
3	Analyse simple connectedness using Rung's Theorem	A	1
4	Analyse the behaviour of the radius of convergence for an analytic continuation along a curve.	A	1, 2
5	Understand how big the range of an entire function is as well as Picard and related theorems.	U	2

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**The Maximum Modulus Theorem**			
	1.1	The Maximum Principle, Chapter 6 section 1	15	1
	1.2	Schwarz's Lemma Chapter 6 section 2		1

	1.3	Convex Functions and Hadamard's Three circles Theorem Chapter 6 section 3		1
	1.4	Practicum :- Phragmen- Lindelof Theorem		
2	**Compactness and Convergence in the space of Analytic**			
	2.1	The space of continuous functions C (G, Ω) Chapter 7 section 1	10	1
	2.2	Spaces of analytic functions Chapter 7 section 2		1
	2.3	The Riemann Mapping Theorem (Statement Only) Chapter 7 section 4		1
	2.4	Weierstrass Factorization Theorem Chapter 7 section 5		1
	2.6	Practicum: -Factorization of sine Function Chapter 7 section 6, Spaces of Meromorphic functions	15	1
3	**Runge's theorem**			
	3.1	The gamma function Chapter 7 section 7	10	2
	3.2	The Riemann zeta Function Chapter 7 section 8		2
	3.3	Runge's Theorem Chapter 8 section 1		3
	3.4	Simple Connectedness Chapter 8 section 2		3
	3.5	Practicum: -Mittag Leffler's Theorem Chapter 8 section 3	10	3
4	**Analytic continuation and Entire functions**			
	4.1	Schwarz Reflection Principle Chapter 9 section 1	10	4
	4.2	Analytic Continuation along a path Chapter 9 section 2		4
	4.3	Monodromy Theorem (without proof) Chapter 9 section 3		4
	4.4	Jensen's Formula Chapter 11 section 1		5
	4.5	Practicum: - Hadamard factorization theorem	5	5

5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally The genus and order of an entire function Chapter 11 section

Text Book:

- John B. Conway, Functions of One Complex Variable, Second Edition.

References:

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variables, Addison Wesley.
3. Lang. S, Complex Analysis, Springer.
4. 4. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990

Course 18

Discipline	Mathematics
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC408
Course Title	Basic Topology
Course Level	400-499
Course Summary	Course introduces properties of topological spaces, including Compactness and connectedness, and Separation axioms.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4
Pre-requisite, if any	Fundamental of Analysis, Basics of metric space and analysis

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains *	PO No.
1	Understand the concept of subspace and closed sets of a topological space, neighbourhoods and interior point of a point in a topological space	U	1,2
2	Prove a selection of theorems concerning topological spaces, continuous functions, quotient topologies, compact and Lindeloff space.	U	1
3	Summarise the concept of connectedness, local connectedness and path connectedness.	U	1,2
4	Classify and compare spaces with respect to separation axiom	An	1

Course Content

Module	Units	Course description	Hrs	CO Nos
1	**Bases and Sub bases**			
	1.1	Bases and Sub bases (Chapter 4, Section 3)	3	1
	1.2	Subspaces (Chapter 4, (Section 4)	3	1
	1.3	Closed sets and Closure (Chapter 5, Section 1)	3	1
	1.4	Neighbourhoods, Interior and Accumulation points (Chapter 5, Section 2 (2.1 to 2.10 and 2.13)	3	1
	1.5	Practicum: Problems in chapter 5 (Section 1 and 2)	8	1

2	**Continuous functions**			
	2.1	Making functions continuous and Quotient Spaces (Chapter 5, Section 4.1 to 4.12)	6	2
	2.2	Smallness condition on a Space (Chapter 6, Section 1)	6	2
	2.3	Practicum Problems in chapter 5 (Section 4)	8	2
3	**Connectedness**			
	3.1	Connectedness (Chapter 6, Section 2)	4	3
	3.2	Local Connectedness and Paths (Chapter 6, Section 3)	4	3
	3.3	Practicum Problems in chapter 6 (Section 2 and 3)	7	3
4	**Separation Axiom**			
	4.1	Hierarchy of Separation Axioms (Chapter 7, Section 1)	8	4
	4.2	Compactness and Separation Axioms (Chapter 7, Section 2 (2.1 to 2.10)	7	4
	4.3	Practicum: Problems (Chapter 7, Section 1 and 2)	7	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** ➢ Study the concept of nearness relation on a set and the one-to-one correspondence between set of topologies on a set and the set of nearness relation on that set. ➢ Study the concept of embedding problem, extension problem and lifting problem. ➢ Study the concept of identification space and identification maps. ➢ Study the concept of local connectedness.			

Text Book:

- Introduction to General Topology, KD Joshi

References

1. Munkres J.R, Topology-A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

2. Stephen Willard, General Topology, Addison-Wesley, 2004.

3. Dugundji, Topology, Universal Book Stall, New Delhi, 1989.

4. Topology of Metric Spaces, S Kumaresan, 2nd edition, Narosa Publication House

Course 19

Discipline	Mathematics
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC409
Course Title	Measure Theory and Integration
Course Level	400-499
Course Summary	This course provides a comprehensive exploration of measure theory and integration, with a primary focus on the development and applications of the Lebesgue measure and integral. The syllabus covers fundamental concepts such as Lebesgue outer measure, sigma algebra of Lebesgue measurable sets, outer and inner approximation techniques, countable additivity, and the Borel-Cantelli Lemma. Students will delve into non-measurable sets, including the Cantor set and Cantor Lebesgue function. The course concludes with a generalization of measurability concepts for functions on general measurable spaces. Students will study integration over general measure spaces, utilizing the Caratheodory construction of measure. The construction of product measures is introduced, and classic theorems of Fubini and Tonelli are proven. By the end of the course, students will have a comprehensive understanding of measure theory and integration, with the ability to apply these concepts in both Lebesgue and general measure spaces. The course aims to equip students with the analytical tools necessary for advanced mathematical applications and research.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4
Pre-requisite, if any	Course in Real analysis and metric space.

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO No.
1	Acquire a deep understanding of the principles behind the Lebesgue measure, including its introduction, outer measure, and the sigma algebra associated with Lebesgue measurable sets	A	1,2,3
2	Recognize and analyse non-measurable sets, including specific examples like the Cantor set, and comprehend the implications of their existence	An	1,2
3	Develop proficiency in integrating functions within the Lebesgue framework, including the Riemann integral, Lebesgue integral of bounded and non-negative measurable	E	1,2,3

	functions, and the General Lebesgue Integral.		
4	Acquire a comprehensive understanding of general measure spaces, including their properties and construction, enabling them to analyse and work with measures in a broader context.	An	1,7,8
5	Proficient in utilizing the Caratheodory construction of measure, allowing them to construct product measures and prove classic theorems such as Fubini and Tonelli in the context of general measure spaces.	S	1,2,8

Course content

Module	Units	Course description	Hrs	CO Nos
1	**Lebesgue measure**			
	1.1	Introduction	15	CO1
	1.2	Outer measure		CO1
	1.3	Measurable sets		CO1
	1.4	Outer and inner approximation of Lebesgue measurable sets		CO1
	1.5	Practicum: Countable additivity, Borel Cantelli lemma	7	CO1
Chapter 2- Section 2.1 -2.5 (Relevant topics)				
2	**Measurable functions**			
	2.1	Non measurable set	15	CO2
	2.2	Cantor set		CO2
	2.3	Lebesgue measurable functions and integration		CO2
	2.4	Sequential pointwise limits and simple approximation		CO2
	2.5	Littlewood's three principles, Egoroff's theorem and Lusin's theorem (all theorems without proof		CO2
	2.6	Practicum: Problems	8	CO2
Chapter 2 - Section 2.6, 2.7, 3.1 to 3.3 (Relevant topics)				
3	**Lebesgue integration**			
	3.1	Riemann integral	8	CO3
	3.2	Lebesgue integral of a bounded measurable function over a set of finite measure		CO3
	3.3	Lebesgue integral of a measurable non negative function		CO3
	3.4	General Lebesgue integral		CO4

	3.5	Practicum: Countable additivity and continuity of integration, Integrating derivatives	7	CO4
Chapter-4 Section 4.1 to 4.5, Chapter -6 section 6.5 (Relevant topics)				
4	**General Measure spaces**			
	4.1	Measure and measurable sets (theorems without proof)	7	CO 5
	4.2	Signed measure		CO 5
	4.3	Caratheodory measure induced by an outer measure (Proposition 5,6,7 statement only)		CO 5
	4.4	Practicum: problems	8	CO 5
	Chapter 17 - Section 17.1 to 17.4, Chapter 18- section 18.4 (Relevant topics)			
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Some Suggestions Problems on Measurable sets Cantor set Construction of outer measures Radon Nikodym Theorem (without proof)			

Text Book:

- HL Royden, P.M. Fitzpatrick, Real Analysis 4th edition

References:

1. 1. Barra, G. de. Measure Theory and integration, New Age International (P) Ltd., New Delhi, 1981 (Reprint 2003)
2. Halmos, P.R. Measure Theory, D. van Nostrand Co., 1974
3. 3. Jain, P.K., and Gupta,V.P. Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986 (Reprint 2000).
4. Bartle, R.G., The Elements of Integration, John Wiley & Sons, Inc New York, 1966.

Course 20

Discipline	Mathematics
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC410
Course Title	A First Course in Chaotic Dynamical Systems
Course Level	400-499
Course Summary	The aim of this course is to provide insight into elementary topics and current studies in the theory of chaotic dynamical systems. The focus will be on providing the students with basics in the area and introduce them to the fundamentals in this field. This course discusses the various definitions of Mathematical Chaos in elementary analytical way.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4
Pre-requisite, if any	Course in Real analysis and metric space.

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcomes	Learning Domain	PO No.
1	Analyse the properties of fixed and periodic points	A	1
2	Understand The dynamics of Quadratic Map	U	1, 2
3	Understand the concepts of Chaos	U	1
4	Understand the concepts of Fractals and its dimension	U & A	2

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1		**Orbits**		
	1.1	3.1 Iterations	10	1
	1.2	3.2 Orbits		1
	1.3	3.3 Types of Orbits		1
	1.4	3.4 Other Orbits		1
	1.5	3.5 The doubling theory		1
	1.6	5.1 A fixed point theorem		1
	1.7	5.2 Attraction and Repulsion		1
	1.8	5.3 Calculus of Fixed points		1
	1.7	Practical: - the computer may lie	10	1

2	**(Periodic points, Bifurcation and Quadratic family)**			
	2.1	5.5 Periodic points	10	2
	2.2	6.1 The dynamics of Quadratic Map		2
	2.3	6.2 The saddle point Bifurcation		2
	2.4	7.1 The case c=-2		2
	2.5	7.2 The case c<-2		2
	2.6	Practical: Exercise problems	10	
3	**Symbolic dynamics and Chaos**			
	3.1	9.2 The sequence space	15	3
	3.2	9.3 The Shift map		3
	3.3	9.4 Conjugacy (Definition only)		3
	3.4	10.1 The three properties of a Chaotic System		3
	3.5			3
4	**Fractals**			
	4.1	13 Newton's Method (definitions and statement of theorems only)	10	4
	4.2	14.1 The Chaos game		4
	4.3	14.2 the Cantor set Revisited		4
	4.4	14.3 The Sierpinski Triangle		4
	4.5	14.4 The Koch Snowflake		4
	4.6	14.6 Fractal dimension		4
	4.7	Practical: - The chaos game.. This game allows students to understand the construction of the Sierpinski triangle via the chaos game. Fractalina. This applet allows you to set up the vertices, compression ratios, and rotations associated to an iterated function system and then compute and view the resulting fractal. Fractanimate. This applet allows you to string together a collection of fractal images generated by Fractalina into a movie. We encourage you to become quite familiar with Fractalina before trying to use this applet.	10	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally 10.2 Other Chaotic system 16. The Julia set (Definition and some properties)			

Textbook:

1. Devaney, Robert L., 1948-. A First Course in Chaotic Dynamical Systems: Theory and Experiment. Reading, Mass.: Addison-Wesley, 1992.

References:

1. Feldman, David P. *Chaos and Fractals: An Elementary Introduction*. Oxford University Press, 2012.

2. Flake, Gary William. *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptations*. The MIT Press, 1998

3. Sayama, Hiroki, *Introduction to the Modelling and Analysis of Complex Systems*. OpenSUNY Textbooks.

4. Kaplan, Daniel, and Leon Glass. *Understanding Nonlinear Dynamics*. Springer-Verlag, 1995

5. Strogatz, Steven. *Nonlinear dynamics and chaos: with applications to physics, biology, chemistry and engineering*. Westview Press, 2001

6. Peitgen, Heinz-Otto, Hartmut Jürgens, and Dietmar Saupe. *Chaos and fractals: new frontiers of science*. Springer, 2004

7. Smale, Stephen, Morris W. Hirsch, and Robert L. Devaney. *Differential equations, dynamical systems, and an introduction to chaos*. (3rd edition.) Academic Press. 2012.

8. Devaney, Robert L. *An Introduction to Chaotic Dynamical Systems*. (2nd edition.) Westview Press, 2003.

9. Ott, Edward. *Chaos in Dynamical Systems*. (2nd edition.) Cambridge University Press, 2002.

Course 21

Discipline	Mathematics
Semester	VIII
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC411
Course Title	Functional Analysis
Course Level	400-499
Course Summary	This course covers fundamental concepts in functional analysis, including Normed Spaces and Continuity of Linear Maps. Module 2 explores Hahn-Banach Theorems and Banach Spaces. Module 3 delves into the Uniform Boundedness Principle, Closed Graph, and Open Mapping Theorems. Module 4 concludes with the Bounded Inverse Theorem and Spectrum of a Bounded Operator. These modules provide a comprehensive understanding of key topics in functional analysis.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO No.
1	Discuss the concept of normed linear spaces and Banach Spaces.	An	1,2,3,7,8
2	Analyse the Hahn Banach theorems and applications.	E	1,2,3,7,8
3	Discuss the uniform bounded principle and its applications.	E	1,2,3,7,8
4	Analyse the closed graph theorem and its applications.	An	1,2,3,7,8
5	Comprehend the spectrum of an operator and its various properties.	E	1,2,3,7,8

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Normed Spaces and Continuity**			
	Normed spaces and continuity of linear maps. [Chapter II: Section 5 and Chapter II: Section 6 (Excluding 6.5 (d) and Theorem 6.8)].		15	1
	Practicum: Problems on pages 79-83 and pages 100-104 of the prescribed text.			
2	**The Hahn Banach Theorems**			

	Hahn-Banach theorems and Banach spaces. (Chapter II: Section 7-Section 7.10, and Chapter II: Section 8).	20	2
	Practicum: Problems on pages 120-124 and pages 134-137 of the prescribed text.		
3	**Uniform boundedness, closed graph and open mapping theorems**		
	Uniform boundedness principle, closed graph and open mapping theorems (Chapter III: Sections 9 to 9.3 and 10 of the Text).	20	3, 4
	Practicum: Relevant Problems on pages 161-166 and pages 178-182 of the prescribed text.		
4	**Bounded inverse theorem and spectrum of a bounded operator.**		
	Bounded inverse theorem, spectrum of a bounded operator (Section 11.1,12 (Except 12.4) of the text).	20	5
	Practicum: Relevant Problems on pages 212- 215 of the prescribed text.		
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Suggestions for Teacher Specific Content Linear Spaces and linear maps Metric Spaces and continuous functions Completeness, Compactness, Lebesgue measure and integration on R ,L^p spaces		

Text Book:

1. Functional Analysis - Balmohan V Limaye (Revised 3rd Edition) , New Age International Publishers.

References:

1. Introductory Functional Analysis, KREYSZIG, Wiley classic library Edition
2. Introduction to Topology and modern analysis, SIMMONS.G.F, McGrow- hill, 1963 New York
3. Functional Analysis, WALTER RUDIN,Tata McGraw Hill Publishers
4. Functional Analysis A First course, M. THAMBAN NAIR, Prentice-Hall of India Pvt.Ltd.

5. SYLLABUS FOR DISCIPLINE SPECIFIC ELECTIVE COURSES IN MATHEMATICS

COURSE 01

Discipline	Mathematics
Semester	III
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE201
Course Title	Numerical Analysis
Course Level	200-299
Course Summary	This course covers techniques to find the roots of equations via various mathematical methods. Numerical solutions of integration and ordinary differential equations are discussed. Different methods to interpolate and extrapolate is also discussed.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Basic operations on number system

COURSE OUTCOME

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain algebraic and transcendental equations and find at least one root.	U	1, 2
2	Illustrate interpolation and apply different method to approximate a polynomial	A	1, 2
3	Apply different techniques to find the value of integral	A	1, 2
4	Solve ordinary differential equations using various methods	A	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO
1	**Solutions of Algebraic and Transcendental Equations**			
	1.1	Introduction (Sec 2.1)	15	1
	1.2	The Bisection Method (Sec 2.2)		1

	1.3	The Method of false position (2.3)		1
	1.4	The Iteration Method (2.4)		1
	1.5	Newton-Raphson Method (2.5)		1
	1.6	Generalised Newton-Raphson Method		1
2	**Interpolation**			
	2.1	Introduction (Sec 3.1)	15	2
	2.2	Forward Differences (Sec 3.3.1)		2
	2.3	Backward Differences (Sec 3.3.2)		2
	2.4	Lagrange's Interpolation Formula		2
	2.5	Newton's formula for Interpolation(Sec 3.6)		2
3	**Numerical Integration**			
	3.1	Trapezoidal Rule (Sec 5.4.1)	15	3
	3.2	Simpson $1/3^{rd}$ Rule (Sec 5.4.2)		3
	3.3	Simpson $3/8^{th}$ Rule (Sec 5.4.3)		3
	3.4	Romberg Integration (Sec 5.4.6)		3
4	**Numerical Solutions of ODE**			
	4.1	Solution by Taylor series (Sec 7.2)	15	4
	4.2	Picard's Method (Sec 7.3)		4
	4.3	Euler's Method (Sec 7.4) (7.4.1 omitted)		4
	4.4	Runge-Kutta Methods (Sec 7.5)		4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally. **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** ➢ Problem solving using the methods discussed in the module 1, 2, 3 and 4. ➢ Extra reading and practice: Stirling's formula, Bessel's formula, Boole's and Weddle's Rules.			

Textbook:

1. Introductory Methods of Numerical Analysis, S.S. Sastry, 4th Edn, Prentice-Hall of India.

References:

1. Jain, M. K., Iyengar, S. R. K., & Jain R. K. (2012). Numerical Methods for Scientific and Engineering Computation (6th ed.). New Age International Publishers. Delhi
2. Bradie, Brian (2006). A Friendly Introduction to Numerical Analysis. Pearson Education India. Dorling Kindersley (India) Pvt. Ltd. Third Impression, 2011
3. Chapra, Steven C. (2018). Applied Numerical Methods with MATLAB for Engineers and Scientists (4th ed.). McGraw-Hill Education.
4. Fausett, Laurene V. (2009). Applied Numerical Analysis Using MATLAB. Pearson. India

COURSE 02

Discipline	Mathematics
Semester	IV
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE202
Course Title	Vector Calculus
Course Level	200-299
Course Summary	This course introduces vector functions, derivatives of vector functions, arc length, unit tangent vectors, curvature, normal vectors of a curve, and directional derivatives. The course also explores vector integration, Green's theorem, Stokes theorem and Divergence Theorem.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4
Pre-requisite, if any	Vector Algebra

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO
1	Understand scalars and vectors	**U**	**1**
2	Understand derivative of a vector function	**U**	**1, 2**
3	Study to integrate vector functions	**A**	**1**
4	Understand Stokes, Divergence and Greens Theorem	**U**	**1, 2**
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Vectors and Geometry of Space**			
	1.1	Scalars and Vectors , Types of vectors, addition of vectors (7.1-7.4)	15	1
	1.2	Dot product of two vectors and its properties (7.10-7.11)		1
	1.3	Vector product and its properties (7.13,7.14)		1
	1.4	Scalar triple product and vector triple product and its properties (7.18,7.19,7.20)		1

	1.5	Practicum- problems from sec 7.13,7,14,7.18,7.19 and 7.20	5	1
2	**Derivative of Vector Functions**			
	2.1	Vector functions and derivative of vector function (8.1,8.2)	10	2
	2.2	General rules of differentiation (8.3)		2
	2.3	Velocity and acceleration (8.9)		2
	2.4	Scalar and vector fields, Gradient of a scalar field , geometrical interpretation (8.10,8.11,8.12)		2
	2.5	Directional derivative and properties of Gradient (8.13,8.14)		2
	2.6	Divergence and curl of a vector functions(8.15,8.16)		2
	2.7	Practicum:- Problems from section 8.10 - 8.16	10	2
3	**Integration of Vector Functions**			
	3.1	Integration of Vector functions (8.21)	15	3
	3.2	Line Integrals, circulation and work done (8.22,8.23,8.24)		3
	3.3	Surface integrals and Volume integrals (8.25,8.26)		3
	3.4	Practicum:- Repeated operations by ∇ (8.20) and problems	5	3
4	**Theorems in Vector Integration**			
	4.1	Divergence theorem (8.27)	5	4
	4.2	Greens theorem (8.28)		4
	4.3	Stokes theorem (8.29)		4
	4.4	Practicum : Problems from section 8.27,8.28 and 8.29	10	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **Some Suggestions for Teacher Specific Contents:** 1.Geometrical interpretation and Physical interpretation of divergence and Curl. 2. Extra problems on Div, Grad and curl and their properties.			

Textbook:

1. A Textbook of Engineering Mathematics., N P Bali, Manish Goyal. 8th Edn**.**

References:

1. George B Thomas, Jr.Thomas' Calculus Twelth Edition ,Pearson
2. H. Anton, Bivens, Devis, Calculus, Seventh Edition, Wiley India
3. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, India

COURSE 03

Discipline	Mathematics
Semester	IV
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE203
Course Title	Special Functions and Integral Transforms
Course Level	200-299
Course Summary	This course provides a solid foundation in Laplace transforms and its application in solving differential equations. This course also introduces Fourier series, Fourier transforms and explore its significance.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Basic differentiation and integration

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Understand and apply Laplace transform, inverse Laplace transform and to solve ODE	A	1, 2, 3
2	Apply various operations on transforms	An	1, 2
3	Solve problems using Fourier series	A	1, 2
4	Evaluate Fourier sine and cosine transforms in various Scientific problems	An	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**LAPLACE TRANSFORMS**			
	1.1	Introduction and definition(18.1,18.2)	15	1
	1.2	Linearity property (18.3)		1
	1.3	Laplace transforms of some elementary functions (18.4)		1

	1.4	Properties of Laplace transforms(18.5)		1
	1.5	Inverse Laplace transforms (18.6)		1
2	**APPLICATIONS OF LAPLACE TRANSFORMS**			
	2.1	Laplace transform of derivatives and integrals(18.7,18.8)	15	2
	2.2	Multiplication by t^n, Division by t(18.9,18.10)		2
	2.3	Convolution theorem(18.11)		2
	2.4	Application to differential equations (18.12)		2
3	**FOURIER SERIES**			
	3.1	Periodic functions(10.1)	15	3
	3.2	Fourier series (10.2)		3
	3.3	Dirichlet's conditions(10.4)		3
	3.4	Fourier series of discontinuous functions (10.5)		3
	3.5	Change of interval (10.6)		3
	3.6	Half range series(10.7)		3
4	**INTEGRAL TRANSFORMS**			
	4.1	Integral Transforms(20.1)	15	4
	4.2	Fourier integral theorem (Proof excluded)(20.2)		4
	4.3	Fourier sine and cosine integrals (Proof excluded)(20.3)		4
	4.4	complex form of Fourier integral (Proof excluded) (20.4)		4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **Some Suggestions for Teacher Specific Contents**: ➢ Problem solving from module 1, 2 and 3 ➢ Problems relating to Fourier transform			

Textbook:

1. A Textbook of Engineering Mathematics, N.P. Bali, Dr Manish Goyal, Laxmi Publications

References:

1. Lokenath Debnath, Dambaru Bhatta . Integral Transforms and Their Applications (3rd ed.). CRC Press Taylor & Francis Group, 2015.
2. Baidyanath Patra. An Introduction to Integral Transforms. CRC Press, 2018, Ist Edition.
3. Joel L. Schiff. The Laplace Transform-Theory and Applications. Springer 1999.
4. Rajendra Bhatia. Fourier Series (2nd ed.) Texts and Readings in Mathematics. Hindustan Book Agency, Delhi 2003**.**

COURSE 04

Discipline	Mathematics
Semester	V
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE301
Course Title	Operations Research
Course Level	300-399
Course Summary	This undergraduate course in Mathematics introduces LPP and techniques to solve Linear Programming Problem. The course also explores dual-primal relationship, Transportation and Assignment problems.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Elementary matrix transformations, plotting a graph.

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain Simplex method and its variation	U	1, 2
2	Differentiate between dual , primal and study their characterizations	U	1
3	Apply Hungarian method to solve transportation problem	A	2
4	Solve problems using Assignment method	A	2

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Linear Programming**			
	1.1	Important definitions (Section 3.2)	17	1
	1.2	Graphical solution methods of LP problem (Section 3.3)		1
	1.3	Simplex method (Section 4.1- 4.3)		1
	1.4	Two Phase method (Section 4.4.1)		1
2	**Duality in Linear Programming**			
	2.1	Formulation of Dual linear programming problem (Section 5.2.1,5.2.2, 5.2.3)	13	2

	2.2	Rules for constructing dual from primal (Section 5.2.4)		2
	2.3	Standard results on Duality (Section 5.3, appendix 27.A)		2
	2.4	Dual Simplex method		2
3	**Transportation problems**			
	3.1	Mathematical model of transportation problem (Section 9.2)	15	3
	3.2	Transportation algorithm (Sectio 9.3)		3
	3.3	Method of finding initial solution (Section 9.4)		3
	3.4	Test for optimality (Section 9.5.3, 9.5.4)		3
4	**Assignment problems**			
	4.1	Mathematical model of Assignment problem (Section 10.2)	15	4
	4.2	Solution methods of Assignment problem (Section 10.3)		4
	4.3	Unbalanced problem (Section 10.4.3, 10.4.4)		4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** Problem solving using the methods discussed in the module 1, 2 ,3 and 4			

Text Book:

1. Operations research Theory & Applications, J K Sharma,3rd edition, Macmillan

References:

1. Prem Kumar Gupta and D.S. Hira – Operations Research – 7th Edition (2014)
2. J.K. Sharma – Operations Research: Theory and Applications – 6th edition
3. Frederick S. Hillier & Gerald J Lieberman – Introduction to Operations Research – 10th edition
4. Hamdy A. Taha - Operations Research: An Introduction – 8th edition
5. Kanti Swarup,P.K. Gupta , Man Mohan - Operation Research
6. Aumann R.J.- Mixed and Behaviour strategies in infinite extensive

COURSE 05

Discipline	Mathematics
Semester	V
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE302
Course Title	Graph Theory
Course Level	300-399
Course Summary	Graph theory began in 1736 when the Swiss mathematician Euler solved Konigsberg seven-bridge problem. It has been two hundred and eighty years till now. Graph theory is the core content of Discrete Mathematics, and Discrete Mathematics is the theoretical basis of computer science and network information science. This course introduces in an elementary way some basic knowledge and the primary methods in Graph Theory
Hours	60 (Lecture/Tutorial – 60)
Credits	4

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO
1	Classify precise and accurate mathematical definitions of objects in graph theory.	U	1
2	Learn about Operations on graphs	U	1, 2
3	Study the concepts of Characterization of Trees	A	1, 2
4	Understand Eulerian Graphs, Hamiltonian graphs, and their applications	A	1
5	Assimilate various graph theoretic concepts and familiarize with their applications	An	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Introduction to Graph Theory			
	1.1	Definition of a Graph 1.1		1

1	1.2	More definitions 1.3	15	1
	1.3	Vertex Degrees 1.4		1
	1.4	Sub graphs 1.5		1
	1.5	Paths and Cycles 1.6		1
	1.6	Matrix representation of graphs 1.7		1
2	**Trees and Connectivity**			
	2.1	Definitions and simple properties 2.1	15	2
	2.2	Bridges 2.2		2
	2.3	Spanning Trees 2.3		3
	2.4	Cut vertices and Connectivity 2.6		3
3	**Euler Tours and Hamiltonian Cycles**			
	3.1	Euler Tours 3.1	20	4
	3.2	Hamiltonian Graphs 3.3		4
	3.3	Matchings and Augmenting paths 4.1		4
4	**Planar graphs and Colouring**			
	4.1	Plane and planar Graphs 5.1	10	5
	4.2	Euler's formula 5.2		5
	4.3	Non Hamiltonian plane graphs 5.5		5
	4.4	Vertex Colouring 6.1 (No proofs included)		5
	4.5	Vertex Colouring Algorithm 6.2 & Critical graphs 6.3 (definition Only)		5
	4.6	Edge colouring 6.5 (No proofs included)		5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally			

Text Book:

John Clark, A First look at Graph Theory

References:

1. J. A. Bondy, U.S.R. Murty: Graph Theory; Springer; 2000.
2. S. M. Cioaba and M.R. Murty: A First Course in Graph Theory and Combinatorics;
2. Hindustan Book Agency; 2009.
3. John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.
4. R. Diestel: Graph Theory(4th Edn.); Springer-Verlag; 2010
5. J. L. Gross: Graph theory and its applications (2nd edn.); Chapman & Hall/CRC; 2005.
6. F. Harary: Graph Theory; Narosa Pub. House, New Delhi; 1992.
7. Narsingh Deo: Graph Theory with Applications to Engineering & Computer Science; Dover Publications Inc; New York
8. W. T. Tutte: Graph Theory; Cambridge University Press; 2001

COURSE 06

Discipline	Mathematics
Semester	VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE303
Course Title	Complex Analysis I
Course Level	300-399
Course Summary	This course provides an introduction to complex analysis which is the theory of complex functions of a complex variable. We will start by introducing the complex plane, along with the algebra and geometry of complex numbers, and then we will make our way via differentiation, integration, complex dynamics, power series representation and Laurent series into territories at the edge of what is known today.
Hours	75 (Lecture/Tutorial – 45, Practicum - 30)
Credits	4
Pre-requisite, if any	Foundation course in Real Analysis, Complex Numbers

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO
1	Analyze limit, continuity and differentiation of functions of complex variables, and Cauchy Rieman theorem	An	1
2	Understand Cauchy theorem and Cauchy integral formulas and apply these to evaluate complex contour integrals.	U	1, 2
3	Represent functions as Taylor, power and Laurent series,	A	1
4	Analyze and classify singularities and poles, find residues and evaluate complex integrals using the residue theorem	An	1,2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Analytic functions **Chapter 2 (Sections 12, 15, 16, 18 to 22, 24 to 26);**			

1	**Chapter 3 (Sections 29, 30, 33 to 36)**			
	1.1	Functions of a complex variable, limits, theorems on limits, continuity	10	1
	1.2	derivatives, differentiation formulas		1
	1.3	Cauchy-Riemann equation, sufficient condition for differentiability		1
	1.4	Analytic functions, examples, harmonic functions.		1
	1.5	practicum : Problems in Corresponding Exercise	5	
2	**Complex Integrals** **Chapter 4 (Sections 37 to 41, 43, 44, 46, 48 to 54)**			
	2.1	Derivatives of functions, definite integrals of functions, contours, contour integrals	15	2
	2.2	some examples, upper bounds for moduli of contour integrals, antiderivatives		2
	2.3	Cauchy-Goursat theorem (without proof), simply and multiply connected domains		2
	2.4	Cauchy's integral formula, an extension of Cauchy's integral formula		2
	2.5	Liouville's theorem and fundamental theorem of algebra		2
	2.6	Maximum modulus principle.		2
	2.7	Practicum :- Problems in Corresponding Exercise	5	2
3	**Series** **Chapter 5 (Sections 55 to 60 and 62)**			
	3.1	Convergence of sequences and series,	10	3
	3.2	Taylor's series, proof of Taylor's theorem,		3
	3.3	Examples .		3
	3.4	Laurent's series (without proof), examples		3
	3.5	Practicum :- Problems in Corresponding Exercise	10	
4	**SINGULAR POINTS**			

	4.1	Isolated singular points	10	4
	4.2	Residues ,		4
	4.3	Cauchy's residue theorem,		4
	4.4	Three types of isolated singular points, residues at poles,		4
	4.5	examples. Applications of residues		4
	4.7	Practicum :- Problems in Corresponding Exercise	5	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Problems on residues and evaluating integrals			

Text Book:

1. Complex variables and applications by James Ward Brown & Ruel V. Churchill (8 th edition)

References:

1. Complex Analysis by Elias M. Stein and Rami Shakarchi
2. Functions of one complex variable - I by John B Conway
3. Complex Analysis by Lars Ahlfors
4. Complex Analysis by Serge Lang

COURSE 07

Discipline	Mathematics
Semester	VI
Type of Course	Discipline Specific Elective Course (DSE)
Course Code	24UMATDSE304
Course Title	Algebra - II
Course Level	300-399
Course Summary	This course on linear algebra provides a comprehensive introduction to the fundamental concepts and techniques of linear algebra. The course covers a wide range of topics, including vector spaces, coordinates, linear transformations, linear functionals, matrix of linear transformations, dual spaces, characteristic values, annihilating polynomials, invariant subspaces, simultaneous triangulisation and diagonalisation, direct sum decomposition, and invariant direct sums.
Hours	60 (Lecture/Tutorial – 60)
Credits	4
Pre-requisite, if any	Groups and its properties

COURSE OUTCOMES

CO No.	Expected Course outcomes	Learning domain*	PO
1	Understand and construct direct products of groups and analyse the structure of finitely generated abelian groups	An	1,2,3,4, 6,7
2	Comprehend the concepts of normal subgroups, factor groups and simple groups, identify and apply the properties of factor groups and homomorphisms, compute factor groups and analyse their properties.	A	1,2,3,4, 6,7
3	Understand group action on a set, construct examples of G-sets and orbits and apply the results on G-sets to the study of finite groups	A	1,2,3,4, 6,7
4	Comprehending Sylow theorems, students will apply the Sylow theory to classify groups of different orders	An	1,2,3,4, 6,7
5	Analysing homomorphisms, factor rings, prime and maximal ideals	A	1,2,3,4, 6,7
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Direct Products**			
	1.1	Direct Products	4	1
	1.2	The structure of finitely Generated Abelian groups	2	1
	1.3	Applications	2	1
	1.4	Factor groups	4	2
	1.5	Homomorphisms and factor groups	2	2
	1.6	Normal subgroups and inner automorphisms	2	2
2	**Factor Groups**			
	2.1	Factor group computations and Simple groups	6	2
	2.2	Center and Commutator subgroups	2	2
	2.3	Group action on a set :The notion of a group action	3	3
	2.4	Isotropy subgroups, Orbits	3	3
	2.5	Application of G-sets to finite groups	4	3
3	**Sylow theorems**			
	3.1	Isomorphism theorems	4	2
	3.2	Sylow theorems	5	4
	3.3	Applications of the Sylow theorems	5	4
	Factor rings			
	4.1	Factor rings	2	5
	4.2	Homomorphisms, Properties of homomorphisms	2	5
	4.3	Fundamental homomorphism theorem (for rings)	2	5
	4.4	Prime and maximal ideals	4	5
	4.5	Prime Fields	2	5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **Problems of section 11, 19-28 of Text**			

Text book:

1. A First Course in Abstract Algebra, John B. Fraleigh, Neall E Brand 8th edition, Pearson Education,2021

References:

1. Contemporary Abstract Algebra - Joseph A. Gallian, 10th Edition
2. Abstract Algebra – D. S. Dummit and R. M. Foote, 3rd Edition
3. Algebra – M. Artin, 2nd Edition
4.Topics in Algebra – I. N. Herstein, 2nd Edition
5. Rings and Modules – C. Musili, 2nd revised Edition

6. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES IN MATHEMATICS – MINOR PATHWAY

Course 01

Discipline	Mathematics
Semester	I
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC101
Course Title	Ground Roots of Mathematics
Course Level	100-199
Course Summary	This course provides a solid foundation in both mathematical logic and the principles of calculus. Beginning with "Basic Logic," students explore propositional logic, propositional equivalence, predicates, and quantifiers.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains*	PO
1	Explain the language of Mathematics and communicate in a proper way.	Understand	1, 2, 3
2	Apply matrices to solve systems of linear equations using methods of Gaussian elimination and matrix inversion	Apply	1, 2
3	Explain and apply the process of differentiation	Apply	1, 2
4	Characterize increasing/decreasing functions using their derivatives	Apply	1, 2
5	Apply L'Hospital's rule to evaluate indeterminate forms	Apply	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO No.
1	**Basic Logic (15 Hours)**			
	1.1	Propositional Logic (1.1, Text 1)	8	CO 1
	1.2	Propositional Equivalence (1.3, Text 1)		CO 1

	1.3	Predicates and Quantifiers (1.4, Text 1)		CO 1
	1.4	Practicum	7	CO 1
2	**Matrices (20 Hours)**			
	2.1	Linear System, Coefficient Matrix, Augmented Matrix	12	CO 2
	2.2	Gauss Elimination and Back Substitution		CO 2
	2.3	Elementary Row Operations, Row-Equivalent Systems		CO 2
	2.4	Gauss Elimination: The three Cases of systems		CO 2
	2.5	Row Echelon Form and Information from It (**Text 2: Chapter 7 - Section:7.3)**		CO 2
	2.6	Practicum	8	CO 2
3	**Derivatives (15 Hours)**			
	3.1	Introduction to Techniques of Differentiation (without proof) (2.3, Text 3)	8	CO 3
	3.2	Higher derivatives, The product and quotient rules (Without Proof) (2.4, Text 3)		CO 3
	3.3	Derivatives of trigonometric functions (Using formulas only) (2.5, Text 3)		CO 3
	3.4	Chain Rule (2.6, Text 3)		CO 3
	3.5	Implicit Differentiation (2.7, Text 3)		CO 3
	3.6	Practicum	7	CO 3
4	**Applications of Derivatives (20 Hours)**			
	4.1	Analysis of Functions I: Increase, decrease and Concavity (3.1 Text 3)	12	CO 4
	4.2	Analysis of Functions II: Relative extrema (3.2 Text 3) (Excluding - Geometric implications of multiplicity, Analysis of polynomials)		CO 4
	4.3	L'Hôpital's Rule (6.5 Text 3)		CO 5
	4.5	Indeterminate forms (6.5 Text 3)		CO 5
	4.6	Practicum	8	CO 4, CO 5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS: ➢ Determine the output of a combinatorial circuit constructed using basic logic gates. Also, building a digital circuit produces the required output. (Eg: Build a digital circuit that produces the output $(p \vee \neg r) \wedge (\neg p \vee (q \vee \neg r))$ with input bits p, q and r . ➢ Using a graphing calculator, visualize the effect of stretching and scaling (horizontal & vertical) of functions. ➢ Match the graphs of functions with the graphs of their derivatives.			

	➢ Use a graphing utility to make rough estimates of the locations of all horizontal tangent lines ➢ Use the implicit plotting capability of a CAS to graph a curve. Suggested software: Desmos, GeoGebra etc.

The practicum component is to be done in the classroom under the strict guidance of the teachers. A minimum of 30 problems is to be solved, and a handwritten copy of the solutions should be kept in the department.

Textbooks:

4. Discrete Mathematics and its application, Kenneth H Rosen, 7th Ed McGraw Hill Publishing.
5. Advanced Engineering Mathematics, Kreyszig, Erwin, 9th edition Wiley International Edition.
6. Calculus, 10th Edition, Howard Anton, Irl Bivens and Stephen Davis John Wiley and Sons, Inc.

References:

6. Hofstadter, Douglas R. Gödel, Escher, Bach: An Eternal Golden Braid. Expanded ed. Basic Books, 2007.
7. Copi, Irving M., Carl Cohen. Introduction to Logic. 5th ed. Routledge, 2018.
8. Stewart, James. Calculus: Early Transcendentals. 10th ed. Cengage Learning, 2023.
9. Thompson, Silvanus P. Calculus Made Easy. 5th ed. Dover Publications, 2014.
10. Thomas, George B., Jr., and Maurice D. Weir. Thomas' Calculus. 15th ed. Pearson, 2023.

Course 02

Discipline	Mathematics
Semester	II
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC102
Course Title	Gateway to Mathematics
Course Level	100-199
Course Summary	This course offers a comprehensive exploration of integral and partial differentiation calculus. Topics include integration methods, the definite integral, and the Fundamental Theorem of Calculus. Practical sessions cover integration applications like area between curves and double integrals. In partial differentiation, functions of several variables, partial derivatives, and the Chain rule are studied, with practical exercises reinforcing concepts. Applications of partial derivatives include directional derivatives, gradients, tangent planes, and identifying extreme values and saddle points. Through theory, practice, and real-world examples, students gain a deep understanding of integral and partial differentiation calculus principles and their practical applications.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	The Course 'Ground Roots of Mathematics'

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain	PO
1	Compute definite integrals of single-variable functions	A	1,2,3,7,8
2	Explain the geometric interpretation integrals and finding areas	U & A	1,2,3,7,8
3	Explain the concept of partial derivatives and experience its applications	U	1,2,3,7,8
4	Explore vector functions and directional derivatives	A	1,2,3,7,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	Integration			
	1.1	Integrals and Integration methods (Review)	9	1

1	1.2	The Definite Integral 2		1
	1.3	The Fundamental Theorem of Calculus (Proof of theorems excluded)		1
	1.5	Practicum 4.1, 4.5(excluding discontinuity and integrability), 4.6 (excluding dummy variables, mean value theorem for integrals and integrating rate of changes)	6	1
2	**Applications of Integration**			
	2.1	Area between two curves (5.1)	12	2
	2.2	Length of plane curve (5.2)		2
	2.3	Double Integrals over rectangular regions (14.1)		2
	2.5	Practicum	8	2
3	**Partial Differentiation**			
	3.1	Functions of several variables (13.1)	12	3
	3.2	Partial Derivatives(13.3)		3
	3.3	The Chain Rule(13.5)		3
	3.6	Practicum	8	3
4	**Applications of Partial Derivatives**			
	4.1	Directional Derivative and Gradient (13.6)	12	4
	4.2	Tangent plane and normal line(13.7)		4
	4.3	Extreme values and saddle points(13.8)		4
	4.6	Practicum	8	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Real life application of Integration and partial differentiation			

Textbook:

Calculus, 10th Edition, Howard Anton, Irl Bivens and Stephen Davis John Wiley and Sons, Inc.

References:

1. Thomas' Calculus, 11th Edition, Maurice D Weir, Joel Hass, Frank.R. Giordano, Pearson Education.
2. Calculus and Analytic Geometry, George B Thomas Jr, Ross L Finney, Pearson Education.

Course 03

Discipline	Mathematics
Semester	III/IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC204
Course Title	Differential Equations and Vector Calculus
Course Level	200-299
Course Summary	This course provides a solid foundation in differential equations and techniques of solving first orde differential equations. This course also introduces vector differential calculus and explores vector integration also . The focus is on practical applications, preparing students for real-world problem-solving.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Develop the idea of solving first order DE	A	1, 2, 3
2	Apply first order DE to practical situations and solve	A	2, 3
3	Explore vector functions, derivatives, arc length, and curvature of curves.	A	1, 2, 3
4	Master line integrals, vector fields, and their applications	An	1,2
5	Apply fundamental theorems in vector calculus to problem-solving.	A	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO
1	**First Order Differential Equations**			
	1.1	Separable variables (2.1 of Text 1)	8	1
	1.2	Exact differential equations (2.2 of Text 1)		1
	1.3	Linear equations (2.3 of Text 1)		1
	1.4	Solutions by substitutions (2.4 of Text 1)		1, 2
	1.5	Practicum (Problems)	7	
2	**First Order Differential Equations of Higher Degree**			

	2.1	Equations of the First Order and not of First degree (3.1 of Text 1)	12	1
	2.2	First Order equations of higher degree solvable for p (3.2 of Text 1)		1
	2.3	Equations of the first degree in x and y, Lagrange's and Clairaut's equation (3.5 of Text 1)		1, 2
	2.4	Practicum: - Equations solvable for y and equations solvable for x	8	2
3	**Vector Differential Calculus**			
	3.1	Scalar and vector fields, Gradient of a scalar field, geometrical interpretation (8.10,8.11,8.12 of Text 2)	12	3
	3.2	Directional derivative and properties of Gradient (8.13,8.14 of Text 2)		3
	3.3	Divergence and curl of a vector functions (8.15,8.16 of Text 2)		3, 5
	3.4	Practicum :- Problems	8	
4	**Vector Integration**			
	4.1	Integration of Vector functions (8.21)	13	4
	4.2	Line Integrals, circulation and work done (8.22,8.23,8.24)		4
	4.3	Surface integrals and Volume integrals (8.25,8.26)		4, 5
	4.4	Practicum :- Theorems in integration	7	5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Some Suggestions for Teacher specific contents ➢ Homogeneous Differential equations, Integrating Factors of Differential Equations ➢ Visualization of curves and conic section, Obtaining Points of farthest and closest approach of Planets/ Satellites ➢ Integration in vector fields, Finding Work done, Flow, circulation and flux			

Textbooks:

1. A first course in Differential equations with Applications, A H Siddiqi P Manchanda, Macmillian publishers
2. A textbook of Engineering Mathematics, N. P. Bali, Manish Goyal, Laxmi Publications

References:

1. Joyce, David D., and George C. Parker. Vector Calculus and Its Applications. 4th ed. Jones & Bartlett Publishers, 2022.
2. Schroeder, Glenn N. Vector Analysis for Computer Graphics. 3rd ed. A K Peters/CRC Press, 2017.
3. Grewal, B. S., Higher Engineering Mathematics, 44th Edition, Khanna Publishers, 2021.
4. Anton, H., Bivens, Devis. Calculus, tenth Edition, Wiley India.
5. Kreyszig,E. Advanced Engineering Mathematics, Wiley, India

Course 04

Discipline	Mathematics
Semester	III/IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC205
Course Title	Mathematics for Business and Economics
Course Level	200-299
Course Summary	This course provides an introduction to mathematical methods and theories applicable in economics and business to analyse real life problems.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	Graphing functions □ Basics of differential Calculus □ Multivariable functions and partial differentiation □ Percentage calculation □ Basics of logarithmic and exponential functions

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain the difference between simple and compound interest	U	1, 3
2	Calculate the future value of a principal under annual compounding and under continuous compounding	A	2, 3
3	Recognize a geometric progression	A	2
4	Evaluate a geometric series and calculate the total investment obtained from a regular savings plan	E	2, 3, 10
5	Use net present values to appraise investment projects and calculate the internal rate of return, the present value of an annuity	A	2, 3, 10
6	Use discounting to compare investment projects	U, A	1, 3
7	Understand classical optimization techniques and marginal concepts in economics	U	1, 3
8	Analyse the real-life problems in business and economics and to model it mathematically	A, An, C	2, 3,6, 10
9	Apply elementary algebra and differential calculus in economics and business problems and solve it mathematically	A, C	1, 2, 3

10	Solve linear programming problem using graphical method	C	2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO
1	**Mathematics of Finance** **Text 2 : Chapter 3 (Sec 3.2 to 3.4)**			
	1.1	Compound Interest	8	1, 2
	1.2	Geometric Series		3, 4
	1.3	Investment Appraisal		5, 6
	1.4	Practicum	7	
2	**Mathematical Economics** **Text 1 : Chapter 4 (Sec 4.1 to 4.7)**			
	2.1	Introduction to System of Equations	12	7
	2.2	Graphical Solutions to Linear System of Equations		7,8
	2.3	Supply-and-Demand Analysis		8,9
	2.4	Break-Even Analysis		8,9
	2.5	Elimination and Substitution Methods		8,9
	2.6	Income detemination models		8,9
	2.7	IS-LM Analysis		8,9
	2.8	Practicum	8	8,9
3	**Optimization Techniques** **Text 1 : Chapter 10 (Sec 10.6 to 10.10)**			
	3.1	Optimization of Functions, The Successive-Derivative Test	8	7
	3.2	Marginal Concepts in Economics		7, 8, 9
	3.3	Optimising Economic function for Business		8, 9
	3.4	Relationship Among Total, Marginal, and Average Functions		9
	3.5	Practicum	7	
4	**Linear Programming Problem** **Text 1 : Chapter 7 (Sec 7.1 to 7.4)**			
	4.1	Use of Graphs in LPP, Maximization Using Graphs	12	7, 10
	4.2	The Extreme-Point Theorem, Minimization Using Graphs		7, 10
	4.3	Practicum	8	4, 5
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Some Suggestions for Teacher specific contents: 1. Constrained Optimization problems with Lagrange Multipliers 2. Applicable mathematics in economics and business using spreadsheets 3. Applications of definite integral in consumers and producers surplus			

The practicum component is to be done in the classroom under the strict guidance of the teachers. A minimum of 30 problems is to be solved, and a handwritten copy of the solutions should be kept in the department.

TEXT BOOKS

1. Edward T Dowling, Theory and Problems of Mathematical Methods for Business and Economics, Schaum's Outline Series ,McGraw Hill (1993)
2. Ian Jacques, Mathematics for Economics and Business, 5th Edition, Prentice Hall(2006).

SUGGESTED READINGS

1. Taro Yamne, Mathematics for Economists-An elementary survey, PRENTICE-HALL, INC.
2. Robert Brechner, Contemporary Mathematics for Business and Consumers, Fifth Edition
3. N G DAS, J K DAS, Business Mathematics and Statistics, Tata McGraw-Hill (2012)
4. Martin Anthony, Norman Biggs, Mathematics for economics and finance Methods and Modelling, CAMBRIDGE UNIVERSITY PRESS (2012)

7. SYLLABUS FOR DISCIPLINE SPECIFIC COURSES IN MATHEMATICS – MINOR PATHWAY FOR COMPUTER APPLICATIONS

Course 01

Discipline	Mathematics
Semester	I
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC111
Course Title	Foundation of Mathematics
Course Level	100-199
Course Summary	This course will transform you from a matrix novice to a manipulator, teaching you how to perform operations, analyze properties, and solve systems of equations. You'll delve deeper into the world of linear algebra by exploring determinants and inverses, unlocking powerful tools for working with matrices. We'll also touch on the fascinating concepts of rank, linear independence, eigenvalues, and eigenvectors, providing a strong foundation for further exploration. Beyond numbers, you'll be introduced to basic logic, equipping you with the ability to analyze and reason about propositions. By the end, you'll have the essential skills to solve problems and bridge the gap between mathematics and logic.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Provide a strong foundation in the basic theory of matrices.	U	2,8
2	Explore vector spaces, linear independence, eigenvalues and eigenvectors.	U	2,8
3	Apply linear algebra concepts to real-world problems in image processing.	C	2,8
4	Foster critical thinking and problem-solving skills in the context of linear algebra and image processing.	An	1,2,8
5	Foster practical application of linear algebra principles in image processing through hands-on practicum experiences, cultivating critical thinking and problem-solving skills in real-world scenarios.	A	2,4
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Description	Hours	CO
1	**Matrices**			
	1.1	Basics of matrices	3	1
	1.2	Elementary operations	3	1
	1.3	Normalization	4	1
	1.4	Rank of matrix	3	1
	1.5	Practicum	8	1
2	**Determinants**			
	2.1	Determinant	2	2
	2.2	Inverse of a matrix	3	2
	2.3	Linear independence	3	2
	2.4	Eigen values and Eigen vectors	3	2
	2.5	Practicum	8	2
3	**Solution of equations**			
	3.1	Gauss Elimination method	3	3
	3.2	Gauss Jordan Method	3	3
	3.3	Gauss Seidel Method	3	3
	3.4	Practicum	8	3
4	**Basic logic**			
	4.1	Propositional logic	6	4
	4.2	Propositional equivalences (all proofs are deleted in this module)	6	4
	4.3	Practicum	6	4
5	**Teacher specified contents: (practicum)** ● Analyzing the relationship between determinants and invertibility of matrices. ● Solve problems related to applying eigenvalue-eigenvector concepts to analyze stability of systems, image compression techniques, or diagonalization of matrices ● Problems involving solving systems of linear equations using different methods, analyzing the computational complexity of each method, and choosing the most efficient method for specific cases. Problems involving proving logical equivalences using truth tables, constructing logical statements to represent real-world scenarios, and analyzing the validity of arguments using propositional logic.			5

Mode of Assessment: The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE). The percentage weightage for CCA and ESE will be as per the undergraduate regulations of the college.

References

1. Ian Chiswell & Wifrid Hodges: Mathematical Logic, Oxford university press
2. Shanti Narayan - Matrices (S. Chand & Company)
3. Introduction to Linear Algebra by Gilbert Strang
4. Linear Algebra and Its Applications by David C. Lay

Course 02

Discipline	Mathematics
Semester	II
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC112
Course Title	Discrete Mathematics
Course Level	100-199
Course Summary	This course provides an introduction to discrete mathematics, covering fundamental concepts in combinatorics, set theory, graph theory, and some algorithms. Combinatorics equips you with techniques for counting arrangements and selections of objects.Set theory establishes the foundation for understanding sets, their properties, and how to manipulate them.Graph theory introduces graphs, a powerful tool for modeling relationships and explores their properties and applications.The course concludes with exploring bridges, paths within graphs, and Dijkstra's algorithm, a tool for finding shortest paths.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Apply the basic concepts in combinatorial graph theory in science, business and industry	Apply	2,8
2	Proficiency in Set Theory and Operations	Understand	2,8
3	Solve problems in areas like network routing, circuit design, and navigation.	Apply	2,8
4	Apply graph theoretical algorithms to solve problems in daily life.	Apply	2,8
5	Apply combinatorial graph theory, set operations, and graph algorithms to solve real-world problems across various domains, ensuring practical proficiency and effective problem-solving skills.	Apply	2,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Description	Hours	CO
1	**Combinatorics**			
	1.1	Theory of counting	2	1
	1.2	Multiplication rule	2	1
	1.3	Ordered sample and permutations	2	1
	1.4	Unordered samples without repetition	2	1
	1.5	Permutations involving indistinguishable objects	2	1
	1.6	Multinomial coefficient	2	1
	1.7	Unordered samples with repetition	2	1
	1.8	Practicum	6	1
2	**Set theory**			
	2.1	Sets	2	2
	2.2	Set operations	2	2
	2.3	Functions	2	2
	2.4	Sequences	3	2
	2.5	Summations (all proofs are omitted in this module)	2	2
	2.6	Practicum	8	2
	Graph Theory			
3	3.1	Introduction and more definitions	2	3
	3.2	Examples	2	3
	3.3	Trees and connectivity	2	3
	3.4	Minimal spanning trees	2	3
	3.5	Binary trees and tree searching.	2	3
	3.6	Practicum	8	3
	Bridges, path and algorithm			
4	4.1	Leonhard Euler and the seven bridges of Konigsberg	2	4
	4.2	Euler's graph, Hamiltonian graphs	2	4
	4.3	Planar graphs and Euler's theorem	2	4
	4.4	The shortest path problem	2	4
	4.5	Dijkstra' s Algorithm	2	4
	4.6	Practicum	8	4
5		Teacher specified contents: (practicum)		5

		• Solve problems related to applying counting techniques to different situations. This could involve finding the number of possible arrangements for seating a committee, selecting lottery numbers, or distributing candies among friends. • Work on problems involving proving set relationships, defining functions with specific properties for given sets, and analyzing sequences with specific patterns. • Solve problems involving representing real-world scenarios with graphs (e.g., social networks, transportation routes), identifying graph properties (connected, Eulerian, Hamiltonian), and applying Euler's theorem to analyze graphs.		

Mode of Assessment: The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE). The percentage weightage for CCA and ESE will be as per the undergraduate regulations of the college.

References

1. K.H. Rosen: Discrete Mathematics and its Applications (Sixth edition), Tata McGraw Hill Publishing Company, New Delhi
2. Lipschutz: Set Theory and related topics (Second Edition), Schaum Outline Series, Tata McGraw-Hill Publishing Company, New Delhi. (Reprint 2009)
3. John Clark, Derek Allen Holton(1991), A first look at graph theory , Allied Publishers
4. Douglas B west (1995), Introduction to Graph Theory, 2nd edition, Pearson Education
5. Engineering Mathematics, N.P. Bali, Manish Goyal

Course 03

Discipline	Mathematics
Semester	III/IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC211
Course Title	Calculus and Numerical Analysis
Course Level	200-299
Course Summary	This course covers calculus and numerical methods.Calculus part focuses on differentiation (including chain rule and implicit differentiation), finding extreme values of functions, understanding definite integrals and the fundamental theorem of calculus, calculating areas between curves, and introduction to double integrals.Numerical methods part covers solving equations using various methods (bisection, Regula-Falsi, fixed point iteration, Newton-Raphson, Horner's, and Graeffe's root squaring methods), numerical differentiation (backward and forward interpolation formulas), and numerical integration (trapezoidal rule, Simpson's 1/3 and 3/8 rules). There is also a section on solving ordinary differential equations using single step methods (Taylor series, Euler's method, and Runge-Kutta method).
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Utilize differentiation rules (including chain rule and implicit differentiation) to find the derivatives of functions.	A	2,8
2	Apply various root-finding methods to solve nonlinear algebraic equations.	A	2,8
3	Analyze functions to identify extreme values and calculate definite integrals using numerical methods	An	2,8
4	Implement numerical differentiation and integration techniques to approximate derivatives and integrals of functions.	A	2,8
5	Demonstrate proficiency in applying numerical methods to solve real-world problems encountered in the practicum.	C	4
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Description	Hours	CO
1	**Calculus**			
	1.1	Differentiation rules	2	1
	1.2	Chain rule	2	1
	1.3	Implicit differentiation	2	1
	1.4	Extreme values of the functions	2	1
	1.5	Definite integrals	2	1
	1.6	Fundamental theorem of calculus	2	1
	1.7	Area between curves	2	1
	1.8	Introduction to double integrals	2	1
	1.9	Practicum	6	1
2	**Solutions of equations**			
	2.1	Bisection method	2	2
	2.2	Regula- falsi method	2	2
	2.3	Fixed point iteration method	2	2
	2.4	Newton Raphson's method	2	2
	2.5	Honor's method	2	2
	2.6	Graeffe's root squaring method	2	2
	2.7	Practicum	8	
3	**Numerical differentiation and integration**			
	3.1	Backward interpolation formula and problems	2	3
	3.2	Forward interpolation formula and problems	2	3
	3.3	Numerical integration by trapezoidal rule	2	3
	3.4	Simpson's 1/3 rd rule	2	3
	3.5	Simpson's 3/8 th rule	2	3
	3.6	Practicum	8	
4	**Numerical methods**			
	4.1	Ordinary differential equations – single step methods	2	4
	4.2	Taylor's series method	2	4
	4.3	Euler's method for first order equations	1	4
	4.4	Fourth order Runge kutta method for solving first and second equations	2	4
	4.5	Practicum	8	
5	**Teacher specified contents: (practicum)** ● Analyzing the convergence rate of different methods and interpreting results, problems related to Comparing the efficiency (number of iterations needed) of different methods for specific function, Handling cases where methods might not converge (e.g., multiple roots).			5

	• Using implicit differentiation to find the derivative of functions defined implicitly, Analyzing the behavior of functions using derivatives (e.g., finding increasing/decreasing intervals) • Identifying and classifying extreme values (maxima/minima) of functions using critical points and second derivative test. • Applying numerical methods to analyze real-world data (e.g., calculating average rate of change from discrete data points). Analyzing the error associated with different numerical methods for differentiation and integration.	

Mode of Assessment: The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE). The percentage weightage for CCA and ESE will be as per the undergraduate regulations of the college.

References

1. Thomas calculus 12th edition by George B. Thomas Jr. revised by Maurice Weir, Joel Hass, Pearson Education
2. Numerical Recipes: The Art of Scientific Computing by William H. Press et al.
3. Introduction to Numerical Analysis by Kendall E. Atkinson
4. Finite Difference Methods for Ordinary and Partial Differential Equations by Randall J. LeVeque
5. Numerical Differentiation: Algorithms and Applications by K. E. Atkinson
6. Elementary Numerical Analysis by Kendall E. Atkinson

Course 04

Discipline	Mathematics
Semester	III/IV
Type of Course	Discipline Specific Course (DSC)
Course Code	24UMATDSC212
Course Title	Mathematics for Data Science
Course Level	200-299
Course Summary	This course is designed to provide students with a comprehensive understanding of advanced mathematical concepts and their practical applications in solving real-world problems. The course focuses on mastering eigenvalue-eigenvector analysis, solving linear systems and inequalities, applying linear programming techniques, understanding real-valued functions of multiple variables, and utilizing optimization techniques. Hands-on practicum experiences will foster critical thinking skills and practical proficiency.
Hours	75 (Lecture/Tutorial – 45, Practicum – 30)
Credits	4
Pre-requisite, if any	The Course 'Foundation of Mathematics'

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Master eigenvalue-eigenvector analysis, apply it in solving matrix equations, and comprehend the significance of singular value decomposition.	An	2,8
2	Solve linear systems and inequalities, apply linear programming techniques for optimization, and understand their applications in real-world scenarios.	A	2,8
3	Grasp real-valued functions of multiple variables, apply multivariable calculus techniques in problem-solving, and analyse their practical applications.	An	2,8
4	Master fundamental analysis concepts, utilize optimization techniques such as gradients and the Hessian matrix, and demonstrate proficiency in integration, including double integrals and Fubini's theorem	A	2,8
5	Demonstrate practical proficiency in applying advanced mathematical techniques, including eigenvalue-eigenvector analysis, linear programming, multivariable calculus, and optimization	C	2,4

	methods, through hands-on practicum experiences, effectively solving real-world problems and fostering critical thinking skills.		
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Description	Hours	CO
	Eigenvalues and eigenvectors			
1	1.1	Eigen values and Eigenvectors	3	1
	1.2	Characteristic Polynomial, Definition of Left/Right Eigen values and Eigenvectors	4	1
	1.3	Cayley – Hamilton theorem	3	1
	1.4	Singular value Decomposition	4	1
	1.5	Interpretation of Eigenvalues/vectors.	3	1
	1.6	Practicum	9	
2	**Linear system and Optimization**			
	2.1	Linear Systems Definition, applications	2	2
	2.2	Solving linear systems, linear inequalities	3	2
	2.3	Linear programming	3	2
	2.4	Practicum	8	
3	**Multivariable functions**			
	3.1	Definition, examples	2	3
	3.2	Simple demos	2	3
	3.3	Applications	2	3
	3.4	Practicum	6	
	Multivariable Calculus			

4	4.1	Analysis elements Distance, Limits, Continuity.	3	4
	4.2	Differentiability, the gradient and the Gaussian.	3	4
	4.3	Optimization problems Simple examples, motivation, the role of (Hessian maxima and minima and related extreme conditions.	5	4
	4.4	Double integrals, Fubini's theorem, properties, applications	3	4
	4.5	Practicum	7	
5	Teacher specified contents: (practicum) ● Identifying eigenvalues and eigenvectors of small matrices, applying characteristic polynomials to find eigenvalues. ● Formulating real-world problems as linear systems (e.g., resource allocation). ● Solving linear inequalities using graphical methods or simplex methods, applying linear programming techniques to optimize data-driven models (e.g., maximizing profit in a marketing campaign). ● Performing simple operations on multivariable functions (addition, subtraction, scalar multiplication). ● Applying double integrals to calculate volume or mass under a surface represented by a multivariable function. ● Using Fubini's theorem to simplify double integrals.			5

Mode of Assessment: The assessment shall be a combination of Continuous Comprehensive Assessment (CCA) and an End Semester Evaluation (ESE). The percentage weightage for CCA and ESE will be as per the undergraduate regulations of the college.

References

1. Gilbert Strang, Linear Algebra and its Applications. Thomson /Brooks Cole (Available in a Greek Translation).
2. Thomas M. Apostol, Calculus, Wiley, 2nd Edition, 1991 ISBN 960-07-0067-2.
3. Michael Spivak. Calculus, publish or Perish, 2008, ISBN 978-0914098911.
4. Ross L. Finney, Maurice D.Weir and Frank R. Giordano. Thomas's Calculus, Pearson 12th Edition 2009.
5. David C. Lay, Linear Algebra and Its Applications, 4th Edition.
6. Yourself saad, Iterative Methods for spare Linear Systems.

8. SYLLABUS FOR MULTIDISCIPLINARY COURSES (MDC) IN MATHEMATICS

Course 01

Discipline	Mathematics
Semester	I
Type of Course	MultiDisciplinary Course (MDC)
Course Code	24UMATMDC101
Course Title	Mathematics for Competitive Examinations
Course Level	101-199
Course Summary	This mathematics course covers topics like number systems, logical reasoning and mathematical measurements. This course explores concepts such as HCF, LCM, fractions, ratio, percentage, and time-related problem-solving, providing comprehensive preparation for various competitive examinations.
Hours	60 (Lecture/Tutorial – 30, Practicum – 30)
Credits	3
Pre-requisite, if any	Basic operations on number system

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Develop a solid understanding of various types of numbers. Master techniques for calculating HCF and LCM and gain proficiency in simplifications, squares and square roots.	U	2
2	Solving problems related to profit, loss and age and apply these principles to real world scenarios.	A	1
3	Acquire logical reasoning skills by exploring concepts such as ratio, proportion, etc	A	1, 2
4	Gain expertise in mathematical measurements through topics like time and work, work and wages, and time and distance. Apply mathematical concepts to solve practical problems in these areas.	U & A	1
5	Demonstrate practical proficiency in applying advanced mathematical techniques, including eigenvalue-eigenvector analysis, linear programming, multivariable calculus, and optimization methods, through hands-on practicum experiences, effectively solving real-world problems and fostering critical thinking skills.	C	2, 4
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Introduction to Arithmetic**			
	1.1	Number (1 chapter)	8	1
	1.2	H.C.F and L.C.M. (2 chapter)		1
	1.3	Simplification (4 chapter)		1
	1.4	Average (6 chapter)		1
	1.5	Practicum: - Problems (chapter 2,4,6)	8	1
2	**Computation**			
	2.1	Problems on ages (8 chapter)	8	2
	2.2	Percentage (10 chapter)		2
	2.3	Profit and Loss (11 chapter)		2
	2.5	Practicum: - Square root and Cube root problems	8	2
3	**Ratio Of Numbers**			
	3.1	Ratio and Proportion (12 chapter)	7	3
	3.2	Partnership (13 chapter)		3
	3.3	Chain Rule (14 chapter)		3
	3.4	Practicum: Surds and Indices Problems	7	3
4	**Problems Related to Time**			
	4.1	Time and Work (15 chapter)	7	4
	4.2	Pipes and Cisterns (16 chapter)		4
	4.3	Time and Distance (17 chapter)		4

	4.4	Practicum: problems (chapter 15,17)	7	4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** ➢ Discuss different number systems, such as decimal, binary, octal, and hexadecimal, and their conversions. ➢ Show how number theory concepts apply in various real-life scenarios, like cryptography or data encoding. ➢ Provide examples where LCM and HCF are used, such as in simplifying fractions, adding and subtracting fractions, or solving equations. ➢ Incorporate problems where knowledge of roots is essential, such as in Geometry, Physics, or Engineering. ➢ Provide examples where ratios and proportions are used in real-life situations, such as in finance, cooking, or map scales. ➢ Provide examples of profit and loss situations in business, trading, and investment scenarios. ➢ Discuss problem-solving strategies for analyzing profit and loss situations and determining the best course of action. ➢ Provide examples of interest calculations in banking, investments, loans, and savings accounts. ➢ Show the difference between simple interest and compound interest and how they affect the total amount over time.		

References :

1. Quantitative Aptitude by R.S. Aggarwal, Sultan Chand and company Ltd, New Delhi, 2012

2. Quantitative Aptitude for Competitive Examinations by Abhijit Guha, McGraw Hill Education 2011

Course 02

Discipline	Mathematics
Semester	II
Type of Course	MultiDisciplinary Course (MDC)
Course Code	24UMATMDC102
Course Title	Applicable Mathematics
Course Level	100-199
Course Summary	This course covers various mathematical topics essential for competitive exams. Modules include Problems on Trains, Boats and Streams, and Alligation and Mixture. Practicums reinforce learning through problem-solving. Module 2 focuses on Simple Interest and Compound Interest, with practical exercises on Banker's Discount. Module 3 explores Area, Volume, Surface Areas, Calendar problems, and Cloaks. The practicum enhances understanding. Module 4 includes Races,Progressions, and heights & distances. Practical sessions involve solving linear and quadratic equations. Through theory and practice, students develop proficiency in these mathematical concepts crucial for competitive examinations.
Hours	60 (Lecture/Tutorial – 30, Practicum – 30)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Gain expertise in mathematical measurements through topics like problems on trains, Boats and streams etc.	**U**	**1,2**
2	Learn the essentials of data analysis, including concepts of simple interest, compound interest and solving calendar problems. Develop analytical skills to interpret and utilize data effectively.	**A**	**2**
3	Apply mathematical concepts to solve practical problems in areas, volumes etc	**A**	**1,2**
4	Gain expertise in problems of Races and Games of Skill, Heights and Distances ,etc	**U**	**1,2**
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Course Content

Module	Units	Course description	Hrs	CO Nos
1	**MODULE 1**			
	1.1	Problems on Trains (18 chapter of Text 1)	15	1
	1.2	Boats and Streams (19 chapter of Text 1)		1
	1.3	Alligation and Mixture (20 chapter of Text 1)		1
	1.4	Practicum: - Problems in Chapters 18,19 and 20 of the text		1
2	**MODULE 2**			
	2.1	Simple Interest (21 chapter of Text 1)	15	2
	2.2	Compound Interest (22 chapter of Text 1)		2
	2.5	Practicum: - Banker's Discount problems		2
3	**MODULE 3**			
	3.1	Area (23 chapter of Text 1)	15	3
	3.2	Volume and Surface Areas (24 chapter of Text 1)		3
	3.3	Calendar (28 chapter of Text 1)		3
	3.4	Cloaks (29 chapter of Text 1)		3
	3.5	Practicum: - Problems in Chapters 23,24,28,29 of Text 1)		3
4	**MODULE 4**			
	4.1	Races and Games of Skill (30 chapter of Text 1)	15	4
	4.2	Arithmetic and Geometric Progressions (33 chapter of Text 1)		4
	4.3	Heights and Distances (37chapter of Text 1)		4
	4.5	Practicum		4

5	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Quadratics equations

Textbook

Objective Arithmetic, Dr.R.S. Aggarwal, S.Chand Publishing

References

1. Quantitative Aptitude by R.S. Aggarwal, Sultan Chand and company Ltd, New Delhi, 2012
2. Quantitative Aptitude for Competitive Examinations by Abhijit Guha, McGraw Hill Education 2011

Course 03

Discipline	Mathematics
Semester	III
Type of Course	MultiDisciplinary Course (MDC)
Course Code	24UMATMDC201
Course Title	MATHEMATICS IN NATURE
Course Level	200-299
Course Summary	This course provides a solid foundation in Fibonacci and Lucas numbers, their properties, and applications in natural phenomena and diverse real-world scenarios. This course also introduces Golden ratio and explore its significance.
Hours	45 (Lecture/Tutorial – 45)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain Fibonacci and Lucas numbers, their properties, and applications in natural phenomena and diverse real-world scenarios	U	1
2	Analyze and apply Fibonacci's impact on artistic expressions, scientific realms, and interdisciplinary connections across various fields	A	1,2
3	Comprehend the significance of the golden ratio, its geometric interpretations, applications in human anatomy, arts and mathematical constructions	A	1
4	Understand and apply the concepts of finite and infinite continued fractions, convergence, recursive definitions, and their implications in solving problems.	A	1,2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**Fibonacci Numbers in Nature, Arts & Science**			
	1.1	The rabbit problem, Fibonacci numbers, Recursive definition, Lucas numbers, Fibonacci and Lucas primes.	15	1
	1.2	Different types of Fibonacci and Lucas numbers		1

	1.3	Fibonacci numbers in nature: Fibonacci and flowers, Fibonacci and trees, Fibonacci and sunflowers, Fibonacci - pinecones, artichokes and pineapples, Fibonacci and bees, Fibonacci and subsets.		2
	1.4	Fibonacci and atoms, Fibonacci and reflections. Fibonacci - paraffins and cycloparaffins		2
2	**Fibonacci Numbers in Arts and Science**			
	2.1	The golden ratio, Mean proportional, A geometric interpretation.	15	3
	2.2	Ruler and compass construction, Euler construction. Generation by Newton's method		3
	2.3	The golden ratio revisited: Golden ratio and human body, Golden ratio and centroids of circles.		3
3	**Continued Fractions**			
	3.1	Finite continued fractions, convergence of a continued fraction.	10	4
	3.2	Recursive definition, Infinite continued fraction.		4
	3.3	An infinite continued fraction for – β, Pell's equation.		4
4	**Recurrence Relation**			
	4.1	Linear homogeneous recurrence relation	5	4
	4.2	Linear homogeneous recurrence relation with constant coefficients		4
5	**Teacher Specific Contents** (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Some Suggestions for Teacher specific content ➢ Fibonacci and male bees. ➢ Fibonacci and sewage treatment. ➢ Fibonacci and the Balmer series. ➢ Proofs of Theorems 3.1, 3.2 and 3.3 ➢ Violin and golden triangle. ➢ Golden ratio by origami.			

Textbook:

Fibonacci and Lucas Numbers with applications, Thomas Koshy, John Wiley and Sons 2001.

References:

1. Richard A Dunlap. The Golden Ratio and Fibonacci Numbers, World Scientific Publishing Co. Pt. Ltd.
2. Mario Livio. The Golden Ratio, Broadway Books, New York.

9. SYLLABUS FOR SKILL ENHANCEMENT COURSES (SEC) IN MATHEMATICS

Course 01

Discipline	Mathematics
Semester	IV
Type of Course	Skill Enhancement Course (SEC)
Course Code	24UMATSEC201
Course Title	Document preparation using LaTeX
Course Level	200-299
Course Summary	This course introduces the basic concepts of LaTeX. Participants taking this course will be able to create and design documents in LaTeX and presentations in Beamer with confidence.
Hours	45 (Lecture/Tutorial – 45)
Credits	3
Pre-requisite, if any	There are no prerequisites for this course, except knowledge of editing text. The course can be taken by any learner who wants to create documents using LaTeX**.**

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Explain the fundamental principles of LaTeX typesetting	U	1
2	Apply advanced LaTeX formatting techniques to create professional-quality documents	A	1, 2
3	Analyze and troubleshoot common errors in LaTeX documents	An	1, 2
4	Create and customize bibliographies using BibTeX in LaTeX	C	1
5	Demonstrate effective collaboration using LaTeX for group writing projects	A	2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	1.1	Preparing the input file	15	1

	1.2	Sentences and paragraphs, the document, sectioning, displayed material		1
	1.3	Running LaTeX		1
	1.4	Changing the type style		1
	1.5	Mathematical Formulas: common structures, Mathematical symbols, Arrays, Delimiters, Multiline formulas, Putting one thing above another, spacing and changing style in math mode		1
		Text 1: Chapter 2 – Sections: 2.1 to 2.3; Chapter 3 – Sections: 3.1 & 3.3		
2				
	2.1	Defining commands and environments	15	
	2.2	Figures and other floating bodies: Figures and Tables		
		Text 1: Chapter 3 – Sections: 3.4 & 3.5.1		
3				
	3.1	Cross references	15	
	3.2	Bibliography and citation		
	3.3	Books		
	3.4	Slides: Slides and overlays		
		Text 1: Chapter 4 – Sections: 4.2 & 4.3; Chapter 5 – Sections: 5.1 & 5.2.1		
4	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Writing a document			

Textbook:

1. Lamport, Leslie. LaTeX: A Document Preparation System, Addison-Wesley, 2 nd edition, 1994.

References:

2. Goossens, M., Mittelbach, F. F., Samarin, a. The LaTeX Companion, AddisonWesley, 1993.

3. Krishnan, E. LATEX Tutorials: A Primer,

Course 02

Discipline	Mathematics
Semester	V
Type of Course	Skill Enhancement Course (SEC)
Course Code	24UMATSEC301
Course Title	Introduction to Python for Mathematical Computation
Course Level	300-399
Course Summary	Students who complete this course will: 1. Have the basic skills required for Python programming. 2. Be able to solve Mathematical problems using Python programs
Hours	45 (Lecture/Tutorial – 45)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Discuss the basics of Python programming language.	U	1,2,3
2	Apply strings and lists, tuples, and packages for computation.	A	1,2
3	Employ NumPy for efficient numerical and mathematical operations in Python.	S	1,2
4	Sketch various types of plots (line plots, scatter plots, histograms) using Matplotlib.	A	1,2,7,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1			15	
	1.1	Getting started with Python		1
	1.2	Variables and data types		1
	1.3	Operators, Python string		1

	1.4	Python Lists		1
	1.5	Mutable and immutable types, input from keyboard		1
	1.6	While and for loops, conditional execution		1
	1.7	Modify loops, functions, Python modules and packages		1
		Text1 chapter 2 section 2.1-2.10 &2.13-2.15		
		Practicum		
2				
	2.1	Creating array and matrices	15	2
	2.2	Copying, arithmetic operations		2
	2.3	Cross product, dot product		2
	2.4	Saving and restoring		2
	2.5	Matrix inversion		3
	2.6	Vectorised functions		3
	2.7	Text-1 chapter 3- 3.1& 3.2		3
		Practicum		
3				
	3.1	The Matplotlib module	15	3
	3.2	Plotting mathematical function		3
	3.3	Famous curves		3
	3.4	Power series , Fourier series		4
	3.5	2D plot using colors		4
	3.6	Fractals		4
	3.7	Mesh grids		4
	3.8	3D plots		4
		Text 1: Chapter 4 – Sections: 4.1 to 4.10.		
		Practical		

5	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally **SOME SUGGESTIONS FOR TEACHER SPECIFIC CONTENTS:** Practical session Plotting famous curves, 2D plots and 3D plots

Textbook:

1. Ajith Kumar B P. Python for Education, Inter-University Accelerator Centre - New Delhi ,2010.

References:

1. Eric Matthes. Python Crash Course: A hands-on, project-based introduction to programming – 3rd edition, no starch press, 2023.
2. Wes McKinney. Python for Data Analysis, O'Reilly Media, Inc., 2022.
3. Robert Johansson. Numerical Python: A Practical Techniques Approach for Industry, A press, 2015.

Course 03

Discipline	Mathematics
Semester	VI
Type of Course	Skill Enhancement Course (SEC)
Course Code	24UMATSEC302
Course Title	Computations and Graphics using SageMath
Course Level	300-399
Course Summary	Students who complete this course will: 1. Have the basic skills required for Python programming. 2.Be able to solve Mathematical problems using Python programs
Hours	45 (Lecture/Tutorial – 45)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Discuss the basic commands used for mathematical calculations using Sage Math	**U**	**1**
2	Apply basic programming skills in Sage Math to compute the limits and derivatives of various functions	**A**	**2**
3	Apply Sage Math to do various operations in Matrices.	**A**	**1, 2**
4	Use Sage Math to plot various mathematical functions and data structures.	**A**	**1**
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1	**INTRODUCTION**			
	1.1	Sage as a Calculator – First Computations Elementary Functions and Usual Constants On-line help and Automatic Completion	3	1
	1.2	Python Variables Symbolic Variables (Using Variables and Expressions) First Graphics (Graphics - Plotting Functions)	3	1

	1.3	Symbolic Expressions and Simplification – Symbolic Expressions, Transforming Expressions, Usual Mathematical Functions, Assumptions, Some Pitfalls	3	1
	1.4	Equations – Explicit Solving, Equations with no Explicit Solution	3	1
	1.5	Analysis – Sums, Limits, Sequences, Power Series Expansions, Series, Derivatives, Partial Derivatives, Integrals	5	2
2	**BASIC LINEAR ALGEBRA**			
	2.1	Basic Linear Algebra - Matrix Computations, Reduction of a Square Matrix	3	2
	2.2	Elementary Constructs and Manipulations – Vector and Matrix Constructions	3	2
	2.3	Basic Manipulations and Arithmetic on Matrices, Basic Operations on Matrices	4	3
3	**GRAPHING**			
	3.1	2 D Graphics - Graphical Representation of Function	5	3
	3.2	Parametric Curves, Curve in Polar Coordinates, Curve defined b	5	4
	3.3	3 D Curves	4	4

Text Book:

- Paul Zimmermann, Alexandre Casamayou, Nathann Cohen, Guillaume Connan, Thierry Dumont, Laurent Fousse, François Maltey, Matthias Meulien, Marc Mezzarobba, Clément Pernet, Nicolas M. Thiéry, Erik Bray, John Cremona, Marcelo Forets, Alexandru Ghitza, Hugh Thomas. *Computational Mathematics with SageMath*., SIAM, 2018

References:

1. Razvan A. Mezei. Introduction to Programming Using SageMath, Wiley, 2020.
2. The Sage Development Team, Tutorial Release 10.2 ,2023, (https://doc.sagemath.org/pdf/en/tutorial/sage_tutorial.pdf).
3. Gregory V. Bard, William Stein, Sage for Undergraduates, American Mathematical Society, 2015)
4. Robert Beezer, A first course in Linear algebra, Congruent Press, 2015, (http://linear.ups.edu/)
5. Tom Judson and Robert Beezer, Abstract Algebra Theory and Applications., open source textbook supported by National Science Foundation, 2022. (http://abstract.ups.edu/)
6. Razvan A Mezei, An Introduction to SAGE Programming: With Applications to SAGE Interacts for Numerical Methods by, Springer, 2015

10. SYLLABUS FOR VALUE ADDITION COURSES (VAC) IN MATHEMATICS

Course 01

Discipline	Mathematics
Semester	III
Type of Course	Value Addition Course (SEC)
Course Code	24UMATVAC201
Course Title	Mastering Problem Solving through Vedic Mathematics
Course Level	200-299
Course Summary	This course provides a comprehensive exploration of Vedic Mathematics, a traditional Indian system known for its speed and efficiency in problem-solving. Through a structured four-unit approach, students will understand the importance of Vedic Mathematics, advanced arithmetic techniques, root calculations, and applications in algebra, empowering them with valuable tools for quick and accurate problem-solving.
Hours	45 (Lecture/Tutorial – 45)
Credits	3

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Attain proficiency in mental calculation techniques for addition, subtraction, multiplication, and division, fostering quicker and more accurate problem-solving.	S	1,2,3,7, 8
2	Apply Vedic Mathematics to solve a diverse range of mathematical problems, including algebraic expressions and equations, showcasing versatility in problem-solving.	A	1,2,3,7, 8
3	Apply Vedic Mathematics skills to real-world scenarios, including ratio and proportions, percentage calculations, profit and loss analysis, and interest calculations.	A	1,2,3,7, 8
4	Apply Vedic Mathematics principles to algebraic expressions, including efficient multiplication of polynomials and solving systems of linear equations.	An	1,2,3,7, 8
5	Empower students with traditional Indian mathematical wisdom, providing them with valuable tools deeply rooted in cultural and historical contexts.	A	1,2,3,7, 8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
1				
	1.1	Overview of Vedic Mathematics-History and its importance, Vedic Sutras and sub-sutras	12	1
	1.2	Addition : Ekadhikena Purvena		1
	1.3	Subtraction :Nikhilam Navatascaramam, Dasatah, Digit Separator Method		1
	1.4	Multiplication : Ekanyunena Purvena, Multiplication of numbers having two- digits and three-digits using Urdhva Tiryagbhyam, Multiplication by series of 1's and 9's		1
	1.5	Division : Urdhva – Tiryakgbhyam		1
2				
	2.1	Squares: Squares of numbers up to three-digits using Ekadhikena Purvena, Dwanda yoga	19	2
	2.2	Square roots : Duplex Method		2
	2.3	Cubes: Cubes of two-digit numbers using Nikhilam		2
	2.4	Cube roots : Cube Root of a number having less than 7 digits using Beejank		3
	2.5	Divisibility and simple Osculators		3
	2.6	Applications: Ratio and proportions, Percentage, Profit and Loss, Simple interest, Compound Interest		3
3				
	3.1	Multiplication in algebra: Multiplication of polynomials of the form ax+by, ax2+bx+c	14	4
	3.2	Simple Equations: Solving simple equations in one variable		5
	3.3	Simultaneous Simple Equations: Solution of system of linear equations in two variables		5

4	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally

Textbooks:

1. Thakur, Rajesh Kumar. The Essentials of Vedic Mathematics, Rupa Publications India Pvt Ltd, 2013.
2. Bharati Krishna Tirthaji. Vedic Mathematics: Sixteen Simple Mathematical formulae from the Vedas, Motilal Banarsidass, 1981.
3. Tyra, M. Magical Book On Quicker Maths, BSC Publishing Co. Pvt. Ltd, 5th Edition, 2018

Reference:

1. Vedic Mathematics for All Ages: A Beginner's Guide: 16 Sutras For Mental Calculations Easily Explained Formulae With Practice Exercises, Vandana Singhal, Second Revised Edition 2021.

Course 02

Discipline	Mathematics
Semester	IV
Type of Course	Value Addition Course (SEC)
Course Code	24UMATVAC202
Course Title	Business Mathematics
Course Level	200-299
Course Summary	This course provides an introduction to complex analysis which is the theory of complex functions of a complex variable. We will start by introducing the complex plane, along with the algebra and geometry of complex numbers, and then we will make our way via differentiation, integration, complex dynamics, power series representation and Laurent series into territories at the edge of what is known today.
Hours	45 (Lecture/Tutorial – 45)
Credits	3
Pre-requisite, if any	Calculus

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Perform various matrix operations	A	1
2	Formulate and solve system of linear equations from real life problems	C	1, 2
3	Apply excel spreadsheet functions to perform matrix operations and to solve simultaneous equations and linear programming problems	A, S	2
4	Apply interpolation methods to estimate values between points in data set	A	1
5	Learn Freehand Method, Semi-average method, Moving average method & Method of Least squares to analyse underlying causes of trends or systematic patterns over time.	An	1, 2
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO
1	**Matrix Algebra**			

	1.1	Introduction to matrices and vectors	15	1
	1.2	Basic principles of matrix multiplication, Matrix multiplication – the general case (using excel)		1
	1.3	The matrix inverse and the solution of simultaneous equations		1
	1.4	Determinants (using excel)		1
	1.5	Minors, cofactors and the Laplace expansion		2
	1.6	The transpose matrix, the cofactor matrix, the adjoint and the matrix inverse formula (Exclude the derivation of the matrix-inverse formula)		2
	1.7	Application of the matrix inverse to the solution of linear simultaneous equations (using excel)		2
	1.8	Cramer's rule		2
		Text 1: Chapter 15 - Sections 15.1 to 15.9 & 15.12		
2	**Linear Programming Problems**			
	2.1	linear Equations: Straight line graphs, An Economic Application- Supply and Demand	15	2
	2.2	Simultaneous Equations		2
	2.3	Linear Inequalities: Inequalities & Economic Applications		2
	2.4	Linear Programming - Formulation and Graphic Solution (using excel)		3
		Text 2: Chapter 1 – Sections: 1.1, 1.2, 1.3(Excluding Complications, Three Equations in Three Unknowns and Gaussian Elimination); Chapter 2 – Sections: 2.1 & 2.2 Text3: Chapter 2 (excluding section 2.5)		3
3	**Interpolation and Time Series Analysis**			
	3.1	Time Series, Necessity of time series analysis	15	4
	3.2	Components of time series, Some adjustments of time series data		5
	3.3	Measurement of trend: Freehand Method, Semi-average method, Moving average method, Method of Least squares. (Linear Trend only)		5
		Text 4: Chapter 18 - Sections 18.1 to 18.8		

4	Teacher Specific Contents (This can be either classroom teaching, practical session, field visit etc. as specified by the teacher concerned) This content will be evaluated internally Solving Real life problems

TEXT BOOKS:

1. Rosser, Mike, and Piotr Lis. Basic mathematics for economists. 3rd ed. Routledge, 2016.
2. Pemberton, Malcolm, and Nicholas Rau. Mathematics for economists: an introductory textbook,4th ed. Manchester University Press, 2016.
3. ND, Vohra. "Quantitative techniques in management.", 3rd ed. Tata McGraw Hill New Delhi, 2007.
4. Ghosh, Ram Krishna, and Suranjan Saha. Business Mathematics and Statistics, (Algebra, Geometry, and Business Statistics). New Central Book Agency, 2019
5. Harmon, Mark. "Step-by-step optimization with Excel Solver." Excel Master Series, 2011.

REFERENCES:

1. Sheldon Ross. An Elementary Introduction to Mathematical Finance.3rd Edition, Cambridge Advanced Sciences,2011
2. David Promislow. Fundamentals of Actuarial Mathematics. Wiley, 3rd Edition, 2015
3. Luenberger. Investment Science (Indian Edition), Oxford University Press, 2nd Edition,2013

Course 03

Discipline	Mathematics
Semester	VI
Type of Course	Value Addition Course (SEC)
Course Code	24UMATVAC301
Course Title	Mathematical Computation and Visualization with R
Course Level	300-399
Course Summary	This course delves into the realm of mathematical computation and visualization using the powerful R programming language. Students will embark on a journey through the fundamentals of R, exploring its functionality and applications in various mathematical domains.
Hours	45 (Lecture/Tutorial – 45)
Credits	3
Pre-requisite, if any	Basic Knowledge of Progamming

COURSE OUTCOMES (CO)

CO No.	Expected Course outcomes	Learning domain*	PO
1	Apply R to represent and manipulate sets, including operations like union, intersection, and difference	U	1,2,3,6, 7
2	Apply matrix concepts to represent and solve system of linear equations in R	A	1,2,3,6, 7
3	Solve various matrix operations	A	1,2,3,6, 7
4	Compute determinants of matrices using R & employ Cramer's rule to solve system of linear equations in R	A	1,2,3,6, 7
5	Apply R to analyze functions	A	1,2,3,6, 7
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

COURSE CONTENT

Module	Units	Course description	Hrs	CO Nos
	R Functions and an Overview of Sets Using R			
	1.1	Functions, Parameter versus Argument, Argument Order and Parameter Names, Environments, Scope	3	1

1	1.2	Sets, Venn diagram, Cardinality of sets, Implementing the Subset Function in R, Equality of Sets, Empty Set.	3	
	1.3	Operations on Sets – Intersection, Union, Complement, Cross Product of two sets.	3	
2	**System of Linear Equations and Matrices In R**			
	2.1	Matrix & Vector in R	3	2
	2.2	Solving a System of Linear Equations with R (Gaussian Elimination in R)	3	
	2.3	Matrix Operations in R - Addition, Scalar multiplication, Dot product, Transpose	4	
	2.4	Determinant, function, Cramer's rule in R	4	
3	**Plotting Graphs In R**			
	3.1	Basic arithmetic, Define and Evaluate a Function, Graph a Function in R, Find Roots of a Function, Store Roots as a Variable and Display the First Root, Evaluate a Function with a Variable, Add a Point to a Graph, Evaluate a Function at Multiple Values, Add Multiple Points to a Graph	5	3,4,5
	3.2	Define a Function from a Function, Define a Function and Graph It, Identify Intersection Points and Add Them to the Graph, Add a Line Segment to a Graph	5	

Text Book

1. Claster, William B. Mathematics and programming for machine learning with R: from the ground up. CRC Press, 2021.
2. Yoshida, Ruriko. Linear algebra and its applications with R. CRC Press, 2021.
3. Pfaff, Thomas J. Applied Calculus with R. Springer International Publishing, 2023.

References:

1. Zuur, Alain F., Elena N. Ieno, and Erik HWG Meesters. A Beginner's Guide to R. New York: Springer, 2009.
2. Matloff, Norman. The art of R programming: A tour of statistical software design. No Starch Press, 2011.
3. Strang, Gilbert. Introduction to linear algebra. Wellesley-Cambridge Press, 2022.
4. Weir, Maurice D., et al. Thomas' calculus: early transcendentals: based on the original work by George B. Thomas, Jr. Addison-Wesley, 2006.