SYLLABUS

DIBRUGARH UNIVERSITY

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME (FYIPGP)
[AS PER NEP 2020]
IN DIBRUGARH UNIVERSITY

MATHEMATICS

(Recommended by B.O.S. in Mathematics, D.U. in its meetings held on 09.02.2024 and approved by joint UG-PG Board meeting held on 6/06/2024 and passed by the Academic Council meeting held on 13/06/2024 and effective from the session 2024-25)

PREAMBLE

As recommended by the University Grants Commission (UGC) and proposed for implementation by Dibrugarh University, the Department of Mathematics works to implement the relevant components of New Education Policy (NEP), 2020 for Five Years Integrated Post Graduate Programmes (FYIPGP) under Choice Based Credit System (CBCS). The following facts are taken into consideration when designing the basic structure of the Post FYIPGP programme:

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

INTRODUCTION

The Five Years Integrated Post Graduate Programme (FYIPGP) syllabus of Mathematics in light of 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 FYIPGP degree programme offers certificates, diplomas and degrees as follows:

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

UG Diploma: Diploma course consists of eight Major disciplines, four Minor disciplines, three MDGEC, two AEC, three VAC, three SEC.

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

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

5-year PG Degree : 5-year PG degree course consists of twenty five Major disciplines, ten Minor disciplines, three MDGEC, two AEC, three VAC, three SEC, Community engagement (NCC/NSS/Adult Education/Student mentoring/ NGO/ Govt. Institutions, etc.), Internship, Research Ethics and Methodology, two Dissertation/ four DSE, Project/DSE.

AIM

The FYIPGP 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 FYIPGP 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, MATLAB, C 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. Also aims students' flexibility to move from one discipline to another, to move one institution to another, to switch alternative modes of learning.

Programme Educational Objectives (PEO):

PEO 1: Fundamental Knowledge and Skills

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.

PEO 2: Analytical and 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.

PEO 3: Application of Mathematics

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.

PEO 4: Communication and Collaboration

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.

PEO 5: Ethical and Professional Responsibilities

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.

PEO 6: Lifelong Learning and Adaptability

Graduates will pursue lifelong learning in order to keep up with new developments and trends in the mathematics and to adjust to the changing needs of both academia and the workforce.

PEO 7: Research and Innovation

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.

PROGRAMME OUTCOMES ARE GRADUATE ATTRIBUTES STATED AS FOLLOWS:

PO1: Disciplinary Knowledge

Being able to demonstrate comprehensive knowledge and coherent understanding of both the theoretical and applied components of mathematics as well as chosen interdisciplinary areas of study in a broad multidisciplinary context; ability to connect relevant disciplines, as well as recent innovations, with the learning disciplines of choice.

PO2: Communication Skills

Capability to express various mathematical ideas clearly through computational methods, graphical methods, examples and their geometrical representations; ability to use mathematics effectively as a precise language of communication in other fields; ability to pay close attention, read texts and research papers critically, and communicate complicated information clearly and concisely to a variety of organisations and audiences.

PO3: Moral and Ethical Awareness/Reasoning

Ability to recognise ethical issues that are pertinent to one's work and pledge not to engage in unethical behaviour such as plagiarism, copyright and infringement of intellectual property rights; ability to appreciate recent developments in various fields and one’s research with honesty and integrity in all aspects.

PO4: Multicultural Competence

Ability to corelate and compare recent developments in various branches of mathematics in a variety of organisations worldwide; ability to collaborate research in various fields of mathematics with other researchers from a variety of communities and organisations; ability to effectively participate in a multicultural group or society and interact politely with diverse groups, and the acquisition of knowledge of the values and beliefs of multiple cultures, and a global viewpoint to honour diversity.

PO5: Information/Digital Literacy

Ability to access, asses and utilize Information and Communications Technology (ICT) tools. Ability to understand, read and write programming language/packages/modules (MATLAB; C) for computation, simulation, graphs and solutions.

PO6: Reflective Thinking

An understanding of how a researcher or an investigator influences and shapes the information one creates; ability to formulate appropriate questions pertaining to the ideas in various branches of mathematics in order to propose new solutions using the domain knowledge of mathematics; ability to interpret the findings and use them to solve a variety of problems found in numerous fields of mathematics and real-life.

PO7: Cooperation/Team Work

Ability to collaborate with diverse teams in an effective and respectful manner; capacity to cooperate with people from varied backgrounds in the interests of a common goal.

PO8: Research Related Skills

The ability to formulate appropriate questions, problems, and hypotheses by analysing and interpreting the ideas from various branches of mathematics; ability to demonstrate the results, theories, techniques and proofs using the concepts of various fields of mathematics; ability to develop methodology and design research proposals.

PO9: Problem Solving

Ability to work independently and do in-depth study to find ways that mathematics is used in various industries and in daily life to improve job possibilities in a wide range of fields and academic study; ability to use innovative, imaginative, lateral thinking, interpersonal skills, and emotional intelligence; ability to tackle various challenges in both familiar and unfamiliar circumstances, then apply what they've learned to actual scenarios.

PO10: Critical Thinking

Capability to analyse and synthesise theoretical and applied problems, as well as acquire knowledge and skills through logical reasoning, analytical thinking and evaluations; ability to find gaps and logical faults in arguments; inculcate a healthy attitude to be a lifelong learner.

Programme Specific Outcomes:

The Programme Specific Outcomes of FYIPGP programme in Mathematics are listed in the following. After completing the programme the students will be able to-

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 MATLAB, C, 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.

Teaching Learning Process:

The outcome-based approach demands a considerable transition from teacher centric to learner centric pedagogies, as well as from passive to active/participatory pedagogies, especially in the context of undergraduate study. This course promotes the systematic and sequential acquisition of knowledge and skills. It also focuses on practical abilities, as well as an awareness of the link between theory and practice. Teaching strategies involve discussions, presentations, use of required textbooks, e-learning tools, other self-study materials; project, internship, exploring industrial needs and other research activities and so on.

Assessment Methods:

A variety of assessment procedures appropriate for the Mathematics discipline will be used to determine how well students are progressing keeping in view of the programme outcomes. Continuous evaluation will decide the final grade which include both in-semester evaluation and the final exam. In-semester evaluation will consist of class exams, mid-term exams, homework assignments, etc. as determined by the concerned teacher of the course of study. The following techniques will be used to evaluate how successfully students are meeting their goals: tutorials, timed exams, problem-based assignments, lab reports for practical assignments, observations of practical skills, individual project reports, team project reports, oral presentations, including seminar presentations, viva voce interviews, group discussions, quiz and so on.

STRUCTURE OF FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME (FYIPGP) AS PER NEP-2020 IN MATHEMATICS FOR DIBRUGARH UNIVERSITY

Semester	Course	Title of the Paper &Paper Code	Credit
I (FIRST)	**C-1**	Calculus and Classical Algebra	4
	Minor 1	Differential Calculus	4
	GEC-1	**(Any one)** • Foundation in Mathematics-I • History of Mathematics • Mathematics in Everyday Life	3
	AEC 1	AEC Language: MIL/ Regional Language	4
	SEC 1	Computer Laboratory-I	3
	VAC 1	Value Added Course 1	2
	Total Credit		**20**
II (SECOND)	**C-2**	Real Analysis & Differential Equation	4
	Minor 2	Real Analysis	4
	GEC 2	**(Any one)** • Foundation in Mathematics-II • Business Mathematics	3
	AEC 2	AEC: Language and Communication Skills (English) II	4
	SEC 2	Computer Laboratory-II	3
	VAC 2	Value Added Course 2	2
	Total Credit		**20**
III (THIRD)	**C-3**	Theory of Real functions	4
	C-4	Group Theory I	4
	Minor 3	Differential Equations	4
	GEC-3	**(Any one)** • Financial Mathematics • Combinatorial Mathematics	3
	SEC-3	Mathematical Logic	3
	VAC 3	Value Added Course 3	2
	Total Credit		**20**

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Calculus and Classical Algebra**
Course Code	**:**	**MTHC1**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisite:

- Ideal of fundamentals of differentiation and integration,
- Trigonometric and logarithmic functions,
- Arithmetic.

Course Objectives: The course will introduce to the learners the concept of De Moivre's Theorem and its application in the expansion of some trigonometric functions. Students will learn the techniques of successive differentiation, Leibnitz theorem, and L'Hospital rule for evaluation of limit. It will explain various types of reduction formula for integration of trigonometric function and applications in finding the volume and surface area of revolution of curve. The course will also introduce the system of linear equation and how to solve such systems.

Course outcomes: After completing the course a learner will be able to

CO1: Apply De'Moivre theorem to different problems.

ILO 1.1: Demonstrate the use of De'Moivre's theorem in raising complex numbers to powers and extracting roots.
ILO 1.2: Solve problems involving the trigonometric form of complex numbers using De'Moivre's theorem.

CO2: Discuss expansion of trigonometric and hyperbolic functions.

ILO 2.1: Derive the series expansions for sine, cosine, and hyperbolic sine, and cosine functions.
ILO 2.2: Analyze the convergence of trigonometric and hyperbolic function expansions.

CO3: Apply Leibniz theorem to obtain successive differentiation.

ILO 3.1: Utilize Leibniz's theorem to find higher-order derivatives of product functions.
ILO 3.2: Solve problems involving successive differentiation using Leibniz's rule.

CO4: Utilize L'Hospital rule in finding limit of quotient of functions.

ILO 4.1: Apply L'Hospital's rule to evaluate limits of indeterminate forms such as 0/0 and ∞/∞.
ILO 4.2: Analyze and solve problems involving limits where L'Hospital's rule is applicable.

CO5: Evaluate maxima and minima of functions.

ILO 5.1: Determine the critical points of a function and classify them as maxima, minima, or saddle points.
ILO 5.2: Apply the first and second derivative tests to find and verify local maxima and minima of functions.

CO6: Describe reduction formula involving both trigonometric and logarithmic functions

ILO 6.1: Develop reduction formulas for integrals involving trigonometric functions.
ILO 6.2: Apply reduction formulas to solve integrals involving logarithmic functions.

CO7: Evaluate length of curves and area & volume of revolution of curves.

ILO 7.1: Calculate the arc length of a given curve using integral formulas.
ILO 7.2: Evaluate the area and volume generated by rotating a curve around an axis using integral methods.

CO8: State well ordering property of positive integers and fundamental theorem of Algebra.

ILO 8.1: Explain the well-ordering property of positive integers and its implications.
ILO 8.2: State and apply the fundamental theorem of algebra in solving polynomial equations.

CO9: Apply Division and Euclidean Algorithm to find GCD.

ILO 9.1: Use the Division Algorithm to express the gcd of two integers as a linear combination.
ILO 9.2: Implement the Euclidean Algorithm to determine the greatest common divisor of two integers.

CO10: Describe congruence relation between integers.

ILO 10.1: Explain the concept of congruence relations and their properties.
ILO 10.2: Solve problems involving modular arithmetic using congruence relations.

CO11: Demonstrate row reduction and echelon form of matrix.

ILO 11.1: Perform row operations to transform a matrix into row echelon form.
ILO 11.2: Demonstrate the process of reducing a matrix to its reduced row echelon form.

CO12: Solve system of linear equations.

ILO 12.1: Apply matrix methods, such as Gaussian elimination, to solve systems of linear equations.
ILO 12.2: Utilize the inverse matrix method and Cramer's rule to find solutions to systems of linear equations.

Mapping of Cos with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO8	CO2	X	X	CO6	X
CONCEPTUAL	C10	X	CO3, CO11, CO12	X	CO5	X
PROCEDURAL	X	CO1, CO4	CO9	X	CO7	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	De Moivre's Theorem with rational indices and its applications, Expansion of sinx, cosx, sinhx and coshx and related problems.	09	03	-	12
II (10 Marks)	Successive Differentiation, Leibnitz Theorem and its application, L'Hospital's Rule, Applications of maxima & minima.	09	03	-	12
III (12 Marks)	Reduction Formulae of the types $\int \sin^n x dx, \int \cos^n x dx, \int \tan^n x dx, \int (\log x)^n dx$ and $\int \sin^m x \cos^n x dx$ and their derivations with definite integrals. Rectification, volume and surface area of revolution of a curve.	09	03	-	12
IV (12 Marks)	Composition of functions, well ordering property of positive integers, Division algorithm, Divisibility & Euclidean algorithm, GCD, LCM, Prime numbers, Congruence relation between integers, Statement of the Fundamental Theorem of Arithmetic.	09	03	-	12
V (16 Marks)	System of Linear Equations, Row Reduction and Echelon Form, Matrix equation $Ax = b$. Solution set of a linear system, Linear Dependence and Independence of vectors as elements of R^n.	09	03	-	12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Das B.C.& Mukherjee B.N., Higher Trigonometry, U N Dhur & Sons, 1933.
2. Thomas G.B. & Finney R.L., Calculus, Pearson Education, 2007.
3. Burton, D.M. Elementary Number Theory, McGraw Hill, 7th Ed., 2023.

REFERENCE BOOKS:

1. Arumugam S., Somasundaram A., & Isaac A.T., Differential Calculus, CBS Publishers, 2021.
2. Greenhill A.G., Differential and Integral Calculus, Alpha Edition, 2020.
3. Khanna V.K.& Bhambri S.K., Abstract Algebra, Vikash Publishing, 2017.
4. Lay David C., Lay S.R., & McDonald J.J., Linear Algebra and Its Application, Pearson, 2015.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	L	L	M	L	M	S	S
CO2	S	S	L	L	L	S	M	S	S	S
CO3	S	S	L	L	L	M	L	M	S	S
CO4	S	S	L	L	L	M	L	M	S	S
CO5	S	S	L	M	L	S	M	S	S	S
CO6	S	S	L	L	L	S	M	M	S	S
CO7	S	S	L	L	L	M	L	M	S	S
CO8	S	S	L	L	L	M	L	M	S	S
CO9	S	S	L	L	L	M	L	M	M	S
CO10	S	S	L	L	L	S	M	M	S	S
CO11	S	S	L	L	L	S	M	S	S	S
CO12	S	S	L	M	L	S	S	S	S	S

S= Strong. M= Medium, L= Low

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Differential Calculus**
Course Code	**:**	**MINMTH1**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Differential Calculus deals with the outline of basic concepts of differential calculus and its application in solving various problems.

COURSE OBJECTIVE:

The objectives of the course are

i. To introduce the important concept of calculus and their applications
ii. To apply Rolles theorem, mean value theorem etc. in various problems

Course Outcome:

Students will be able to

CO1: define limit, continuity and differentiability and solve the problems

ILO 1.1: Analyse the continuity and differentiability of a function

ILO 1.2: Use Leibinitz theorem to find the higher order differentiation of products of functions.

CO2: get the knowledge of partial differentiations and evaluate partial differentials

ILO 2.1: Evaluate the partial differentials of a function

ILO 2.2: Discuss and use Euler's theorem on homogeneous functions.

CO3: apply differential calculus in finding tangent, normal etc. and trace a curve

ILO 3.1: find the equation of tangent and normal of any curve

ILO 3.2: Use calculus to determine the curvature of a curve

ILO 3.3: Discuss the steps to trace a curve.

CO 4: analyse Rolle's theorem, mean value theorem etc. and interpret them

ILO 4.1: Give a geometrical interpretation of Rolle's theorem.

ILO 4.2: Construct the Taylor/ Maclaurin series of a given function.

ILO 4.3: Assess the maxima and minima of a function.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO1					
Conceptual Knowledge			CO1	CO4		
Procedural Knowledge	CO3		CO2		CO4	
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (13 Marks)	Limit and Continuity (ε- δ definition), Types of discontinuity, Differentiability of functions, Leibnitz's theorem.	09	03	-	12
II (13 Marks)	Successive differentiation. Partial differentiation, Euler's theorem on homogeneous functions.	09	03	-	12
III (17 Marks)	Tangents and normals, Curvature, Asymptotes, Singular points, Parametric and polar representation of curves, Tracing of curves.	12	04	-	16
IV (17 Marks)	Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(l+x)^m$, Maxima and Minima, Indeterminate forms.	15	05	-	20
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Anton H., Bivens I. & Davis S., Calculus, John Wiley and Sons Inc., 2002.
2. Thomas G.B. & Finney R.L., Calculus, Pearson Education, 2007.

REFERENCE BOOK:

1. Arumugam S., Somasundaram A., & Isaac A.T., Differential Calculus, CBS Publishers,

2021.

Mapping of Course Outcome to Program Outcome

CO/PO	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	M	S	S	M
CO2	S	S	M	M	M	M	M	S	S	M
CO3	S	S	M	M	M	M	M	S	S	M
CO4	S	S	M	M	M	M	M	S	S	M

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-I**
Course Code	**:**	**GECMTH1A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Foundation in Mathematics is a unique course to initiate the students to some fundamental topics of Mathematics. This course equips students with mathematical tools and techniques, the study of the logical and philosophical basis of mathematics, including whether the axioms of a given system ensure its completeness and its consistency. Topics include sets and logic, relation and functions, calculus and differential equations. This course prepares students for advanced studies in mathematical logic, calculus and their various applications by developing skills, strategies and reasoning needed to succeed in mathematics.

Pre-Requisites:

- Introduction to Sets and Logic.
- Basic concepts of calculus.
- Key concepts of relation and functions.

Course Objectives:

The course on Foundation in Mathematics-I aims the students to achieve in a more practical and definite ways. This sets the stage for more advanced mathematical concepts and real-world applications. The goal is to capture from specific and numeric reasoning to general and abstract reasoning using the language and structure of algebra to investigate, represent, and solve problems.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Interpret and communicate quantitative information and mathematical and statistical concepts.

ILO1.1: Achieve a solid understanding of using estimation skills and when to estimate results.

ILO1.2: Read, interpret, and make decisions about data summarized numerically.

ILO1.3: Demonstrate proficiency in using basic terminology and principles.

CO2: Understanding the fundamental concepts of logic and set theory and apply the knowledge to everyday matters.

ILO2.1: Analyze the logical structure of statements symbolically, including the proper use of logical connectives, predicates, and quantifiers.

ILO2.2: Evaluate the truth of a statement using the principles of logic.

ILO2.3: Properly use the vocabulary and symbolic notation of higher mathematics in definitions, theorems, and problems.

CO3: Explore how relations and functions are applicable in daily life.

ILO3.1: Identify and differentiate between reflexive, symmetric, transitive and equivalence relations.

ILO3.2: Define one-to-one and onto functions and apply them in real-life scenarios.

ILO3.3: Analyze and interpret real-life examples such as in social networks, transportation systems, etc.

CO4: Understand the foundation of calculus and its applications in mathematics and physics.

ILO4.1: Interpret equations and graphs of the basic classes of functions.
ILO4.2: Evaluate limits by using limit laws and other evaluation techniques.
ILO4.3: Apply differentiation to geometric application, physical application, and modelling problems.

CO5: Systematic approach for solving problems and finding solutions in various fields, from physics to finance.

ILO5.1: Recognise differential equations and use the appropriate method to solve them.

ILO5.2: Use an initial condition to find a particular solution of a differential equation.

ILO5.3: Solve problems involving exponential growth and decay.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		CO4
Procedural Knowledge			CO1, CO2	CO3	CO4	CO5
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (9 Marks)	**Sets and Logic** Statements, truth values, negation, quantifiers, connectives (conjunction, disjunction, conditional, biconditional). Converse and contrapositive of conditional statement. Equivalent statements, sets, subsets, types of set, operation on sets, Cartesian product.	06	03	-	9
II (17 Marks)	**Relation and Functions** Relation, types of relations, equivalence relation and class, partition of sets. Function, graph of functions, composition of functions and invertible functions, Images and pre-images of sets under a mapping.	08	04	-	12
III (17 Marks)	**Calculus** Limits, continuity, Differentiability of function, Derivatives of different types of functions, second order derivatives, rate of change of quantities, increasing and decreasing function, Maxima and Minima, introduction to integrals and its applications.	08	04	-	12
IV (17 Marks)	General and particular solutions of differential equations, separation of variables, Homogeneous equations, Linear Differential Equations of first order, General and particular solutions of homogeneous and non-homogeneous linear differential equations of second order with constant	08	04	-	12

	coefficients.				
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Kumar A., Kumaresan S., &Sarma, B.K., A Foundation Course in Mathematics, Narosa Publishing House, 2018.
2. Stewart I., Tall D., The Foundations of Mathematics. Oxford University Press, 2nd Ed., 2015.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong') and moderate ('Medium') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	M	S	M	M	S
CO2	S	S	S	S	S	M	M	S	S	M
CO3	S	S	S	S	S	M	M	S	S	M
CO4	S	M	S	S	S	M	S	M	S	S
CO5	S	M	S	S	S	M	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**History of Mathematics**
Course Code	**:**	**GECMTH1B**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The History of Mathematics course explores the development of mathematical concepts, theories, and practices from ancient civilizations to modern times. This course examines the contributions made by important historical eras and individuals to a variety of mathematical disciplines, including number theory, calculus, geometry, and algebra. The cultural and historical settings in which these mathematical concepts originated and developed will become more clear to the students. Students will understand mathematics' influence on science, technology, and society as well as its continuing influence on modern mathematical thought by exploring the discipline's historical development.

Pre-Requisites:

- Basic concepts of arithmetic operations.
- Introduction to geometry.

COURSE OBJECTIVE:

1. To develop a comprehensive understanding of the origins and development of mathematics in ancient India, medieval India, including the contributions of Hindu and Greek mathematicians.

2. To study the evolution of major mathematical concepts and theories in areas like algebra, geometry, calculus, and number theory.

3. To analyze how the technological, social, and cultural environments shaped the conceptualization of mathematics.

4. To gain an understanding of how mathematical discoveries have impacted society, science, and technology.

COURSE OUTCOME:

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

CO1: describe the development and significance of mathematics in ancient India, focusing on Hindu contributions and their historical context.

ILO1: Identify and describe significant mathematical contributions from ancient India, such as advancements in algebra, trigonometry, and arithmetic.

ILO2: Examine the cultural, religious, and intellectual environment in which Hindu mathematicians made their contributions.

ILO3: Highlight the lives and works of prominent Hindu mathematicians such as Aryabhata, Brahmagupta, and Bhaskara II.

ILO4: Explain how Hindu mathematical discoveries influenced later mathematical developments in India and other regions.

CO2: analyze the development of numeral systems, including the decimal place-value system, zero symbol, and various numerical notations in Hindu literature.

ILO1: Describe the progression from early numerical notations to the development of the decimal place-value system.

ILO2: Discuss the introduction and impact of the zero symbol and its role in the decimal place-value system.

ILO3: Explain how the Hindu numeral system, including the concept of zero, spread and influenced other cultures and mathematical systems.

ILO4: Analyze different numerical notations used in ancient Hindu texts and their applications.

CO3: apply Euclidean geometry principles by exploring Euclid's "Elements," including the Pythagorean Theorem and geometric algebra.

ILO1: Describe the foundational principles and axioms of Euclidean geometry as presented in Euclid's "Elements."

ILO2: Detail the Pythagorean Theorem and various proofs, including those found in Euclid's "Elements."

ILO3: Discuss how Euclid applied geometric methods to solve algebraic problems, demonstrating the concept of geometric algebra.

CO4: evaluate Archimedes' methods for estimating pi and his contributions to geometry.

ILO1: Explain the techniques Archimedes used to approximate the value of pi, including the method of exhaustion.

ILO2: Discuss key geometric discoveries and theories proposed by Archimedes, such as the area of a circle and the surface area of a sphere.

ILO3: Investigate how Archimedes' work in geometry and pi estimation influenced later mathematicians and the development of mathematics.

CO5: synthesize knowledge of arithmetic algorithms, geometry, linear congruences, sine tables, and Diophantine equations, tracing their development and transmission in ancient and medieval India.

ILO1: Describe important arithmetic algorithms, such as those for multiplication and division, used in ancient India.

ILO2: Detail how linear congruences were formulated and solved in ancient Indian mathematical texts.

ILO3: Examine the development of sine tables and their importance in the work of Indian mathematicians like Aryabhata.

ILO4: Investigate the techniques and algorithms used by Indian mathematicians to solve Diophantine equations and their impact on number theory.

ILO5: Explore how mathematical discoveries from ancient and medieval India were transmitted to other cultures and influenced global mathematics.

Cognitive Map of Course Outcomes with Bloom's Taxonomy:

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE		CO1	CO3		CO4	
CONCEPTUAL KNOWLEDGE	CO1		CO3	CO2	CO4	
PROCEDURAL KNOWLEDGE			CO3	CO2	CO4	
METACOGNITIVE KNOWLEDGE					CO5	

UNITS	CONTENTS	L	T	P	Total Hours
I (9 Marks)	A glimpse of ancient India; Hindus and mathematics; Scope and development of Hindu mathematics.	06	03	-	09
II (17 Marks)	Numeral terminology; The development of Numerical Symbol; The decimal place-value system; Persistence of the old system; Word numerals; Alphabetic notations; The zero symbol; The place-value notation in Hindu literature.	08	04	-	12
III (17 Marks)	Euclid: Introduction to the Elements; Book I and Pythagorean Theorem; Book II and Geometric Algebra. Archimedes; Estimating the values of pi. Ramanujan's view on Magic square.	08	04	-	12
IV (17 Marks)	Ancient and Medieval India: Arithmetic algorithms; Geometry; Linear congruence; Construction of Sine tables; Transmission to and from India. Diophantine Equations in Greece and India; Early Mathematics in India. Linear Equations in One and Two unknown. The Rule of three	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**

- Seminar presentation on any of the relevant topics
- Assignment
- Group Discussion
- Quiz
- Viva-Voce

TEXTBOOKS:

1. Datta B., Narayan Singh A., History of Hindu Mathematics (Part I), Gyan Publishing House, 2021.
2. Kartz Victor J., A History of Mathematics: An Introduction, Pearson, 2009.
3. Burton David M., The History of Mathematics: An Introduction, Mc Graw Hill, 2011.
4. Bigyanor Itihas (বিজ্ঞানৰ ইতিহাস) edited by J. Sarma, Dibrugarh University.

Mapping of Course Outcomes to Program Outcomes:

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong') and moderate ('Medium') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	M	M	M
CO2	S	S	M	M	L	M	M	M	M	M
CO3	S	S	M	M	L	S	M	M	S	S
CO4	S	S	M	M	L	M	M	M	S	S
CO5	S	S	M	M	L	S	M	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Mathematics in Everyday Life**
Course Code	**:**	**GECMTH1C**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course aims to equip students with practical mathematical skills and understanding that can be applied in daily life

Course Objectives:

1. To develop numeracy skill for everyday life.
2. To induce financial literacy for everyday use.
3. To develop the skill of measurement, estimation and interpretation for everyday use.

Course Outcomes (COs):

Students shall able to

CO1: Perform basic arithmetic operations (addition, subtraction, multiplication, division) with confidence.

ILO 1.1: Use simple mathematical tools like addition, subtraction etc to solve everyday real problems

ILO 1.2: Recognize and apply various strategies for mental arithmetic and estimation.

CO2: Apply concepts of fractions, decimals, and percentages in everyday contexts.

ILO 2.1: Understand place value and its implications for operations with numbers.

ILO 2.2: Recognize and apply mathematical concepts like fractions, percentage in real-world contexts

CO3: Calculate interest rates, loans, credit, and other financial products accurately. Gain the skills to manage personal finances, including budgeting, saving, and investing.

ILO 3.1: Understanding and calculating interest rates, loans, and investments.
ILO 3.2: Creating and analyzing budgets and financial plans.
ILO 3.3: Applying principles of risk and return in financial decision-making.

CO4: Define standard units of measurement for length, weight, volume, and temperature. Estimate measurements and quantities in practical situations. Convert between different units of measurement.

ILO 4.1: Understanding and applying concepts of shape, space, and measurement.
ILO 4.2: Solving problems involving area, volume, and other geometric properties.
ILO 4.3: Using geometric reasoning in fields such as architecture,

engineering, and art.

CO5: Collect, organize, and interpret data necessary for decision making in everyday life.

ILO 5.1: Interpret and analyze quantitative information

ILO 5.2 : Integrate mathematics with other disciplines, showing how mathematical principles apply across different fields of study

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		
Procedural Knowledge			CO1, CO2	CO3	CO4	
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (13 Marks)	Money: Interest, Present value and APR, Mortgage Repayments, Annuities, Investing, Personal Finance.	08	04	-	12
II (17 Marks)	Business Applications: Stock Control, Linear Programming, Transporting Goods, Jobs and people, Hierarchies in Large Organizations, Investing for profits.	08	04	-	12
III (17 Marks)	Social Sciences: Voting methods, Voting dilemmas, Simpson's paradox, False positives, Measuring inequality.	08	04	-	12
IV (13 Marks)	Computer Applications: Introduction, Pseudorandom numbers, Codes and ciphers, Search engine.	06	03	-	09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOK:

1. Haigh John, Mathematics in Everyday Life, 2nd edition, Springer Nature Switzerland AG, 2019.

Mapping of Course Outcomes to Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	M	M
CO2	S	S	S	S	S	M	M	S	S	M
CO3	M	S	S	M	S	S	M	S	S	M
CO4	M	M	S	S	M	S	S	S	S	S
CO5	S	M	S	S	S	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Computer Laboratory-I**
Course Code	**:**	**MTHS 1.1**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=6)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

This course provides an in-depth understanding of advanced mathematical concepts and techniques, with a focus on practical applications using Matlab or Mathematica. The course covers fuzzy sets, basic commands and operations in Matlab/Mathematica, solutions of algebraic equations, evaluation of mathematical expressions, techniques of sketching conics, and matrix operations. Students will engage in hands-on practical sessions to reinforce theoretical knowledge and develop problem-solving skills in real-world contexts.

Prerequisites

- Basic understanding of high school mathematics, including algebra, trigonometry, and calculus.
- Introductory knowledge of programming or computational tools is recommended.

Course Objectives

1. **Develop Mathematical Reasoning:** Enhance students' ability to reason mathematically and understand fundamental mathematical axioms.
2. **Comprehend and Expand Mathematical Concepts:** Enable students to comprehend and build upon basic and advanced mathematical concepts.
3. **Logical Analysis and Theorem Crafting:** Equip students with skills to analyze and craft logical arguments to substantiate mathematical theorems.
4. **Advanced Mathematical Knowledge:** Provide deep insights into various mathematical domains, including fuzzy sets and parametric curves.
5. **Problem-Solving Methodologies:** Master diverse problem-solving methodologies applicable to mathematical issues.
6. **Effective Communication:** Develop proficiency in communicating mathematical ideas with precision and clarity.
7. **Professional and Applied Mathematics Skills:** Enhance professional mathematical skills and gain expertise in specialized areas of applied mathematics.
8. **Computational and Research Skills:** Acquire necessary mathematical and computational skills for engaging in independent research.
9. **Real-Life Problem-Solving:** Prepare students to address real-life and complex mathematical problems using advanced techniques.
10. **Technical Report Preparation:** Train students to prepare clear and precise technical mathematical reports, such as dissertations and theses.

Course Outcomes (COs)

CO1: Demonstrate proficiency in using basic commands in Matlab/Mathematica to evaluate mathematical expressions and solve algebraic equations.

> **ILO1:** explain the function of basic commands in Matlab/Mathematica such as clc, help, clear, format, exit, linspace, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, and commands for trigonometric and inverse trigonometric functions.

ILO2: Apply basic commands in Matlab/Mathematica to evaluate mathematical expressions, including arithmetic operations, exponential and logarithmic functions, trigonometric functions, and computation of complex numbers.

CO2: Analyze graphs of various functions and polynomials using Matlab/Mathematica to understand their properties.

ILO1: Explain the use of graph plotting commands in Matlab/Mathematica, such as plot, title, legend, hold on, axis, grid on, figure, clf, and close all.

ILO2: Apply Matlab/Mathematica commands to plot and analyze graphs of various functions and polynomials, including linear, quadratic, exponential, logarithmic, trigonometric functions, and polynomials of degrees 4 and 5.

ILO 3: Analyze the Behavior of Various Functions

CO3: Utilize techniques for sketching conics and parametric curves using Matlab/Mathematica to explore their geometric properties.

ILO1: explain the use of commands in Matlab/Mathematica for sketching conics and parametric curves, such as ezplot, fplot, plot, and other relevant plotting functions.

ILO2: Apply Matlab/Mathematica commands to sketch and analyze the geometric properties of conics (e.g., ellipses, hyperbolas) and parametric curves (e.g., cycloids, epicycloids, hypocycloids).

CO4: Apply Matlab/Mathematica to obtain surfaces and volumes of revolution and perform matrix operations.

ILO1: Use Matlab/Mathematica to calculate and visualize surfaces and volumes of revolution for given functions.

ILO2: Utilize Matlab/Mathematica to perform matrix operations, including addition, multiplication, inversion, and transposition.

CO5: Interpret the procedural steps involved in using Matlab/Mathematica for various mathematical computations.

ILO1: Explain the procedural steps for performing basic mathematical computations in Matlab/Mathematica, such as evaluating expressions, solving equations, and plotting graphs.

ILO2: Demonstrate interpreting of the procedural steps for advanced mathematical computations in Matlab/Mathematica, including matrix operations, solving systems of equations, and performing calculus operations.

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge				CO2		
Procedural Knowledge		CO5	CO1, CO3, CO4			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I **(17 Marks)**	Basic commands of Matlab or Mathematica, Evaluation of different mathematical Expressions, Solutions of algebraic equation. **List of Practicals** 1. Basic commands of Matlab or Mathematica: clc, help, clear, format, exit, line space, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, commands for trigonometric and inverse trigonometric function, abs, exp, sqrt, log, log2, log10, mod, plot, title, legend, hold on, axis, grid on, figure, clf, close all. 2. Evaluation of arithmetic expression, exponential and logarithms, trigonometric functions, computation of complex numbers. 3. Solution of algebraic equation, simultaneous linear equations.	-	00	15x2	30
II **(13 Marks)**	Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **List of Practicals** 5. Plotting of graphs of function $e^{ax + b}$, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax +b), |ax + b| and to illustrate the effect of a and b on the graph. 6. Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.	-	00	07x2	14
III **(13 Marks)**	Techniques of sketching conics, polar equation of conics 1. Sketching parametric curves (E.g., Trochoid, cycloid, epicycloids, hypocycloid). 2. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, hyperbolic paraboloid using cartesian coordinates.	-	00	08x2	16
IV **(17 Marks)**	Surface and volume of revolution, polar equation of conics, Matrix operations. **List of Practicals** 1 Obtaining surface of revolution of curves. 2 Tracing of conics in Cartesian coordinates/ polar coordinates. 3 Matrix operations (addition, multiplication, inverse, transpose).	-	00	15x2	30
	Total			**45X2**	**90**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Pratap Rudra, Getting started with MATLAB: A quick Introduction for Scientist and Engineers, Oxford University Press, 2010.
2. Wolfram S., The Mathematica, Cambridge University Press, 2003.
3. Thomas G.B. & Finney R.L., Calculus, 9th Ed., Pearson Education, Delhi, 2005.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	S	M	S	S	S	S
CO2	M	S	S	M	S	S	S	S	S	S
CO3	M	M	S	S	S	M	S	S	S	S
CO4	M	M	M	S	S	M	S	S	S	S
CO5	M	M	M	S	S	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis and Differential Equations**
Course Code	**:**	**MTHC2**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Real Analysis & Differential Equations has two parts. The first part includes axioms of real number systems, review of the algebraic and order properties of the set R of real numbers. Sequences and their types with their convergence and divergence properties. The second part includes the various solution concepts of differential equations and their properties. The whole course is so designed that the students will learn the theories and concepts used in the real analysis and also the tools to solve differential equations.

Prerequisites:

- Introduction to Set Theory
- Calculus

Course Objectives:

The course on Real Analysis & Differential Equations is designed for the students to demonstrate theoretical knowledge and have problem solving skills on topics of Real Analysis & Differential Equations. The course will describe appropriate theorems, principles and concepts relevant to Real Analysis in the first section and Differential Equations in the second section. Both these sections provide a background for the study of mathematical analysis and also the application of differential equations in other branches of studies.

Course Outcomes (COs):

Students will be able to

CO1: Demonstrate the Algebraic, Order and the Completeness properties of the real numbers.

ILO1.1: List the algebraic and order properties of real numbers.

ILO1.2: Find supremum and infimum of sets.

ILO1.3: Describe Archimedean principle and its corollaries.

ILO1.4: Explain the properties of countable and uncountable sets.

CO2: Examine the convergence of real sequences and series.

ILO 3.1: Discuss the basic convergence properties of sequences and series.

ILO 3.2: Determine convergence and divergence of sequences and series.

ILO 3.3: Apply Archimedean principle in obtaining convergence of sequences and series.

CO3: Execute various solution concepts of differential equations

ILO 3.1: Classify the general, particular, explicit, implicit and singular solutions of differential equations.

ILO 3.2: Solve Exact differential equations, linear equations and Bernoulli equations.

ILO 3.3: Apply the solution methods of differential equations to solve problems.

CO4: Describe the solution techniques of homogeneous and non-homogeneous differential equations of second order

ILO 4.1: Solve homogeneous and non-homogeneous linear differential equations.

ILO 4.2: Solve Euler equations.

ILO 4.3: Solve differential equations using method of undetermined coefficients and method of variation of parameters.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO2	CO1, CO2				
Conceptual Knowledge		CO3	CO1,CO2	CO2		
Procedural Knowledge		CO3, CO4	CO1, C03, CO4	CO3, CO4		
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
	(A) Real Analysis				
I (13 Marks)	Review of Algebraic and Order Properties of R, -neighborhood of a point in R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Existence of greatest integer function, Density of Rational (and Irrational) numbers in R, Intervals, Nested interval theorem, Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets. Idea of finite sets, countable sets, uncountable sets and uncountability of R.	12	04	-	16
II (17 Marks)	Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence	12	04	-	16

	Criterion. Infinite series and its convergence, Cauchy Criterion.				
	(B) Differential Equations				
III (13 Marks)	Concepts and definition of 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 equation and Bernoulli equations, special integrating factors and transformations.	09	03	-	12
IV (17 Marks)	General solution of homogeneous equations of second order, principle of superposition for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Bartle R.G. & Sherbert D.R., Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore,2002.
2. Kumar A.& Kumarasen S., A Basic Course in Real Analysis, CRC Press, Reprint 2021.
3. Ross S.L., Differential Equations, 3rd Ed., John Wiley and Sons, India,2004.

REFERENCE BOOKS:

1. Thomas G.B. & Finney R.L., Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. Coddington E. A., An Introduction to Ordinary Differential Equation, Dover Publications, 1989.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	S	S	S
CO2	S	S	M	S	M	S	S	M	M	S
CO3	S	M	M	S	M	S	M	S	S	S
CO4	M	S	S	M	S	S	M	M	M	M

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis**
Course Code	**:**	**MINMTH2**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Real Analysis includes axioms of real number systems, sequence and series and their convergence. It is so designed that the students will learn the theories and concepts used in the real analysis. It also recognizes the contribution and impacts of real analysis in different areas of science.

Prerequisites:

- Introduction to Set Theory
- Calculus

Course Objectives:

The course on Real Analysis is designed for the students to demonstrate theoretical knowledge and have problem solving skills on topics of Real Analysis. The course will describe appropriate theorems, principles and concepts relevant to Real Analysis and provide a background for the study of Functional Analysis, Measure Theory, Topology, etc. It will deal with problems relevant to topics related to Real Analysis using ideas and techniques some of which are at the forefront of the discipline.

Course Outcomes (COs):

Students will be able to

CO1: Demonstrate the Algebraic, Order and the Completeness properties of the real numbers.

ILO1.1: List the algebraic and order properties of real numbers.

ILO1.2: Find supremum and infimum of sets.

ILO1.3: Deduce results as corollaries to the properties of the real numbers.

CO2: Examine the convergence of real sequences and series.

ILO2.1: Deduce Cauchy's convergence criterion and apply it to determine whether a sequence is convergent or not.

ILO2.2: Deduce monotone convergence theorem and apply it determine whether a sequence is convergent or not.

ILO2.3 Apply Archimedean principle in obtaining convergence of sequences.

CO3: Apply standard tests for convergence of sequences and series.

ILO 3.1: Describe Comparison test, Root test, Ratio test, Leibnitz's test of convergence.
ILO 3.2: Apply Comparison test, Root test, Ratio test, Leibnitz's test to determine whether a sequence is convergent or not.
ILO 3.3: Define absolute and conditional convergence with examples.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO2	CO1, CO2				
Conceptual Knowledge		CO3	CO1	CO1, CO3		
Procedural Knowledge		CO3	CO1, CO2, CO3			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (13 Marks)	Finite and infinite sets, countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.	09	03	-	12
II (17 Marks)	Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).	15	05	-	20
III (13 Marks)	Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, convergence of p-series, alternating series,	09	03	-	12
IV (17 Marks)	Comparison test, Root test, Ratio test, Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Kumar A. & Kumarasen S., A Basic Course in Real Analysis, CRC Press, Reprint, 2021.
2. Bartle R.G. & Sherbert D.R., Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore,2002.

REFERENCE BOOKS:

1. Fischer E., Intermediate Real Analysis, Springer Verlag,1983.
2. Ross K.A., Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	S	S	S
CO2	S	S	M	S	M	S	S	M	M	S
CO3	S	M	M	S	M	S	M	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-II**
Course Code	**:**	**GECMTH2A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, P=0, T=1)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Foundation in Mathematics is a unique course to initiate the students to some fundamental topics of Mathematics. This course equips students with mathematical tools and techniques, the study of the difference operator with their relation and interpolation of function for the set of tabulated points. Topics include counting principles, numerical and probability. This course prepares students for advanced studies by developing skills, strategies and reasoning needed to succeed in mathematics.

Pre-Requisites:

- Introduction to Permutation and Combination.
- Basic concepts of operators.
- Introduction to Probability.

Course Objectives:

The course on Foundation in Mathematics-II aims the students to achieve in a more practical and definite ways. This sets the stage for more advanced mathematical concepts and real-world applications. The goal is to capture from specific and numeric reasoning to general and abstract reasoning using the language and structure of algebra to investigate, represent, and solve problems.

Course Outcomes (Cos):

On successful completion of the course, the students will be able to

CO1: Apply systematic strategies to count possible outcomes.
ILO1.1. Apply counting principles in a fair and unbiased manner.
ILO1.2: Read, interpret, and make decisions about data summarized numerically.
ILO1.3: Evaluate skills for both academic and real-world problem solving.

CO2: Understanding the fundamental concepts of interpolation methods.
ILO2.1: Use of various interpolation methods, including linear, polynomial, and spline interpolation.
ILO2.2: Understand their applications and limitations.
ILO2.3: Evaluate the accuracy and sources of interpolation error.

CO3: Understand the basic concepts of probability, random variables.
ILO3.1: Concept of random variables and distinguish between discrete and continuous types.
ILO3.2: Calculate the expected value, and variance of random variables.
ILO3.3: Analyze and interpret uncertain or random phenomena in real-world situations.

CO4: Understand the foundation of economic models, market analysis, and final forecasting.
ILO4.1: Develop critical thinking and data literacy skills.

ILO4.2: Evaluate data critically, discerning between reliable and unreliable information.
ILO4.3: Make predictions based on statistical models.

CO5: Use moment generating functions to find moments.

ILO5.1: Apply probability models to real-world problems in fields.

ILO5.2: Construct and interpret confidence intervals for parameter estimates.

ILO5.3: Stochastic processes, statistical learning and actuarial science.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		CO5
Procedural Knowledge			CO1, CO2	CO3		CO5
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (17 Marks)	**Counting Principles** Sum and Product rule of counting, permutation and combination, multinomial theorem, Pigeon hole principle, inclusion-exclusion principle, set partitions.	08	04	-	12
II (17 Marks)	**Finite Differences and Interpolation** Introduction, forward difference operator, Operators E & D, backward differences, central differences, Newton' forward and backward interpolation formulae, Lagrange's interpolation formula.	10	05	-	15
III (17 Marks)	**Probability** Introduction to probability, Random experiment, event, axiomatic approach to probability, conditional probability, Multiple theorem on probability, Bayes' theorem (Statement Only with Applications), random variables and distributions.	08	04	-	12
IV (9 Marks)	**Statistics** Introduction to statistics, Measure of Central Tendency.	04	02	-	06

	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - 2**0 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Rao, G. S., Numerical Analysis. New Age International Publishers, 2003.
2. Berge, C., Principles of Combinatorics. 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.
5. Ross, S. M., Introduction to probability and statistics for engineers and scientists, Elsevier, 2021.

Mapping of Course Outcomes to Program Outcomes

This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong') and moderate ('Medium') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	M	S	M	M	S
CO2	S	S	M	S	S	S	M	S	S	M
CO3	S	S	S	S	S	S	M	S	M	M
CO4	S	M	S	S	M	S	S	M	S	S
CO5	S	M	S	S	S	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Business Mathematics**
Course Code	**:**	**MTHG 2B**
Nature of the Course	**:**	**Multi-Disciplinary Generic Elective Course (MDGEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Business Mathematics is a vital subject that equips students with mathematical tools and techniques used in business and finance. The course covers fundamental concepts such as matrices, calculus, and finance, with a focus on their applications in business scenarios. Topics include linear equations, functions, matrices, differential calculus, and financial mathematics. This course prepares students for advanced studies in finance, business, and economic challenges by honing their analytical and mathematical skills, which are required for a successful career in business.

Pre-Requisites:

- Introduction to Real Analysis.
- Basic concepts of matrices.
- Basic concepts of financial mathematics.

COURSE OBJECTIVE:

1. To develop a solid understanding of fundamental mathematical concepts, including algebra, calculus, and finance, and their relevance to business applications.
2. To develop mathematical skills to solve real-world business problems using linear equations, functions, and matrices.
3. To enhance computational skills in differential calculus to optimize business functions and analyze changes in business environments.
4. To develop analytical and problem-solving skills by working through practical business scenarios and mathematical models.
5. To enhance mathematical and analytical skills to prepare for further studies in business, finance, and economics.

COURSE OUTCOME:

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

CO1: apply matrix algebra, including calculating determinants, adjoints, and inverses, to solve simple business and economic problems.

ILO1: Compute the determinant of a matrix and explain how it can be used to determine the solvability of a system of linear equations in business applications.

ILO2: Calculate the adjoint of a given matrix and demonstrate its use in finding the inverse of the matrix for business problem-solving.

ILO3: Find the inverse of a matrix and use it to solve linear systems related to business and economic problems.

ILO4: Apply matrix operations such as addition, subtraction, multiplication, and inversion to model and solve business and economic problems.

CO2: analyze mathematical functions, including linear, quadratic, and polynomial, by applying the concepts of limits, continuity, and differentiation.

ILO1: Analyze the limits of linear, quadratic, continuity and polynomial functions in business contexts.

ILO2: Apply differentiation to linear, quadratic, and polynomial functions to determine marginal costs, revenues, and other rates of change in business scenarios.

ILO3: Apply differentiation techniques to solve optimization problems in business, such as maximizing profit or minimizing cost.

CO3: apply concepts of simple and compound interest, and different types of interest rates to perform compounding and discounting of sums.

ILO1: Apply the simple interest formula to determine interest amounts and total sums for different business investments and loans.

ILO2: Use the compound interest formula to calculate future values and present values of business investments and savings accounts.

ILO3: Calculate the compounded amount of investments over multiple periods using different interest rates.

CO4: formulate linear programming problems (LPP) based on business scenarios and sketch graphs of linear equations and inequalities.

ILO1: Define the decision variables and constraints for a given business problem to formulate a linear programming model.

ILO2: Express business constraints as linear inequalities and incorporate them into the linear programming model.

ILO3: Draw graphs of linear equations and inequalities to visually represent the feasible region of a linear programming problem.

CO5: evaluate and solve linear programming problems using graphical methods to find optimal solutions.

ILO1: Plot the feasible region of a linear programming problem on a graph based on the given constraints.

ILO2: Determine the coordinates of the corner points (vertices) of the feasible region and understand their significance in finding the optimal solution.

ILO3: Calculate the value of the objective function at each corner point to identify the optimal solution for the linear programming problem.

Cognitive Map of Course Outcomes with Bloom's Taxonomy:

This cognitive map aligns the key Course Outcomes (COs) with Bloom's Taxonomy across various knowledge dimensions. The map illustrates how each outcome engages different cognitive processes and types of knowledge, providing a comprehensive view of the educational objectives in the curriculum.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE			CO1, CO3		CO5	CO4
CONCEPTUAL KNOWLEDGE			CO1, CO3	CO2	CO5	CO4
PROCEDURAL KNOWLEDGE			CO1, CO3	CO2	CO5	
METACOGNITIVE KNOWLEDGE						

UNITS	CONTENTS	L	T	P	Total Hours
I (17 Marks)	**Matrices** Definition of a matrix. Types of matrices; Algebra of matrices. Calculation of values of determinants up to third order; Adjoint of a matrix; Finding inverse of a matrix through ad joint; Applications of matrices to solution of simple business and economic problems	08	04	-	12
II (17 Marks)	**Differential Calculus** Mathematical functions and their types – linear, quadratic, polynomial; Concepts of limit and continuity of a function; Concept of differentiation; Rules of differentiation – simple standard forms. Applications of differentiation – elasticity of demand and supply; Maxima and Minima of functions (involving second or third order derivatives) relating to cost, revenue and profit.	08	04	-	12
III (13 Marks)	**Basic Mathematics of Finance** Simple and compound interest, Rates of interest – nominal, effective and continuous – their inter relationships; Compounding and discounting of a sum using different types of rates.	08	04	-	12
IV (13 Marks)	**Linear Programming** Sketching of graphs of (i) Linear equation ax + by + c=0 and (ii) Linear inequalities. Formulation of linear programming problem (LPP). Graphical solution to LPP.	06	03		09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Vohra N.D., Business Mathematics and Statistics, McGraw Hill Education (India) Pvt. Ltd, 2012.
2. Singh J. K., Business Mathematics, Himalaya Publishing House, 2021.

REFERENCE BOOKS:

1. Mizrahi A., Sullivan M., Mathematics for Business and Social Sciences: Applied approach. Wiley and Sons, 1976.
2. Thukral J.K., Mathematics for Business Studies, Mayur Publications, 2009.

Mapping of Course Outcomes to Program Outcomes:
This table illustrates the alignment between the key Course Outcomes (COs) and the Programme Outcomes (POs), highlighting the significant ('Strong') and moderate ('Medium') contributions of each course outcome toward achieving the broader educational goals of the program.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	S	S	S	S	S
CO2	S	S	M	M	L	S	M	M	S	S
CO3	S	S	M	M	L	S	S	M	S	S
CO4	S	S	M	M	L	S	M	S	S	S
CO5	S	S	M	M	L	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Computer Laboratory-II**
Course Code	**:**	**MTHS 2.1**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=6)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

• Basic understanding of differential equations, calculus, and programming concepts.

Course Objectives:

The objectives of this course are:

- To model various real-life problems, such as exponential decay models, lake pollution models, etc., using MATHEMATICA/MATLAB/Open-source software.
- To plot recursive sequences and sequences of partial sums using MATHEMATICA/MATLAB.

Course Outcomes (COs)

CO1: Utilize modeling techniques to solve real-life problems such as exponential decay and lake pollution using MATHEMATICA/MATLAB.

ILO1: Explain the steps to model exponential growth and decay problems using MATHEMATICA/MATLAB.

ILO2: Apply modeling techniques to solve the lake pollution model and interpret the results.

CO2: Interpret recursive sequences and sequences of partial sums to understand their convergence properties.

ILO1: Use MATHEMATICA/MATLAB to plot recursive sequences and study their convergence.

ILO2: Interpret the behavior of sequences of partial sums to determine convergence or divergence.

CO3: Implement and study drug assimilation models and limited growth population models.

ILO1: Interpret drug assimilation into the blood using MATHEMATICA/MATLAB.

ILO2: Apply modeling techniques to limited growth population models and analyze the impact of harvesting.

CO4: Apply ecological and epidemiological models.

ILO1: Implement predatory-prey models and analyze the population dynamics.

ILO2: Utilize epidemic scenarios using MATHEMATICA/MATLAB and interpret the spread of disease.

CO5: Verify mathematical theorems and concepts through plotting and analysis.

ILO1: Explain MATHEMATICA/MATLAB to verify the Bolzano-Weierstrass theorem through plotting.

ILO2: Implement the convergence and divergence of sequences and series through visualizations.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create

Procedural Knowledge			CO1			
Conceptual Knowledge				CO2		
Procedural Knowledge			CO3			
Procedural Knowledge			CO4, CO5			
Procedural Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (17 Marks)	Introduction to compartmental model, exponential growth of population, exponential decay model, lake pollution model (case study of Lake Burley Griffin). **List of Practicals** 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).	-	00	15x2	30
II (9 Marks)	Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), limited growth of population, limited growth with harvesting. **List of Practicals** 1. Case of single cold pill and a course of coldpills. 2. Limited growth of population (with and without harvesting).	-	00	5x2	10
III (17 Marks)	Predatory-prey model, epidemic model of influenza, battle model. **List of Practicals** 1. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two preyone predator). 2. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers). 3. Battle model (basic battle model, jungle warfare, long range weapons).	-	00	10x2	20
IV (17 Marks)	Plotting recursive sequences, convergence sequences, convergent subsequences, divergent sequences and infinite series 1. Plotting of recursive sequences. 2. Study the convergence of sequences through plotting. 3. Verify Bolzano-Weierstrass theorem through	-	00	15x2	30

	plotting of sequences and hence identify convergent subsequences from the plot. 4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.				
	Total			**45X2**	**90**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

TEXTBOOKS:

1. Barnes B., Fulford Glenn R., Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and NewYork,2009.
2. Abell Martha L., Braselton James P., Differential Equations with MATHEMATICA, 3rd Ed., Elsevier AcademicPress,2004.

REFERENCE BOOK:

1. Edwards C.H.& Penny D.E., Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.

Mapping of Course Outcomes to Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	S	M	S	S	S	S
CO2	M	S	S	M	S	S	S	S	S	S
CO3	M	M	S	S	S	M	S	S	S	S
CO4	M	M	M	S	S	M	S	S	S	S
CO5	M	M	M	S	S	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Theory of Real Functions**
Course Code	**:**	**MTHC3**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisite: Basic idea of differential calculus

Course Objectives: The course aims to equip the learners with an in-depth knowledge of the theory of real functions. Idea of limit, continuity, uniform continuity, differentiability and their application will be discussed. Rolle's theorem and other mean value theorem will also be introduced. Maclaurin series and Taylor series will be applied to different problems.

Course Outcomes:

CO1: Evaluate limit of functions.

ILO 1.1: Calculate the limit of a function at a point using algebraic simplification and limit laws.

ILO 1.2: Analyze and solve problems involving limits of functions using epsilon-delta definitions.

CO2: Examine continuity and uniform continuity of functions.

ILO 2.1: Determine the continuity of a function at a point and on an interval using the definition of continuity.

ILO 2.2: Distinguish between continuity and uniform continuity and apply these concepts to various functions.

CO3: Solve problems involving Rolle's theorem.

ILO 3.1: State and prove Rolle's theorem, and apply it to find points where the derivative of a function is zero.

ILO 3.2: Solve problems involving Rolle's theorem to verify the existence of roots within a given interval.

CO4: Apply mean value theorem to inequalities.

ILO 4.1: State and prove the mean value theorem and use it to establish inequalities involving derivatives.

ILO 4.2: Apply the mean value theorem to solve problems related to the behavior of functions on closed intervals.

CO5: Discuss Taylor series with different forms of remainder.

ILO 5.1: Derive the Taylor series expansion of a function and identify different forms of the remainder term.

ILO 5.2: Analyze the error in approximation using Taylor series with different forms of the remainder.

CO6: Apply Maclaurin series and Taylor series to mathematical problems

ILO 6.1: Utilize Maclaurin series to approximate functions and solve related mathematical problems.

ILO 6.2: Apply Taylor series to approximate functions and solve practical problems, considering the remainder term for accuracy.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	X	X	X	CO2	X	X
CONCEPTUAL	X	X	CO3, CO4	X	X	X
PROCEDURAL	CO5	X	CO1, CO6	X	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (13 Marks)	Limit of a function, Sequential Criterion of limits, Divergence criteria, Limit theorems & their applications. Infinite Limits and limits at infinity and statements of the related theorems.	06	02	-	08
II (13 Marks)	Continuous Functions and sequential criterion of continuity and discontinuity. Algebra of continuous functions & their application to problems, Continuity on an interval, Bolzano theorem, intermediate value theorem, Location Root Theorem, Preservation of interval theorem. Uniform Continuity, Statement of non-uniformity criteria, Uniform Continuity Theorem.	09	03	-	12
III (17 Marks)	Differentiability of a function at a point and in an interval, Caratheodory's Theorem, Algebra of differentiable functions and their applications. Relative Extrema, Interior Extremum Theorem. Rolle's Theorem, Mean Value Theorems, Darboux's Theorem, Application of Mean Value Theorem to inequalities	15	05	-	20
IV (17 Marks)	Taylor's Theorem with Lagrange's form of remainder & Cauchy's form of remainder, Application of Taylor's theorem to convex function. Taylor & Maclaurin series and their applications to simple problems.	15	05	-	20
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
    - Seminar presentation on any of the relevant topics
    - Assignment
    - Group Discussion
    - Quiz
    - Viva-Voce

TEXTBOOKS:

1. Bartle R. G. & Sherbert D. R., Introduction to Real Analysis, 4th Ed., Wiley, 2021
2. Kumar A., Kumaresan S., A Basic Course in Real Analysis, Taylor & Francis Group, 2014.

REFERENCE BOOKS:

1. Fitzpatrick P. M., Advance Calculus, 2nd Edition, AMS Indian Edition, 2010
2. Fischer E., Intermediate Real Analysis, Springer Verlag, 1983.
3. Ross K.A., Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag,2003.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	M	L	S	M	S	S	S
CO2	S	S	L	M	L	S	M	S	S	S
CO3	S	S	L	M	L	S	M	S	S	S
CO4	S	S	L	M	L	S	M	S	S	S
CO5	S	S	L	M	L	S	M	S	S	S
CO6	S	S	L	M	L	S	M	S	S	S

S= Strong. M= Medium, L= Low

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Group Theory I**
Course Code	**:**	**MTHC4**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisites: Set theory and basic knowledge of Arithmetic.

Course Objectives: The course intends to introduce to the learners the abstract structure called group. Besides various examples of group the learners will deal with different groups like abelian group, cyclic group, normal subgroup, quotient group. Important theorems like Lagrange's theorem, Caley's theorem, isomorphism theorems will also be discussed at length. Construction of new group from existing ones, viz., quotient group, direct product of groups is an important objective of this course.

Course Outcomes:

CO1: Identify groups like Klein 4-group, symmetric group, Dihedral group.

ILO 1.1: Recognize and describe the structure and properties of the Klein 4-group.

ILO 1.2: Identify and analyze the elements and properties of symmetric and dihedral groups.

CO2: State Lagrange's theorem, isomorphism theorems, fundamental theorem of Abelian groups.

ILO 2.1: State and explain Lagrange's theorem and its implications in group theory.

ILO 2.2: Describe the isomorphism theorems and the fundamental theorem of Abelian groups, providing examples of each.

CO3: Analyze permutation group.

ILO 3.1: Describe the structure and properties of permutation groups, including cycle notation and transpositions.

ILO 3.2: Solve problems involving the properties and operations of permutation groups.

CO4: Apply Lagrange's theorem to examine divisibility of a group by a subgroup.

ILO 4.1: Use Lagrange's theorem to determine the possible orders of subgroups within a finite group.

ILO 4.2: Apply Lagrange's theorem to analyze and solve problems involving the divisibility of the order of a group by the order of its subgroups.

CO5: Construct quotient group from a group and a normal subgroup.

ILO 5.1: Define and construct quotient groups given a group and a normal subgroup.

ILO 5.2: Demonstrate the process of forming quotient groups and solve related problems.

CO6: Solve problems applying properties of isomorphism.

ILO 6.1: Identify and prove isomorphisms between groups using the properties of group homomorphisms.

ILO 6.2: Solve problems involving group isomorphisms, including determining if two groups are isomorphic.

CO7: Explain direct product of groups.

ILO 7.1: Define and construct the direct product of two groups, explaining the resulting group's structure and properties.

ILO 7.2: Solve problems involving the direct product of groups and analyze its properties in various contexts.

Mapping of COs with Bloom's Taxonomy.

COGNITIVE KNOWLEDGE DIMENSION	COGNITIVE PROCESS DIMENSION					
	REMEMBERING	UNDERSTANDING	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL	CO1, CO2	X	X	X	X	X
CONCEPTUAL	X	X	CO6	CO3	X	CO5
PROCEDURAL	X	CO4, CO7	X	X	X	X
METACOGNITIVE	X	X	X	X	X	X

UNITS	CONTENTS	L	T	P	Total Hours
I (13 Marks)	Symmetries of equilateral triangle and square, definition and examples of groups, elementary property of groups, abelian groups, subgroups, centralizer and center of groups.	09	03	-	12
II (10 Marks)	Order of an element, cyclic groups, permutation group and Dihedral groups.	09	03	-	12
III (13 Marks)	Cosets, Lagrange's theorem and its applications, Normal subgroup, Quotient groups.	09	03	-	12

IV (12 Marks)	Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.	09	03		12
V (12 Marks)	External direct product, Internal direct product, Statement of fundamental theorem of abelian groups, classification of finite abelian groups.	09	03		12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

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

- Describe various group structures onsets.
- Identify the group structures present in different branches of sciences.

TEXTBOOKS:

1. Gallian J.A., Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, NewDelhi,1999.
2. Fraleigh J. B., A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

REFERENCE BOOKS:

1. Dummit D.S. & Foote R. M., Abstract Algebra 3rd Ed., Wiley, 2011.
2. Rotman J. J., An Introduction to the Theory of Groups, 4th Ed., Springer Verlag,1995.
3. Herstein, I.N., Topics in Algebra, Wiley, India, 2006.

Mapping of Course outcome to Programme outcome.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	M	L	S	M	S	S	S
CO2	S	S	L	M	L	S	L	M	S	S
CO3	S	S	M	M	L	S	L	S	S	S
CO4	S	S	M	M	L	S	L	S	S	S
CO5	S	S	M	M	L	S	L	S	S	S
CO6	S	S	M	M	L	S	M	S	S	S
CO7	S	S	M	M	L	S	M	S	S	S

S= Strong. M= Medium, L= Low

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Differential Equations**
Course Code	**:**	**MINMTH3**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Differential Equation focuses on the various methods for solving ODE and PDE.

COURSE OBJECTIVE:

The objectives of the course are

i. To introduce the concept of differential equations, mathematical modelling and their application
ii. To explain the solution techniques of ODE and PDE.
iii.

Course Outcome:

Students will be able to

CO1: understand exact differential equation and solve them

ILO 1.1: Construction of integrating factor.

ILO 1.2: Determine the solution of exact differential equations.

CO2: Explain the basic theory of linear differential equation, Wronskian and its properties.

ILO 2.1: Use of Wronskian in solving the differential equation

ILO 2.2: Discuss methods for solving higher order differential equations.

ILO 2.3: Solve the differential equations of first order and higher degree.

CO3: distinguish various techniques for solving linear homogeneous and non-homogeneous differential equations

ILO 3.1: discuss CF and PI in solving differential equations

ILO 3.2: Explain method of variation of parameter in solving differential equation and apply it.

ILO 3.3: give the significance of total differential equation

CO 4: introduce PDE and understand basic techniques of solving PDE

ILO 4.1: Construction of PDE

ILO 4.2: Differentiate various techniques of solving PDE

CO 5: Classify second order PDE

ILO 5.1: techniques of classification of PDE

ILO 5.2: Examples of elliptic, parabolic and hyperbolic PDE.

Cognitive Map

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						CO1, CO4
Conceptual Knowledge	CO5	CO4	CO3			
Procedural Knowledge						
Metacognitive Knowledge		CO2				

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	First order exact differential equations. Integrating factors, rules to find an integrating factor.	09	03	-	12
II (13 Marks)	First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.	09	03	-	12
III (12 Marks)	Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.	09	03	-	12
IV (13 Marks)	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	09	03		12
V (10 Marks)	Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.	09	03		12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - 2**0 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz

- Viva-Voce

TEXTBOOKS:

1. Ross S. L., Differential Equations, 3rd Ed., John Wiley and Sons,1984.

2. Boyce, W. E. and DiPrima, R. C., Elementary Differential Equation and Boundary Value Problems, 7th Edition, John Wiley & Sons (Asia), 2001.

REFERENCE BOOKS:

1. Sneddon I.N., Elements of Partial Differential Equations, McGraw-Hill, International Edition, 1967.
2. Raisinghania M.D., Ordinary and Partial Differential Equations, 19thEd., S. Chand and Company, 2020.

Mapping of Course Outcome to Program Outcome

CO/PO	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	M	S	S	S
CO2	S	S	M	M	S	M	M	S	S	S
CO3	S	S	M	M	S	M	M	S	S	S
CO4	S	S	M	M	s	M	M	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Mathematical Finance**
Course Code	**:**	**GECMTH3A**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Aim: The main motive of this course is to give students a basic introduction to finance and the applications of mathematics to it. The course focuses on the mathematical properties and relations between concepts of financial markets in investment and other economic activities. In the era of mathematical modelling being used in understanding stock market behaviour and large dynamic data, this introductory course in Mathematics of finance is well placed to prepare students interested in choosing a career in the field of mathematical finance.

Prerequisites:

(a) Basic Mathematical skills taught upto the 10+2 level.

Course Outcomes (COs):

Students will be able to

CO 1**:** Apply basic mathematical tools (functions, equations, inequalities) to construct and analyze economic models of markets including Supply and demand relationships, Market equilibrium conditions and the impact of government interventions (e.g., excise taxes) on market. outcomes.

ILO 1.1: Form economic models of markets using functions, equations, and inequalities.

ILO1.2: Calculate the future value of investments considering interest rates and compounding intervals.

ILO 1.3: Explain the impact of different compounding frequencies on investment growth.

CO 2: Analyze the stability of market equilibrium using the Cobweb model and its economic interpretations.

ILO 2.1: Identify the key factors influencing the stability of market equilibrium in the Cobweb model (e.g., slope of supply and demand curves).

ILO 2.2: Explain the economic interpretation of the Cobweb model's results, including its implications for real-world markets.

CO3: Apply the concept of the derivative to analyze and solve economic problems related to **Demand and Elasticity,** Production and Cost, **Market Structures, Firm Efficiency and Growth.**

ILO 3.1: Define key economic concepts like elasticity of demand, marginal cost, marginal revenue, and economic profit.

ILO 3.2: Utilize derivatives to calculate elasticity coefficients and interpret them to understand consumer behaviour.

ILO 3.3: Apply derivative analysis to identify production levels that maximize profit for firms.

ILO 3.4: Analyze the impact of market structures on pricing and output decisions using derivative tools.

ILO 3.5: Determine startup and breakeven points for firms using cost functions and derivative analysis.

CO4: Apply fundamental mathematical concepts and financial theories to analyze investment opportunities, make informed investment decisions, and evaluate financial instruments.

ILO 4.1: Utilize the time value of money concepts (present value, future value, internal rate of return) to assess the cash flow implications of various investment options.

ILO 4.2: Differentiate between pricing, hedging, and pure investment strategies and apply appropriate techniques for each, considering risk aversion and market conditions.

ILO 4.3: Demonstrate the characteristics, and risks associated with different investment instruments in the market for future cash, such as savings deposits, money market instruments, and various types of bonds, using metrics like yield and duration.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1,CO2		CO1, CO2			
Conceptual Knowledge		CO3	CO1, CO2	CO2, CO3		
Procedural Knowledge		CO3, CO4	CO1, CO3			
Metacognitive Knowledge						

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Mathematical models in economics: Introduction, A model of the market, Market equilibrium, Excise tax. The elements of finance: Interest and capital growth, Income generation, The Interval of compounding.	06	03	-	09
II (12 Marks)	The Cobweb model: How stable is market equilibrium? An example, The general linear case, Economic interpretation.	06	03	-	09
III (12 Marks)	The derivative in economics: Elasticity of demand, profit maximization, Competition versus monopoly, The efficient small firm, startup and breakeven points.	06	03	-	09

IV (12 Marks)	Introduction to investment Science: Cash flow, investment and markets, comparison principle, arbitrage, risk aversion. Typical investment problems: Pricing, Hedging, pure investment.	06	03		09
V (12 Marks)	Basic theory of interest: Principal and interest, compound interest, compounding at various intervals, continuous compounding, present value, present and future values of streams, internal rate of return, Evaluation criteria. The market for future cash: Savings deposits, money market instruments, various bonds, Bond details, Yield, duration, Macaulay duration.	06	03		09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

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

- apply models to financial mathematics/industries
- ability to use mathematical tools to market economy.

TEXTBOOKS:

1. Anthony M. & Biggs N., Mathematics for Economics and Finance: Methods and Modelling, Cambridge University Press: Reprinted 2009.
2. Chiang A. C. & Wainwright K., Fundamental Methods of Mathematical Economics, 4th Ed., McGraw Hill Education, 2017.

REFERENCE BOOKS:

1. Luenberger David G., Investment Science, Stanford University: 1998.
2. Ross S., An elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.

Mapping of Course Outcomes to Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	M	S	S	S
CO2	S	S	M	S	M	S	S	M	M	S
CO3	S	M	M	S	M	S	M	S	S	S
CO4	M	S	S	M	S	S	M	M	M	M

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Combinatorial Mathematics**
Course Code	**:**	**MTHG 3B**
Nature of the Course	**:**	**Multi-Disciplinary Generic Elective Course (MDGEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

Combinatorial Mathematics course covers a range of fundamental concepts and techniques used in combinatorics, as well as their applications in various fields.

Prerequisites:

- Basics of Set Theory

Course Objectives:

1. To develop problem-solving skills and logical thinking required for tackling combinatorial problems.
2. To enhance the ability to construct rigorous mathematical proofs, including combinatorial proofs and inductive reasoning.
3. To equip with a toolkit of methods and techniques that are widely applicable in various scientific and engineering disciplines.

Course Outcomes (COs):

Students will be able to

CO1: Apply basic counting principles such as the rule of sum, rule of product, principles of inclusion-exclusion, permutations, and combinations.

ILO 1.1: Define and explain key combinatorial concepts, including sets, permutations, and combinations.

ILO 1.2: Apply basic counting principles and principles of inclusion-exclusion

CO2: Investigate properties and applications of combinatorial structures such as partitions, permutations, and derangements. Solve problems involving the binomial theorem and Pascal's triangle.

ILO 2.1: Calculate permutations and combinations in various contexts, including those with repetitions and restrictions.

ILO 2.2: Write detailed solutions and proofs for combinatorial problems, demonstrating a thorough understanding of the concepts.

CO3: Solve problems using recurrence relations and generating functions.

ILO 3.1: Formulate and solve problems involving recurrence relations.

ILO 3.2: Utilize generating functions to approach and solve counting problems.

CO4: Apply advanced topics like Pólya's enumeration theorem and Burnside's lemma.

ILO 4.1: Understand and apply advanced topics such as Pólya's Enumeration Theorem and Burnside's Lemma to solve counting problems involving symmetries.

ILO 4.2: Use combinatorial reasoning to ensure the correctness and efficiency of solutions.

CO5: Construct combinatorial designs such as balanced incomplete block designs (BIBD) and Latin squares.

ILO 5.1: Understand and apply concepts of combinatorial design, including block designs and Latin squares.

ILO 5.2: Develop and employ strategies for solving complex combinatorial problems

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO3	CO5		
Procedural Knowledge			CO1, CO2	CO3	CO4	
Metacognitive Knowledge					CO5	

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (12 Marks)	Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers	06	03	-	09
II (12 Marks)	Principle of Inclusion and Exclusion, Derangements, Inversion formulae	06	03	-	09
III (12 Marks)	Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.	06	03	-	09

IV (12 Marks)	Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.	06	03	-	09
V (12 Marks)	Integer partitions, Systems of distinct representatives. Polya theory of counting: Necklace problem and Burnside's lemma, Polya's theorems and their immediate applications	06	03	-	09
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - 2**0 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

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

- Use combinatorial approach in solving algebraic problems
- Explain counting principles.

TEXTBOOK:

1. Balakrishnan V. K., Introductory Discrete Mathematics, Dover Publications Inc., 2000.

REFERENCE BOOKS:

1. Lint J.H. van & Wilson R.M., A Course in Combinatorics, 2nd Ed., Cambridge University Press,2001.
2. Krishnamurthy V., Combinatorics, Theory and Applications, East-West Press 2008.
3. Brualdi R.A., Introductory Combinatorics, 5th Ed., Pearson Education Inc., 2009.
4. Cameron P. J., Combinatorics, Topics, Techniques, Algorithms, Cambridge University Press, 1995.

Mapping of Course Outcomes to Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	M
CO2	S	S	S	S	S	M	M	S	S	M
CO3	M	S	S	M	S	S	M	S	M	S
CO4	M	M	S	S	M	S	S	S	S	S
CO5	S	M	S	S	S	S	S	S	S	S

FIVE YEARS INTEGRATED POST GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Mathematical Logic**
Course Code	**:**	**MTHS 3.1**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Course Description:

The course on Mathematical Logic aims to provide students with a solid foundation in the principles and applications of formal logic. It covers key topics such as propositional logic, predicate logic, and the formalization of logical arguments. The course also includes an introduction to set theory and its role in logic, as well as an examination of relations, partitionsand partial ordered relation.

Course Objectives:

- To develop the ability to apply logical reasoning to solve complex problems inmathematics and computer science, enhancing their analytical and critical thinking skills through exercises and real-world applications.
- To be proficient in formal logical reasoning and prepared to engage in further study or professional work that involves mathematical logic.

Course Outcomes (COs):

Student will be able to

CO1: Understand Fundamental Concepts

ILO 1.1: Define and explain key concepts in mathematical logic, including propositions, logical connectives, truth tables, and logical equivalence.

ILO 1.2: Understand and explain the structure and elements of formal proofs, including axioms, theorems, lemmas, and corollaries.

CO2: Apply Propositional Logic

ILO 2.1: Construct and analyze truth tables for various logical statements.

ILO 2.2: Apply rules of inference and logical equivalences to simplify and manipulate logical expressions.

ILO 2.3: Use propositional logic to prove the validity of arguments.

CO3: Understand and Apply Predicate Logic

ILO 3.1: Define and explain the elements of predicate logic, including predicates, quantifiers, and domains of discourse.

ILO 3.2: Translate statements between natural language and predicate logic notation.

ILO 3.3: Apply rules of inference in predicate logic to prove the validity of arguments.

CO4: Analyze Logical Systems and Proof Techniques

ILO 4.1: Understand and apply various proof techniques, including direct proof, proof by contradiction, and proof by induction.

ILO 4.2: Analyze and construct formal proofs in both propositional and predicate logic.

ILO 4.3: Understand the concepts of consistency, completeness, and soundness in logical systems.

CO5: Develop Problem-Solving Strategies

ILO 5.1: Develop and implement strategies for solving complex problems in mathematical logic.

ILO 5.2: Use logical reasoning to analyze and solve problems in various mathematical contexts.

Cognitive Map of Course Outcomes with Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO2				
Conceptual Knowledge		CO1, CO2	CO4	CO5		
Procedural Knowledge			CO1, CO2	CO3	CO4	
Metacognitive Knowledge						CO5

UNITS	**CONTENTS**	**L**	**T**	**P**	**Total Hours**
I (21 Marks)	Introduction, statements, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.	10	05	-	15

II (21 Marks)	Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.	12	06	-	18
III (18 Marks)	Relation: Cartesian Product set, relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial order relations, n-array relations.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- One Internal Examination - **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce

LEARNING OUTCOMES:

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

- Analyze the truth and falsity of a logical statement.
- Differentiate between a logical statement and an ordinary statement.
- Define and describe various properties of sets.

TEXTBOOK:

1. Kumar A., Kumaresan S., Sarma B. K., A Foundation Course in Mathematics, Alpha Science International, 2017.

REFERENCE BOOKS:

1. Srivastava S.M., A Course on Mathematical Logic, Springer, 2012
2. Halmos P.R., Naive Set Theory, Springer,1974.
3. Kamke E., Theory of Sets, Dover Publishers,1950.
4. Grimaldi R.P., Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.

Mapping of Course Outcomes to Program Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	M	M
CO2	S	S	S	S	S	M	M	S	S	M
CO3	M	S	M	M	S	S	M	S	S	M
CO4	M	M	S	S	M	S	S	S	S	S
CO5	S	M	S	S	S	S	S	S	S	S

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