UNIVERSITY OF CALCUTTA

NotificationNo.CSR/13/2023

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.07.2023 approved the Syllabi of the under mentioned subjects for semester wise Four-year (Honours & Honours with Research) / Three-year (Multidisciplinary) programme of U.G. courses of studies, as applicable under CCF,2022 . under this University, as laid down in the accompanying pamphlet.

Name of Subject:

1.Anthropology
2.BBA
3.Bengali
4.BFAD
5.Bio Chemistry
6.Botany
7.Chemistry
8.Commerce
9.Economics
10.Education
11.English
12.Geology
13.Hindi
14.History,Islamic History & Culture
15.Home Science
16.Human Rights
17.Journalism & Mass Communication
18.Mathematics
19.Microbiology (Honours)
20.Molecular Biology
21.Philosophy
22.Physiology
23.Political Science
24.Psychology
25.Social Science
26.Sociology
27.Urdu
28.Women's Studies
29.Zoology

The above shall be effective from the academic session 2023-2024.

12/7/2023

SENATE HOUSE

KOLKATA-700 073

Prof.(Dr.) Debasis Das

Registrar

SYLLABUS
FOR
FOUR -YEAR (EIGHT-SEMESTER) B.SC. DEGREE COURSE IN MATHEMATICS
UNDER THE UNIVERSITY OF CALCUTTA

Odd Semester: July to December

Even Semester: January to June

Syllabus for the 4 Year B.Sc. course in Mathematics effective from the academic year **2023-2024.**

COURSE STRUCTURE-CCF

	DSC/ Core	Minor (m1 & m2)	IDC/MDC	AEC	SEC	CVAC	Summer Internship	Dissertation/ Research work	Total Credit
Semester	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3= 3	(1x4= 4)+(1x8= 8)= 12	172
1	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
2	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
3	2x4= 8 2x(3TH+1P/TU)	1x4= 4 (m2) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4				21
4	4x4= 16 4x(3TH+1P/TU)	1x4= 4 (m2) 3TH+1P/TU		1x2= 2 2TH +0P/TU					22
5	4x4= 16 4x(3TH+1P/TU)	m1+m2 2x4= 8 2x(3TH+1P/TU)							24
6	3x4= 12 3x(3TH+1P/TU)	2x4= 8 m1+m2 2x(3TH+1P/TU)					1x3		23
7	4x4= 16 4x(3TH+1P/TU)							1x4*	20
8	3x4= 12 3x(3TH+1P/TU)							1x8 *	20
Credits	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3=3	(1x4)+(1X8)= 12	172
Marks	22x100=2200	8x100=800	3x75=225	4x50=200	3x100=300	4x50=200	1x75=75	1x100+1x200=300	Total Marks =4300

Marks= 25 marks per credit. Credit for Summer Internship has been adjusted from 4 to 3 to adjust the total marks

*Candidates who will not pursue Dissertation/ Research work then he/she will have to study additional 1 DSC/Core paper o f 4 credits in the 7th Semester & 2 DSC/ Core Papers of 4 Credits each in the 8th Semester.

Note: Tutorial marks will be awarded based on internal assessment– byevaluation of internal assignments for SEC papers and by internal examination for Core, Minor, IDC papers.

NAMES OF DSCC/ MAJOR PAPERS (Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATh-H-CC1-1-Th	Calculus, Geometry & Vector Analysis
II	MATH-H-CC2-2-Th	Basic Algebra
III	MATH-H-CC3-3-Th MATH-H-CC4-3-Th	Real Analysis Ordinary Differential Equations – I & Group Theory - I
IV	MATH-H-CC5-4-Th MATH-H-CC6-4-Th MATH-H-CC7-4-Th MATH-H-CC8-4-Th	Theory of Real Functions Mechanics – I Partial Differential Equations -I & Multi-variate Calculus – I Group Theory – II & Ring Theory - I
V	MATH-H-CC9-5-Th MATH-H-CC10-5-Th MATH-H-CC11-5-Th MATH-H-CC12-5-Th	Probability & Statistics Ring Theory -II & Linear Algebra – I Riemann Integration & Series of Functions Mechanics - II

NAMES OF MINOR PAPERS(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MINOR 1	Calculus, Geometry & Vector Analysis
II	MINOR 2	Basic Algebra
III	MINOR 3	Ordinary Differential Equations – I & Group Theory - I
IV	MINOR 4	Mechanics – I
V	MINOR 5	Real Analysis
VI	MINOR 6	Partial Differential Equations -I & Multi-variate Calculus – I

NAMES OF SEC PAPERS(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-H-SEC1-1-Th	C Language with Mathematical Applications
II	MATH-H-SEC2-2-Th (Any one out of 2 Courses on Right Column)	SEC 2.1 : Python Programming and Introduction to Latex SEC 2.2 :Artificial Intelligence
III	MATH-H-SEC3-3-Th	Linear Programming & Rectangular Games

NAMES OF IDC PAPERS (Each carries 3 credits or 75 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-H-IDC1-1-Th	Mathematical Logic
II	MATH-H-IDC2-2-Th	Financial Mathematics
III	MATH-H-IDC3-3-Th	Bio – Mathematics

SYLLABUS IN DETAIL

MATH-H-CC1-1-Th
Calculus, Geometry & Vector Analysis

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Calculus
[Marks:20] [16 classes]

• Differentiability of a function at a point and in an interval. Meaning of sign of derivative. Differentiating hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to functions of type e^{ax+b}sin x, e^{ax+b}cos x, $(ax + b)^n$ sin x, $(ax + b)^n$ cos x. Indeterminate forms. L'Hospital's rule (statement and example).
• Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sec^n x\, dx$, $\int (log\, x)^n dx$, $\int \sin^n x \sin^m x\, dx$, $\int \sin^n x \cos^m x\, dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Group B: Geometry
[Marks:35] [28 classes]

• Rotation of axes and second degree equations, classification of conics using the discriminant, reduction to canonical form, tangent and normal, polar equations of conics.
• Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, identification of quadric surfaces like cone, cylinder, ellipsoid, hyperboloid, classification of quadrics.

Group C: Vector Analysis
[Marks: 20] [16 classes]
• Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

References:

[1] G.B. Thomas and R.L. Finney, Calculus, 14th Ed., Pearson Education, Delhi, 2018.
[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley

(India) P. Ltd. (Pearson Education), Delhi, 2022.
[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2015.
[4] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1998.
[5] T. Apostol, Calculus, Volumes I and II, Wileyand Sons, 1969
[6] R. R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing, 2020.
[7] Marsden, J., and Tromba, Vector Calculus, W. H. Freeman & Co., 6th edition, 2011.
[8] M.R. Speigel, Schaum's outline of Vector AnalysisTata McGraw Hill Ed., 2011.
[9] S. L. Loney, Co-ordinate Geometry, 6th Edition, Arihant Publications, 2016.
[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Macmillan and Co., Ltd., London, 2018.

MATH-H-CC2-2-TH
Basic Algebra

Full Marks: 100 (Theory: 75 and Tutorial:25)

Group A
[Marks:25[] [20 classes]

• Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
•Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Application of Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
•Inequalities: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.

Group B
[Marks: 25] [20 classes]

•Relation: equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
•Mapping: composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f : X \to Y$ and $B \subseteq Y$.
•Well-ordering property of positive integers, Principles of Mathematical induction, equivalence of Wellordering property and Principles of Mathematical induction (statement only), division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as ϕ, τ, σ and their properties.

Group C
[Marks:25] [20 classes]

•Systems of linear equations, homogeneous and non-homogeneous systems. Existence and Uniqueness of solution. The matrix equation $Ax = b$, row reduction and echelon forms, uniqueness of reduced echelon form. Rank of a matrix and characterization of invertible matrices, Pivot positions, basic and free variables, parametric description of the solution set. Existence and uniqueness theorem.

•Vectors in R^n , algebraic and geometric properties of the vectors. Vector form of a linear system and the column picture. Existence of solutions and linear combination of vectors. Geometry of linear combination and subsets spanned by some vectors. Uniqueness of solution and linear independence of vectors. Algebraic and geometric characterizations of linearly independent subsets.

References

[1] Titu Andreescu and DorinAndrica, Complex Numbers from A to Z, 2nd Ed., Springer Nature, 2014.

[2] Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

[3] David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

[4] Gilbert Strang; Introduction to Linear Algebra (5th Edition); Wellesley-Cambridge Press, 2019.

[5] Anton Howard and Chris Rorres; Elementary Linear Algebra with Supplemental Applications (11th Edition); Wiley, 2014.

[6] K. Hoffman, R. Kunze, Linear algebra, Prentice Hall India Learning Pvt. Ltd., 2015.

[7] W.S. Burnside and A.W. Panton, Theory of equations, Dublin University Press Series, S. Chand and Company Pvt. Ltd., 1986.

MATH-H-SEC1-1-Th

C Language with Mathematical Applications

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60 classes)

Overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language, higher level language

• Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

• Operation and Expressions: Arithmetic operators, relational operators, logical operators.

• Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

• Control Statements: While statement, do-while statement, for statement.

•Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

• User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

• Introduction to Library functions: stdio.h, math.h, string.hstdlib.h, time.h etc.

Sample problems:

1. Display first 15 natural numbers.
2. Compute the sum of first 10 natural numbers.
3. Read 10 numbers from keyboard and find their average.
4. Find the sum of first 15 even natural numbers.
5. Write a program to find factorial of a number using recursion.
6. Write a program to make a pyramid pattern with numbers increased by 1.

7. From the terminal read three values, namely, length, width, height. Print a message whether the box is a cube or rectangle or semi-rectangle.
8. Find the AM, GM, HM of a given set of numbers.
9. Write a program to print multiplication table.
10. Write a program that generates a data file containing the list of customers and their contact numbers.
11. Find the maximum and minimum element of a given array.
12. Sort the elements of an array in ascending order
13. Write a program to read in an array of names and to sort them in alphabetical order.
14. Write a program for addition of two matrices.
15. Find the transpose of a given matrix.
16. Find the product of two matrices.
17. Write a program to check whether two given strings are an anagram.
18. Write a program to check Armstrong and Perfect numbers.
19. Write a program to check whether a number is a prime number or not.
20. Prepare a code for summing a Series.
21. Compute approximate value of pi .
22. Compute the area under a given curve.
23. Solve a quadratic equation.
24. Write a program to solve a system of two linear equations in two unknowns.
25. Write a program to find the shortest distance between two straight lines (parallel or intersecting or skew) in space.
26. Prepare an investment report by calculating compound interest.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.
[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.
[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.
[4] C. Xavier : C-Language and Numerical Methods, New Age International, 2007.
[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980

MATH-H-SEC 2.1-2-Th
Python Programming and Introduction to Latex

Full marks: 100
(Theory: 75 and Tutorial: 25)

Group A: Python Programming
[Marks: 50][40 classes]

Python Programming Language, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing and Output, Editing, Saving, and Running a Script, Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

Data types and expressions: Variables and the Assignment Statement, Program Comments and Doc strings. Data Types-Numeric integers and Floating-point numbers. Boolean string. Mathematical operators, PEMDAS.Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).

Loops and selection statements: Definite Iteration: for Loop, Executing statements a given number of times, Specifying steps using range( ) , Loops that count down, Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elseif-else, nested if, nested if-else. Compound Boolean Expressions, Conditional Iteration: while Loop –with True condition, break Statement. Random Numbers. Loop Logic, errors and testing.

Strings, Lists, Tuple, Dictionary: Accessing characters, indexing, slicing, replacing.Concatenation (+), Repetition (*).Searching a substring with the 'in' Operator, Traversing string using while and for. String methods- find, join, split, lower, upper. len( ).

Lists – Accessing and slicing, Basic Operations (Comparison, +),List membership and for loop.Replacing element (list is mutable). List methods- append, extend, insert, pop, sort. Max( ), min( ). Tuples. Dictionaries-Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), Traversing a Dictionary. Math module: sin(), cos(),exp(), sqrt(), constants- pi, e.

Design with functions: Defining Simple Functions- Parameters and Arguments, the return Statement, tuple as return value. Boolean Functions. Defining a main function. Defining and tracing recursive functions.

Working with Numbers: Calculating the Factors of an Integer, Generating Multiplication Tables, converting units of measurement, Finding the roots of a quadratic equation

Algebra and Symbolic Math with SymPy: symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Converting strings to mathematical expressions. Solving equations, Solving quadratic equations, Solving for one variable in terms of others, Solving a system of linear equations.

Plotting using SymPy , Plotting expressions input by the user, Plotting multiple functions

Sample problems:

1. Convert number from decimal to binary system.
2. Convert number from decimal to octal system.
3. Convert from Hexadecimal to binary system.
4. Write a program to read one subject mark and print pass or fail. Use single returnvalues function with argument.
5. Find the median of a given set of numbers.
6. Write a Python function that takes two lists and returns True if they have at least one common member.
7. Write a program for Enhanced Multiplication Table Generator.
8. Write down Unit converter code.
9. Write down Fraction Calculator code.
10. Write down Factor Findercode.
11. Write down Graphical Equation Solver code.
12. Write down a code for solving Single-Variable Inequalities.
13. Prepare an investment report by calculating compound interest.
14. Write a python program to open and write the content to file and read it.
15. Write a python program to check whether a given year is leap year or not and also print all the months of the given year.

Group B: Introduction to Latex
[Marks: 25] [20 classes]

Introduction to LATEX: Preparing a basic LATEX file. Compiling LATEX file.

Document classes: Different type of document classes, e.g., article, report, book etc.

Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

List structures: Itemize, enumerate, description etc.

Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

Customization of fonts: Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines.

Figures: Changing and placing the figures, alignments

Packages: amsmath,amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. special characters.

Sample Projects:

1. Write down aresearch article.
2.Write down a given mathematical derivation.
3. Writea book chapter.
4. Write a report on a practical done in laboratory with results, tables and graphs.
5. Present graphical analysis taking graphs plotted in gnuplot.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Kenneth A Lambert, Fundamentals of Python: First programs, 2nd edition – Cengage Learning India, 2019.
[2] Saha Amit, Doing Math with Python - No starch press, San Francisco, 2015.

[3] E. Balgurusamy, Problem solving and Python programming- Tata McGraw Hill, 2017.
[4] LATEX- A Document Preparation System, Leslie Lamport, Addison-Wesley, 1994.
[5] E. Krishnan, LATEXTutorials A PRIMER, Indian TEXusers group, 2003.
[6] GeorgeGratzer,Practical LATEX, Springer, 2014.

MATH-H-SEC 2.2-2-Th

Artificial Intelligence

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60classes)

Course Description:
This course aims to introduce the fundamental concepts of artificial intelligence (AI) to individuals from all academic backgrounds. Participants will develop a broad understanding of AI technologies, their implications, and their potential applications in various fields. The course will emphasize practical examples and real-world case studies to facilitate comprehension and inspire innovative thinking.

Course Objectives:

- Understand the basics of artificial intelligence and its subfields.
- Explore real-world applications of AI across different industries.
- Gain insights into the ethical, social, and economic implications of AI.
- Develop an appreciation for the potential of AI to drive innovation and transformation.

Course Outcome:

- Define and explain the fundamental concepts and subfields of AI.
- Identify real-world applications of AI across various industries.
- Analyze the ethical, social, and economic implications of AI.
- Recognize the potential of AI to drive innovation and transformation in different domains.

Unit 1: Introduction to Artificial Intelligence

- Definition and scope of AI
- Historical overview and key milestones
- Differentiating AI from human intelligence

Unit 2: AI Subfields and Technologies

- Machine learning: Supervised, unsupervised, and reinforcement learning
- Deep learning and neural networks
- Natural language processing (NLP) and computer vision

Unit 3: Applications of AI

- AI in healthcare: Diagnosis, treatment, and medical imaging
- AI in finance: Fraud detection, algorithmic trading, and risk assessment
- AI in transportation: Autonomous vehicles and traffic optimization
- AI in customer service and chatbots
- AI in education: Personalized learning and intelligent tutoring systems

Unit 4: Ethical and Social Implications of AI

- Bias and fairness in AI systems
- Privacy and data protection concerns
- Impact of AI on employment and the workforce
- AI and social inequality

Unit 5: Other Important Issues

- Ethical guidelines and responsible AI practices
- AI and Innovation
- Emerging trends and future directions in AI
- AI and creativity: Generative models and artistic applications

MATH-H-SEC3-3-Th
Linear Programming and Rectangular Games

Full Marks: 100 (Theory : 75 marks and Tutorial: 25 marks)
(60classes)

• Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and

Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

• Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

• Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions. Algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

• Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values.

Post-optimal Analysis**:** Discrete changes in the cost vector, Discrete changes in the requirement vector, Discrete changes in the coefficient matrix, Addition of a variable, Addition of a constraint.

• Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.

• Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method to solveRectangular games. Inter-relation between theory of games and L.P.P.

Note:1. Students will learn formulation of L.P.P. and obtaining optimal solution of L.P.P. using software package.

2. A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
[2] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th

Ed., Tata McGraw Hill, Singapore, 2009.
[3] Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
[4] G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
[5] Churchman, Ackoff, Arnoff, Introduction to Operations Research, John Wiley and Sons Inc., 1957.
[6] Billy, E. Gillet, Introduction to Operations Research: A Computer Oriented Algorithmatic Approach, TMH Edition, 1979.
[7] Swarup K., Gupta P.K., Man Mohan, Operations Research, Sultan Chand and Sons, 2020.
[8] Chakraborty J. G. and Ghosh, P.R., Linear Programming and Game Theory, Moulik Library, 1979.

MATH-H-IDC1-1-Th

Mathematical Logic

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

Introduction: propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions.

General Notions: Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Propositional Logic: Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Lindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Modal PropositionalLogic: Introduction, modal operators, well formed formulas, axioms of systems K, T, B, S4, S5, Rules of inference, interpretation in Kripke frame, validity, connection of accessibility relation with the systems, Statements of soundness and completeness theorems.

Predicate Logic: First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus.

Fuzzy Logic: Many-valued logic, 3-valued logic of Lukasiewich, the truth tables of conjunction, disjunction, negation and implication, tautology and validity, Infinite valued logic, calculation of truth values of the logical connectives.

Applications (briefidea): Applicationsof Modal Logic in Artificial Intelligence, database theory, distributed system, cryptography. Applications of Fuzzy Logic in Artificial Intelligence, Soft computing, Decision theory, NLP, Pattern recognition.

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London, 1997.
[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York ,1990.
[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier, 1952.
[4] J.H.Gallier; Logic for computer science; John.Wiley& Sons, 1987.
[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York 1972.
[6] Chakraborty, M., Lecture note: A journey through the logic wonderland, IIEST, Shibpur, 2016.

MATH-H-IDC2-2-Th
Financial Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

- Profit, Loss and discount, Dividend, Calculation of income tax, Tabulations, Bar graphs, Pie charts, Line graphs.

- Introduction to Financial Markets and Instruments: Money Market and Capital Market, Financial Instruments – Stock, Bonds, Derivatives; Concept of Value (intrinsic) vs. Price of Financial Instruments, Concept of Arbitrage.

- Time Value of Money: Interest (simple and compound, discrete and continuous), Annuities, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), Comparison of NPV and IRR.
- Bonds: Bond Valuation; Bond Prices and Yields; Duration, Convexity, Interest Rate Risk; Fixed vs. Floating Rate Bonds, Immunization.
- Portfolio Theory: Brief introduction to expectation, variance, covariance and correlation; Asset Return and Risk; Portfolio Risk (Variance) and Return– Historical and Ex-Ante; Diversification and Risk Reduction; Feasible and Optimal Portfolio – Efficient Frontier; Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References

[1] David G. Luenberger; Investment Science; Oxford University Press, Delhi, 1998.

[2] John C. Hull; Options, Futures and Other Derivatives, 6th Ed.; Prentice-Hall India, Indian reprint, 2006.

[3] Sheldon Ross; An Elementary Introduction to Mathematical Finance, 2nd Ed, Cambridge University Press, USA, 2003.

[4] Chandra P., Investment Analysis and Portfolio Management; McGraw Hill Education, 5th Ed., 2017.

[5] Ales Cerny: Mathematical Techniques in Finance: Tools for incomplete markets, PrincetonUniversity Press, 2009.

[6]S.R. Pliska, Introduction to Mathematical Finance: Discrete time model, 1st Ed., Wiley, 1997.

[7] Karatzas and S. Shreve, Method of Mathematical Finance, Springer, New York, 2016.

MATH-H-IDC3-3-Th

Bio - Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45 classes)

Mathematical biology and the modelling process: What is a model? Essential features of a modelling approach, Identification of variables, parameters, constants for a model; type of models (linear-nonlinear and continuous – discrete).

Simple single-species continuous population growth models:
Malthus model (1798): deduction (basic assumptions), analytic solution, doubling time; behavior of population size as $t \to \infty$, Stability analysis of the steady states of the Malthus model; limitations.

Logistic model (Verhulst 1838): motivation (Gause's 1934 Experiments) and formulation (basic assumptions), analytic solution, behavior of population size as $t \to \infty$ for different initial population size, carrying capacity. Effects of harvesting in a single species population: Constant-yield harvesting, constant-effort harvesting.

One dimensional models, fixed points, stability analysis of fixed points, phase diagrams.
Non-dimensionalization and re-parametrization in a model: Necessity and applications.

Bifurcation: Saddle-node, transcritical and pitchfork bifurcations in one-dimensional case.

Insect outbreak model (Morris, 1963): The spruce budworm model – deduction (basic assumptions), analysis of steady states, presence of saddle-node bifurcation; real life applications.

Interacting populations: Predator-prey model (basic assumptions) and Lotka (1925)-Volterra (1926) model (basic assumptions) – deduction, Steady states.

Chemical Reaction Kinetics; Law of mass action; Enzymatic reaction;
Enzyme Kinetics; Elimination of variables – model reduction; Michaelis-Menten kinetics (proposed in 1913). Formulation of model (basic assumptions) and steady states.

Gene regulation networks: Introduction, basic assumptions, two dimensional model; Constitutive gene expression; Gene transcription regulation by activators; Gene transcription regulation by repressors; Regulation of gene transcription: auto-activation and auto-inhibition.

Epidemic models: Basic terminologies.
SI model (assumptions), Kermack-McKendrick SIR model 1927 (basic assumptions) assuming total population as constant, Formulation of the models. Concept of basic reproduction number.

Discrete single-species models: Linear models, growth models, decay models, discrete Logistic models.

Overview of nonlinear difference equations: Steady states and linear stability analysis, Graphical solution of difference equations – cobwebbing.

References

[1] L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
[2] J. D. Murray, Mathematical Biology, Springer, 1993.
[3] Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
[4] F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
[5] M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.
[6] F. Brauer and C. Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer, 2012.
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[9] R F Morris, The Memoirs of the Entomological Society of Canada, Cambridge.org, 1963.

SYLLABUS
FOR
THREE -YEAR (SIX-SEMESTER) B.SC. COURSE
UNDER THE UNIVERSITY OF CALCUTTA

Odd Semester: July to December

Even Semester: January to June

Syllabus for the 3 Year B.Sc. course in Mathematics effective from the academic year **2023-2024.**

COURSE STRUCTURE-MDC

	CC1	CC2	Minor	IDC	AEC	SEC	CVAC	Summer Internship	Total Credit
Semester	8x4= 32	8x4= 32	6x4= 24	3x3=9	4x2= 8	3x4=12	4x2=8	1x3= 3	128
1	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
2	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
3	1x4= 4 (3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+1P/TU	1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4			21
4	2x4=8 4x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU	1x4= 4 (3TH+1P/TU)		1x2= 2 2TH +0P/TU				22
5	2x4= 8 2x(3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	2x4= 8 2x(3TH+ 1P/TU						20
6	1x4= 4 (3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)						20
Credits	8x4= 32	8x4= 32	6x4= 24	3x3= 9	4x2= 8	3x4= 12	4x2= 8		125+3 =128
Marks	8x100= 800	8x100= 800	6x100= 600	3x75= 225	4x50= 200	3x100= 300	4x50= 200		Total Marks =3200

Marks= 25 marks per credit.

Total credit=125+3 (for summer internship) = 128
Summer Internship: As mentioned in clause no. 8 (G)

Note: Tutorial marks will be awarded based on internal assessment – by evaluation of internal assignments for SEC papers and by internal examination for Core, Minor, IDC papers.

Modules Offered by Mathematics Department

NAMES OF CORE COURSES(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-CC1-1-Th	Calculus, Geometry & Vector Analysis
II	MATH-MD-CC2-2-Th	Basic Algebra
III	MATH-MD-CC3-3-Th	Ordinary Differential Equations& Group Theory
IV	MATH-MD-CC4-4-Th MATH-MD-CC5-4-Th	Mechanics Statistics & Numerical Analysis
V	MATH-MD-CC6-5-Th MATH-MD-CC7-5-Th	Real Analysis Partial Differential Equations & Multivariate Calculus
VI	MATH-MD-CC8-6-Th	Advanced Algebra& Riemann Integration

NAMES OF SEC PAPERS (Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-SEC 1-1-Th	C Language with Mathematical Applications
II	MATH-MD-SEC 2-2-Th (Any one out of twocourses on right column)	SEC 2.1 : Python Programming and Introduction to Latex SEC 2.2 : Artificial Intelligence
III	MATH-MD-SEC3-3-Th	Linear Programming & Rectangular Games

NAMES OF IDC PAPERS (Each carries 3 credits or 75 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-IDC1-1-Th	Mathematical Logic
II	MATH-MD- IDC2-2-Th	Financial Mathematics
III	MATH-MD-IDC3-3-Th	Bio - Mathematics

SYLLABUS IN DETAIL

MATH-MD-CC1-1-Th
Calculus, Geometry & Vector Analysis

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Calculus
[Marks:20] [16 classes]

• Differentiability of a function at a point and in an interval. Meaning of sign of derivative. Differentiating hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to functions of type e^{ax+b}sin x, e^{ax+b}cos x, $(ax + b)^n$ sin x, $(ax + b)^n$ cos x. Indeterminate forms. L'Hospital's rule (statement and example).
• Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sec^n x\, dx$, $\int (log\, x)^n dx$, $\int \sin^n x \sin^m x\, dx$, $\int \sin^n x \cos^m x\, dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Group B: Geometry
[Marks:35] [28 classes]

• Rotation of axes and second degree equations, classification of conics using the discriminant, reduction to canonical form, tangent and normal, polar equations of conics.
• Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, identification of quadric surfaces like cone, cylinder, ellipsoid, hyperboloid, classification of quadrics.

Group C: Vector Analysis
[Marks: 20] [16 classes]
• Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

References:

[1] G.B. Thomas and R.L. Finney, Calculus, 14th Ed., Pearson Education, Delhi, 2018.
[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley

(India) P. Ltd. (Pearson Education), Delhi, 2022.
[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2015.
[4] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1998.
[5] T. Apostol, Calculus, Volumes I and II, Wileyand Sons, 1969
[6] R. R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing, 2020.
[7] Marsden, J., and Tromba, Vector Calculus, W. H. Freeman & Co., 6th edition, 2011.
[8] M.R. Speigel, Schaum's outline of Vector AnalysisTata McGraw Hill Ed., 2011.
[9] S. L. Loney, Co-ordinate Geometry, 6th Edition, Arihant Publications, 2016.
[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Macmillan and Co., Ltd., London, 2018.

MATH-MD-CC2-2-TH
Basic Algebra

Full Marks: 100 (Theory: 75 and Tutorial:25)

Group A
[Marks:25[] [20 classes]

• Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
•Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Application of Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
•Inequalities: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.

Group B
[Marks: 25] [20 classes]

•Relation: equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
•Mapping: composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f : X \to Y$ and $B \subseteq Y$.
•Well-ordering property of positive integers, Principles of Mathematical induction, equivalence of Wellordering property and Principles of Mathematical induction (statement only), division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as ϕ, τ, σ and their properties.

Group C
[Marks:25] [20 classes]

•Systems of linear equations, homogeneous and non-homogeneous systems. Existence and Uniqueness of solution. The matrix equation $Ax = b$, row reduction and echelon forms, uniqueness of reduced echelon form. Rank of a matrix and characterization of invertible matrices, Pivot positions, basic and free variables, parametric description of the solution set. Existence and uniqueness theorem.

•Vectors in R^n , algebraic and geometric properties of the vectors. Vector form of a linear system and the column picture. Existence of solutions and linear combination of vectors. Geometry of linear combination and subsets spanned by some vectors. Uniqueness of solution and linear independence of vectors. Algebraic and geometric characterizations of linearly independent subsets.

References

[1] Titu Andreescu and DorinAndrica, Complex Numbers from A to Z, 2nd Ed., Springer Nature, 2014.

[2] Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

[3] David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

[4] Gilbert Strang; Introduction to Linear Algebra (5th Edition); Wellesley-Cambridge Press, 2019.

[5] Anton Howard and Chris Rorres; Elementary Linear Algebra with Supplemental Applications (11th Edition); Wiley, 2014.

[6] K. Hoffman, R. Kunze, Linear algebra, Prentice Hall India Learning Pvt. Ltd., 2015.

[7] W.S. Burnside and A.W. Panton, Theory of equations, Dublin University Press Series, S. Chand and Company Pvt. Ltd., 1986.

MATH-MD-SEC1-1-Th

C Language with Mathematical Applications

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60 classes)

Overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language, higher level language

• Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

• Operation and Expressions: Arithmetic operators, relational operators, logical operators.

• Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

• Control Statements: While statement, do-while statement, for statement.

•Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

• User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

• Introduction to Library functions: stdio.h, math.h, string.hstdlib.h, time.h etc.

Sample problems:

1. Display first 15 natural numbers.
2. Compute the sum of first 10 natural numbers.
3. Read 10 numbers from keyboard and find their average.
4. Find the sum of first 15 even natural numbers.
5. Write a program to find factorial of a number using recursion.
6. Write a program to make a pyramid pattern with numbers increased by 1.

7. From the terminal read three values, namely, length, width, height. Print a message whether the box is a cube or rectangle or semi-rectangle.
8. Find the AM, GM, HM of a given set of numbers.
9. Write a program to print multiplication table.
10. Write a program that generates a data file containing the list of customers and their contact numbers.
11. Find the maximum and minimum element of a given array.
12. Sort the elements of an array in ascending order
13. Write a program to read in an array of names and to sort them in alphabetical order.
14. Write a program for addition of two matrices.
15. Find the transpose of a given matrix.
16. Find the product of two matrices.
17. Write a program to check whether two given strings are an anagram.
18. Write a program to check Armstrong and Perfect numbers.
19. Write a program to check whether a number is a prime number or not.
20. Prepare a code for summing a Series.
21. Compute approximate value of pi .
22. Compute the area under a given curve.
23. Solve a quadratic equation.
24. Write a program to solve a system of two linear equations in two unknowns.
25. Write a program to find the shortest distance between two straight lines (parallel or intersecting or skew) in space.
26. Prepare an investment report by calculating compound interest.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.
[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.
[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.
[4] C. Xavier : C-Language and Numerical Methods, New Age International, 2007.
[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980

MATH-MD-SEC 2.1-2-Th
Python Programming and Introduction to Latex

Full marks: 100
(Theory: 75 and Tutorial: 25)

Group A: Python Programming

[Marks: 50][40 classes]

Python Programming Language, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing and Output, Editing, Saving, and Running a Script, Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

Data types and expressions: Variables and the Assignment Statement, Program Comments and Doc strings. Data Types-Numeric integers and Floating-point numbers. Boolean string. Mathematical operators, PEMDAS.Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).

Loops and selection statements: Definite Iteration: for Loop, Executing statements a given number of times, Specifying steps using range( ) , Loops that count down, Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elseif-else, nested if, nested if-else. Compound Boolean Expressions, Conditional Iteration: while Loop –with True condition, break Statement. Random Numbers. Loop Logic, errors and testing.

Strings, Lists, Tuple, Dictionary: Accessing characters, indexing, slicing, replacing.Concatenation (+), Repetition (*).Searching a substring with the 'in' Operator, Traversing string using while and for. String methods- find, join, split, lower, upper. len( ).

Lists – Accessing and slicing, Basic Operations (Comparison, +),List membership and for loop.Replacing element (list is mutable). List methods- append, extend, insert, pop, sort. Max( ), min( ). Tuples. Dictionaries-Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), Traversing a Dictionary. Math module: sin(), cos(),exp(), sqrt(), constants- pi, e.

Design with functions: Defining Simple Functions- Parameters and Arguments, the return Statement, tuple as return value. Boolean Functions. Defining a main function. Defining and tracing recursive functions.

Working with Numbers: Calculating the Factors of an Integer, Generating Multiplication Tables, converting units of measurement, Finding the roots of a quadratic equation

Algebra and Symbolic Math with SymPy: symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Converting strings to mathematical expressions. Solving equations, Solving quadratic equations, Solving for one variable in terms of others, Solving a system of linear equations.

Plotting using SymPy , Plotting expressions input by the user, Plotting multiple functions

Sample problems:

1. Convert number from decimal to binary system.
2. Convert number from decimal to octal system.
3. Convert from Hexadecimal to binary system.
4. Write a program to read one subject mark and print pass or fail. Use single returnvalues function with argument.
5. Find the median of a given set of numbers.
6. Write a Python function that takes two lists and returns True if they have at least one common member.
7. Write a program for Enhanced Multiplication Table Generator.
8. Write down Unit converter code.
9. Write down Fraction Calculator code.
10. Write down Factor Findercode.
11. Write down Graphical Equation Solver code.
12. Write down a code for solving Single-Variable Inequalities.
13. Prepare an investment report by calculating compound interest.
14. Write a python program to open and write the content to file and read it.
15. Write a python program to check whether a given year is leap year or not and also print all the months of the given year.

Group B: Introduction to Latex
[Marks: 25] [20 classes]

Introduction to LATEX: Preparing a basic LATEX file. Compiling LATEX file.

Document classes: Different type of document classes, e.g., article, report, book etc.

Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

List structures: Itemize, enumerate, description etc.

Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

Customization of fonts: Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines.

Figures: Changing and placing the figures, alignments

Packages: amsmath,amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. special characters.

Sample Projects:

1. Write down aresearch article.
2.Write down a given mathematical derivation.
3. Writea book chapter.
4. Write a report on a practical done in laboratory with results, tables and graphs.
5. Present graphical analysis taking graphs plotted in gnuplot.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Kenneth A Lambert, Fundamentals of Python: First programs, 2nd edition – Cengage Learning India, 2019.
[2] Saha Amit, Doing Math with Python - No starch press, San Francisco, 2015.

[3] E. Balgurusamy, Problem solving and Python programming- Tata McGraw Hill, 2017.
[4] LATEX- A Document Preparation System, Leslie Lamport, Addison-Wesley, 1994.
[5] E. Krishnan, LATEXTutorials A PRIMER, Indian TEXusers group, 2003.
[6] GeorgeGratzer,Practical LATEX, Springer, 2014.

MATH-MD-SEC 2.2-2-Th

Artificial Intelligence

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60classes)

Course Description:
This course aims to introduce the fundamental concepts of artificial intelligence (AI) to individuals from all academic backgrounds. Participants will develop a broad understanding of AI technologies, their implications, and their potential applications in various fields. The course will emphasize practical examples and real-world case studies to facilitate comprehension and inspire innovative thinking.

Course Objectives:

- Understand the basics of artificial intelligence and its subfields.
- Explore real-world applications of AI across different industries.
- Gain insights into the ethical, social, and economic implications of AI.
- Develop an appreciation for the potential of AI to drive innovation and transformation.

Course Outcome:

- Define and explain the fundamental concepts and subfields of AI.
- Identify real-world applications of AI across various industries.
- Analyze the ethical, social, and economic implications of AI.
- Recognize the potential of AI to drive innovation and transformation in different domains.

Unit 1: Introduction to Artificial Intelligence

- Definition and scope of AI
- Historical overview and key milestones
- Differentiating AI from human intelligence

Unit 2: AI Subfields and Technologies

- Machine learning: Supervised, unsupervised, and reinforcement learning
- Deep learning and neural networks
- Natural language processing (NLP) and computer vision

Unit 3: Applications of AI

- AI in healthcare: Diagnosis, treatment, and medical imaging
- AI in finance: Fraud detection, algorithmic trading, and risk assessment
- AI in transportation: Autonomous vehicles and traffic optimization
- AI in customer service and chatbots
- AI in education: Personalized learning and intelligent tutoring systems

Unit 4: Ethical and Social Implications of AI

- Bias and fairness in AI systems
- Privacy and data protection concerns
- Impact of AI on employment and the workforce
- AI and social inequality

Unit 5: Other Important Issues

- Ethical guidelines and responsible AI practices
- AI and Innovation
- Emerging trends and future directions in AI
- AI and creativity: Generative models and artistic applications

MATH-MD-SEC3-3-Th
Linear Programming and Rectangular Games

Full Marks: 100 (Theory : 75 marks and Tutorial: 25 marks)
(60classes)

• Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and

Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

• Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

• Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions. Algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

• Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values.

Post-optimal Analysis**:** Discrete changes in the cost vector, Discrete changes in the requirement vector, Discrete changes in the coefficient matrix, Addition of a variable, Addition of a constraint.

• Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.

• Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method to solveRectangular games. Inter-relation between theory of games and L.P.P.

Note:1. Students will learn formulation of L.P.P. and obtaining optimal solution of L.P.P. using software package.

2. A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
[2] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th

Ed., Tata McGraw Hill, Singapore, 2009.
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[4] G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
[5] Churchman, Ackoff, Arnoff, Introduction to Operations Research, John Wiley and Sons Inc., 1957.
[6] Billy, E. Gillet, Introduction to Operations Research: A Computer Oriented Algorithmatic Approach, TMH Edition, 1979.
[7] Swarup K., Gupta P.K., Man Mohan, Operations Research, Sultan Chand and Sons, 2020.
[8] Chakraborty J. G. and Ghosh, P.R., Linear Programming and Game Theory, Moulik Library, 1979.

MATH-MD-IDC1-1-Th

Mathematical Logic

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

Introduction: propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions.

General Notions: Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Propositional Logic: Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Lindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Modal PropositionalLogic: Introduction, modal operators, well formed formulas, axioms of systems K, T, B, S4, S5, Rules of inference, interpretation in Kripke frame, validity, connection of accessibility relation with the systems, Statements of soundness and completeness theorems.

Predicate Logic: First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus.

Fuzzy Logic: Many-valued logic, 3-valued logic of Lukasiewich, the truth tables of conjunction, disjunction, negation and implication, tautology and validity, Infinite valued logic, calculation of truth values of the logical connectives.

Applications (briefidea): Applicationsof Modal Logic in Artificial Intelligence, database theory, distributed system, cryptography. Applications of Fuzzy Logic in Artificial Intelligence, Soft computing, Decision theory, NLP, Pattern recognition.

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London, 1997.

[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York ,1990.

[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier, 1952.

[4] J.H.Gallier; Logic for computer science; John.Wiley& Sons, 1987.

[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York 1972.

[6] Chakraborty, M., Lecture note: A journey through the logic wonderland, IIEST, Shibpur, 2016.

MATH-MD-IDC2-2-Th
Financial Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)

(45classes)

- Profit, Loss and discount, Dividend, Calculation of income tax, Tabulations, Bar graphs, Pie charts, Line graphs.

- Introduction to Financial Markets and Instruments: Money Market and Capital Market, Financial Instruments – Stock, Bonds, Derivatives; Concept of Value (intrinsic) vs. Price of Financial Instruments, Concept of Arbitrage.

- Time Value of Money: Interest (simple and compound, discrete and continuous), Annuities, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), Comparison of NPV and IRR.
- Bonds: Bond Valuation; Bond Prices and Yields; Duration, Convexity, Interest Rate Risk; Fixed vs. Floating Rate Bonds, Immunization.
- Portfolio Theory: Brief introduction to expectation, variance, covariance and correlation; Asset Return and Risk; Portfolio Risk (Variance) and Return– Historical and Ex-Ante; Diversification and Risk Reduction; Feasible and Optimal Portfolio – Efficient Frontier; Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References

[1] David G. Luenberger; Investment Science; Oxford University Press, Delhi, 1998.

[2] John C. Hull; Options, Futures and Other Derivatives, 6th Ed.; Prentice-Hall India, Indian reprint, 2006.

[3] Sheldon Ross; An Elementary Introduction to Mathematical Finance, 2nd Ed, Cambridge University Press, USA, 2003.

[4] Chandra P., Investment Analysis and Portfolio Management; McGraw Hill Education, 5th Ed., 2017.

[5] Ales Cerny: Mathematical Techniques in Finance: Tools for incomplete markets, PrincetonUniversity Press, 2009.

[6]S.R. Pliska, Introduction to Mathematical Finance: Discrete time model, 1st Ed., Wiley, 1997.

[7] Karatzas and S. Shreve, Method of Mathematical Finance, Springer, New York, 2016.

MATH-MD-IDC3-3-Th

Bio - Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45 classes)

Mathematical biology and the modelling process: What is a model? Essential features of a modelling approach, Identification of variables, parameters, constants for a model; type of models (linear-nonlinear and continuous – discrete).

Simple single-species continuous population growth models:
Malthus model (1798): deduction (basic assumptions), analytic solution, doubling time; behavior of population size as $t \to \infty$, Stability analysis of the steady states of the Malthus model; limitations.

Logistic model (Verhulst 1838): motivation (Gause's 1934 Experiments) and formulation (basic assumptions), analytic solution, behavior of population size as $t \to \infty$ for different initial population size, carrying capacity. Effects of harvesting in a single species population: Constant-yield harvesting, constant-effort harvesting.

One dimensional models, fixed points, stability analysis of fixed points, phase diagrams.
Non-dimensionalization and re-parametrization in a model: Necessity and applications.

Bifurcation: Saddle-node, transcritical and pitchfork bifurcations in one-dimensional case.

Insect outbreak model (Morris, 1963): The spruce budworm model – deduction (basic assumptions), analysis of steady states, presence of saddle-node bifurcation; real life applications.

Interacting populations: Predator-prey model (basic assumptions) and Lotka (1925)-Volterra (1926) model (basic assumptions) – deduction, Steady states.

Chemical Reaction Kinetics; Law of mass action; Enzymatic reaction;
Enzyme Kinetics; Elimination of variables – model reduction; Michaelis-Menten kinetics (proposed in 1913). Formulation of model (basic assumptions) and steady states.

Gene regulation networks: Introduction, basic assumptions, two dimensional model; Constitutive gene expression; Gene transcription regulation by activators; Gene transcription regulation by repressors; Regulation of gene transcription: auto-activation and auto-inhibition.

Epidemic models: Basic terminologies.
SI model (assumptions), Kermack-McKendrick SIR model 1927 (basic assumptions) assuming total population as constant, Formulation of the models. Concept of basic reproduction number.

Discrete single-species models: Linear models, growth models, decay models, discrete Logistic models.

Overview of nonlinear difference equations: Steady states and linear stability analysis, Graphical solution of difference equations – cobwebbing.

References

[1] L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
[2] J. D. Murray, Mathematical Biology, Springer, 1993.
[3] Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
[4] F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
[5] M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.
[6] F. Brauer and C. Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer, 2012.
[7] S. H. Strogatz, Nonlinear Dynamics and Chaos, Perseus Books, 1994.
[8] N.F. Britton, Essential Mathematical Biology, Springer-Verlag London, 2003.
[9] R F Morris, The Memoirs of the Entomological Society of Canada, Cambridge.org, 1963.