MANIPUR UNIVERSITY
FOUR YEAR UNDERGRADUATE PROGRAMME (FYUP)
IN MATHEMATICS, 2025

INTRODUCTION

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

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

UG Certificate: Certificate course consists of two Major disciplines, two Minor disciplines, two MDC, two AEC, two VAC and two SEC and one internship.

UG Diploma: Diploma course consists of eight Major disciplines, four Minor disciplines, three MDC, two AEC, three VAC, three SEC and one internship.

3-year UG Degree: 3-year UG degree course consists of fifteen Major disciplines, six Minor disciplines, three MDC, two AEC, three VAC, three SEC, Community engagement (NCC/NSS/Adult Education/Student mentoring/ NGO/ Govt. Institutions, etc.) and Internship.

4-year Honours/Honours with Research Degree: 4-year honours degree course consists of twenty Major disciplines, eight Minor disciplines, three MDC, two AEC, three VAC, three SEC, Community engagement (NCC/NSS/Adult Education/Student mentoring/ NGO/ Govt. Institutions, etc.), Internship, Research Methodology, three DSE/Dissertation.

AIMS FOR UG DEGREE IN MATHEMATICS

The UG Programme in mathematics is designed to teach students how to think critically, logically, and analytically, which enables them to employ mathematical reasoning in real-world situations. A UG degree in mathematics will expose students to a variety of intriguing and practical concepts that will help them in their preparation for a variety of mathematics-oriented jobs in industry, government, business, commerce, finance and research.

The programme covers broad range of topics on pure and applied mathematics. Also covers hands-on sessions in Computer Lab using various software, LaTaX, Python, MATLAB etc. which enables students to corelate and compare with recent developments in various branches of mathematics in a variety of organisations worldwide.

The programme aims to increase students' skill in mathematics as well as other cross-disciplinary subjects like commerce, physics, computer sciences, economics, and statistics etc. They have the option to undertake these courses through MOOCs/SWAYAM. They have flexibility to move from one discipline to another, to move one institution to another, to switch alternative modes of learning.

ATTRIBUTES OF A GRADUATE IN MATHEMATICS

Core Competency: Graduates will be well-versed in mathematical theories, concepts, and techniques, enabling them to solve challenging problems and pursue advanced study in mathematics or related fields.

Critical Thinking : Graduates will acquire the analytical and critical thinking abilities needed to formulate, evaluate, and resolve real-world issues using logical reasoning and mathematical modelling.

Problem-solving: Graduates will be adept at using computational tools and mathematical concepts to solve problems in a variety of sectors, including science, engineering, technology, and economics.

Communication Skills: Graduates will be able to effectively convey mathematical concepts, both orally and in writing, as well as collaborate in multidisciplinary teams to solve challenging problems.

Moral and Ethical Awareness: Graduates will exhibit a dedication to moral behaviour and professional obligations, which include comprehending how mathematical solutions affect society and maintaining a high standard of professional development.

Research Skills: Graduates will be equipped with the capacity to carry out autonomous research, enhancing their understanding of mathematics and stimulating their imagination in addressing abstract and practical issues.

Qualification Descriptors

The qualification descriptor suggests the generic outcomes and attributes to be obtained while obtaining the degree of B.A./B.Sc. (Major) Mathematics or B.A./B.Sc. with Mathematics as a minor subject. The qualification descriptors indicate the academic standards on the basis of following factors:

i. Level of knowledge
ii. Understanding
iii. Skills
iv. Competencies and attitudes
v. Values

PROGRAMME LEARNING OUTCOME

PLO1 **Disciplinary knowledge**: Bachelor degree in Mathematics is the culmination of in-depth knowledge of Algebra, Calculus, geometry, Real analysis, Differential equations and several other branches of pure and applied mathematics, this also leads to study of relevant areas such as computer science and other disciplines.

PLO2 **Communication Skills**: Ability to communicate the various mathematical concepts effectively using variety of examples mostly having real life applications and their geometric visualization. The skills and knowledge gained in this programme will lead to the proficiency in analytical reasoning which can be used to express thoughts and views in mathematically or logically correct statements.

PLO3 **Critical thinking and analytical reasoning**: The students undergoing this programme acquire the ability of critical thinking and logical reasoning and will apply in formulating or generalizing specific hypothesis, conclusion. The learner will be able to recognize and distinguish the various aspects of real-life problems.

PLO4 **Problem solving**: The Mathematical knowledge gained by the student through this programme develops an ability to solve the problems, identify and define appropriate computing requirements for its solutions. This programme will enhance the overall development.

PLO5 **Research related skills**: After the completion of this programme, the student will develop the capability of inquiring about appropriate questions relating to the Mathematical concepts, arguments. He/she will be able to define problems, formulate hypothesis, proofs, write the results obtained clearly.

PLO6 **Information/ digital literacy**: The completion of this programme will enable the learner to use appropriate softwares to solve the system of algebraic and differential equations.

PLO7 **Self-directed learning**: The student after the completion of the programme will be able to work independently, make an in-depth search of various areas of Mathematics and resources for self learning in order to enhance knowledge in mathematics.

PLO8 **Moral and ethical awareness / reasoning**: The student after the completion of the course will develop an ability to identify unethical behaviour such as fabrication, falsification or misinterpretation of data and adopting objectives, unbiased and truthful actions in all aspects of life in general and Mathematical studies in particular.

PLO9 **Lifelong learning**: This programme provides self directed learning and lifelong learning skills. With these skills, the learner will be able to think independently, improve personal development.

Programme Specific Outcomes

PSO1: Demonstrate the acquisition of comprehensive knowledge and coherent understanding in chosen elective and core subjects in mathematics.

PSO2: Apply mathematical techniques and tools, such as mathematical modeling, computational methods, and statistical analysis, to solve real-world problems in various fields.

PSO3: Possess strong analytical and critical thinking skills, enabling them to construct rigorous logical arguments, develop proofs, and solve complex mathematical problems.

PSO4: Proficient in using modern mathematical software and computational tools such as LaTeX, Python, MATLAB, and other relevant technologies to analyze data and solve mathematical problems.

PSO5: Communicate mathematical ideas and solutions to a variety of audiences, including mathematicians, scientists, engineers, and non-specialists, both orally and in writing.

PSO6: Formulate research questions, literature review, methodology, presentation of findings, and demonstrate dedication to lifelong learning and professional development.

PSO7: Utilize the skills that necessary for success in national level competitive exams, pursuing doctoral research degree, teaching and others.

Course Structure of the
FOUR YEAR UNDERGRADUATE PROGRAMME (FYUP)
IN MATHEMATICS, 2025 BASED ON NEP-2020

Semester	Course		Title of the paper	Credit
	Category	Code		
I (FIRST)	Major	**MJC45MAT101(T)25**	Algebra	4
	Minor	**MNC45MAT101(T)25**	Algebra	4
	MDC	**MDC45MSC101(T)25**	Quantitative Aptitude	3
	AEC			4
	SEC	**SEC45MAT101(T)25** **SEC45MAT101(P)25**	LaTeX	3
	VAC			2
	Total Credit			20

MJC45MAT101(T)25 : Algebra

Nature of Course	**Major**			
Course Code	**MJC45MAT101(T)25**			
Course Title	**Algebra**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	4	**3**	**1**	**4**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Set, function, matrix, determinant, polynomial, equation, inequation, means.**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Not required**			

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Course Learning Outcomes: After completion of the course, a student will be able to

1.	Employ De Moivre's theorem in a number of applications to solve numerical problems.
2.	Solve polynomial equations of degree three and four.
3.	Solve problems based on standard inequalities.
4.	Recognize consistent and inconsistent systems of linear equations by using rank.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	De Moivre's theorem	De Moivre's theorem for integer and rational indices, applications of De Moivre's theorem, summation of series	9	3	-	12
II	Polynomial equations	Polynomial functions, polynomial equations, fundamental theorem of algebra (statement only), Descarte's rule of signs, relation between roots and coefficients of a polynomial equation, symmetric function of the roots of an equation, sum of powers of the roots, Cardan's method of cubic and Ferrari's method for biquadratic equations.	9	3	-	12
III	Inequalities	Arithmetic mean, geometric mean, mean of m^{th} power, Cauchy-Schwartz inequality, inequalities of Holder, Minkowski and Chebyshev.	9	3	-	12
IV	Matrices	Rank of a matrix, linear independence, rank and elementary operations, row reduction and echelon forms, system of linear equations, solution of the matrix equation AX=B, solution sets of linear systems.	9	3	-	12
V	Matrices	Characteristic equation, eigenvectors and eigen values, Cayley- Hamilton theorem, inverse of matrix, orthogonal matrix.	9	3	-	12

Suggested Readings

1. **MK Singal, Asha Rani Singal,** (2020); *Algebra* (31st Ed) R Chand & Co, New Delhi.
2. **Chandrika Prasad,** (2014). *Text Book on Algebra and Theory of Equations* Pothishala Pvt. Ltd, Allahabad.

Additional Readings:

1. **Kolman, Bernard, & Hill, David R.** (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
2. **Lay, David C., Lay, Steven R., & McDonald, Judi J.** (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.
3. **Andrilli, Stephen, & Hecker, David** (2016). *Elementary Linear Algebr*a (5th ed.). Academic Press, Elsevier India Private Limited.

Teaching plan (MJC45MAT101(T)25: Algebra):

Week 1: De Moivre's theorem for integer and rational indices [1] Chapter 5 (Section 2, 4).
Week 2: Applications of De Moivre's theorem to various problems. [1] Chapter-5 (Section-3.1 to 3.4)
Week 3: Summation of series. [1] Chapter-5 (Section-3.5)
Week 4: Polynomial functions, polynomial equation, fundamental theorem of algebra (statement only), and related problems**.** [1] Chapter-4 (Section-5, 6, 7)
Week 5: Descarte's rule of signs, relation between roots and coefficients of a polynomial equation and related problems. [1] Chapter-4(section-7, 8, 9)
Week 6: Symmetric function of the roots of an equation, sum of powers of the roots and related problems. [1] Chapter-4(section-10, 11)
Week 7: Arithmatic mean, geometric mean, mean of m^{th} power and related problems. [2] Chapter-3 (Section-3.3, 3.4, 3.41, 3.42, 3.43, 3.5, 3.51)
Week 8: Cauchy-Schwartz inequality. [2] Chapter-3 (Section-3.7)
Weak 9: Inequalities of Holder, Minkowski and Chebyshev and related problems. [2] Chapter-3 (Section-3.7)
Week 10: Row reduction and Echelon forms, rank of a matrix, linear independence, rank and elementary operations.
[2] Chapter-6(Section-6.4, 6.41 to 6.46, 6.67, 6.7),
Week 11: System of linear equations, solution of the matrix equation AX=B;
[1] Chapter-6(Section-13, 15)
Week 12: Solution sets of linear systems; [1] Chapter 7 (Section-7.2 &7.3)
Week 13: Characteristic equation, eigenvectors and eigen values; [2] Chapter 6 (Section 6.6, 6.61).
Week 14: Cayley-Hamilton theorem; [2] Chapter 6 (Section 6.63).
Week 15: Inverse of matrix, orthogonal matrix. [2] Chapter-6 (Section-6.7, 6.8)

Assessment Methods

- Oral and written examinations,
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions,

MNC45MAT101(T)25 : Algebra

Nature of Course	**Minor**			
Course Code	**MNC45MAT101(T)25**			
Course Title	**Algebra**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	4	**3**	**1**	**4**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Set, function, matrix, determinant, polynomial, equation, inequation, means.**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Not required**			

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Course Learning Outcomes: After completion of the course, a student will be able to

1.	Employ De Moivre's theorem in a number of applications to solve numerical problems.
2.	Solve polynomial equations of degree three and four.
3.	Solve problems based on standard inequalities.
4.	Recognize consistent and inconsistent systems of linear equations by using rank.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
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III	Inequalities	Arithmetic mean, geometric mean, mean of m^{th} power, Cauchy-Schwartz inequality, inequalities of Holder, Minkowski and Chebyshev.	9	3	-	12
IV	Matrices	Rank of a matrix, linear independence, rank and elementary operations, row reduction and echelon forms, system of linear equations, solution of the matrix equation AX=B, solution sets of linear systems.	9	3	-	12
V	Matrices	Characteristic equation, eigenvectors and eigen values, Cayley- Hamilton theorem, inverse of matrix, orthogonal matrix.	9	3	-	12

Suggested Readings

1. **MK Singal, Asha Rani Singal,** (2020); *Algebra* (31st Ed) R Chand & Co, New Delhi.
2. **Chandrika Prasad,** (2014). *Text Book on Algebra and Theory of Equations* Pothishala Pvt. Ltd. Allahabad.

Additional Readings:

1. **Kolman, Bernard, & Hill, David R.** (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
2. **Lay, David C., Lay, Steven R., & McDonald, Judi J.** (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.
3. **Andrilli, Stephen, & Hecker, David** (2016). *Elementary Linear Algebr*a (5th ed.). Academic Press, Elsevier India Private Limited.

Teaching plan (MNC45MAT101(T)25: Algebra):

Week 1: De Moivre's theorem for integer and rational indices [1] Chapter 5 (Section 2, 4).
Week 2: Applications of De Moivre's theorem to various problems. [1] Chapter-5 (Section-3.1 to 3.4)
Week 3: Summation of series. [1] Chapter-5 (Section-3.5)
Week 4: Polynomial functions, polynomial equation, fundamental theorem of algebra (statement only), and related problems**.** [1] Chapter-4 (Section-5, 6, 7)
Week 5: Descarte's rule of signs, relation between roots and coefficients of a polynomial equation and related problems. [1] Chapter-4(section-7, 8, 9)
Week 6: Symmetric function of the roots of an equation, sum of powers of the roots and related problems. [1] Chapter-4(section-10, 11)
Week 7: Arithmatic mean, geometric mean, mean of m^{th} power and related problems. [2] Chapter-3 (Section-3.3, 3.4, 3.41, 3.42, 3.43, 3.5, 3.51)
Week 8: Cauchy-Schwartz inequality. [2] Chapter-3 (Section-3.7)
Weak 9: Inequalities of Holder, Minkowski and Chebyshev and related problems. [2] Chapter-3 (Section-3.7)
Week 10: Row reduction and Echelon forms, rank of a matrix, linear independence, rank and elementary operations.
[2] Chapter-6(Section-6.4, 6.41 to 6.46, 6.67, 6.7),
Week 11: System of linear equations, solution of the matrix equation AX=B;
[1] Chapter-6(Section-13, 15)
Week 12: Solution sets of linear systems; [1] Chapter 7 (Section-7.2 &7.3)
Week 13: Characteristic equation, eigenvectors and eigen values; [2] Chapter 6 (Section 6.6, 6.61).
Week 14: Cayley-Hamilton theorem; [2] Chapter 6 (Section 6.63).
Week 15: Inverse of matrix, orthogonal matrix. [2] Chapter-6 (Section-6.7, 6.8)

Assessment Methods

- Oral and written examinations,
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions,

MDC45MSC101(T)25 : Quantitative Aptitude

Nature of Course	**MDC**			
Course Code	**MDC45MSC101(T)25**			
Course Title	**Quantitative Aptitude**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	3	**3**	**0**	**3**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Concept of unitary methods, ratio and proportion, mensuration, arrangements**			
Pre Requisite Course Required	**10 Mathematics**			
Faculty Eligibility and Specialization	**Not required**			

Course Objectives: The main aim of this course is to gain knowledge of elementary ideas about arithmetic abilities which one finds in daily life. It will help the students from any background to get acquainted with this knowledge and get prepared for any competitive examinations.

Course Learning Outcomes: This course will enable the students to:

1.	gain sufficient ideas of mental and arithmetic abilities.
2.	handle mental/quantitative aptitude test questions with great ease.
3.	acquire the skill of solving problems of daily life quickly.
4.	formulate real-life problems mathematically and solve using quantitative techniques.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Arithmetic Ability I	Chain Rule –Time and Work – Pipes and Cisterns Time and Distance – Problems on Trains – Boats and Streams	12	-	-	12
II	Arithmetic Ability II	Simple Interest – Compound Interest – Stocks and Shares.	9	-	-	9
III	Arithmetic Ability III	Clocks – Area	6	-	-	6
IV	Arithmetic Ability IV	Volume and Surface Area	9	-	-	9
V	Arithmetic Ability V	Permutations and Combinations.	9	-	-	9

Suggested Readings

1. Scope and treatment as in "*Quantitative Aptitude*", S. Chand and Company Ltd. Ram Nagar, New Delhi (2007).

Additional Readings:

1. NCERT Mathematics text books for standard VIII, IX, X, XI.

Teaching plan (MDC45MSC101(T)25: Quantitative Aptitude):

1. **Week 1&2:** Chain Rule –Time and Work – Pipes and Cisterns,[1] Chapters 14, 15 & 16.
2. **Week 3&4: Time** and Distance-Problems on Trains-Boats and Streams [1] Chapters 21, 22 & 29.
3. **Week 5-7:** Simple Interest-Compound Interest-Stocks and Shares. [1] Chapters 17, 18 & 19.
4. **Week 8 & 9:** Clocks – Area [1] Chapters 24, 25.
5. **Week 10-12:** Volume and Surface Area. [1] Chapter 28.
6. **Week 13-15:** Permutations and Combinations. [1] Chapters 30 & 31.

Assessment Methods

- Oral and written examinations,
- Problem-solving exercises,
- Individual and group project reports,
- Interactive sessions,

SEC45MAT101(T)25 : La*TeX* (Theory)

Nature of Course	**SEC**			
Course Code	**SEC45MAT101(T)25**			
Course Title	**LaTeX (Theory)**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	2	**2**	**0**	**2**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Basic Computer Literacy**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Master in Mathematics with Computer Programming knowledge**			

Course Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and webpages.

Course Learning Outcomes: After studying this course the student will be able to:

1.	typeset mathematical formulas, use nested list, tabular & array environments.
2.	create or import graphics.
3.	use beamer to create presentation.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Getting Started with La*TeX*	Introduction to *TeX* and La*TeX*, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.	6	-	-	6
II	Mathematical Typesetting with La*TeX*-I	Accents and symbols, Mathematical Typesetting (Elementary and Advanced)**:** Subscript/ Superscript, Fractions, Roots, Ellipsis, Mathematical Symbols.	6	-	-	6
III	Mathematical Typesetting with La*TeX*-II	Arrays, Tables, Delimiters, Multiline formulas, Spacing and changing style in math mode.	6	-	-	6
IV	Graphics in La*TeX*	Graphics in LaTeX, Simple pictures using PS Tricks, Plotting of functions.	6	-	-	6
V	Beamer Presentation in La*TeX*	Beamer presentation.	6	-	-	6

SEC45MAT101(P)25 : La*TeX* (Practical)

Nature of Course	**SEC**			
Course Code	**SEC45MAT101(P)25**			
Course Title	**La*TeX* (Practical)**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	1	**1**	**0**	**2**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Basic Computer Literacy**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Master in Mathematics with Computer Programming knowledge**			

Course Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and webpages.

Course Learning Outcomes: After studying this course the student will be able to:

1.	typeset mathematical formulas, use nested list, tabular & array environments.
2.	create or import graphics.
3.	use beamer to create presentation.

Detailed Syllabus Content

Unit	Unit Name	List of Practicals	L	T	P	Total
I	LaTeX Practical-1	[1] Chapter 9 (Exercises 4 to 10)	-	-	4	4
II	LaTeX Practical-2	[1] Chapter 10 (Exercises 1 to 4 and 6 to 9)	-	-	4	4
III	LaTeX Practical-3	[1] Chapter 11 (Exercises 1, 3, 4, and 5)	-	-	3	3
IV	LaTeX Practical-4	[1] Chapter 15 (Exercises 5, 6 and 8 to 11).	-	-	4	4

Suggested Readings

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. **Lamport, Leslie** (1994). *LaTeX*: *A Document Preparation System*, User's Guide and Reference Manual (2nd ed.). Pearson Education.Indian Reprint.

Teaching Plan {SEC45MAT101(T)25 : La*TeX* (Theory)}:

Weeks 1 to 3: Introduction to TeX and LaTeX, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.
[1] Chapter 9 (9.1 to 9.5)[2] Chapter 2 (2.1 to 2.5)

Weeks 4 to 6: Accents of symbols, Mathematical typesetting (elementary and advanced): subscript/superscript, Fractions, Roots, Ellipsis, Mathematical symbols..[1] Chapter 9 (9.6 and 9.7)

Weeks 7 to 9: Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode [2] Chapter 3 (3.1 to 3.3)

Weeks 10 to 12: Graphics in LaTeX, Simple pictures using PS Tricks, Plotting of functions.
[1] Chapter 9 (Section 9.8)[1] Chapter 10 (10.1 to 10.3)[2] Chapter 7 (7.1 and 7.2)

Weeks 13 to 15: Beamer presentation.
[1] Chapter 11 (Sections 11.1 to 11.4)

List of Essential Major Equipments

- **Computer Laboratory**

Essential Software (Open-source)

- **La*TeX***

Student Activities

- Practical assignments and laboratory reports,
- Interactive sessions,

Course Structure of the
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Sem.	Course		Title of the paper	Credit
	Cat.	Code		
II	**Major**	**MJC45MAT102(T)25**	Differential Calculus	4
	Minor	**MNC45MAT102(T)25**	Differential Calculus	4
	MDC	**MDC45MAT102(T)25**	Elementary Mathematics-I	3
	AEC			4
	SEC	**SEC45MAT102(T)25** **SEC45MAT102(P)25**	Python Programming	3
	VAC			2
Total Credit				20

MJC45MAT102(T)25: Differential Calculus

Nature of the course	**Major**			
Course code	**MJC45MAT102(T)25**			
Course Title	**Differential Calculus**			
Course Level	**100**			
Credit Details	**Total credit**	**Lecture/week**	**Tutorial/week**	**Total Hour/week**
	4	**3**	**1**	**4**
Course Audience	**BA/BSc Second Semester**			
Proposed by	**Board of Under Graduate Studies of Department of Mathematics, Manipur University**			
Pre-Requisites	**Function, limit, continuity, differentiation**			
Pre-Requisite Course required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Not required**			

Course Objectives: The primary objective of this course is to introduce the basic concepts of limit including indeterminate forms, continuity and differentiation and their application on finding tangents, normals, curvature, asymptotes etc., partial differentiation and mean value theorems.

Course learning outcomes: After completion of the course, a student will be able to

1	understand concept of the limit of a function, evaluate limit of a function, and differentiate the various types of discontinuity.
2	calculate the derivatives of hyperbolic functions, evaluate the successive derivatives, apply Leibnitz's theorem , and evaluate limits of indeterminate forms (e.g., 0/0, ∞/∞) using techniques like L'Hopital's Rule.
3	understand and apply Rolle's Theorem, the Mean Value theorem, Taylor's Series and Maclaurin's Series.
4	Determine the equations of tangents and normals to a curve, and analyse the concavity and convexity of functions and locate points of inflexion, calculate the curvature and center of curvature of a given curve.
5	calculate the partial derivatives of functions with multiple variables, apply Euler's theorem on homogeneous functions, differentiate implicit functions and calculate total differential coefficients, and understand the concept of an exact differential and its applications.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Limit and Continuity	Limit and continuity, different types of discontinuity	9	3	-	12
II	Differentiation	Derivatives of hyperbolic functions, successive differentiation, Leibnitz theorem, indeterminate forms	9	3	-	12
III	Expansion of Function	Roll's Theorem, Mean Value Theorem, Taylor's Series, Maclaurin's Series and Cauchy's Series in finite form, expansion of functions in infinite power series	9	3	-	12

IV	Application of Derivatives	Tangent and normal, curvature, centre of curvature, asymptotes, concavity and convexity of inflexion, singular points	9	3	-	12
V	Partial Differentiation	Partial differentiation, homogeneous functions, Eulers theorem on homogenous functions, differentiation of implicit functions, total differential coefficients, exact differential, partial derivatives of two functions, converse of Eulers theorem	9	3	-	12

Suggested Readings

1. **Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014)**. *Thomas' Calculus* (14th Edition, 2021), Pearson Education, Delhi. Indian Reprint.
2. **B. C. Das, B. N. Mukherjee**. *Differential Calculus* (59th Edition), U.N. Dhur & Sons Private Ltd., Kolkata (2024).

Teaching Plan (MJC45MAT201(T)25 : Differential Calculus):

Unit I: Limit of a function and limit laws, ε-δ definition of limit and one-sided limits [1] Chapter 2(Section 2.2 - 2.4);
Continuity [1] Chapter 2(Section 2.5); Different types of discontinuity [2] Chapter 4(Section 4.3);
Limits involving infinity and Asymptotes of graphs [1] Chapter 2(Section 2.6)

Unit II: Differentiation

Derivatives of a function and Rules of differentiation [1] Chapter 3(Section 3.2 - 3.3);
Derivative of Trigonometric hyperbolic functions [2] Chapter 7(Section 7.9);
Derivative of implicit functions [1] Chapter 3(Section 3.7);
Successive differentiation [2] Chapter 8(Section 8.1 – 8.3);
Leibnitz's Theorem [2] Chapter 8(Section 8.5);
Indeterminate forms and L'Hospital's Rule [2] Chapter 11

Unit III: Expansion of Function

Roll's Theorem and its geometrical interpretation [2] Chapter 9(Section 9.1 - 9.2);
Mean Value Theorem and its geometrical interpretation [2] Chapter 9(Section 9.3 - 9.4);
Taylor Series, Maclaurin's Series and Cauchy's Series in finite form [2] Chapter 9 (Section 9.5 - 9.7);
Expansion of functions in infinite power series [2]Chapter 9(Section 9.9)

Unit IV: Application of Derivatives

Tangent and normal [2] Chapter 14 (Section 14.2 - 14.6, 14.12 - 14.17);
Curvature and Center of curvature [2] Chapter 15 (Section 15.1 - 15.4, 15.7 - 15.8);
Asymptotes [2] Chapter 16(Section 16.2 - 16.7);
Concavity and Convexity of inflexion [2] Chapter 19 (Section 19.1 - 19.5)

Unit V: Partial Differentiation

Functions of two or more variables, partial differentiation, homogeneous functions, Eulers Theorem on homogenous functions, differentiation of implicit functions, total differential coefficients, exact differential, partial derivatives of two functions, converse of Eulers Theorem [2] Chapter 12 (Section 12.1 - 12.3, 12.5 - 12.13)

Linkage between Programme Outcomes (POs) and Course Learning Outcomes (COs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓		✓		✓
CO2	✓		✓		✓		✓
CO3	✓		✓		✓		✓
CO4	✓		✓		✓		✓
CO5	✓		✓		✓		✓

Assessment Methods

- Oral and written examination
- Closed book and open book tests
- Problem solving exercises
- Seminar and presentations
- Interactive sessions

MNC45MAT102(T)25: Differential Calculus

Nature of the course	**Minor**			
Course code	**MNC45MAT102(T)25**			
Course Title	**Differential Calculus**			
Course Level	**100**			
Credit Details	**Total credit**	**Lecture/week**	**Tutorial/week**	**Total Hour/week**
	4	**3**	**1**	**4**
Course Audience	**BA/BSc Second Semester**			
Proposed by	**Board of Under Graduate Studies of Department of Mathematics, Manipur University**			
Pre-Requisites	**Function, limit, continuity, differentiation**			
Pre-Requisite Course required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Not required**			

Course Objectives: The primary objective of this course is to introduce the basic concepts of limit including indeterminate forms, continuity and differentiation and their application on finding tangents, normals, curvature, asymptotes etc., partial differentiation and mean value theorems.

Course learning outcomes: After completion of the course, a student will be able to

1	understand concept of the limit of a function, evaluate limit of a function, and differentiate the various types of discontinuity.
2	calculate the derivatives of hyperbolic functions, evaluate the successive derivatives, apply Leibnitz's theorem, and evaluate limits of indeterminate forms (e.g., 0/0, ∞/∞) using techniques like L'Hopital's Rule.
3	understand and apply Rolle's Theorem, the Mean Value theorem, Taylor's Series and Maclaurin's Series.
4	determine the equations of tangents and normals to a curve, and analyse the concavity and convexity of functions and locate points of inflexion, calculate the curvature and center of curvature of a given curve.
5	calculate the partial derivatives of functions with multiple variables, apply Euler's theorem on homogeneous functions, differentiate implicit functions and calculate total differential coefficients, and understand the concept of an exact differential and its applications.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Limit and Continuity	Limit and continuity, different types of discontinuity	9	3	-	12
II	Differentiation	Derivatives of hyperbolic functions, successive differentiation, Leibnitz theorem, indeterminate forms	9	3	-	12
III	Expansion of Function	Roll's Theorem, Mean Value Theorem, Taylor's Series, Maclaurin's Series and Cauchy's Series in finite form, expansion of functions in infinite power series	9	3	-	12
IV	Application of Derivatives	Tangent and normal, curvature, centre of curvature, asymptotes, concavity and convexity of inflexion, singular points	9	3	-	12
V	Partial Differentiation	Partial differentiation, homogeneous functions, Eulers theorem on homogenous functions, differentiation of implicit functions, total differential coefficients, exact differential, partial derivatives of two functions, converse of Eulers theorem	9	3	-	12

Suggested Readings

1. **Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel** (2014). *Thomas' Calculus* (14th Edition, 2021), Pearson Education, Delhi. Indian Reprint.

2. **B. C. Das, B. N. Mukherjee**. *Differential Calculus* (59th Edition), U.N. Dhur & Sons Private Ltd., Kolkata (2024).

Teaching Plan (MNC45MAT102(T)25 : Differential Calculus):

Unit I: Limit of a function and limit laws, ε-δ definition of limit and one-sided limits [1] Chapter 2(Section 2.2 - 2.4);
Continuity [1] Chapter 2(Section 2.5); Different types of discontinuity [2] Chapter 4(Section 4.3);
Limits involving infinity and Asymptotes of graphs [1] Chapter 2(Section 2.6)

Unit II: Differentiation

Derivatives of a function and Rules of differentiation [1] Chapter 3(Section 3.2 - 3.3);
Derivative of Trigonometric hyperbolic functions [2] Chapter 7(Section 7.9);
Derivative of implicit functions [1] Chapter 3(Section 3.7);
Successive differentiation [2] Chapter 8(Section 8.1 – 8.3);
Leibnitz's Theorem [2] Chapter 8(Section 8.5);
Indeterminate forms and L'Hospital's Rule [2] Chapter 11

Unit III: Expansion of Function

Roll's Theorem and its geometrical interpretation [2] Chapter 9(Section 9.1 - 9.2);
Mean Value Theorem and its geometrical interpretation [2] Chapter 9(Section 9.3 - 9.4);
Taylor Series, Maclaurin's Series and Cauchy's Series in finite form [2] Chapter 9 (Section 9.5 - 9.7);
Expansion of functions in infinite power series [2]Chapter 9(Section 9.9)

Unit IV: Application of Derivatives

Tangent and normal [2]Chapter 14(Section 14.2 - 14.6, 14.12 - 14.17);
Curvature and Centre of curvature [2]Chapter 15(Section 15.1 - 15.4, 15.7 - 15.8);
Asymptotes [2]Chapter 16(Section 16.2 - 16.7);
Concavity and Convexity of inflexion [2]Chapter 19(Section 19.1 - 19.5)

Unit V: Partial Differentiation

Functions of two or more variables, partial differentiation, homogeneous functions, Eulers Theorem on homogenous functions, differentiation of implicit functions, total differential coefficients, exact differential, partial derivatives of two functions, converse of Eulers Theorem [2] Chapter 12 (Section 12.1 - 12.3, 12.5 - 12.13)

Linkage between Programme Outcomes (POs) and Course Learning Outcomes (COs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓		✓		✓
CO2	✓		✓		✓		✓
CO3	✓		✓		✓		✓
CO4	✓		✓		✓		✓
CO5	✓		✓		✓		✓

Assessment Methods

- Oral and written examination
- Closed book and open book tests
- Problem solving exercises
- Seminar and presentations
- Interactive sessions

MDC45MAT102(T)25 : Elementary Mathematics-I

Nature of Course	**MDC**			
Course Code	**MDC45MAT102(T)25**			
Course Title	**Elementary Mathematics-I**			
Course level	**100**			
Credit details	**Total Credit**	**Lecture/Week**	**Tutorial/week**	**Total Hour/Week**
	3	**3**	**0**	**3**
Course Audience	**BA/BSc Second Semester**			
Proposed by	**Board of Under-Graduate of Department of Mathematics, Manipur University**			
Pre Requisites	**Concept of numbers, counting, equations**			
Pre Requisite Course Required	**10 Mathematics**			
Faculty Eligibility and Specialization	**Not Required**			

Course Objectives: The course is aimed at imparting concepts frequently used in Mathematics at a primary level and also required in other disciplines. It aims at giving basic knowledge of the subject to students from any background which is often required for a student preparing for various competitive examinations.

Course learning outcomes: After completion of the course, a student will be able to

1.	define and identify various types of sets, understand various set operations like union, intersection, difference, and complement to sets, and use Venn diagrams to visualize these operations.
2.	understand the concepts of relations and functions, visualize various special functions graphically, and identify the domain and range of functions, particularly trigonometric functions.
3.	use PMI to prove mathematical statements and theorems, understand and apply the fundamental principle of counting, and solve problems involving the arrangement (permutations) and selection (combinations) of objects.
4.	**u**nderstand the basic algebra of complex numbers, including calculating the modulus and conjugates, represent complex numbers graphically, find solutions to quadratic equations, including the calculation of square roots for complex numbers.
5	identify and negate of statements, and understand the construction of compound statements using logical connectors like "Or" and "And", interpret logical implications ("If then", "Only if", "If and only if") and use quantifiers ("there exists", "for all"), construct truth tables to determine the validity and equivalence of statements, including the converse and contrapositive, apply principles of mathematical reasoning to validate statements and arguments.

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Sets	Introduction with historical notes, Sets and their representations, Finite and Infinite sets, Equal sets, Subsets, power sets, Universal sets, Venn diagram, Operations on set, Union, Intersection, Difference of sets, Complement of sets, Practical problems on union and intersection	9	-	-	9

II	Relation, function	Introduction, Cartesian product, Relations, Functions, Graphs of some special functions, graphical representation of linear inequalities in one and two variables and their solutions, trigonometric functions, domain and range of such functions	9	-	-	9
III	Principle of Mathematical Induction, Permutation, Combination	Introduction of PMI, Motivation, PMI, Fundamental Principle of Counting, Permutations, Combinations	9	-	-	9
IV	Complex numbers and quadratic equations	Introduction, Algebra of complex numbers, the Modulus and the Conjugates of a Complex number, Argand plane and Polar Representation, Quadratic equations, Square roots	9	-	-	9
V	Mathematical reasoning	Introduction, Statements, Negation of a statement, Compound statement, Special words "Or", "And", Implications If then, Only if, If and only if, Quantifiers, there exists, for all, truth table, equivalence of statements, Converse, Contrapositive, validating statements	9	-	-	9

Suggested Readings:

NCERT Mathematics Text Book for Standard XI

Additional Readings:

B S Vatssa, *Discrete Mathematics*, 3rd Edition, Vishwa Prakashan

Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are:

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Short answer type questions
- Long answer type questions
- Objective type questions
- Multiple choice questions
- Statement, reasoning and explanation

Linkage between Programme Outcomes (POs) and Course Learning Outcomes (COs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
CO1		√	√				√		
CO2		√	√	√					
CO3		√	√	√		√			
CO4		√	√				√		

Assessment methods

- Oral and written examination
- Closed book and open book tests
- Problem solving exercises
- Seminar and presentations
- Interactive sessions

SEC45MAT102(T)25 : Python Programming

Nature of Course	**SEC**			
Course Code	**SEC45MAT102(T)25**			
Course Title	**Python Programming**			
Course level	**100**			
Credit details	**Total Credit**	**Lecture/Week**	**Tutorial/week**	**Total Hour/Week**
	2	**2**	**0**	**2**
Course Audience	**BA/BSc Second Semester**			
Proposed by	**Board of Under-Graduate of Department of Mathematics, Manipur University**			
Pre Requisites	**Basic Computer Literacy**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization				

Detailed Syllabus Content

Unit	Unit Name	Detailed Syllabus	L	T	P	Total
I	Introduction to Python	Python Identifiers, keywords, and Indentation, data types: Int, float, Boolean, string, and list; variables, Operators, precedence of operators, expressions, statements, comments; modules, functions and their use, flow of execution, parameters and arguments	6	-	-	6
II	Control Statements	Branching, looping, break, continue, and pass, mutable and immutable structures. Testing and debugging a program	6	-	-	6
III	Functions	return values, parameters, local and global scope, exit function, function composition, and recursion	6	-	-	6
IV	Visualization using 2D and 3D graphics	Visualization using graphical objects like Point, Line, Histogram, Sine and Cosine Curve, and 3D objects	5	-	-	5
V	Data Structures	Built-in data structures: Strings, lists, Sets, Tuples, and dictionaries, and associated operations. Basic searching and sorting methods using iteration and recursion	5	-	-	5

SEC45MAT102(P)25 : Python Programming (Practical)

Nature of Course	**SEC**			
Course Code	**SEC45MAT102(P)25**			
Course Title	**Python Programming (Practical)**			
Course Level	**100**			
Credit Details	**Total Credit**	**Lecture/Week**	**Tutorial/Week**	**Total Hour/Week**
	1	**1**	**0**	**2**
Course Audience	**BA/BSc First Semester**			
Proposed by	**Board of Under-Graduate Studies of Department of Mathematics, Manipur University**			
Pre Requisites	**Basic Computer Literacy**			
Pre Requisite Course Required	**10+2 Mathematics**			
Faculty Eligibility and Specialization	**Master in Mathematics with Computer Programming knowledge**			

Course Objectives: This course is designed to introduce the student to the basics of programming using Python. The course covers the topics essential for developing well documented modular programs using different instructions and built-in data structures available in Python.

Course Learning Outcomes: After completion of the course, a student will be able to

1.	develop, document, and debug modular python programs to solve computational problems
2.	select a suitable programming construct and data structure for a situation
3.	use built-in strings, lists, sets, tuples and dictionary in applications
4.	define classes and use them in applications
5.	use files for I/O operations

Detailed Syllabus Content

Unit	Unit Name	List of Practical	L	T	P	Total
I	**Introduction to Python:**	1. Execution of expressions involving arithmetic, relational, logical, and bitwise operators in the shell window of Python IDLE. 2. Write a Python function to produce the outputs such as: a) * * * * * * * * * * * * * (b) 1 232 34543 4567654 567898765 3. Write a Python program to illustrate the various functions of the "Math" module.	-	-	3	3

		4. Write a function that takes the lengths of three sides: **side1**, **side2** and **side3** of the triangle as the input from the user using the **input** function and return the area of the triangle as the output. Also, assert that the sum of the length of any two sides is greater than the third side.				
II	Control Statements	5. Write a program to check whether a given number is positive, negative, or zero. 6. Write a program to check whether a person is eligible to vote. 7. Write a program to print even numbers from 1 to 50 using for loop. 8. Write a program to print numbers from 20 to 1 using for loop. 9. Write a program to count the vowels in a string given by user. 10. Write a program to find factorial of a number using While loop. 11. Write a program to calculate the GCD/LCM for two given number. 12. Write a program to calculate the sum of the first n natural numbers using for loop. 13. Write a program that calculates and prints the sum of cubes of even numbers up to a specified limit (e.g., 20) using a while loop 14. Write a program to print the sequence 1,2,3…n using do while loop 15.	-	-	3	3
III	**Functions:**	16. Write a Python function that takes a number as an input from the user and computes its factorial. 17. Write a Python function to return nth terms of the Fibonacci sequence 18. Write a function that takes a number with two or more digits as an input and finds its reverse and computes the sum of its digits. 19. Write a function that takes two numbers as input parameters and returns their least common multiple and highest common factor. 20. Write a function that takes a number as an input and determines whether it is prime or not. 21. Write a function that finds the sum of the terms of the following series: a) $1 - x^2/2! + x^4/4! - x^6/6! + \dots x^n/n!$ b) $1 + x^2/2! + x^4/4! + x^6/6! + \dots x^n/n!$ 22. Write a Python function that takes two strings as an input from the user and counts the number of MAThing characters in the given pair of strings.	-	-	3	3

		23. Write a Python function that takes a string as an input from the user and displays its reverse. 24. Write a Python function that takes a string as an input from the user and determines whether it is palindrome or not. 25. Write a Python function to calculate the sum and product of two compatible matrices 26. Write a function that takes a list of numbers as input from the user and produces the corresponding cumulative list where each element in the list present at index i is the sum of elements at index j <=i. 27. Write a function that takes **n** as an input and creates a list of n lists such that i^{th} list contains first five multiples of i. 28. Write a function that takes a sentence as input from the user and calculates the frequency of each letter. Use a variable of dictionary type to maintain the count. 29. Write a Python function that takes a dictionary of *word***:***meaning*pairs as an input from the user and creates an inverted dictionary of the form meaning: list-of-words.				
IV	Visualization using 2D and 3D graphics	30. Write a menu-driven program to create mathematical 3D objects Curve, Sphere, Cone, Arrow, Ring, and Cylinder. 31. Write a program that makes use of a function to accept a list of n integers and displays a histogram. 32. Write a program that makes use of a function to display sine, cosine, polynomial and exponential curves.			3	3
V	Data Structures	33. Write a function that reads a file **file1** and displays the number of words and the number of vowels in the file. 34. Write a Python function that copies the content of one file to another. 35. Write a function that reads a file **file1** and copies only alternative lines to another file **file2**. Alternative lines copied should be the odd numbered lines.			2	2

Suggested Readings:

1. **Downey, A.B.,** (2015), *Think Python–How to think like a Computer Scientist*, 3rd edition. O'Reilly Media.
2. **Taneja, S. & Kumar, N.,** (2017), *Python Programming-A Modular Approach*. Pearson Education.

Additional Readings:

1. **Brown, M. C.** (2001).*The Complete Reference: Python*, McGraw Hill Education.
2. **Dromey, R. G.** (2006), *How to Solve it by Computer*, Pearson Education.
3. **Guttag, J.V.** (2016), *Introduction to computation and programming using Python*. MIT Press.
4. **Liang,Y.D.** (2013), *Introduction to programming using Python*. Pearson Education.

Teaching Plan (SEC45MAT202(T)25: Python Programming-Theory)

Lecture 1: Python Identifiers, keywords, and Indentation, data types: Int, float,
Lecture 2: Boolean, string, and list; variables
Lecture 3: Operators, precedence of operators,
Lecture 4: expressions, statements
Lecture 5: comments; modules, functions, and their use
Lecture 6: flow of execution, parameters, and arguments
Lecture 7: if Statements with examples
Lecture 8: switch Statements with examples
Lecture 9: while loop with examples
Lecture 10: do while loop with examples
Lecture 11: for loop with examples
Lecture 12: break, continue, and pass, mutable and immutable structures.
Lecture 13: Functions: return values,
Lecture 14: Functions: parameters
Lecture 15: Local Scope with examples
Lecture 16: Global scope with examples
Lecture 17: exit function, function composition
Lecture 18: function recursion with examples
Lecture 19: Visualization using graphical objects like Point
Lecture 20: Visualization using line
Lecture 21: Visualization using histogram
Lecture 22: Sine and cosine curve
Lecture 23: Potting of 3D graph
Lecture 24: Built-in data structures: Strings, lists
Lecture 25: Concepts of Sets, Tuples with examples
Lecture 26: Concept of dictionaries, and associated operations
Lecture 27: Basic searching and sorting methods using iteration
Lecture 28: Basic searching and sorting methods using recursion

Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are:

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Short answer type questions
- Long answer type questions
- Objective type questions
- Multiple choice questions
- Statement, reasoning and explanation

Linkage between POs and COs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
CO1		√	√				√		
CO2		√	√	√					
CO3		√	√	√		√			
CO4		√	√				√		

Assessment methods

- Oral and written examination
- Closed book and open book tests
- Problem solving exercises
- Seminar and presentations
- Interactive sessions