LEARNING OUTCOME-BASED CURRICULUM

FOR

FOUR YEAR UNDERGRADUATES PROGRAM (FYUGP)

IN

MATHEMATICS

UNDER

New Education Policy (NEP), 2020

DEPARTMENT OF MATHEMATICS
RABINDRANATH THAKUR VISHWAVIDYALAYA
HOJAI, ASSAM

Course structure and curriculum for the four-year UG program (As per NEP 2020) in Mathematics

(W.E.F 2023)

PREAMBLE:

In alignment with the recommendations of the University Grants Commission (UGC) and in accordance with the proposed implementation by Rabindranath Tagore University, the Department of Mathematics is actively engaged in incorporating the pertinent elements of the National Education Policy (NEP), 2020 into the Four-Year Undergraduate Programme (FYUGP). The following key considerations have been taken into account while formulating the foundational structure of the undergraduate curriculum:

- Flexibility to switch between disciplines of study,
- Opportunity for learners to select the courses of their interest across all disciplines,
- Flexible entry and exit options with UG certificates, UG diplomas, or UG degrees depending on the number of credits earned,
- Flexibility for students to switch between institutions so they can engage in multi- and/or interdisciplinary learning,
- Flexibility to switch to alternative modes of learning,
- Knowledge required for self-employment initiatives and an entrepreneurship mindset,
- Ability for complex critical thinking and real-life problem solving,
- Capability to understand global issues, multicultural competence, and digital literacy,
- Capable of research skills, communication skills, community-based engagement, environmental awareness, responsibility, and accountability.

INTRODUCTION:

The Undergraduate (UG) syllabus of Mathematics, in light of the New Education Policy (NEP), 2020, consists of Major (Core) disciplines, Minor disciplines, Multi-Disciplinary Generic Elective Courses (MDGEC), Ability Enhancement Courses (AEC), Value-Added Courses (VAC), Skill Enhancement Courses (SEC), Research Ethics and Methodology, Dissertation (Collection of Data, Analysis and Preparation of Report), and Discipline-Specific Electives (DSE).

The UG degree program offers certificates, diplomas, and degrees as follows:

UG Certificate: Student opts to exit after completion of 1st year securing 40 credits, she/he may be awarded a UG Certificate, provided she/he completed one vocational course of 4 credits during the summer vacation of the first year.

UG Diploma: Student opts to exit after completion of 2nd year securing 80 credits, she/he may be awarded a UG Diploma, provided she/he completed one vocational course of 4 credits during the summer vacation of the second year.

3-year UG Degree: Student opts to exit after completion of either 1st year or completion of 2nd year may be allowed to re-enter within three years and complete the degree programme within the stipulated maximum period of seven years.

Students opt to exit after completion of the third year securing 120 credits will be eligible for a UG degree with a Major discipline without Honours.

4-year Honours Degree: For 4-year honours degree the major subject/ discipline requires 80 credits and the minor subject/ discipline requires 32 credits. The student who exists after completion of the 6th semester/ 3rd year, she/he requires 60 credits in the major subject/ discipline and 24 credits in the minor subject/discipline.

Note: Students who intend to complete a four-year degree programme will have two options in 7th & 8th semesters as follows:

- **Bachelor's Degree of Honours with Research:** Students who wish to get a **Bachelor's Degree of Honours with Research** have to study **MAJ-MTH-7.1, MAJ-MTH-7.2, and MAJ-MTH-7.3** each of 4 credits, and **DISSERTATION** of 4 credits as the major subjects in 7th semester. Accordingly, in the 8th semester, they will have to study **MAJ-MTH-8.1 and MAJ-MTH-8.2,** each of 4 credits, along with **DISSERTATION** of 8 credits as the major subjects.

- **Bachelor's Degree of Honours:** Students who wish to get a **Bachelor's Degree of Honours** have to study **MAJ-MTH-7.1, MAJ-MTH-7.2, MAJ-MTH-7.3, and MAJ-MTH-7.4** each of 4 credits as the major subjects in 7th semester. Accordingly, in the 8th semester, they will have to study **MAJ-MTH-8.1, MAJ-MTH-8.2, MAJ-MTH-8.3, and MAJ-MTH-8.4,** each of 4 credits as the major subjects.

AIM:

The Undergraduate Programme in Mathematics is meticulously designed to cultivate critical, logical, and analytical thinking among students, equipping them to apply mathematical reasoning effectively in real-world contexts. The programme offers exposure to a wide array of engaging and practical mathematical concepts, thereby preparing students for diverse career opportunities in the industry, government, business, commerce, finance, and research sectors.

The curriculum encompasses a comprehensive range of topics in both pure and applied mathematics. In addition, it includes practical sessions conducted in computer laboratories, utilizing various software tools such as MATLAB, C, and others. These sessions are intended to help students connect theoretical knowledge with contemporary developments in mathematical research and applications across various global institutions and organizations.

Furthermore, the program is designed to enhance students' proficiency not only in mathematics but also in interdisciplinary fields such as commerce, physics, computer science, economics, and statistics. It also promotes academic flexibility, enabling students to transition across disciplines, institutions, and learning modalities with ease.

Program Educational Objective:

PEO-1. Fundamental Knowledge and Skills:

Graduates will possess a strong foundation in mathematical theories, principles, and methodologies, equipping them with the analytical skills necessary to address complex problems and pursue advanced studies or professional careers in mathematics and related disciplines.

PEO-2. Analytical and Critical Thinking:

Graduates will develop advanced analytical and critical thinking skills essential for formulating, assessing, and solving real-world problems through logical reasoning and mathematical modelling.

PEO-3. Communications & Collaborations:

Graduates will be proficient in communicating mathematical concepts clearly and effectively, both orally and in writing. They will also be capable of working collaboratively within multidisciplinary teams to address complex problems.

PEO-4. Ethical & Professional Responsibilities:

Graduates will demonstrate a strong commitment to ethical conduct and professional responsibility, including an awareness of the societal impact of mathematical solutions and a dedication to continuous professional growth and excellence.

PEO-5. Lifelong Learning and Adaptability:

Graduates will engage in lifelong learning to stay abreast of emerging developments and trends in the field of mathematics, enabling them to adapt

effectively to the evolving demands of both academia and the professional landscape.

PEO-6. Research & Innovation:

Graduates will be equipped with the ability to conduct independent research, thereby deepening their understanding of mathematical concepts and fostering creativity in addressing both abstract and practical problems.

Program Specific Outcomes:

The Programme Specific Outcomes of the FYUGP program in Mathematics are listed in the following. After completing the program, the students will be able to:

PSO-1 Demonstrate the acquisition of comprehensive knowledge and a coherent understanding of both core and elective subjects within the discipline of mathematics.

PSO-2 Apply mathematical techniques and tools—including mathematical modelling, computational methods, and statistical analysis—to effectively solve real-world problems across a range of disciplines.

PSO-3 Possesses advanced analytical and critical thinking skills, enabling the construction of rigorous logical arguments, the development of mathematical proofs, and the resolution of complex mathematical problems.

PSO-4 Demonstrate proficiency in the use of modern mathematical software and computational tools, such as MATLAB, C, and other relevant technologies, for data analysis and the solution of mathematical problems.

PSO-5 Effectively communicates mathematical ideas and solutions to diverse audiences—including mathematicians, scientists, engineers, and non-specialists—through both oral and written means.

PSO-6 Formulate well-defined research questions, conduct comprehensive literature reviews, apply appropriate methodologies, and effectively presents research findings, while demonstrating a commitment to lifelong learning and continuous professional development.

PSO-7 Utilize the essential skills required for success in national-level competitive examinations, pursuing doctoral research, academic teaching, and other professional endeavours.

Teaching Learning Process:

The outcome-based approach necessitates a significant shift from teacher-centric to learner-centric pedagogies, and from passive to active and participatory learning methods, particularly at the

undergraduate level. This course is designed to facilitate the systematic and sequential acquisition of knowledge and skills, with an emphasis on practical competencies and a clear understanding of the relationship between theory and practice.

Teaching methodologies include interactive discussions, student presentations, the use of prescribed textbooks, ICT, e-learning tools, and other self-directed learning resources. In addition, the curriculum integrates projects, internships, exploration of industry requirements, and engagement in research activities to enhance experiential learning and real-world application.

Assessment:

A diverse range of assessment methods, tailored to the specific demands of the mathematics discipline, will be employed to evaluate students' academic progress in alignment with the intended programme outcomes. A system of continuous assessment will be implemented to determine final grades, comprising both in-semester evaluations and a final examination.

In-semester evaluations may include class tests, mid-term examinations, homework assignments, and other components as determined by the respective course instructor. To comprehensively assess students’ achievement of learning objectives, the following evaluative techniques will be utilized: tutorials, timed examinations, problem-based assignments, lab reports for practical work, assessment of practical skills through observation, individual and team project reports, oral presentations (including seminars), viva voce interviews, group discussions, quizzes, and other relevant methods.

Date: 1/8/2023
Page No.

Proceedings of the Syllabus Committee meeting, RTU, Hojai (Department of Mathematics), held on 01/08/2022 at 12.00 noon in the Department of Mathematics Rabindra Nath Tagor University, Hojai

Members Present:

1. Mr. Naren ch. Boro, co-ordinator 1/8/23
2. Dr. Dipjyoti Kalita @Kalita 1/8/23
3. Dr. Lurendra Kakoti 1/8/23
4. Mr. Pradip B. chetry 1/8/23
5. Dr. Mubibb Basumotary 01/8/23
6. Md. Samser Ali Seikh, Samser Ali Seikh
7. Dr Jnanjyoti Sarma. (VIRTUALY PRESENT) Through Google meet

The HoD, Mathematics & Co-ordinator UG-NEP-2020 Syllabus committee of Rabindra Nath Tagor University, Mathematics placed the draft of UG-program Syllabus for four year Under graduate Program before the meeting and request for discussion.

After the placing the Syllabus by the Co-ordinator Syllabus Committee, Mr. Naren ch. Boro all the members verified the Syllabus for Semester I and Semester-II and after threadbare discussion the meeting resolved to approved the Syllabus and forward to EC-RTU for approval.

The meeting Conclude with thanks from Co-ordinator Mr. Naren ch. Boro.

Department of Mathematics
Rabindranath Tagore University
Hojai, Assam

1/8/23

Date:
Page No.

Rabindranath Tagore University * Department of Mathematics * Hojai * Date

PROCEEDINGS BOARD OF STUDIES

DEPARTMENT OF MATHEMATICS, RTU, HOJAI

Dt— 23/03/24

Today 23/03/24 (Saturday) a meeting of Board of studies (Mathematics) is held at 12:00 Noon, in the Department of mathematics, RTU, in presence of following Board members.

Members Present:

1. Sri Narench Boro
   Chairman & HOD, RTU
   (Mathematics)
   23/3/24

2. Dr. Hemanta Kr. Sarmah
   Subject expert & HOD, GU.
   (Mathematics)
   Online Present 23/3/24

3. Dr. Deepjyoti Kalita
   Member, Dept. Maths, RTU
   23/3/24

4. Dr Lukendra Kakati
   Member, Dept of Maths Lanka Mahavidyalaya.
   Online Present 23/3/24

5. Dr. Bhagyajyoti Nath
   Member, Dept. Maths, RTU.
   23/03/24

In the meeting the chairman of Board of studies & HOD placed the draft syllabus of UG-programme (Maths) for 3rd, 4th, 5th & 6th Semester (under NEP 2020) before the board members.

All the members present in the meeting present their views on the draft syllabus and resolved to approve the syllabus and forward to EC-RTU for final approval.

The meeting ended with vote of thanks by Dr. Deepjyoti Kalita member BOS, RTU.

Head
Department of Mathematics
Rabindranath Tagore University
Hojai, Assam

23/03/24

13/05/2025

Date:
Page No.

Rabindranath Tagore University, Hojai * Department of Mathematics * Date 13/5/25

Proceedings Board of studies

Dept. of Mathematics, RTU, Hojai

Today 13/5/25 (Tuesday) a meeting of Board of studies (Dept. of Maths) held at 11:00 AM in the Department of Mathematics, RTU, Hojai, in the presence of following members.

Members Present.	Signatures
1. Sri Naren Ch Baro Chairman & HOD, Maths RTU, Hojai	13/5/25
2. Dr. Hemanta Kumar Sarmah (Subject Expart) Professor & HOD, Maths, G.U.	Hemanta Kr. Sarmah 13/5/25
3. Sri Pradip B. Chetri (Member) Asst. Professor, Lumding College, Lumding	Pradip Bahadur Chetri 13/05/25.
4. Md. Samser Ali Seikh (Member) Asso. Professor, Haji Anfar Ali College, Doboka	Samser Ali Seikh 13/5/25
5. Dr. Deepjyoti Kalita (member) Asso. Professor, RTU, Hojai	Deepjyoti Kalita 13/5/25
6. Dr. Bhagyajyoti Nath (Member) Asst. Professor, RTU, Hojai	Bhagyajyoti Nath 13/05/2025.

In the meeting the chairman & HOD, Mathematics of RTU, placed the draft syllabus for 5th, 6th 7th & 8th Semester for UG classes as per NEP 2020. for

Contd —

Date:
Page No.

discussion. on the revised syllabus of 5th & 6th Semester ~~also~~ the members placed their views and at the same time they all agreed to implement the syllabus prepared for sem- V, VI VII and VIII for UG course under RTU as per NEP 2020 model.
The Syllabus for sem - V & VI and VII & VIII will be implemented from session 25-26 & 26-27 respectively.

Finally the meeting resolved that

1) The syllabus prepared for the sem V & VI are accepted & will be implimented from Academic session 25-26.
2) The syllabus for sem- VII & VIII are accepted and will be implemented from session 26-27.

13/5/25

Head
Department of Mathematics
Rabindranath Tagore University
Hojai, Assam

PROCEEDINGS, BOARD OF STUDIES (UG & PG)
DEPARTMENT OF MATHEMATICS, RTV, HOJAI

Date:
Page No.

Dated: 21.05.26

Proceedings of the meeting of Board of Studies (UG & PG), Department of Mathematics, Rabindra nath Tagore Vishwavidyalaya regarding the finalisation of course curriculum of FYUGP (7th & 8th Sem) and Two years P.G. courses of Mathematics.

Members Present:

1) Sri Naren Ch. Boro — 21/05/26
Chairman BOS & HOD

2) Prof. Hemanta Kumar Sarmah — Virtually present
Subject expert & HOD, G.U.

3) Dr. Deepjyoti Kalita — 21/5/26
Asso. Professor (Member)

4) Dr. Bhagyajyoti Nath — 21/05/26
Asstt. Professor (Member)

5) Md. Samser Ali Saikh — Virtually present
Asso. Professor (Member)

6) Mr. Pradip B. Chetri — Virtually present
Asstt. Professor (Member)

In the beginning the chairman of BOS welcomed the members of the Board and he placed the Revised version of Syllabus for FYUGP (7th & 8th Semester) and two year P.G. course before the house for discussion.

Date:
Page No.

During the meeting all the members present put their views and all of them annonemously agreed to accept the Syllabus Prepared and to implement in coming Semesters in Rabindranath Thakur Vishwavidyalaya.

In the meeting Dr. Hemanta Kr. Sarmah (Sub. expert), Md. Samser Ali Saikh (member) & Mr. Pradip B. Chetri (member) present their views virtually and finally all the members approved the Syllabus Prepared.

Hence, the meeting resolved to accept the Syllabus Prepared for both UG and PG courses accordingly, under Rabindranath Thakur Vishwavidyalaya, Hojai.

21/05/26

Detailed Structure of Syllabus

SEMESTER-1

CLASS	COURSES	SUBJECT PAPERS	CREDITS
SEMESTER-I	CORE	MAJ-MTH-1.1: CALCULUS	4
	MINOR	MIN-MTH-1.1 FUNDAMENTAL CALCULUS	4
	SEC	SE-MTH-1.1 COMPUTER ALGEBRA SYSTEM	3
	MD	MD-MTH-1.1 BASIC MATHEMATICS-I	3
	AECC	…	2
	VAC	…	2+2
	VOC/MINOR RESEARCH PROJECT	…	…
			Total-20

Note: MAJ: core subject, MIN: minor subject,
GE/MD: Generic elective/Multidisciplinary subject

Core Course

MAJ-MTH-1.1: Calculus (Including Practical)

Total marks: 100 (Theory: 45, Internal Assessment: 30, Practical: 25)

Course objective:

The objective of learning the course is to

- *Give an idea of successive differentiation, Leibnitz's theorem, and L'Hospital rule for evaluating limit,*
- *To explain various types of reduction formulas for integration of trigonometric and exponential functions and applications in finding volume and surface of revolution of curves,*
- *To give the idea of vectors product their applications in physical problems.*

Course Outcomes:

After going through this course, the students will be able to

CO-1 *Apply calculus to real-life problems,*

CO-2 *Learn to find the limits of functions,*

CO-3 *Understand different vector operations and their applications in physical problems.*

UNIT 1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its application to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hopital's rule, applications in business, economics and life sciences. [1]: Chapter 4 (Sections 4.3-4.5 (page 124-157), 4.7). [2]: Chapter 7 (Section 7.8), Chapter 11 (Section 11.1). **Marks-15**

UNIT 2: Reduction formulae, derivations, and illustrations of reduction formulae of the type $\int \sin nx\,dx$, $\int \cos nx\,dx$, $\int \tan nx\,dx$, $\int \sec nx\,dx$, $\int (log\ x)^n\,dx$, $\int sin^n x\,cos^m x dx$, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. [1]: Chapter 9 (Sections 9.4 (Pages 471-475 (excluding lines in R3). [2]: Chapter 8 (Sections 8.2-8.3 (pages 532-538 (excluding integrating products of tangents and secants), Chapter 6 (Section 6.2-6.5 (excluding arc length by numerical methods) **Marks-15**

UNIT 3: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics, and planetary motion, Kepler's second law.[1] Chapter 9 (Section 9.3 (pages 468-469)), Chapter 10. **Marks-15**

Practical / Lab work to be performed on a computer:

List of the practicals to be done using Matlab / Mathematica / Maple / Scilab / Maxima etc.

(i) Plotting the graphs of the following functions: ax, $[x]$ (greatest integer function), $\sqrt{ax+b}$, $|ax+b|$, $c \pm |ax+b|$, $x^{\pm n}$, $x^{\frac{1}{n}}, n \in \mathbb{Z}$. $\frac{|x|}{x}$, $sin\left(\frac{1}{x}\right)$, $xin\left(\frac{1}{x}\right), e^{\pm\frac{1}{x}}$, $x \neq 0$. $e^{ax+b}, \log(ax+b), \frac{1}{ax+b}, \sin(ax+b), \cos(ax+b), |\sin(ax+b)|, |\cos(ax+b)|$.

Observe and discuss the effect of changes in the real constants a, b, and c on the graphs. 9

(ii) Plotting the graphs of polynomials of degree 4 and 5, the graphs of their first and second derivatives, and analysis of these graphs in the context of the concepts covered in Unit 1.

(iii) Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid.

(iv) Tracing of conic in cartesian coordinates.

(v) Obtaining the surface of the revolution of curves.

(vi) Graph of hyperbolic functions.
(vii) Computation of limit, Differentiation, Integration, and sketching of vector-valued functions.
(viii) Complex numbers and their representations, Operations like addition, Multiplication, Division, and Modulus. Graphical representation of polar form.
(ix) Find numbers between two real numbers and plotting of finite and infinite subsets of R.

Text Books:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and Sons (Asia), Pt Ltd., Singapore, 2002.

MINOR -I

MIN-MTH-1.1: Fundamental Calculus

Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objectives:

The aim of the course is to

- *Give an idea of the graph of functions,*
- *Give the idea of the limit of functions and their evaluations,*
- *Learn the technique of successive differentiation, Leibnitz's theorem, and the L'Hospital rule for evaluating limit,*
- *Study Roll's theorem, M.V. Theorem, etc, and their remainder terms,*
- *Give the idea of functions of several variables.*

Course outcomes:

After going through the subject students will be able to

CO-1 *Understand the basic concept of functions and their graphs.*
CO-2 *Learn the Limit and continuity, differentiability of functions.*
CO-3 *Recall about Tangent and normal curves.*
CO-4 *Recall about the maximum and minimum of a function.*
CO-5 *Solving problems related to expansion of functions and different forms of remainders.*
CO-6 *Derive the functions of several variables and their partial derivatives.*

Unit 1: Graphs of simple concrete functions such as polynomial, Trigonometric, Inverse trigonometric, Exponential, and logarithmic functions [1] Chapter 1 (Sections 1.1 to 1.3), and Chapter 7 (Sections 7.2, 7.3, and 7.6). **Marks-10**

Unit 2: Limits and continuity of a function including approach, Properties of continuous functions including Intermediate value theorem. [2] Chapter 1. **Marks-11**

Unit 3: Differentiability, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives. [2] Chapter 3 (Sections 3.2, 3.3, and 3.6), and Exercise 26, page 184.

Marks-15

Unit 4: Roll's theorem, Lagrange's mean value theorem with geometrical interpretations and simple applications, Taylor's theorem, Taylor's series and Maclaurin's series, Maclaurin's series expansion of functions such as heir use in polynomial approximation and error estimation. [1]: Chapter 4 (Sections 4.2, and 4.3), [2] Chapter 9 (Sections 9.8, and 9.9. **Marks-12**

Unit 5: Functions of two or more variables, Graphs and level curves of functions of two variables, Partial differentiation up to second order. [2] Chapter 13 (Sections 13.1 and 13.3). **Marks-12**

Textbooks:

1. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13th ed). Pearson Education, Delhi. Indian Reprint 2017.
2. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi

GENERIC ELECTIVE-I/Multi-disciplinary-I
MD-MTH-1.1: Basic Mathematics-I

Total Marks: 75 (Theory: 45, Internal Assessment: 30)

Course Objective:

The objectives of this Course are

- *To introduce the basic concepts of sets and mathematical logic in order to develop critical and logical thinking in solving the problems.*
- *To explain the key concepts of calculus, namely, limits, continuity, differentiability of functions, and their various applications.*

Course Outcome:

After the completion of this course, the learner will be able to

CO-1 *Identify the Mathematical objects, to describe social and physical systems*
CO-2 *Use the critical and rational approach for the solution of a problem.*
CO-3 *Describe various algebraic structures onsets*
CO-4 *Apply Calculus to real-life problems.*

UNIT-1: Sets and Logic sets, subsets, types of set, operations on sets, Cartesian product, Statements, truth values and truth table, negation, conjunction and disjunction, Statements with quantifiers, Compound statements, implications, biconditional proposition, converse, contrapositive and inverse propositions, propositional equivalence, predicates and quantifiers, tautology and contradictions. [1] ch-2(2.1-2.25), ch-1(1.1-1.5). **Marks-15**

UNIT-2: Relation and Functions: Relation and Functions, types of relation and functions, graphs of functions, compositions of functions and invertible function, Binary operations. [1] ch-4(4.1-4.4), ch-3(3.1-3.6). **Marks-10**

UNIT-3: **Calculus:** Limits, Continuity, Differentiability of function, Derivatives of different types of functions, Second order derivatives, rate of change of quantities, increasing and decreasing functions, Maxima and minima, Introduction to Integrals, Basic properties, definite integrals, Applications of integrals. [2] ch-2(2.2-2.5), ch-3(3.2-3.6), ch-4(4.7), ch-5(5.3). **Marks-14**

UNIT-4: **Differential equations:** General and particular solutions of differential equation, separation of variables, Homogenous equations, Linear differential equations of first order, General and particular solutions of homogenous and non-homogenous linear differential equations of second order with constant coefficients.[3] ch-1(1.1, 1.2, 1.4, 1.5, 1.6), ch-3(3.1-3.5). **Marks-6**

Text Books:

1. Kumar, A., Kumaresen, S., & Sarma, B.K., A Foundation course in Mathematics, Narosa Publishing House, 2018.
3. Differential calculus, by B.C.Das
4. Integral calculus, by B.C.Das

SEC-I

SE-MTH-1.1: Computer Algebra Systems and Related Software

Total marks: 75 (Theory: 50, Practical: 25)

Course objective:

The aim of the course is to provide a preliminary idea about

- *Computer operations,*
- *Calculations through a computer,*
- *The concept of plotting graphs in a computer.*

Course outcomes:

After going through the course, the students will learn

CO-1 *To calculate basic arithmetic through a computer in an easy way,*

CO-2 *To use algebraic properties in calculation, programming, etc.*

Unit 1: Introduction to CAS and Applications: Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two

variables using Plot3D and Contour Plot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise-defined functions, Combining graphics. [1] Chapter 12 (Sections 12.1 to 12.5) [2] Chapter 1, and Chapter 3 (Sections 3.1 to 3.6, and 3.8) Chapter 6 (Sections 6.2, and 6.3). **Marks-25**

Unit 2: Working with Matrices: Simple programming in a CAS, working with matrices, performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization. [2] Chapter 7 (Sections 7.1 to 7.8). **Marks-25**

Practical:

List of the practicals to be done using Matlab / Mathematica / Maple / Scilab / Maxima etc.
Six practicals should be done by each student. The teacher can assign practical from the exercises from [1, 2].

Text Books:

1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2. Torrence. Bruce F., & Torrence, Eve A. (2009). The Student's Introduction to Mathematica: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.

Semester-II

CLASS	COURSES	SUBJECT PAPERS	CREDITS
SEMESTER-II	CORE	MAJ-MTH-2.1: ALGEBRA	4
	MINOR	MIN-MTH-2.1 REAL ANALYSIS	4
	SEC	SE-MTH-2.1 R-PROGRAMMING	3
	MD	MD-MTH-2.1 BASIC MATHEMATICS-II	3
	AECC	…	2
	VAC	…	2+2
	VOC/MINOR PROJECT	…	…
			Total-20

Note: Students who exits after first year will be awarded undergraduate certificate (in the field/discipline) if He/she completes a summer internship course of credit-4, in Second year.

CORE COURSE
MAJ-MTH-2.1: Algebra
Total marks: 100 (Theory: 60, Internal Assessment: 40)

Course objective:

The objective of the topics is to give

- *Idea about real and complex numbers, De Moiver's theorem and their applications,*
- *Idea of logical statements, idea of relations and functions, and system of linear equations and to solve them through matrix operations.*

Course outcome:

After going through this course, the students will be able to have

CO-1 *A basic idea about real and complex numbers*
CO-2 *Ideas about sets and their algebraic structure*
CO-3 *Know about logical ideas behind the mathematical statements,*
CO-4 *Ideas about functions and their operations,*
CO-5 *Ideas about matrices and their relations with the system of linear equations.*
CO-6 *Knowledge about various applications of the topics in real-life.*

UNIT-1: Polar representation of complex numbers, nth roots of unity, De Moiver's theorem for rational indices and its applications. [1]: Chapter 2. **Marks-10**

UNIT-2*:* Statements and logic, statements with quantifier, compound statements, implications, proofs in Mathematic; Sets, operations on sets, family of sets, power sets, Cartesian product; Functions, one-one, onto functions and bisections, Composition of functions, Inverse of a function, Image and Inverse image of subsets; Relation, Equivalence relations, Equivalence classes and partitions of a set, congruence modulo n in integers; Induction Principles, the well-ordering principle, greatest common divisor of integers. [2] Chapters 1 – 5. **Marks-25**

UNIT 3: Systems of Linear Equations, row reduction and echelon forms, vector equations, the matrix equation Ax = b, solution sets of linear systems, linear independence, introduction to linear transformations, the matrix of a linear transformation; Matrix operations, inverse of a matrix, characterizations of invertible matrices; Determinants, Cramer's rule [3]: Chapter 1 (Sections 1.1 – 1.9); Chapter 2 (Sections, 2.1 – 1.3); Chapter 3 (Sections 3.1 – 3.3)**.** **Marks-25**

Text Books:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to …. Z, Birkhauser, 2006.
2. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.
3. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.

Reference Books:

1. S. Barnard and J.M. Child, Higher Algebra, Arihant, 2016.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory. (3rd Edition), Pearson Education (Singapore) Pvt. Ltd., Indian Reprint, 2005.
3. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

MINOR-II
MIN-MTH-2.1: Real Analysis
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objectives:

The main objective of the topic is

- *To explain a deep understanding of the real line and important terms*
- *Functions and the limit and continuity*
- *To prove the results about convergence and divergence of sequence and series.*

Course Outcomes:

After going through this course the students will be able to

CO-1 *Identify the number system; analyze the properties of the number line,*

CO-2 *Describe various analytical properties of the real number system*

CO-3 *Sequence of numbers and their convergence and divergence and test for convergence and divergence.*

Unit 1: Order completeness of Real numbers, Open and closed sets, Limit of functions, Sequential criterion for limits, Algebra of limits, Properties of continuous functions, Uniform continuity. [1] Chapter 2 (Sections 2.1, and 2.2, Sections 2.3, and 2.4) Chapter 11 (Section 11.1, Definition and Examples only). **Marks-30**

Unit 2: Sequences, Convergent and Cauchy sequences, Subsequences, Limit superior and limit inferior of a bounded sequence, Monotonically increasing and decreasing sequences, Infinite series and their convergences, Positive term series, Comparison tests, Cauchy's nth root test,

D'Alembert's ratio test, Raabe's test, Alternating series, Leibnitz test, Absolute and conditional convergence. [1] Chapter 3, (Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.7), Chapter 9 [Section 9.1(excluding grouping of series)] Sections 9.2 (Statements of tests only), and 9.3 (9.3.1, 9.3.2) Chapter 4 (Sections 4.1 to 4.3). Chapter 5 (Sections 5.1, 5.3, 5.4 excluding continuous extension and approximation). **Marks-30**

Text Book:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.) Wiley India Edition.

Reference Book:

1. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint
2. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). An Introduction to Analysis (2nd ed.). Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015

Generic Elective-II/Multi-disciplinary-II
MD-MTH-2.1: Basic Mathematics-II
Total Marks: 75 (Theory: 60, Internal: 15)

Course Objectives:

The objectives of this Course are

- *To introduce the basic concept of the difference operator with its relation.*
- *Interpolation of a function for the set of tabulated points.*
- *To study the basic concepts of probability and random variables.*

Course Outcomes:

After the completion of this course, the learner will be able to

CO-1 *Build up a strong foundation of the basic Mathematical tools,*

CO-2 *Identify the Mathematical objects to describe social and physical systems.*

Unit-1 Counting Principles Sum and Product rule of counting, permutation and combination. **Marks-20**

Unit-2: Finite Differences and Interpolation Introduction, forward difference operator, Operators E & D, backward differences, central differences, Newton's forward and backward interpolation formulae, Lagrange's interpolation formula. [2] ch-1, ch-2. **Marks-20**

Unit-3: Probability Introduction to probability, Random experiment, event, axiomatic approach to probability, conditional probability, Multiple theorems on probability, Bayes' theorem (Statement Only with Applications), random variables, and distributions. [3] ch 2(2.1,2.2,2.3), ch 3(3.1,3.2).

Marks-20

Text Books:

1. Discrete mathematics theory and applications, D.S. Mallik and M.K.Sen, Revised edition 2.
2. Finite difference and Numerical analysis, H.C.Saxena, S Chand and Company.
3. Elements of probability and statistics, A.P.Baissnab, M.Jas, McGraw Hill.

Reference books:

1. Rao, G. S., Numerical Analysis. New Age International Publishers, 2003.
2. Berge, C., Principles of Combinatory. New York, 1971.
3. Stewart I., Tall D., The Foundations of Mathematics. Oxford University Press, 2015.
4. Shastry S.S., Introductory Methods of Numerical Analysis, PHI, 2012.

SEC-II
SE-MTH-2.1: R-Programming
Total marks: 75 (Theory 50, Practical 25)

Course Objectives:

The objective of the course is to give

- *A basic idea of R- programming language*
- *Introduced various tools in R programming and their uses in writing a computer program*

Course Outcome:

After going through the course students will learn

CO-1 *What is R-programming language?*

CO-2 *Its various tools for writing computer programs to solve mathematical problems*

Unit 1: Getting Started with R - The Statistical Programming Language Introducing R, using R as a calculator; Explore data and relationships in R; Reading and getting data into R: combine and scan commands, viewing named objects and removing objects from R, Types and structures of data items with their properties, Working with history commands, Saving work in R; Manipulating vectors, Data frames, Matrices and lists; Viewing objects within objects, Constructing data objects and their conversions. [1] Chapter 14 (Sections 14.1 to 14.4) [2] Chapter 2, Chapter 3. **Marks-15**

Unit 2: Descriptive Statistics and Tabulation Summary commands: Summary statistics for vectors, Data frames, Matrices and lists; Summary tables. [2] Chapter 4. **Marks-10**

Unit 3: Distribution of Data Stem and leaf plot, Histograms, Density function and its plotting, The Shapiro-Wilk test for normality, The Kolmogorov-Smirnov test. [2] Chapter 5.

Marks-10

Unit 4: Graphical Analysis with R Plotting in R: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts, Bar charts; Copy and save graphics to other applications. [1] Chapter 14 (Section 14.7) [2] Chapter 7. **Marks-15**

Practical to be done in the Computer Lab using Statistical Software R:
[1] Chapter 14 (Exercises 1 to 3) 30 [2] Relevant exercises of Chapters 2 to 5, and 7
Note: The practical may be done on the database to be downloaded from https://data.gov.in/

Textbooks:

1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley Publication.

SEMESTER-III

CLASS	COURSES	SUBJECT PAPERS	CREDITS
SEMESTER-III	CORE	MAJ-MTH-3.1: DIFFERENTIAL EQUATION	4
		MAJ-MTH-3.2: REAL ANALYSIS	4
	MINOR **(ANY ONE)**	MIN-MTH-3.1: ALGEBRA MIN-MTH-3.2 CALCULUS	4
	SEC	SE-MTH-3.1: LATEX & HTML	3
	MD	MD-MTH-3.1: BASICS OF COMPUTER	3
	AECC	…	2
	VAC	…	…
	VOC/MINOR PROJECT	…	…
			Total-20

Note: COR: core subject, MIN: minor subject,
GE/MD: Generic elective/Multidisciplinary subject

CORE COURSE

MAJ-MTH-3.1: Differential Equations (including practical)

Total Marks: 100: (Theory 45, Practical: 25, Internal assessment: 30)

Course Objectives:

The objective of the course is

- *To give an idea about differential equations,*
- *Formation of differential equations*
- *To solve differential equations by various methods*
- *To form a mathematical model in terms of differential equations,*
- *Apply mathematical models to physical problems.*

Course Outcomes:

After going through this course the students will be able to

CO-1 *Know about differential equations and its formation,*

CO-2 *Applications of Differential equations in various fields,*

CO-3 *Forming mathematical models in the form of differential equations,*

CO-4 *To solve various physical problems by mathematical modeling.*

Unit 1: Differential equations and mathematical models. General, particular, explicit, implicit, and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equations, and Bernoulli equations, special integrating factors and transformations. [2] Chapter 1 (Sections 1.1, and 1.6), [3] Chapter 2, [2] Chapter 1 (Section 1.4, pages 35 to 38), and Chapter 2 (Section 2.3). [3] Chapter 3 (Section 3.3, A and B with Examples 3.8, 3.9). **Marks-15**

Unit 2: Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting. [1] Chapter 2 (Sections 2.1, 2.5, and 2.6), [1] Chapter 2 (Sections 2.7, and 2.8), [1] Chapter 3 (Sections 3.1 to 3.3). **Marks-15**

Unit 3: General solution of homogeneous equation of second order, the principle of superposition for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and nonhomogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. [2] Chapter 3 (Sections 3.1 to 3.3, Sections 3.4 (pages 172 to 177), and 3.5), [1] Chapter 5 (Sections 5.1, 5.2, 5.4, and 5.9), and Chapter 6 (Sections 6.1 to 6.4).

Marks-15

List of Practical (using any software):

1. Plotting of second-order solution family of differential equation.
2. Plotting of third-order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of a single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).

Text Books:

1. Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modeling with Case Studies, Using Maple and MATLAB (3rd Ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation 13 and Boundary Value Problems: Computing and Modeling (5th Ed.). Pearson Education.
3. Ross, Shepley L. (2004). Differential Equations (3rd Ed.). John Wiley & Sons. India

Reference Books:

1. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.

2. Ross, Clay C. (2004). Differential Equations: An Introduction with Mathematica (2nd Ed.). Springer

MAJ-MTH-3.2: Real Analysis
Total marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objective:

The aim of the course is

- *To explain a deep understanding of the real line and important terms,*
- *To prove the results of convergence and divergence of sequences and series.*

Course Outcomes:

After going through this course the students will be able to

CO-1 *Identify the number system, analyze the properties of the number line*

CO-2 *Describe various analytical properties of the real number system*

CO-3 *Sequence of numbers and their convergence and divergence and test for convergence and divergence.*

Unit 1: Algebraic and order properties of R, absolute value and real line, bounded sets, supremum and infimum, completeness property of R, the Archimedean property, the density theorem, intervals, nested interval theorem. [1] Chapter 2. **Marks-10**

Unit 2: Real sequences, the limit of a sequence, convergent sequence, bounded sequence, limit theorems, monotone sequences, monotone convergence theorem, subsequences, monotone subsequence theorem, Bolzano Weierstrass theorem for sequences, Cauchy sequences, Cauchy's convergence criterion, properly divergence sequences. [1] Chapter 3. **Marks-30**

Unit 3*:* Infinite series, convergence and divergence of infinite series, Cauchy criterion, Tests for convergence: comparison test, limit comparison test, ratio test, root test, integral test, Absolute convergence, rearrangement theorem, alternating series, Leibniz test, conditional (nonabsolute) convergence. [1] Chapter 9 Sections 9.1-3. **Marks-20**

Text Book:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons, 2002.

Reference Books:

1. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, Jones & Bartlett, Second Edition, 2010.
2. A. Kumar and S. Kumaresan, Basic Course in Real Analysis, CRC Press, 2014.
3. K. A. Ross, Elementary Analysis: The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

MINOR -III
MIN-MTH-3.1: Algebra
Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objective:

The objective of the topics is to give

- *Idea functions trigonometric and exponential, roots of quadratic, cubic equation, relation between roots and coefficients, De Moivre's theorem, and their application.*
- *Types of matrices, solutions of matrix equations, *Preliminary idea about abstract algebra group, ring, vector space.*

Course Outcome:

After going through this course the students will be able to have

CO-1 *A basic idea about functions, types of functions*

CO-2 *Idea about roots of equations and to write equations from roots*

CO-3 *Idea about matrices, matrix operations, solving matrix equations, Cayley Hamilton theorem*

CO-4 *Idea of abstract thinking*

Unit 1: Theory of Equations and Expansions of Trigonometric Functions: Fundamental Theorem of Algebra, Relation between roots and coefficients of nth degree equation, Remainder and Factor Theorem, Solutions of cubic and biquadratic equations, when some conditions on roots of the equation are given, Symmetric functions of the roots for cubic and biquadratic; De Moivre's theorem (both integral and rational index), Solutions of equations using trigonometry and De Moivre's theorem, Expansion for in terms of powers of in terms of cosine and sine of multiples of x. [2] Chapter 3, 4 [3] Chapter 7 (Sections 7.6 and 7.7). **Marks-20**

Unit 2: Matrices: Types of matrices, Rank of a matrix, Invariance of rank under elementary transformations, Reduction to normal form, Solutions of linear homogeneous and nonhomogeneous equations with number of equations and unknowns up to four; Cayley-Hamilton theorem, Characteristic roots and vectors. [4] Chapter 3 (Sections 3.2, 3.5, and 3.7, Section 3.9) Chapter 2 (Sections 2.1 to 2.5) Chapter 7 (Section 7.1, and Example 7.2.2). **Marks-20**

Unit 3: Groups, Rings and Vector Spaces: Integers modulo n, Permutations, Groups, Subgroups, Lagrange's theorem, Euler's theorem, Symmetry Groups of a segment of a line, and regular n-gons for n = 3, 4, 5, and 6; Rings and subrings in the context of C[0, 1] and Definition and examples of a vector space, Subspace and its properties, Linear independence, Basis and dimension of a vector space. [1] Chapter 1 (Section 1.4), Chapter 2 (Section 2.3) Chapter 3 (Sections 3.1, and 3.2) (Sections 3.2, 3.3, and 3.6), and Chapter 5 (Section 5.1) [4] Chapter 4 (Sections 4.1, 4.3, and 4.4). **Marks-20**

Text Books:

1. Beachy, John A., & Blair, William D. (2006). Abstract Algebra (3rd ed.). Waveland Press, Inc.
2. Burnside, William Snow (1979). The Theory of Equations, Vol. 1 (11th ed.) S. Chand & Co. Delhi. Fourth Indian Reprint.
3. Gilbert, William J., & Vanstone, Scott A. (1993). Classical Algebra (3rd ed.). Waterloo Mathematics Foundation, Canada.
4. Meyer, Carl D. (2000). Matrix Analysis and Applied Linear Algebra. Society for Industrial and Applied Mathematics (Siam).

Reference Books:

1. Dickson, Leonard Eugene (2009). First Course in The Theory of Equations. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)
2. Gilbert, William J. (2004). Modern Algebra with Applications (2nd ed.). John Wiley & Sons.

MIN-MTH-3.2: Calculus

Total Marks: 100 (Theory -60, Internal Assessment -40)

Course Objectives: The main objective of the course is to

- Give idea about Successive differentiation, Leibnitz theorem.
- Explain various reduction formulas for integration of trigonometric and exponential functions.
- Give idea about product of vectors and their applications in the real world.

Course Outcomes:

After completion of this paper, students will be able to:

CO-1 Apply calculus to solve real-life problems.

CO-2 Understand different vector operations and their applications.

Unit 1: Successive differentiation, standard order on nth order derivatives and Leibnit'z theorem, partial differentiation, partial derivatives of first and higher orders for functions of two and three variables, Euler's theorem on homogeneous functions. **15 Marks**

Unit 2: Integrals of the form: $\int \frac{px+q}{\sqrt{ax^2+bx+c}}dx,\ \int(px+q)\sqrt{ax^2+bx+c}, \int \frac{dx}{(px+q)\sqrt{ax^2+bx+c}}$.
Integration of rational functions of $sinx$ and $cosx$. Properties of definite integrals.
Reduction formulae for integration of the following functions:
$x^n e^{ax},\ x^m sinnx,\ x^m cosnx,\ x^n(logx)^m,\ \frac{1}{(x^2+k^2)^n},\ sin^n x,\ cos^n x,\ tan^n x,\ cosec^n x.$

20 Marks

Unit 3: Scalar and vector products of two vectors, Scalar triple product, vector triple product, Product of four vectors, Vector point function, limit, continuity, and differentiation of vector function, Partial derivatives of vectors. Gradient of a scalar point function, Divergence, and curl of a vector. **25 Marks**

Text Books:

1. B.C. Das, B.N. Mukherjee, Differential Calculus, U.N. Dhur & Sons Private Ltd.
2. B.C. Das, B.N. Mukherjee, Integral Calculus, U.N. Dhur & Sons Private Ltd.
3. J.G. Chakravorty, P.R. Ghosh, Vector Analysis, U.N. Dhur & Sons Private Ltd.

Reference Book:

1. K.C. Maity, R. K. Ghose, Integral calculus, New central Book Agency, Calcutta.

2. M. Spigel, Vector Analysis, Schaum Outline Series.

GENERAL ELECTIVE/MULTIDISCIPLINARY
MD-MTH-3.1: Basics of Computer
Full marks: 75 (Theory: 50, Practical: 25, Internal: NIL)

Course objective:

The aim of the course is to provide a preliminary idea about

- *Basic Computer operations*
- *Calculations through a computer*
- *Idea of plotting graph in a computer.*

Course outcomes:

After going through the course, the students will learn

CO-1 *To handle computer systems,*

CO-2 *To create document files using MS Word.*

CO-3 *To create presentations and analyse data using MS Excel.*

Unit 1: Introduction to Computers **Marks-10**

What is a Computer? Basic computer organization, Computer Hardware and Software, Input and output devices, System software and Application software, Operating system, and Storage devices.

Unit 2: MS-Word **Marks-10**

Introduction to MS Word, Parts of Windows of Word, Creating and editing a Word document with tables, Figures, and graphs in a presentable format.

Unit 3: MS-Excel **Marks-15**

Introduction to spreadsheets, Construction of spreadsheets using data, Application of formulas and functions for calculation, Use of statistical tools, Preparation of graphs, Histograms, and Charts.

Unit 4: MS-PowerPoint **Marks-15**

Introduction to MS PowerPoint, Features and functions, Creating presentations, Adding animations, Customizing presentations, and Presentation techniques.

Practical:

Ten practical should be done by each student. The teacher can assign practical to the students as per requirements.

Text Book:

1. Sanjay Saxena, A First Course in Computers, Vikash Publishing House Pvt. Ltd.

SEC-III
SE-MTH-3.1: Latex and HTML (Including practical)
Total marks: 75 (Theory 50, Practical 25)

Course Objective:

The main objective of the course is to

- *Introduce with programming language Latex.*
- *With markup language HTML.*

Course Outcome:

After going through the course students will learn

CO-1 *To work with Latex,*

CO-2 *Design the web page through HTML.*

Unit 1: Elements of Latex; Hands-on-training of Latex; graphics in Latex; PS Tricks; Beamer presentation [1] Chapters 9, 10, 11. **Marks-25**

Unit 2: HTML, creating simple web pages, images, and links, design of web pages. [1] Chapters 9-11, 15. **Marks-25**

Practical: **Marks-25**

Six practicals should be done by each student. The teacher can assign practical from the exercises from [1].

Text Book:

1. Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.

Reference Book:

1. L. Lamport, LATEX: A Document Preparation System, User's Guide and Reference Manual. Addison-Wesley, New York, second edition, 1994.

SEMESTER-IV

CLASS	COURSES	SUBJECT PAPERS	CREDITS
SEMESTER-IV	CORE	MAJ-MTH-4.1: THEORY OF REAL FUNCTIONS	4
		MAJ-MTH-4.2: ABSTRACT ALGEBRA	4
		MAJ-MTH-4.3: MULTIVARIATE CALCULUS	4
	MINOR	MIN-MTH-4.1: ANALYTICAL GEOMETRY	4
		MIN-MTH-4.2: PROBABILITY AND STATISTICS	
	AECC	…	2
	VOC/MINOR PROJECT	SUMMER INTERNSHIP	2
			Total-20

Note: MAJ: core subject, MIN: Minor subject, GE/MD: Generic elective/Multidisciplinary subject.

MAJ-MTH-4.1: Theory of Real Functions
Total Marks: 100 (Theory 60, Internal assessment 40)

Course Objective:

The main objective of the course is to

- *Introduce different types of functions and the limit of a function.*
- *Continuity of functions and related theorems*
- *Differentiability of functions*
- *Rolle's theorem, MV Theorem, Taylor series, etc.*

Course outcome:

After going through the course students will be able to

CO-1 *Have a good concept of functions, the continuity of a function, and its geometrical properties*

CO-2 *Idea about the limit of functions and their evaluation technique*

CO-3 *Learn about the differentiability of a function*

CO-4 *Know about the application of Roll's theorem, MV theorem, etc.*

UNIT 1: Cluster point or limit point of a set, limits of a function (ε-δ approach), sequential criterion for limits, divergence criteria, limit theorems, one-sided limits, infinite limits, and limits at infinity. [1] Chapter 4. **Marks-20**

UNIT 2: Continuous functions, the sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on intervals, maximum-minimum theorem, intermediate value theorem, location of roots theorem, preservation of intervals theorem, uniform continuity, uniform continuity theorem. [1] Chapter 5. **Marks-20**

UNIT 3: Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse function, Rolle's theorem, mean value theorem, Darboux's theorem, Cauchy mean value theorem, L'Hospital's rules, Taylor's theorem and applications to inequalities, Taylor's series expansions of exponential and trigonometric functions, ln (1 + x), 1/(ax+b) and n (1+ x). [1] Chapter 6, and Taylor series as in Section 9.4. **Marks-20**

Text Book:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2015.

Reference Books:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, Indian Edn. 2014.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A.Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006

MAJ-MTH-4.2: Abstract algebra
Total Marks: 100 (Theory 60, internal assessment 40)

Course Objective:

The objective of learning the subject is to give

- *Abstract idea about group, subgroup, symmetric properties of geometrical objects.*
- *Idea of rings, fields, integral domains,*
- *Idea of group and ring homomorphism,*
- *The consequences of these mathematical structures.*

Course Outcome:

After going through the course students will learn

CO-1 *The abstract terms group, ring, field, integral domains, etc.*

CO-2 *The idea of symmetries of geometrical objects.*

CO-3 *The significance of permutation, permutation groups cyclic groups, factor groups, etc.*
CO-4 *To apply abstract ideas to real-life problems.*
CO-5 *Abstract idea of ring their examples.*

Unit 1: Definition and examples of the group, elementary properties of the group, symmetries of a triangle, square, dihedral group, order of a group, order of an element in a group, subgroups, subgroup test, subgroup generated by an element of a group, center of a group, centralizer, normalizer, product of two groups, cyclic group, properties of cyclic group. [1]: Chapters 1, Chapter 2, Chapter 3, Chapter 4. **Marks-15**

Unit 2: Permutations, permutation group, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. Normal subgroup, factor groups. [1]: Chapter 5 (till the end of Theorem 5.7), Chapter 7 (till the end of Theorem 7.2), Chapter 9 (Theorem 9.3 and 9.5). **Marks-15**

Unit 3: Group homomorphism, properties of homomorphism, isomorphism, the kernel of group homomorphism, Cayley's theorem, properties of isomorphism, First, Second, and Third isomorphism theorems. [1]: Chapter 6 (till end of Theorem 6.2), Chapter 10. **Marks-15**

Unit 4: Definition and examples of rings, properties of rings, subrings, Zero divisors, integral domains and fields, characteristics of a ring, Boolean ring. Ideals, ideals generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homeomorphisms, properties of ring homeomorphism, Isomorphism theorem I, II, III, Polynomial rings, Division algorithm for F[x], remainder theorem, factor theorem, reducibility and irreducibility of polynomials, Eisenstein's Criterion of irreducibility, content of polynomial, primitive polynomial. [1]: Chapter 12, Chapter 13, Chapter 14, Chapter 15, Chapter 16 and Chapter 17. **Marks-15**

Text Book:

1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited, Delhi.

Reference Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. G. Santhanam, Algebra, Narosa Publishing House, 2017.
3. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
4. David S. Dummit and Richard M. Foote, Abstract Algebra (2nd edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2003.

MAJ-MTH-4.3: Multivariate Calculus
Total Marks: 100 (Theory 60, Internal assessments 40)

Course Objective:

The objective of the course is to

- *Give an idea of the functions of several variables their derivative, continuity, etc.*
- *To make aware of double and triple integrals, and their physical concept.*
- *Application of integrals in physics, economics, and understanding the architecture of curves and surfaces.*

Course outcome:

After going through the course students will earn about

CO-1 *The concept of variations of functions of several variables*

CO-2 *Understand how to maximize and minimize a multivariable function*

CO-3 *Learn the relations among line integral, double integral, and triple integral*

CO-4 *Familiarize with Green's theorem, Gauss' theorem, Stokes' theorem, etc.*

Unit 1: Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivatives, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines. [1] Chapter 11 (Sections 11.1 and 11.2, 11.3 and 11.4, 11.5, 11.6). **Marks-15**

Unit 2: Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of a vector field, Divergence and curl. [1] Chapter 11 [Section 11.7 (up to page 605)], Section 11.8 (pages 610-614)], Chapter 13 (Section 13.1)**.** **Marks-15**

Unit 3: Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over parallelepiped and solid regions, Volume by triple integrals, triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals. [1] Chapter 12 (Sections 12.1-12.4). **Marks-15**

Unit 4: Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem. [1] Chapter 12 (Sections 12.5 and 12.6) Chapter 13 (Section 13.2, 13.3), [Sections 13.4 (pages 712 to 716), 13.5 (pages 723 to 726)] **Marks-15**

Textbook:

[1] Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

Reference Books:

1. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). Basic Multivariable Calculus. Springer (SIE). First Indian Reprint.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. M. J. Strauss, G. L. Bradley, and K. J. Smith, Calculus (3 Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007. 4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

MINOR
(Choose any one)
MIN-MTH-4.1: Analytical Geometry
Total Marks: 100: (Theory 60, Internal assessment 40)

Course Objective:

The main objective of the course is to

- *Give an idea of two and three-dimensional coordinate systems,*
- *Equations of straight lines, conics,*
- *Equations of a plane, the shortest distance between two planes,*
- *Equations of sphere, cylinder, etc.*

Course Outcome

After going through the course students will learn

CO-1 *The idea of two and three-dimensional coordinate systems,*
CO-2 *The equations of a straight line,*
CO-3 *Equations of a parabola, ellipse, hyperbola,*
CO-4 *Tangent and normal, equations of a plane, the distance between two planes,*
CO-5 *Idea of surfaces like elliptical surfaces, conical surfaces, sections of surfaces by a plane, etc.*
CO-6 *Applications to them in practical problems.*

Unit 1: Transformation of coordinates, pair of straight lines. Parabola, parametric coordinates, tangent and normal, ellipse and its conjugate diameters with properties, hyperbola, and its asymptotes, general conics: tangent, condition of tangency, pole and polar, center of a conic, equation of pair of tangents, reduction to standard forms, central conics, equation of the axes, and length of the axes, polar equation of a conic, tangent and normal and properties. [1] Chapters 3, 4,

10. **Marks-30**

Unit 2: Plane, straight lines, and shortest distance. Sphere, cone and cylinder, central conoids, ellipsoid, hyperboloid of one and two sheets, diametral planes, tangent lines, director sphere, polar plane, section with a given center. [2] Chapters 4,5,6,7 (up to page 125). **Marks-30**

Text Books:

1. R. M. Khan, Analytical Geometry of two and three dimensions and vector analysis. New Central Book Agency 2012.
2. R. J. T. Bell, Coordinate Solid Geometry, Macmillan, 1983.

Reference Book:

1. E. H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press (27 February 2012).

MIN-MTH-4.2: Probability and Statistics

Total Marks: 100 (Theory: 60, Internal Assessment: 40)

Course Objective:

The main objective of learning the subject is to

- *Give the basic idea of Statistics,*
- *Idea about random variables, sample space, probability, etc.*
- *Idea about discrete and continuous variables, distribution of variables, etc.*
- *Idea about correlations, joint distributions, conditional distribution, etc.*

Course Outcome:

After going through the course students will be able to

CO-1 *Have an idea about random variables, events, sample space, continuous and discrete variables, etc.*

CO-2 *They will get an idea about probability, probability mass function, density function, etc.*

CO-3 *They will get an idea about Distribution functions such as Bernoulli distribution, Normal distribution, etc.*

CO-4 *They will get an idea about joint distribution functions, joint probability functions, conditional distribution functions, etc.*

Unit-1: Sample space, Probability set function, Real random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function. [1] Chapter 1 (Sections 1.1, 1.3, 1.5, and 1.6 to 1.9)**.** **Marks-15**

Unit-2: Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric, and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal;

Normal approximation to the binomial distribution. [2] Chapter 5 (Sections 5.2 to 5.4, Sections 5.5, and 5.7) [2] Chapter 6 (Sections 6.2 to 6.4, Sections 6.5, and 6.6)**.** **Marks-15**

Unit-3: Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of a function of two random variables, Joint moment generating function, Conditional distributions, and expectations. [1] Chapter 2 (Sections 2.1, and 2.3). **Marks-15**

Unit-4: The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem, and weak law of large numbers. [1] Chapter 2 (Section 2.4, and Section 2.5) [2] Chapter 14 (Sections 14.1 to 14.3) [2] Chapter 6 (Section 6.7), and Chapter 4 (Section 4.4) [3] Chapter 2 (Section 2.8, and Exercise 76, page 89). **Marks-15**

Text Books:

1. Hogg, Robert V., McKean, Joseph W., & Craig, Allen T. (2013). Introduction to Mathematical Statistics (7th ed.). Pearson Education, Inc.

2. Miller, Irwin & Miller, Marylees. (2014). John E. Freund's Mathematical Statistics with Applications (8th ed.). Pearson. Dorling Kindersley (India). 34 3. Ross, Sheldon M. (2014). Introduction to Probability Models (11th ed.). Elsevier Inc.

Reference Books:

1. Mood, A. M., Graybill, F. A. & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). McGraw-Hill Education Pvt. Ltd. Indian Edition (2017)

SYLLABUS FOR SEMESTER - V and VI (NEP)
COURSE DETAILS

CLASS	CURSE	SUBJECT PAPERS	PAPER CREDITS
SEMESTER-V	CORE	MAJ-MTH-5.1: Numerical methods (including practical) MAJ-MTH-5.2: Partial Differential equations (including practical) MAJ-MTH-5.3: Statics and Dynamics MAJ-MTH-5.4 Riemann integral and metric space	4x4=16
	MINOR-V	(Choose any one) MIN-MTH-5.1: Number theory & Vedic mathematics (compulsory for single minor students) MIN-MTH-5.2: Linear Programming	4
	SEC	x	x
	GE	x	x
	AECC	x	x
	VAD	x	x
	VOC/Minor project	x	x
			Total credit:20

CLASS	COURSE	SUBJECT PAPERS	CREDITS
SEMESTER-VI	CORE	MAJ-MTH-6.1: Complex Analysis (including practical) MAJ-MTH-6.2: Number theory and Vedic mathematics MAJ-MTH-6.3: Linear Algebra MAJ-MTH-6.4: Hydro mechanics	4x4=16
	MINOR-VI	(Choose any one) MIN-MTH-6.1: Programming in C MIN-MTH-6.2: Discrete mathematics	4
	SEC	x	x
	GE	x	x
	AECC	x	x
	VAD	x	x
	VOC		
			Total :20

SEMESTER-V

MAJ-MTH-5.1: Numerical Methods (including practical)
Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical: 25)
Per week: 3 Lectures, 2 Practical, Credits 4 (3+1) each unit carries equal marks.

Course objective: The main objective of the course is to

- Give the idea of various computational techniques to find approximate values for possible roots of algebraic and non-algebraic equations
- To give the idea of finding approximate solutions to a system of linear equations and quadratic equations.

Course outcome: After going through the course, students will be able to

CO-1 Learn the technique of finding the roots of nonlinear functions of a single variable and the solution of a system of linear equations by different methods.

CO-2 Learn the technique of iterative process and non-iterative process to solve a system of linear equations

CO-3 Learn the interpolation technique to compute the value for the tabulated function at points not in the table

CO-4 Learn the technique of finding the appropriate value of an integral numerically

CO-5 Solving some differential equations that can't be solved analytically

UNIT 1: Algorithms, Convergence, Bisection method, False position method, fixed point iteration method, Newton's method, Secant method, LU decomposition, Gauss-Jacobi, Gauss-Siedel, and SOR iterative methods. [1] Chapter 1 (Sections 1.1-1.2), Chapter 2 (Sections 2.1-2.5), and Chapter 3 (Sections 3.5, 3.8). **Marks-15**

UNIT 2: Lagrange and Newton interpolation: linear and higher order, finite difference operators. [1] Chapter 5 (Sections 5.1, 5.3) [2] Chapter 4 (Section 4.3). **Marks-15**

UNIT 3: Numerical differentiation: forward difference, backward difference and central difference. Integration: trapezoidal rule, Simpson's rule, Euler's method. [1]: Chapter 6 (Sections 6.2, 6.4), Chapter 7 (Section 7.2) **Marks-15**

Note: Emphasis is to be laid on the algorithms of the above numerical methods.

Practical / Lab work to be performed on a computer: Use of computer aided software (CAS), for example Matlab / Mathematica / Maple / Maxima etc., for developing the following Numerical programs: (i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N. (ii) To find the absolute value of an integer. (iii) Enter 100 integers into an array and sort them in an ascending order. (iv) Any two of the following (a) Bisection Method (b) Newton Raphson Method (c) Secant Method (d) Regulai Falsi Method (v) LU decomposition Method (vi) Gauss-Jacobi Method (vii) SOR Method or

Gauss-Siedel Method (viii) Lagrange Interpolation or Newton Interpolation (ix) Simpson's rule. Note: For any of the CAS Matlab / Mathematica / Maple / Maxima etc., Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators 19 and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Internal Assessment: 30 marks It will be done through sessional examination, class test, assignment, quize, mini project etc.

Text Books: 1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007. 2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition, 2007.

Reference Book: 1. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008

MAJ-MTH-5.2: Partial Differential Equations (Including practical)

Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical: 25)
per week: 3 Lectures, 2 Practical, Credits: 4 (3+1)

Learning Objectives: The main objective of the course is to

- give idea of partial differential equations their classifications
- forming a partial differential equations,
- solving partial differential equations
- to understand the various physical concepts of partial differential equations**.**

Course outcomes: After going through the course students will be able to

CO-1 learn to form partial differential equations,
CO-2 distinguish various types of partial differential equations, linear, nonlinear, quasilinear pde,
CO-3 various methods of solving partial differential equations,
CO-4 to classify and solve the higher order pde,
CO-5 Learn about Cauchy problem, heat equation, wave equation etc.

Unit I (contact hour: 15) Introduction, Classification, Construction of first order partial differential equations (PDE). Cauchy's problem for first order equations, linear equations of the first order, Integral surfaces passing through a given curve, nonlinear partial differential equations of the first order, Cauchy's method of characteristics, Compatible system of first order equations, Charpit's method. Solutions satisfying given conditions, Jacobi's method. [1] Chapter 2 (Sections 2.1 to 2.3) [2] Chapter 2 (Section 3, 4, 5, 7, 8, 10, 12, 13). **Marks-20**

Unit II: (contact hour: 10) Canonical form of first order PDE, Method of separation of variables for first order PDE. [1] Chapter 2 (Sections 2.6 and 2.7) **Marks-10**

Unit III: (contact hour: 10) The vibrating string, Vibrating membrane, Gravitational potential, Conservation laws. [1] Chapter 3 (Sections 3.1 to 3.3, 3.5, and 3.6) **Marks-15**

Unit IV: (contact hour:10) Reduction to canonical forms, Equations with constant coefficients, General solution. [1] Chapter 4 (Sections 4.1 to 4.5) [2] Chapter 3 (Sections 4, 5) **Marks-15**

Practical /Lab work to be performed in a Computer Lab: ***Modeling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/ Scilab etc. (contact hours: 20)***

1) Solution of Cauchy problem for first order PDE.
2) Plotting the characteristics for the first order PDE.
3) Plot the integral surfaces of a given first order PDE with initial data.
4) Solution of wave equation 2 2 2 2 2 x u c t u ∂ ∂ = ∂ ∂ for any two of the following associated conditions: (a) u(x,0) = φ(x); u(x,0) =ψ (x), x ∈ R;t > 0 (b) u(x,0) = (x); u (x,0) = (x); u(0,t) = 0, x > 0;t > 0 φ t ψ (c) u(x,0) = (x); u (x,0) = (x); u (0,t) = 0, x > 0;t > 0 φ t ψ x (d) u(x,0) = (x); u (x,0) = (x); u(0,t) = 0,u(l,t) = 0; x > 0;t > 0 φ t ψ
5) Solving systems of ordinary differential equations.
6) Solution of one-Dimensional heat equation !! = ! !!! , for a homogeneous rod of length !. That is - solve the IBVP: 26 !! = ! !!!, 0 < ! < !, ! > 0 ! 0,! = 0, ! !,! = 0, ! ≥ 0 ! 0,! = ! ! , 0 ≤ ! ≤ !

Text Book:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Springer, Indian reprint, 2006.
2. Sneddon, I. N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

Reference Book:

Stavroulakis, Ioannis P., & Tersian, Stepan A. (2004). Partial Differential Equations: An Introduction with Mathematica and MAPLE (2nd ed.). World Scientific

Internal assessment: 30 marks

Assessed through sessional examination, class test, assignments, Quiz, viva, etc.

MAJ-MTH-5.3: Statics and Dynamics

Total Marks: 100: (Theory: 60, internal assessment: 40)

Per week: 3 Lectures, 1 Tutorial, Total Credits: 4(3+1)

Learning Objectives: The main objective of the course is to

- understand the various concepts of physical quantities like force, moment and their related motions,
- motions of bodies, velocities,
- motion of objects in various mediums
- Their applications in our daily physical activities.

Course outcomes: After going through the course students will be able to learn

CO-1 the concepts of force, moments, couples, their equilibrium conditions,

CO-2 understand theory behind friction and centre of gravity,

CO-3 Idea of principle of conservation of energy, linear momentum, works energy equation.

CO-4 Learn the translational and rotational motion of rigid bodies etc.

UNIT 1: (contact hour: 30) Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution, Catenary. [1] Chapter 1-9 related sections only **Marks-30**

UNIT 2: (contact hour:30) Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces Potential energy, Impulsive forces, Motion in resisting medium. [1] Vol-II Chapter I Sections 1.1, 1.2,1.3, Chapter –2 Sections 2.1,2.2, Chapter 3 Sections 3.1.3.2, Chapter 4 Sections 4.1, Chapter 5 Sections 5.1,5.3, Chapter 6 Sections 6.1,6.3. [2] Chapter 3 (Sections: 3.1, 3.2, 3.3,3.4). **Marks-30**

Internal Assessment: **40 marks**

Assessed through sessional examination, class test, assignments, Quiz, viva, etc.

1. **Text Book**: S. L. Loney, The Elements of Statics and Dynamics (Vol I & II) Publisher Arihant, 4th Edition 2014.
2. F. Chorlton, Textbook of Dynamics, CBS, Publications 2nd Edition, 1985

Reference books:

1. A.S. Ramsay, Statics, Cambridge University Press, publication year:2009
2. A.S. Ramsay, Dynamics, Cambridge University Press, publication year: 2009
3. M. R. Spiegel, Theoretical Mechanics, Schaum Series 2010.

MAJ-MTH-5.4: Riemann Integration and Metric Spaces

Total Marks: 100: (External 60, internal assessments 40)

Per week: 3 Lectures 1 Tutorial, Credits 4,

Course objective: The main objective of the course is to –

- To develop the idea of analysis, the integrability of a function defined by Riemann, and various properties related to it.
- Idea of improper integrals and properties
- To develop the usual idea of distance into an abstract form on any set of objects, studying its inherent characteristics and the resulting consequences.

Course outcome: After going through the course students will learn to

CO-1 The idea of abstract thinking , analyzing a concept

CO-2 Have an idea about integrability of a function, their related properties.

CO-3 Learn about improper integrals, their related properties.

CO-4 They will learn to analyze how a theory advances from a particular frame to a general frame.

CO-5 Learn some important properties of metric spaces like connectedness, compactness, etc

UNIT 1: Riemann integration: upper and lower sums; Darboux integrability, properties of integral, Fundamental theorem of calculus, mean value theorems for integrals, Riemann sum and Riemann integrability, Riemann integrability of monotone and continuous functions on intervals, sum of infinite series as Riemann integrals, logarithm and exponential functions through Riemann integrals, improper integrals, Gamma functions. [1] Chapter 6 **Marks-20**

UNIT 2: Metric spaces: definition and examples, sequences in metric spaces, Cauchy sequences, complete metric spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces. [2] Chapter 1 Sections 1.1-4, Chapter 2 Sections 2.1, 2.2 **Marks-20**

UNIT 3: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach contraction mapping principle. Connectedness, connected subsets of R, connectedness and continuous mappings. [2] Chapter 3, Sections 3.1, 3.4, 3.5, 3.7 (up to 3.7.7), Chapter 4, Sections 4.1.

Marks-20

Internal Assessment: **40 marks**

It will be assessed through sessional examination, class test, assignment, Quiz, viva, etc.

Text Books:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, Indian Edn. 2014.
2. Satish Shirali & Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint 2009)

Reference Books:

1. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
3. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004

MINOR-V (Choose any one)
MIN-MTH-5.1: Number Theory & Vedic mathematics
(Compulsory for single minor student)

Total Marks: 100 (Theory: 60, internal assessment: 40)

Per week: 3 lectures, 1 Tutorial. Credits 4, each unit carry equal marks

Course objectives: The main objective of the course is to

- give the idea of various number system, focusing on integers, various properties and representation of integers,
- To understand the number theoretic analysis.
- To give some basic ideas of Vedic mathematics

Course outcomes: After completion of the course students will be able to

CO-1 Distinguish integers from other number systems,

CO-2 learns various properties of integers,

CO-3 concepts of congruence, linear congruence,

CO-4 explores the Chinese Remainder Theorem to solve simultaneous linear congruence,

CO-5 Idea of Fermat's and Wilson's theorem,

CO-6 Applying mathematical ideas and concepts within the context of number theory.

CO-7 Able to learn Vedic mathematics and its importance

Unit 1. Well-ordering principle of integers, Archimedean property, first and second principles of finite induction, division algorithm of integers, GCD, Euclidean algorithm, Linear Diophantine equation, prime counting function, statement of the prime number theorem, Goldbach conjecture, linear congruence, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem. [1], chapter 1, chapter 2 (Section 2.5), [2] Chapter 2 (Sections 2.2, 2.3) [1] Chapter 4 (Sections 4.2, 4.4), Chapter 5: Section 5.2 **Marks-25**

Unit 2. Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of Dirichlet Product, The mobius Inversion formula, the greatest integer function, Euler's phi function, Euler's Theorem, and some properties of Euler's phi function. **Marks-20**

Unit 3. Origin of Vedic mathematics, Vedic sutras and sub sutras, addition, subtraction, multiplication by Vedic methods, finding squares and square root of rational numbers, Duplex methods for finding square roots. **Marks-15**

Internal assessment: 40 marks

Accessed through sessional examination, class test, assignments, Quiz etc.

Text Books:

1. David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw Hill, Indian reprint, 2007.
2. G. A. Jones and J. Mary Jones, Elementary Number Theory. Undergraduate Mathematics Series (SUMS). First Indian Print. 2005
3. The essentials of VEDIC MATHEMATICS; by Rajesh Kumar Thakur
4. Vedic mathematics for all, by Dr S K Kapoor.

Reference Books:

Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007. 2. K. C. Chowdhury, A First Course in Number Theory, Asian Books Publications 2012

MIN-MTH-5.2: Linear Programming

Total Marks: 100 (Theory: 60, Internal Assessments: 40)

Per week: 3 Lectures, 1 Tutorial Credits: 4, each unit carries equal credit

Course objective: The main aim of the topic is to give an idea about

- Various optimization techniques pertaining to linear programming.
- Apply linear programming techniques to problems in our real-life situations.

Course outcome: After going through the course, students will be able to -

CO-1 Have ideas about various optimization techniques related to linear programming.

CO-2 Have ideas about the simplex method, Big –M method, Assignment problem, Game theory, etc.

CO-3 Use the technique of optimization in real-life situations.

Unit 1: The Linear Programming Problem: Standard, Canonical and matrix forms, Graphical solution. Hyperplanes, Extreme points, Convex and polyhedral sets. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points. [1] Chapter 1 (Section 1.1, 1.4, and 1.6) [2] Chapter 2 (Sections 2.16, 2.19, and 2.20), and Chapter 3 (Sections 3, 2, 3.4, and 3.10) **Marks-15**

Unit 2: Simplex Method: Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method. [1] Chapter 3 (Sections 3.3, and 3.6, 3.7, and 3.8) **Marks-15**

Unit 3: Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complementary Slackness. [1] Chapter 4 (Sections 4.1 to 4.3) [1] Chapter 6 (Section 6.1, and 6.2, up to Example 6.4) **Marks-15**

Unit 4: Applications, Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving the Transportation Problem. Assignment Problem: Mathematical formulation and Hungarian method of solving. Game Theory: Basic concept, formulation, and solution of two-person zero-sum games, Games with mixed strategies, Linear Programming method of solving a game. [3] Chapter 5 (Sections 5.1, 5.3, and 5.4) [2] Chapter 11 (Sections 11.12 and 11.13) **Marks-15**

Internal Assessment: **40 marks**
It will be assessed through sessional examinations, class tests, assignments, etc

Text Books:

1. Bazaraa, Mokhtar S., Jarvis, John J. and Sherali, Hanif D. (2010). Linear Programming and Network Flows (4th ed.). John Wiley and Sons.
2. Hadley, G. (1997). Linear Programming. Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.

Reference Books:

1. Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to Operations Research (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
2. Thie, Paul R., & Keough, G. E. (2014). An Introduction to Linear Programming and Game Theory. (3rd ed.). Wiley India Pvt. Ltd.

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SEM-VI

MAJ-MTH-6.1: Complex Analysis (including practical)

Total marks: 100: (Theory: 45, Internal Assessment: 30, Practical: 25)
per week: 3 Lectures, Practical 2, Credits 4(3+1) each unit carries equal marks

Course objective*:* The main objective of the course is to

- Give the idea of complex numbers, the complex plane, and complex functions.
- To develop a deep understanding of the topic with related concepts

Course Outcome: After going through the course, students will be able to learn

CO-1 About complex functions and their properties, the Cauchy-Riemann equations, conditions of continuity and differentiability of complex functions.

CO-2 Understanding of the Cauchy integral formula.

CO-3 Learn some elementary functions and to evaluate contour integrals.

Internal assessment: **Marks-30**

It will be assessed through sessional examination, assignment, class test etc.

UNIT 1: Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Limits, Limits involving the point at infinity, continuity. [1]: Chapter 1 (Section 11), Chapter 2 (Section 12, 13) Chapter 2 (Sections 15, 16, 17, 18, 19, 20, 21, 22) **Marks-10**

UNIT 2: Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. [1]: Chapter 2 (Sections 24, 25), Chapter 3 (Sections 29, 30, 34), Chapter 4 (Section 37, 38) **Marks-10**

UNIT 3: Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. [1]: Chapter 4 (Section 39, 40, 41, 43) **Marks-10**

UNIT 4: Antiderivatives, proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula. An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra. [1]: Chapter 4 (Sections 44, 45, 46, 50), Chapter 4 (Sections 51, 52, 53) Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series, uniqueness of series representations of power series. [1]: Chapter 5 (Sections 55, 56, 57, 58, 59, 60, 62, 63, 66) **Marks-15**

LAB WORK TO BE PERFORMED ON A COMPUTER (MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/ MATHEMATICA/ MAPLE ETC.)

1. Declaring a complex number and graphical representation. e.g. Z1 =3 + 4i, Z2 = 4 – 7i
2. Program to discuss the algebra of complex numbers, e.g., Z1 =3 + 4i, Z2 = 4 – 7i, then find Z1 + Z2, Z1 - Z2, Z1 * Z2 and Z1 / Z2
3. To find conjugate, modulus and phase angle of an array of complex numbers. e.g. Z = [2+ 3i, 4-2i, 6+11i, 2-5i]
4. To compute the integral over a straight line path between the two specified end points. e. g., Sin! !" , along the contour C which is a straight line path from -1+ i to 2 - i.
5. To perform contour integration., e.g., (i) (!! − 2! + 1)!" along the Contour C given by x = y2 +1; − 2 ≤ y ≤ 2 . (ii) (!! + 2!! + 1)!" along the contour C given by !! + !! = 1 , which can be 24 (iii) parameterized by x = cos (t), y = sin (t) for 0 ≤ y ≤ 2π.
6. To plot the complex functions and analyze the graph. e.g., (i) f(z) = z, iz, z2 , z 3 , ez and (z4 -1)1/4, etc. 7. To perform the Taylor series expansion of a given function f(z) around a given point z. The number of terms that should be used in the Taylor series expansion is given for each function. Hence plot the magnitude of the function and magnitude of its Taylors series expansion, e.g., (i) f(z) = exp(z) around z = 0, n =40 and (i) f(z) = exp(z2) around z = 0, n = 160.
7. To determines how many terms should be used in the Taylor series expansion of a given function f(z) around z = 0 for a specific value of z to get a percentage error of less than

5%. e.g., for f(z) = exp(z) around z =0, execute and determine the number of necessary terms to get a percentage error of less than 5 % for the following values of z: (i) z = 30 + 30i (ii) z = 10 +103 i

8. To perform Laurents series expansion of a given function f (z) around a given point z. e.g., (i) f(z)= (sin z -1)/z4 around z = 0 (ii) f(z) = cot (z)/z4 around z = 0.

Text Book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.

Reference Book:

1. Joseph Bak and Donald J. Newman, Complex analysis (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997

MAJ-MTH-6.2: Number Theory& Vedic mathematics

Total Marks: 100 (Theory: 60, Internal: 40)
Per week: 3 Lectures, Practical 2, Credits 4(3+1)

Course objective:

- To give the idea of various number systems, focusing on integers, various properties and representation of integers,
- To understand the number theoretic analysis.
- To give some basic ideas of Vedic mathematics

Course outcomes: After completion of the course students will be able to

CO-1 Distinguish integers from other number systems,
CO-2 learns various properties of integers,
CO-3 concepts of congruence, linear congruence,
CO-4 explores the Chinese Remainder Theorem to solve simultaneous linear congruence,
CO-5 Idea of Fermat's and Wilson's theorem,
CO-6 Applying mathematical ideas and concepts within the context of number theory.
CO-7 Able to learn Vedic mathematics and their importance

Unit 1. Division algorithm of integers, GCD, Euclidean algorithm, Linear Diophantine equation, statement of prime number theorem, linear congruence, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem. Number theoretic functions, sum and number of divisors, totally multiplicative functions, the greatest integer function, Euler's phi function, and some properties of Euler's phi function. **Marks-15**

Unit 2. Primitive roots: order of an integer modulo m, primitive roots for primes, composite numbers having primitive roots, theory of indices. **Marks-10**

Unit 3. Quadratic residues: Euler's criterion, Legendre's symbol and its properties, Quadratic Reciprocity Law, Fibonacci numbers and their related identities. **Marks-15**

Unit 4. Origin of Vedic mathematics, Vedic sutras and sub sutras, addition, subtraction, multiplication by Vedic methods, finding squares and square root of rational numbers, Duplex methods for finding square roots. **Marks-20**

Internal assessment: 40 marks

Accessed through sessional examination, class test, assignments, Quiz etc.

Text Books:

5. David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw Hill, Indian reprint, 2007.
6. G. A. Jones and J. Mary Jones, Elementary Number Theory. Undergraduate Mathematics Series (SUMS). First Indian Print. 2005
7. The essentials of VEDIC MATHEMATICS; by Rajesh Kumar Thakur
8. Vedic mathematics for all, by Dr S K Kapoor.

Reference Books:

Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007. 2. K. C. Chowdhury, A First Course in Number Theory, Asian Books Publications 2012

MAJ-MTH-6.3: Linear Algebra

Total Marks: 100: (External 60, Internal Assessment: 40)

Per week: 3 Lectures, 1 Tutorial. Credits: 4

Course Objective: The main objective of learning the topic is to

- Introduce students to the fundamental theory of linear spaces
- To emphasize the application of techniques using the adjoint of a linear operator and minimal solutions to a system of linear equations.

Course Outcome: After going through the course, students will be able to –

CO-1 learn about linear space and its general properties, linear dependence and independence of vectors, bases, dimension of vector space, etc.

CO-2 learn the basic concepts of linear transformations, matrix representation, change of coordinate matrix, etc.

CO-3 Compute characteristic polynomials, eigenvalues, and eigenvectors, properties related.

CO-4 Have an idea of inner product, orthogonality on vector spaces, orthogonal and orthonormal basis, etc.

Unit 1: Vector spaces and subspaces, null space and column space of a matrix, linear transformations, kernel and range, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, and change of basis. [1]: Chapter 4 (Sections 4.1 – 4.7),

Marks-20

Unit 2: Eigenvectors and eigenvalues of a matrix, the characteristic equation, diagonalization, eigenvectors of a linear transformation, complex eigenvalues, [1]: Chapter 4 (Sections 5.1 – 5.5) Invariant subspaces and Cayley-Hamilton theorem. [2]: Chapter 5 (Section 5.4)

Marks-20

Unit 3: Inner product, length, and orthogonality, orthogonal sets, orthogonal projections, the Gram– Schmidt process, inner product spaces; Diagonalization of symmetric matrices, the Spectral Theorem. [1]: Chapter 6 (Sections 6.1 – 6.4, 6.7); Chapter 7 (Section 7.1).

Marks-20

Internal Assessment: **40 marks**

It will be assessed through sessional examination, class test, assignment, mini project, Quiz, viva etc.

Text Books:

1) David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.
2) Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4^{th} Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

Reference Books:

1) S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
2) Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
3) Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4) G. Schay, Introduction to Linear Algebra, Narosa, 1997.

MAJ-MTH-6.4: Hydromechanics

Total Marks: 100: (Theory 60, internal assessment: 40)

per week: 3, Lectures, 1 Tutorial, Credits 4, Each unit carries equal credit

Course objective: The main aim of the objective of the topic is to -

- Give an idea about the mechanics behind the fluid and properties related to whether they are in static or in motion.

Course outcomes: After going through the topic, the students will be able to –

CO-1 Learn the basic ideas behind hydro-mechanics and related principles.

CO-2 Use the idea of hydrostatics and hydromechanics in the practical field**.**

Unit 1: Hydrostatics Pressure equation, condition of equilibrium, lines of force, homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure, fluid at rest under action of gravity, rotating fluids. Fluid pressure on plane surfaces, centre of pressure, resultant pressure on curved surfaces. Gas law, mixture of gases, internal energy, adiabatic expansion. [1] Voll-I Chapter 1-4(related sections only). **Marks-40**

Unit 2: Hydrodynamics Real and ideal fluid, velocity of a fluid at a point, Eulerian and Lagrangian method, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, material local, convective derivatives, local and particle rate of change, equation of continuity in Cartesian and polar form, , acceleration of a fluid particle in Cartesian and polar form ,boundary surface and examples. [1] Vol-II Chapter 1 **Marks-20**

Internal Assessment: **40 marks**
It will be assessed through sessional examination, class test, assignment, Quiz, mini project, viva etc.

Text Book:

1) Besant, W. H., Ramsey, A. S., A Treatise on Hydromechanics. (Part I & part II), G.Bell And Sons Limited. CBS Publication 1988(Indian print).

Reference Books:

1) H. Lamb, Hydrodynamics, University Press
2) F. Chorlton, Fluid dynamics, CBS Publisher First Edition 1985

MINOR–VI (Choose any one)

MIN-MTH-6.1: Programming in C (including practical)

Total Marks: 100 (Theory 45, Internal Assessment 30, Practical 25)
per week: 3 Lectures 2 Practical, Credits: 4(3+1)

Course objective: The main objective of learning the course is to –

- Introduce the students with basic ideas of computer language, high level programming language like C, C^+ etc. And for programming with this language.

Learning outcome: After going through the topic students-

CO-1 Will have an idea about computer programming language like C,C^+ etc.

CO-2 They will be able to apply these ideas in various practical problems through computer.

Unit 1: **(10 classes**) Variables, constants, reserved words, variable declaration, initialization, basic data types, operators and expression (arithmetic, relational, logical, assignment, conditional, increment and decrement), hierarchy of operations for arithmetic operators, size of and comma operator, mixed mode operation and automatic (implicit) conversion, cast (explicit)

conversion, library functions, structure of a C program, input/output functions and statements.

Marks:20

Unit 2: (10 classes) Control Statements: if-else statement (including nested if-else statement), switch statement. Loop control Structures (for and nested for, while and do-while). Break, continue, go to statements, and exit function. **Marks-15**

Unit 3: **(10 classes**) Arrays and subscripted variables: One- and Two-dimensional array declaration, accessing values in an array, initializing values in an array, sorting of numbers in an array, addition and multiplication of matrices with the help of array. Functions: function declaration, actual and formal arguments, function prototype, calling a function by value, recursive function. **Marks-10**

Programmes for practical: (20 class) To find roots of a quadratic equation, value of a piecewise defined function (single variable), factorial of a given positive integer, Fibonacci numbers, square root of a number, cube root of a number, sum of different algebraic and trigonometric series, a given number to be prime or not, sum of the digits of any given positive integer, solution of an equation using N-R algorithm, reversing digits of an integer. Sorting of numbers in an array, to find addition, subtraction and multiplication of matrices. To find sin(x), cos(x) with the help of functions. [1] Chapters"3,"4,"5,"6,"7"and"9 **Marks-10**

Internal assessment: 30 marks

It will be assessed through sessional examination, class test, assignment, Quiz, viva etc.

Text Book:

1) T. Jeyapoovan, A First Course in Programming with C T. Jeyapoovan, Vikash Publishing House Pvt.Ltd.

Reference books:

1) E. Balaguruswamy, Programming with C, Schaum Series.
2) Y. Kanetkar, Let us C, B.P. Publication.

MIN-MTH- 6.2 Discrete Mathematics

Total Marks: 100, Theory: 60, Internal Assessment: 40, Credit: 4;
per week: 3 Lectures,1 Tutorial, Total Credits: 4(3+1)

Course Objective: The main objective of learning the topic is to –

- Give idea of sets; perform operations and algebra on sets.
- To give logical idea of thinking through reasoning, analyzing etc.

Course outcome: After going through the course students will be able-

CO-1 To have idea of sets and set operations, algebra on sets.

CO-2 They will have idea how to think logically through reasoning, analyzing.

CO-3 Learn the field of application of discrete mathematics in practical field in modern digital technology.

Unit-1: (Contact hrs: 15) Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, and lattices as ordered sets, lattices as algebraic structures, sub lattices, products and homomorphisms. **Marks: 20**

Unit-2: (Contact hrs: 15) Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits. **Marks: 20**

Unit-3: (Contact hrs: 15) Definitions, examples and basic properties of graph, pseudographs, complete graphs, bipartite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Marks: 20

Internal Assessment: Marks: 20

It will be assessed through sessional examination, class test, assignment, Quiz, viva etc.

Text Books:

1) B. A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2) Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory (2nd Edition), Pearson Education (Singapore), Pte. Ltd., Indian Reprint 2003.
3) Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint, 2004.

DEPARTMENT OF MATHEMATICS
RABINDRANATH THAKUR VISHWAVIDYALAYA, HOJAI
SYLLABUS FOR FYUGP 4th YEAR (7th and 8th Semester)
As per NEP2020

VII & VIII Semester

Semester	Course	Papers	Credits
VII	MAJOR	MAT-MAJ-7.1:Real analysis and Lebesgue measure MAT-MAJ-7.2: Research Methodology MAT-MAJ-7.3: Classical Mechanics MAT-MAJ-7.4: Mathematical Methods	4x4=16
	MINOR-VII **(Choose one)**	MAT-MIN-7.1:Differential equations MAT-MIN-7.2:Mechanics	4
			Total:20
VIII	MAJOR	MAT-MAJ-8.1: Advanced Complex Analysis *MAT-MAJ-8.2: Topology *****MAT-MAJ-8.3: Mathematical Modeling *****MAT-MAJ-8.4: Advanced Differential equations	4x4=16
	MINOR-VIII **(Choose one)**	MAT-MIN-8.1:Numerical Analysis MAT-MIN-8.2: Linear Algebra	4
	Dissertation	In lieu of MAT-MAJ- 8.2, 8.3 & 8.4, For Honours students with research	4+4+4=12
			Total:20

MAT-MAJ-7.1: Real Analysis and Lebesgue Measure

Total Marks: 100 (Theory: 60, Internal: 40)

Course objective:

- *The main objective of the course is -to give a brief idea about real functions, sequence of real functions, their convergence and divergence criteria*
- *Introduce with Lebesgue measure, measurable functions, lebesgue integral, etc.*

Course outcome: *After completing this course, the student will understand*

CO-1 *How Lebesgue measure on R is defined, how measures may be used to construct. integrals,*

CO-2 *The basic convergence theorems for the Lebesgue integral, the relation between Series and the Hilbert space of square-integrable functions.*

CO-3 *Have familiarity with common examples and counterexamples, knowledge of the content of the major theorems, understanding of the ideas in their proofs, and ability to make direct application of those results to related problems.*

CO-4 *Get the knowledge in sequences of functions and their uniform convergence and get the idea about how to find out the region of convergence of power series.*

CO-5 *Develop the core skills of the subject and research skills in these areas.*

Unit 1: Uniform convergence of a sequence of functions at an interval, Cauchy's criterion, Test for uniform convergence, properties of uniformly convergent sequences and series of functions, results related to uniform convergence with continuity, integration, and differentiation, Weirstrass's approximation theorem, Power series, radius of convergence, Abel's and Tauber's theorem, Fundamental properties. **Marks-15**

Unit 2: Vector-valued function, continuity, differentiation, Functions of bounded variation, their continuity, and monotonicity, Definition, existence of R-S integral, Properties of R-S integral, integration and differentiation, Fundamental theorem of calculus, Integration of vector-valued functions. **Marks-15**

Unit 3: Lebesgue outer measure, Measurable sets, and properties, Borel sets and their measurability, Characterization of measurable sets, Non-measurable sets, Measurable functions and their properties, Operations of measurable functions, Sets of measure zero, Sequence of measurable functions, Convergence in measure. **Marks-15**

Unit 4: Lebesgue integral, Lebesgue integral of a bounded function, Comparison of Riemann integral and Lebesgue integral, Integral of a non-negative measurable function, General Lebesgue integral, Convergence of Lebesgue integral, Bounded convergence theorem, Monotone convergence theorem, Lebesgue convergence theorem. **Marks-15**

Internal Assessment: 40 marks: through sessional exam, class test, assignment, quiz, viva etc.

Text Books:

1. S.C. Malik and SavitaArora, Mathematical Analysis, New Age International Private Limited, 2017

2. H.L. Royden, Real Analysis, Prentice Hall of India, 2011

3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, Anshan Ltd., 2012

Reference Books:

1. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill Education, 1976
2. R.R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing, 2012.

MAT-MAJ-7.2: Research Methodology
Total Marks: 100 (Theory: 60, Internal: 40)

Course objectives:
The aim of the course is to give a brief idea about research objectives, observations, formulas used, and its findings, analyzing and testing of results and prepare report.

Course Outcome: *After completion of this course, the students will be able to:*

CO-1 *The different steps involving in research;*
CO-2 *Identify and formulate research problems;*
CO-3 *Write a good research proposal;*
CO-4 *Collect, analyse and interpret data;*
CO-5 *Apply appropriate tools, techniques and methods;*
CO-6 *Write a research report.*

Unit 1: Introduction to Research Methodology **12 Marks**

Motivation and objective of research, Types of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical, Research methods vs. Methodology, Research process, Criteria of good research.

Unit 2: Formulating the Research Problem **12 Marks**

Defining and formulating a research problem, Selection of the problem, Necessity of defining the problem, Literature review and its importance in defining a problem, Primary and secondary sources , Web as a source , Searching the web , Critical literature review, Identifying gap areas from literature review, Development of working hypothesis.

Unit 3: Research design **12 Marks**

Research design and method, Basic Principles of research design, Need of research design, Features of good design, Important concepts relating to research design, Developing a research plan - Exploration, Description, Diagnosis and Experimentation.

Unit 4: Data collection and analysis **12 Marks**

Collection of primary data, Observation and Interview method, Data collection through Questionnaires and schedule and their differences, Sampling designs, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, Hypothesis, Testing.

Unit 5: Report writing and Presentation **12 Marks**

Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report , Precautions for Writing

Research Reports, Oral and Poster Presentation, Use of visual aids, Importance of effective communication in presentation.

Internal Assessment: 40 marks: Through sessional exam, class test, assignment, Quize, Mini project etc.

Text Books:

1. C.R. Kothari, Research Methodology- Methods and Techniques, New Age International, 2nd Edition. New Delhi (2013).
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 3rd Edition, SAGE Publication (2010).

Reference Books:

1. Y.K.Singh and R.B.Bajpai, Research Methodology-Techniques and Trends, APH. Publishing, 2nd Edn., New Delhi (2007).
2. B.L. Garg, R. Karadia, F. Agarwal, and U.K. Agarwal, An introduction to Research Methodology, RBSA Publishers (2002).

MAT-MAJ-7.3: Classical Mechanics

Total Marks 100 (Theory: 60, Internal: 40)

Course objective: The main objective of the topic is to –

- *Idea of central force field.*
- *Idea of three dimensional motions.*
- *Idea of Lagrangian and Hamiltonian.*

Course outcome: *After going through the topic students will be able to –*

CO-1 *Have an idea about planetary motion and principles behind it.*

CO-2 *Have an idea of various coordinate systems in space.*

CO-3 *Have an idea about formulation of mechanics due to Lagrange and Hamilton.*

Unit 1: Central forces, Central orbit, Apses, Laws of Inverse Square, Kepler's laws of planetary motion [1]. **Marks-15**

Unit 2: Basic idea of motion in three dimensions, Velocity and acceleration in cylindrical and spherical polar coordinates. [1] **Marks-10**

Unit 3: Generalized coordinates, Degrees of freedom, holonomic system, Lagrange's equations for finite forces, conservative system, theory of small oscillation [2]. **Marks-10**

Unit 4: Motion of a rigid body about a fixed point, Euler's dynamical and geometrical equations, Eulerian angles, Deduction of Euler's equation from Lagrange's equation [2]. **Marks-15**

Unit 5: Hamilton's equation of motion, Variational methods, Hamilton's principle, Principle of least action, Deduction of Euler's equation from Hamilton's Equation [2]. **Marks-10**

Internal Assessment: **40 Marks**

It will be assessed through sessional examination, class test, assignment, quiz, viva etc.

Text Books:

1. S.L. Loney, An elementary treatise on the Dynamics of a particle and of Rigid bodies, Cambridge University Press Kindle Edition August 2018.
2. Murray R. Spiegel, Theory and Problems of Theoretical Mechanics, Schaum's Outline series.

Reference Books:

1. M.D. Raisinghania, Dynamics, S. Chand.
2. S. Ganguly, S. Saha, Analytical Dynamics of A particle, New Central Book Agency (P) Ltd.
3. B.D. Sharma, B.S. Tyagi, Brahma Nand, Dynamics of Rigid Bodies, Kedar Nath Ram Nath
4. M. Ray, A Text Book of Dynamics, S. Chand & Company Ltd.

MAT-MAJ-7.4: Mathematical Methods

Total Marks: 100 (Theory: 60, Sessional: 40)

Course objective:

- *To give some ideas about integral equations, their various types and their applications*
- *To give idea of integral transform and their applications*
- *To give idea about Laplace equation their applications*

Course outcome:

- *After going through the course students will be able to have some ideas about integral equations their applications in various problems.*
- *More over after going through the course students will have idea about integral transform of equations, Laplace equations their properties and applications in various mathematical problems.*

Unit 1: **Integral Equations**:

Fredholm Integral Equations: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Iterative scheme for Fredholm Integral equations of second kind Volterra Integral Equations: Volterra Integral Equations of

second kind, Resolvent kernal of Volterra equation and its results, Application of iterative scheme to Volterra equation of the second kind, Convolution type kernels. **Marks-15**

Unit 2: **Integral Transforms**:
Fourier Transform: Fourier Integral Transform. Properties of Fourier Transform, Fourier sine andcosine transforms, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals.

Marks-15

Unit 3: Laplace Transform: Basic properties of Laplace Transform, Convolution theorem and properties of Convolution, Inverse Laplace Transform. Application of Laplace Transform to solution of ordinary and partial differential equations of initial and boundary value problems, Evaluation of definite integrals. The inversion theorem, Evaluation of inverse transforms by residue method. **Marks-15**

Unit 4: Calculus of variations: Calculus of variation with one independent variable, Basic ideas of Calculus of variations, Euler's equation with fixed boundary of the functional containing only the first order derivative of the only dependent variable with respect to one independent variable, Variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications Calculus of Variation with several independent variables: Variational problems with functional dependent on functions of several independent variables having first order derivatives. Variational problems in parametric form, Variational problems with subsidiary condition: Isoperimetric problems, Applications.

Marks-15

Internal assessment: **40 marks:** Through the sessional exam, class test, assignment, quiz, viva etc.

Text Books:
1. R. P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York, 1971
2. M. R. Spiegel, Schaum's Outline Series: Theory and Problems of Laplace Transforms, McGraw-
Hill Book Company, 1965
3. A. S. Gupta, Calculus of variation with Applications : Prentice Hall of India, 1999
Reference Books:
1. S. G. Mikhlin, Linear Integral Equations (Translated from Russia), Hindustan Book Agency, 1960
2. F. B. Hilderbrand, Methods of Applied Mathematics, Dover Publications, 1992
3. R. Courant and D. Hilbert, Methods of Mathematical Physics- Vol- I, Wiley Interscience, New York 1953.

MINOR (Choose one)

MAT-MIN-7.1: Differential Equations

Total Marks: 100(Theory: 60, Internal: 40)

Course Objectives:
The main objective of this course is to introduce the students to the exciting world of differential equations and their solutions methods also about their applications.

Course Outcomes: The course will enable the students to:

CO-1 *Learn basics of differential equations, formation of differential equation and methods for solving.*

CO-2*They will learn how to apply the idea of differential equations in practical problems.*

Unit 1: First Order Ordinary Differential Equations:
Degree and order of differential equations, formation of differential equation, solution of differential equation. First order exact differential equations, Integrating factors, Rules to find an integrating factor. Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving differential equation by reducing its order. [2] Chapter 2 (Sections 2.3, and 2.4), Chapter 3 (Section 3.1), and Chapter 4 (Section 4.1). **Marks-30**

Unit 2: Second Order Linear Differential Equations
Linear homogenous equations with constant coefficients, linear non-homogenous equations, the method of variation of parameters, The Cauchy-Euler equation; Simultaneous differential equations. **Marks-30**
Internal : 40 marks: Through sessional exam, assignment, class test, quiz, viva, mini project etc.

Text Books:
1. Kreyszig, Erwin (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley &Sons, Inc. Wiley India Edition 2015.
2. Ross, Shepley L. (1984). *Differential Equations* (3rd ed.). John Wiley & Sons, Inc.

MAT-MIN-7.2: Mechanics

Total Marks: 100: (Theory: 60, Internal: 40)

Course Objectives: *The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques. It emphasizes knowledge building for applying mathematics in physical world.*

Course Outcomes: *The course will enable the students to:*

CO-1 *Know about the concepts in statics such as moments, couples, and equilibrium in both two and three dimensions.*

CO-2 *Understand the theory behind friction and center of gravity.*

CO-3 *Know about conservation of mechanical energy and work-energy equations.*

CO-4 *Learn about translational and rotational motion of rigid bodies.*

UNIT 1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point

and an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution. **Marks-30.**

UNIT 2: Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion of a Projectile, Motion in resisting medium. **Marks-30.**

Internal: 40 marks: through sessional exam, class test, assignment, quiz,viva etc.

Text Book:

1. S. L. Loney, The elements of Statics and Dynamics (Vol I & II) PublisherArihant, 4th Edition 2014.
2. F. Charlton, Textbook of Dynamics, CBS, Publications 2nd Edition, 1985

Reference books:

1. A.S. Ramsay, Statics, Cambridge University Press, publication year: 2009
2. A.S. Ramsay, Dynamics, Cambridge University Press, publication year: 2009
3. M. R. Spiegel, Theoretical Mechanics, SchaumSeries 2010.

SEM-VIII

MAT-MAJ-8.1: Advanced Complex Analysis

Total marks: 100: (Theory: 60, Internal Assessment: 40)

Course Objectives:

This course aims to introduce some advanced ideas of complex analysis. Emphasis has been given on power series expansions, calculation of residues and transformations.

Course Outcomes:

Completion of the course will enable the students to:

- **CO-1** *Learn the significance of the differentiability of complex functions leading to the understanding of Cauchy−Riemann equations.*
- **CO-2** *Learn about Taylor and Laurent series expansion of different functions.*
- **CO-3** *Understand the role of residue theory in order to find complex integrations.*
- **CO-4** *Lear about isogonal and conformal transformations.*

Unit 1: Complex Integration: Cauchy-Goursat Theorem. Cauchy's integral formula, Higher order derivatives. Morera's theorem, Cauchy's inequality and Liouville's Theorem. The fundamental theorem of Algebra, Gauss's Mean Value Theorem, Maximum Modulus principle, Schwarz lemma, Open mapping theorem. **Marks 15**

Unit 2: Power Series: Taylor's and Laurent's Theorem, Zero and Singularity of an analytic function, The Argument Principle, Rouche's theorem. **Marks 15**

Unit 3: Theory of Residues: Residue, Calculation of Residues, Cauchy's residue theorem, Evaluation of definite integrals. Special theorems used in evaluating integrals, Mittag-Leffer's theorem. **Marks 15**

Unit 4: Analytic functions as mappings: Isogonal and Conformal Transformation, Necessary and sufficient condition of conformal transformation, Bilinear transformations, Geometrical inversion, Invariance of cross ratio, Fixed points of a bilinear transformation, some special bilinear transformation eg.real axis on itself, unit circle on itself, real axis on unit circle etc. Branch point and Branch line, Concept of the Riemann surface. **Marks 15**

Internal assessment: 40 marks: Through the sessional exam, assignment, class test, quiz, viva, etc.

Text Book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw–Hill International Edition, 2009.

Reference Book:

1. Joseph Bak and Donald J. Newman, *Complex analysis* (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

MAT-MAJ-8.2: Topology

Total Marks: 100 (Theory: 60 Internal: 40)

Course objective:

The main objective of the course is to introduce with topological space, their geometrical interpretations, and their applications in different fields.

Course outcome: *After going through the course students will have got ideas -*

- **CO-1** *to identify topological spaces and will be familiar with different types of subsets like open sets, closed sets, neighborhoods, interior, boundary, derived sets, etc. together with the ideas of bases, sub-bases, relative topology, continuous functions, and homeomorphisms.*
- **CO-2** *They can be able to classify different spaces like first countable, second countable, and separable spaces and give the characterization of these spaces using some important results like Urysohn's lemma, and Tietze extension theorem.*
- **CO-3** *To use the idea of compactness and connectedness and give their different characterizations.*
- **CO-4** *To explain the product topology and its relationship with compactness, connectedness,*
- **CO-5** *countability, etc. They can also provide examples of metrizable spaces and can explain the*
- **CO-6** *relationship between embedding and metrization.*

Unit 1: Definition and examples of topological spaces, closed sets, closure, Dense subsets, Neighbourhood, Interior, Exterior and Boundary, Accumulation Points and Derived sets, Bases and sub bases. Sub base and Relative Topology, Continuous Functions and Homeomorphism. **10 Marks**

Unit 2: Countable and uncountable sets, First and second Countable spaces, Lindelof's theorem, Separable spaces, Second Countability and Separability. **10 Marks**

Unit 3: Separation Axioms T0, T1, T2, T31/2 , T4 ; their characterizations and basic properties, Urysohn's Lemma, Tietze Extension Theorem. **10 Marks**

Unit 4: Compactness, continuous functions and compact sets. Basic properties of compactness, Compactness and finite intersection property, sequentially and countably compact sets, Local Compactness and one point compactification. Stone-Cech Compactification, Compactness in metric spaces, Equivalence of compactness, Countable compactness and sequential compactness in metric spaces. **10 Marks**

Unit 5: Connected spaces, connectedness on the real line, components, totally disconnected spaces, Locally connected spaces. **10 Marks**

Unit 6:Tychonoff product topology in terms of standard subbase and its characterizations, Project Maps,Separation Axioms and Product Spaces, Connectedness and Product spaces, Compactness and Product Spaces (Tychonoff's) Theorem, Countability and Product Spaces, Embedding and Metrization, Urysohn Metrization theorem. **10 Marks**

Internal assessment: **40 Marks**: Through the sessional exam, assignment, class test, quiz, viva etc.

Text Books:

1. J. R. Munkres, Topology: A first course, Prentice Hall of India, 1974
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2017

Reference Books:

1. K.D. Joshi, Introduction to General Topology, New Age International Private Limited, 2017
2. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India By PHI)
3. J. Hocking and G. Young, Topology, Addison Wiley Reading, 1961
4. L. A. Steen and J. A. Seebach, Counter Examples in Topology, Dover Publications, 1995.

*MAT-MAJ-8.3: Mathematical Modeling (including practical)

Total Marks: 100 (Theory: 45, Internal: 30, Practical: 25)

Course objective:

The objectives of this course are

- *Enable students to explain real world problem mathematically.*
- *Enable students to apply mathematical concepts to solve real world problem.*
- *Enable students to use mathematical software to solve mathematical models.*

Course outcome:

After going through this course, the students will be able to

***CO-1:** Create mathematical models of real-world systems, such as in science and technology*

***CO-2:** Apply mathematical strategies and techniques to solve problems*

***CO-3:** Use computer software for mathematical modeling*

***CO-4:** Analyze simple physical phenomena to create mathematical models*

Unit -1: **20 Marks**

Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting. [1] Chapter 2 (Sections 2.1, 2.5, and 2.6), [1] Chapter 2 (Sections 2.7, and 2.8), [1] Chapter 3 (Sections 3.1 to 3.3)

Unit 2: **25 Marks**

Monte Carlo Simulation Modeling: Simulating deterministic behaviour (area under a curve, volume under a surface); Generating Random Numbers: Middle square method, Linear congruence; Queuing Models: Harbor system, Morning rush hour. [2] Chapter 5 (Sections 5.1 to 5.2, and 5.5), Chapter 7

Practical / Lab work to be performed in Computer Lab:

Modeling of the following problems using Mathematica/MATLAB/Maple/Maxima/Scilab etc.

1. Growth model (exponential case only).
2. Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting
6. Programming of either one of the queuing model:
   (a) Single server queue (e.g. Harbor system).
   (b) Multiple server queue (e.g. Rush hour).
7. Programming of the Simplex method for 2 / 3 variables.

Text Books:

1. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson.

Reference Books:

1. Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). A First Course in Mathematical Modeling (5th ed.). Brooks/Cole, Cengage Learning.

*MAT-MAJ-8.4: Advanced Differential Equation

Total Marks: 100 (Theory: 60, Internal: 40)

Course objective:

- *To introduce with various forms of differential equations.*
- *Introduce with partial differential equations.*
- *Introduce with various methods of solving differential equations.*

- *Introduce with applications of differential equation in various fields.*

Course outcome: *After completion of the course students will learn –*

CO-1 *The various forms of differential equations and to find solutions of them.*

CO-2 *To Explain and able to apply whether a differential equation has a unique solution or not*

CO-3 *In dealing with solution in series, great prominence has been found to the method of Frobenius*

CO-4 *To handle partial differential equations with different methods mainly Charpit's and the Jacobi's method*

CO-5 *The subject Partial Differential equations have wide range of applications in engineering and technological sciences. Using Partial Differential equations, students can solve wave equations, heat equations, Laplace equations etc.*

CO-6 *Laplace equation that can be solved by Partial Differential Equation is used in real life situations such as electrostatics, gravitation, steady state flow of inviscid fluids, steady state heat conduction etc.*

CO-7 *Using Partial Differential Equations students can formulate other mathematical applications such as semiconductor modeling, mathematical models in biology, astrophysics, etc.*

CO-8 *The students can apply Partial Differential Equations in medical sciences such as Kidney dialysis, blood circulation systems, etc.*

Unit 1: Well-posed problems, Existence, uniqueness, and continuity of solution of ODEs of the first order, Picard's method, Existence and uniqueness of the solution of simultaneous differential equations of the first order, Homogeneous linear systems, Non-homogeneous Linear systems. Variation of Parameters. **15 Marks**

Unit 2: Linear homogeneous differential equation-Ordinary and singular points, Series solution, Method of Frobenius. Solutions of Bessel's and Legendre's equations. **15 Marks**

Unit 3: Two-point boundary value problems, Green's function, Construction of Green's function, Sturm Liouville systems, Sturm separation and comparison theorems, Eigen values and eigen functions, Stability of autonomous system of differential equations, Critical point of an autonomous system and their classification as stable, Asymptotically stable, Strictly stable and unstable, Stability of linear systems with constant coefficients, Linear plane autonomous systems, Perturbed systems, Method of Lyapunov for nonlinear systems. **15 Marks**

Unit 4: Second order linear PDE-Classification, General solution of higher order PDE with constant Coefficients. Method of Characteristics, Classification of quasi-linear equations. **15 Marks**

Internal marks: 40 marks: Through sessional exam, assignment, class test, quiz, viva etc.

Text Books:

1. S.L. Ross, Differential Equations, Second Edition, John Wiley & Sons, India, 2007.
2. I. Stakgold, Green's functions and boundary value problems, Wiley, New York, 1979.
3. I. N. Sneddon, Elements of Partial Differential Equations, Mcgraw Hill 2006

4. W. E. Williams, Partial Differential Equations, Oxford University Press, 1980

Reference Books:

1. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 12th edition, 2021.
2. Lawrence C. Evans, Partial DifferentialEquations, Second Edition, American Mathematical Society, 2014.

NOTE: Dissertation in lieu of MAT-MAJ-8.2, 8.3 &8.4

MINOR (Choose one)

MAT-MIN-8.1: Numerical Methods

Total marks: 100: (Theory: 60, Internal Assessment: 40)

Course Objectives: *To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations and to find the approximate solutions of system of linear equations and ordinary differential equations.*

Course Learning Outcomes: *The course will enable the students to:*

CO-1 *Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.*

CO-2 *Know about methods to solve system of linear equations, such as false position method, fixed point iteration method, Newton's method, Secant method.*

CO-3 *Interpolation techniques to compute the values for a tabulated function at points not in the table.*

CO-4 *Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.*

Unit:1 Normalized floating point representation of real numbers and operations using it, normalization and its consequence, errors in arithmetic operations, absolute and relative error, truncation and round off errors, approximation and significant figures. **Marks-15**

Unit:2 Calculus of finite difference: Different interpolation formulae with remainder terms, finite difference operators and the operation on function of single variable, interpolation with equal and unequal intervals, Newton's formulae, Lagrange's formula,Gauss,Bessel and Starling's formula. **Marks-15**

Unit:3 Numerical differentiation and integration : Numerical differentiation with the help of different interpolation formulae, General Quadrature formula, Trapezoid rule,Simpson's one third and three eight rule,Weddels rule. **Marks-15**

Unit: 4 Solutions of polynomial and transcendental equations: Bisection method, secant method, regular falsi method, fixed point iteration method, Newton's method. **Marks-15**

Internal assessment: 40 marks: Through sessional exam, class test, assignment, Quiz,mini project,viva etc.

Books: 1. Numerical methods, By S.Balachandra Rao and C.K Santha,Univ.Press
2. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.

Reference Book: 1. Numerical methods for Mathematics, Science and Engineering, By J.H.Mathews.
2. Finite differences and Numerical Analysis, By H.C.Saxena, S.Chand co.

MAT-MIN-8.2: Linear Algebra

Total Marks: 100: (Theory 60 Internal Assessment: 40)

Course Objectives: *The objective of this course is to introduce the fundamental theory of vector spaces, also emphasizes the application of techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.*

Course Outcomes: *The course will enable the students to:*

- **CO-1** *Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.*
- **CO-2** *Basic concepts of linear transformations, dimension theorem, matrix representation of a linear*
- **CO-3** *transformation and the change of coordinate matrix.*
- **CO-4** *Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.*
- **CO-5** *Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain an orthonormal basis.*
- **CO-6** *Find the adjoint, normal, unitary, and orthogonal operators.*

Unit 1: Vector spaces and subspaces, null space and column space of a matrix, linear transformations, kernel and range, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, change of basis.[1]: Chapter 4 (Sections 4.1 – 4.7)
Marks-20

Unit 2: Eigenvectors and eigenvalues of a matrix, the characteristic equation, diagonalization, eigenvectors of a linear transformation, complex eigenvalues,[1]: Chapter 4 (Sections 5.1 – 5.5) Invariant subspaces and Cayley-Hamilton theorem.[2]: Chapter 5 (Section 5.4). **Marks-20**

Unit 3: Inner product, length, and orthogonality, orthogonal sets, orthogonal projections, the Gram–Schmidt process, inner product spaces; Diagonalization of symmetric matrices,the Spectral Theorem.[1]: Chapter 6 (Sections 6.1 – 6.4, 6.7); Chapter 7 (Section 7.1) **Marks-20**

Internal assessment:40 marks: Through sessional exam, class test, assignment, Quiz,mini project,viva etc.

Text Books:

1. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian
Reprint, 2007.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall
of India Pvt. Ltd., New Delhi, 2004.

Reference Books:

1. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
3. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4. G. Schay, Introduction to Linear Algebra, Narosa, 1997.