## Semester I

### MAS6121 Matrix and Linear Algebra [3 0 0 3]

Systems of linear equations, Matrices, Elementary row operations, Row-reduced echelon matrices. Vector spaces, Subspaces, Bases and dimensions, Ordered bases and coordinates. Linear transformations, Rank-nullity theorem, Algebra of linear transformations, Isomorphism, Matrix representation, Linear functionals, Annihilator, Double dual, Transpose of a linear transformation. Characteristic values and characteristic vectors of linear transformations, Diagonalizability, Minimal polynomial of a linear transformation, Cayley Hamilton theorem, Invariant subspaces, Direct-sum decompositions, Invariant direct sums, The primary decomposition theorem, Cyclic subspaces and annihilators, Cyclic decomposition, Rational and Jordan forms, Singular Value Decomposition (SVD) and its applications. Inner product spaces, Orthonormal bases, Gram-Schmidt process. Applications of linear algebra in data science, machine learning, optimization, computer graphics, and scientific computing.

**References:**


1. Strang G., *Linear Algebra and Its Applications*, 4th Edition, Cengage Learning, 2005.
2. Hoffman K. and Kunze R.A., *Linear Algebra*, 2nd Edition, Prentice Hall, 2009.
3. Axler S., *Linear Algebra Done Right*, 3rd Edition, Springer, 2024.
4. Halmos P.R., *Finite Dimensional Vector Spaces*, 2nd Edition, Springer, 2015.
5. Friedberg S.H., Insel A.J., and Spence L.E., *Linear Algebra*, 5th Edition, Pearson, 2021.


### MAS6122 Discrete Mathematics and Its Applications [3 0 0 3]

Set Theory-sets and classes, relations and functions, recursive definitions, partially ordered sets (posets), Zorn's lemma, cardinal and ordinal numbers. Combinatorics-permutations and combinations, partitions, pigeonhole principle, inclusion-exclusion principle, recurrence relations, generating functions and their applications to enumeration problems. Logic-propositional and predicate calculus, well-formed formulas, tautologies, equivalence, normal forms, theory of inference. Graph Theory-graphs and digraphs, Eulerian and Hamiltonian cycles, adjacency and incidence matrices, chromatic number, planarity, trees, graph polynomials and combinatorial applications. Introduction to Algebraic Combinatorics-Pólya enumeration theorem and applications. Applications of discrete mathematics in computer science, cryptography, network analysis, optimization, and algorithm design.

**References:**


1. Tremblay J.P. and Manohar R.P., *Discrete Mathematical Structures with Applications to Computer Science*, 1st Edition, McGraw-Hill, 1975.
2. Liu C.L., *Elements of Discrete Mathematics*, 2nd Edition, McGraw-Hill, 1985.
3. Rosen K.H., *Discrete Mathematics and Its Applications*, 9th Edition, McGraw-Hill, 2025.
4. Tucker A., *Applied Combinatorics*, 6th Edition, Wiley, 2012.

5. Grimaldi R.P., *Discrete and Combinatorial Mathematics: An Applied Introduction*, 5th Edition, Pearson, 2019.

**MAS6123 Advanced Differential Equations [3 0 0 3]**

Overview of first order ordinary differential equations, Picard's theorem and qualitative behavior of solutions. Second-order linear differential equations with constant coefficients, homogeneous and non-homogeneous equations, Wronskian, and basic existence and uniqueness concepts. Introduction to boundary value problems and Sturm–Liouville problems with simple applications. Power series solutions of differential equations, introductory concepts of Bessel and Legendre equations and their applications. Basics of nonlinear differential equations and standard methods of solution. Introduction to partial differential equations (PDEs), classification of second-order PDEs, and reduction to standard forms. Basic heat, wave, and Laplace equations with elementary solution techniques. Applications of differential equations in scientific computing, data analysis, machine learning, fluid flow models, population dynamics, and engineering systems.

**References:**

1. Coddington E.A., *An Introduction to Ordinary Differential Equations*, Dover Publications Inc., 1989.
2. Birkhoff G. and Rota G.C., *Ordinary Differential Equations*, John Wiley & Sons, 1989.
3. Amarnath T., *An Elementary Course in Partial Differential Equations*, 2nd Edition, Alpha Science Intl Ltd, 2003.
4. Boyce W.E., DiPrima R.C., and Meade D.B., *Elementary Differential Equations and Boundary Value Problems*, Wiley, 2021.

**MAS6124 Statistics and Probability Theory [3 0 0 3]**

Review of probability theory, conditional probability, and Bayes' theorem. Random variables, expectation, variance, covariance, correlation, and moment generating functions. Discrete and continuous probability distributions, Chebyshev's inequality, joint, marginal, and conditional distributions, independence of random variables, and transformations of random variables. Random sampling, sampling distributions, sample statistics, simulation of random variables, laws of large numbers, and central limit theorem. Point and interval estimation, method of moments, maximum likelihood estimation, and hypothesis testing for means and proportions. Applications of probability and statistics in data science, machine learning, predictive analytics, quality control, finance, and computational modeling.

**References:**

1. Devore J.L., *Probability & Statistics for Engineering and the Sciences*, 8th Edition, Cengage Learning, 2012.
2. Meyer P.L., *Introduction to Probability & Statistics*, 2nd Edition, Addison Wesley Longman Publishing Co, 1970.
3. Ross S.M., *Introduction to Probability Models*, 10th Edition, Academic Press, 2009.

4. Walpole R.E., Myers R.H., Myers S.L., and Ye K., *Probability & Statistics for Engineers and Scientists*, 9th Edition, Pearson, 2024.
5. Johnson R.A., Miller I., and Freund J.E., *Probability and Statistics*, 7th Edition, Pearson, 2020.

**MAS6125 Computer Programming with C [3 0 2 4]**

Introduction to C programming: algorithms, pseudocode, flowcharts, structure of C programs, identifiers, data types, variables, constants, input/output operations, operators, expressions, precedence and associativity, type conversion. Control structures: selection statements (if, switch), iterative statements (while, for, do-while), break, continue, and goto statements. Functions and structured programming: user-defined functions, recursion, parameter passing, storage classes, scope rules, and standard library functions. Arrays and pointers: one-dimensional and multidimensional arrays, pointers, pointer arithmetic, dynamic memory allocation, arrays of pointers, pointers to functions, and command-line arguments. Structures and unions. Introduction to Object-Oriented Programming concepts: classes, objects, inheritance, polymorphism, and comparison between structured and object-oriented programming.

**References:**

1. Kernighan B. W. and Ritchie D. M., *The C Programming Language*, 2nd Edition, PHI, 1988.
2. Balagurusamy E., *Programming in ANSI C*, 8th Edition, McGraw Hill, 2019.
3. Gottfried B. S., *Programming with C*, 4th Edition, Schaum's Outline Series, McGraw Hill, 2018.
4. King K. N., *C Programming: A Modern Approach*, 2nd Edition, W.W. Norton & Company, 2008.
5. Balagurusamy E., *Object Oriented Programming with C++*, 8th Edition, McGraw Hill, 2020.

**MAS6126 Foundation of Data Science with Python [3 0 2 4]**

Introduction to Python programming and the Spyder environment: working directory management, script creation and execution, comments, variables, operators, data types, and sequence data structures including strings, lists, tuples, dictionaries, sets, arrays, and ranges. NumPy and ndarray operations. Pandas DataFrame operations using real-world datasets (e.g., Toyota Corolla dataset): data reading, exploratory data analysis, preprocessing, cleaning, and transformation. Data visualization using Matplotlib and Seaborn libraries including line plots, scatter plots, bar charts, histograms, box plots, and pair plots. Control structures and functions in Python: conditional statements, loops, break/continue statements, and user-defined functions. Introduction to regression and classification techniques for predictive analytics and data-driven decision making. Applications in data science, machine learning, business analytics, scientific computing, and engineering systems.

**References:**

1. Vanderplas J., *Python Data Science Handbook: Essential Tools for Working with Data*, 1st Edition, O'Reilly Media, 2016.
2. McKinney W., *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter*, 3rd Edition, Shroff/O'Reilly, 2022.
3. Grus J., *Data Science from Scratch: First Principles with Python*, 2nd Edition, O'Reilly, 2019.
4. Madhavan S., *Mastering Python for Data Science*, 1st Edition, Packt Publishing, 2015.
5. Guttag J. V., *Introduction to Computation and Programming using Python*, 3rd Edition, MIT Press, 2021.

## Semester II

**MAS6221: Real and Functional Analysis [3 0 0 3]**

Introduction to real analysis, sequences and series, Bolzano –Weierstrass and Heine-Borel theorems, continuity, differentiability and mean value theorem, sequences and series of functions, uniform convergence, Riemann sums, Riemann and improper integrals, monotonic functions, discontinuities and functions of bounded variation, Lebesgue measure and integral, functions of several variables, directional and partial derivatives, derivative as a linear transformation, inverse and implicit function theorems. Metric spaces, normed linear spaces and metric induced by a norm, subspaces, equivalent norms, finite-dimensional and quotient spaces, Banach spaces, Hölder's and Minkowski's inequalities, strong and weak convergence. Bounded linear operators and operator norm, continuous linear functionals, dual and second dual spaces, reflexive spaces, Hahn-Banach theorem, Riesz representation theorem, uniform boundedness principle, open mapping theorem, closed graph theorem.

**References:**

1. Carothers N. L., *Real Analysis*, Cambridge University Press, 2009.
2. Rudin W., *Principles of Mathematical Analysis*, 3rd Edition., Mc Graw Hill, 2023.
3. Limaye B.V., *Functional Analysis*, 3rd Edition, New Age International Private Limited, 2014.
4. Kreyszig E., *Introductory Functional Analysis with Applications*, John Wiley and Sons, 2022.
5. Conway J.B., *A Course in Functional Analysis*, 2nd Edition Springer, 2007.

**MAS6222 Optimization Theory and Applications [3 0 0 3]**

Introduction to optimization problems and mathematical programming, formulation of optimization models, convex sets and convex functions, generalized convexity, quasi-convexity and pseudo convexity. Unconstrained optimization of functions of one and several variables, one-dimensional methods including Fibonacci search, Golden Section method and quadratic interpolation, multidimensional methods including steepest descent, conjugate gradient, Newton and quasi-Newton methods. Constrained optimization: equality and inequality constraints,

Lagrange multipliers, constraint qualifications, Karush-Kuhn-Tucker (KKT) necessary and sufficient conditions, and applications to nonlinear programming problems. Quadratic programming and convex programming, methods of feasible directions, gradient projection methods and cutting-plane methods. Duality theory and sensitivity analysis. Introduction to multi-objective optimization and computational optimization techniques, including Genetic Algorithms, Particle Swarm Optimization and other evolutionary methods, with applications to engineering, data science and scientific computing.

**References:**


1. Rao, S.S., *Optimization Theory and Applications*, Wiley Eastern, 2009.
2. Hadley, G., *Nonlinear and Dynamic Programming*, Addison Wesley, 2018.
3. Taha, H., *Operations Research: An Introduction*, Pearson Education, 2019.
4. Deb, K., *Multi-Objective Optimization Using Evolutionary Algorithms*, John Wiley & Sons Inc, 2009.
5. Bazara, M., Shetty, C. M., *Nonlinear Programming: Theory and Algorithms*, 3rd Edition, John Wiley, 2006.


**MAS6223 Data Structures and Algorithms [3 0 2 4]**

Introduction: Data types, data structures, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, obtaining the complexity of an algorithm. Arrays: Notations and analysis, storage structures for arrays, sparse matrices, structures and arrays of structures. Stacks and Queues: Representations, implementations, and applications. Linked Lists: Singly linked lists, stacks and queues using linked lists, operations on polynomials, doubly linked lists, circularly linked lists, dynamic storage management, garbage collection, and compaction. Trees: Basic terminology, general trees, binary trees, tree traversals: in-order, pre-order, and post-order traversal, building a binary search tree, operations on binary trees, height-balanced trees (AVL). Graphs: Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pairs shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strongly connected components, minimum-cost spanning trees. Sorting and Searching Techniques: Bubble sort, insertion sort, selection sort, merge sort, heap and heap sort, quick sort, sequential searching, binary searching, and hash table methods.

**References:**


1. Tremblay, J.P., Sorenson, P.G., *An Introduction to Data Structures with Applications*, McGraw Hill, 2017.
2. Sahni, S., *Data Structures, Algorithms and Applications in C++*, WCB/McGraw Hill, 1999.
3. Aho, A.V, Ullman, J.D., and Hopcroft, J.E, *Data Structures and Algorithms*, Pearson, 1982.
4. Langsam, Y., Augenstein, M. J., Tenenbaum, A.M., *Data Structures Using C*, Pearson Education, 2015.
5. Richard F. G., Behrouz A. F., Gilberg, R.F., *Data Structures- A Pseudocode Approach with C*, Cengage India Private Limited, 2007.

**MAS6224 Relational Database Management Systems [3 0 2 4]**

Introduction to file and database systems, database system structure, concepts and architecture, data models, schemas and instances, DBMS architecture and data independence, database languages and interfaces, data model, ER model. Relational Models: SQL, data definition, queries in SQL, relational model concepts, relational model constraints, relational algebra, SQL—a relational database language: data definition in SQL, views and queries in SQL, specifying constraints and indexes in SQL, relational database management systems—updates, views, integrity and security, relational database design, functional dependencies and normalization for relational databases, normal forms based on primary keys (1NF, 2NF, 3NF, and BCNF), lossless-join and dependency-preserving decomposition, converting ER diagrams into relations. Data Storage and Query Processing: Record storage and primary file organization, secondary storage devices, operations on files, heap files, sorted files, hashing techniques, index structures for files, different types of indexes, B-Tree and B+ Tree. Transaction Management: Transaction processing, need for concurrency control, desirable properties of transactions, schedules and recoverability, serializability and schedules, concurrency control, types of locks, two-phase locking, deadlock.

**References:**


1. Silberschatz, A., Korth, H. F., Sudarshan, S., *Database System Concepts*, 7th Edition, McGraw-Hill, 2020.
2. Elmasri, R., Navathe, S. B., *Fundamentals of Database Systems*, 8th Edition, Pearson, 2020.
3. Ramakrishnan, R., Gehrke, J., *Database Management Systems*, 3rd Edition, McGraw-Hill, 2003.
4. Date, C. J., *An Introduction to Database Systems*, 8th Edition, Pearson, 2003.
5. Coronel, C., Morris, S., *Database Systems: Design, Implementation, & Management*, 14th Edition, Cengage, 2023.


**MAS6225 Object Oriented Programming [3 0 2 4]**

Object-Oriented Programming: OOP paradigm, basic concepts and benefits of OOP, object-oriented design and development, design steps and examples, object-oriented languages, comparison of structured and object-oriented programming. Arrays and their memory representation, initialization and multidimensional arrays, pointers and pointer operations, arrays of pointers, pointers to pointers, passing pointers to functions, functions and arguments, inline functions, function overloading and polymorphism. Classes and objects, access specifiers, constructors and destructors, operator overloading, type conversion. Storage Classes: automatic vs. fixed declarations, scope, global variables, register specifier, dynamic memory allocation. Inheritance and its Types: single, multiple, multilevel, hierarchical, and hybrid inheritance, virtual functions. Streams and Files: file handling, opening and closing files, file pointers and manipulation, sequential and random access, input and output operations, multi-file programs, command-line arguments. Classes: String, date, array, list, and queue classes. Exception Handling: list of exceptions, catching and handling exceptions.

**References:**


1. Balagurusamy, E., *Object-Oriented Programming with C++*, 9th Edition, McGraw Hill Education, 2026.
2. Robert, L., *Object-Oriented Programming in C++*, 4th Edition, Sams Publishing, 2002.
3. Bjarne, S., *The C++ Programming Language*, 4th Edition, Addison-Wesley, 2013.
4. Herbert S., *C++: The Complete Reference*, 5th Edition, McGraw-Hill, 2015.
5. Stanley, B. L., Josée, L., Barbara, E. M., *C++ Primer*, 5th Edition, Addison-Wesley, 2012.


**MAS6271 Seminar and Technical writing [0 0 0 2]**

Introduction to technical and scientific communication, literature search and review using scholarly sources, formulation of a technical/research problem, structure and preparation of technical reports, research papers and abstracts, mathematical writing and use of LaTeX, preparation of tables, figures and references, citation practices, plagiarism and research ethics, preparation and delivery of technical presentations, seminar participation, discussion and viva-voce.

Students will undertake a literature-based study on a topic related to Mathematics and Computing and submit a technical report followed by an oral presentation.

**References:**


1. Grätzer, G., *Text and Math into LaTeX*, 6th Edition, Springer, 2024.
2. Higham, N. J., *Handbook of Writing for the Mathematical Sciences*, 3rd Edition, SIAM, 2020.
3. Humphrey, J. D. and Holmes, J. W., *Style and Ethics of Communication in Science and Engineering*, Springer, 2024.
4. Bergman, O., Park, S. and Bagniewska, J., *The Communicating Scientist: A Practical Handbook*, Springer, 2025.
5. Datta, D., *LaTeX in 24 Hours: A Practical Guide for Scientific Writing*, Springer, 2017.