Advanced Mathematics			
Course Code	**1MCS101**	Scheme	2026
Type of Course	**BSC**	Semester	I
Teaching Hours/Week (L:T:P)	3:0: 0	CIE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42: 0: 0: 48	SEE Marks	50
Credits	**3**	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	3

Course Outcomes

At the end of the course, the student will be able to:

CO1: Apply inner product space concepts, matrix factorization techniques, least-squares methods, quadratic forms, singular value decomposition, and principal component analysis to solve mathematical and data-driven problems.

CO2: Analyse data using correlation, curve fitting, regression models, and maximum likelihood methods to interpret relationships among variables and develop suitable predictive models.

CO3: Apply unconstrained optimization techniques to formulate and solve optimization problems.

CO4: Apply constrained optimization techniques to solve optimization problems arising in engineering and computational applications.

Module-1: Inner Product Spaces

Orthogonality and least squares: Inner product, orthogonal sets, orthogonal projections, orthogonal bases. Gram-Schmidt orthogonalization process. QR factorizations of matrices, least square problems, applications to linear models (least square lines and least square fitting of other curves).

Number of Hours:8

Module-2: Symmetric and Quadratic Forms

Symmetric and Quadratic Forms: Diagonalization, Quadratic forms, Canonical Forms, The Singular value decomposition. Applications for image processing and statistics, Principal Component Analysis

Number of Hours:8

Module-3: Regression Analysis

Correlation, Regression Analysis, Curve fitting (Linear and Non-linear), Simple linear regression, Multiple linear regression, Multivariate regression analysis, Logistic regression, Maximum Likelihood Method,

Number of Hours:8

Module-4: Unconstrained Optimization

Function of several variables, partial differentiation, local and global optima, convex sets and functions separating hyperplanes, application of Hessian matrix in optimization.

Optimization using gradient descent method and NR method and Fibonacci search.

Number of Hours:9

Module-5: Constrained Optimization

Problem Formulation, Minimax Algorithms applications of unconstrained optimization, Point Pattern Matching, Concept of Lagrangian multiplier, Kuhn Tucker conditions (KKT), Method of Multipliers, Penalty Function, Complex search method, Interior Point Methods for Large-scale Optimization.

Number of Hours:9

Textbooks:

1. Stephen Boyd and Lieven Vandenberghe, Convex Optimization" by , 1st Edition, Cambridge University Press, 2004.
2. Linear Algebra and Optimization for Machine Learning, Charu C. Aggarwal, Springer, 2020
3. Linear Algebra and its applications, David C. Lay, Steven R. Lay, Judi J Mc. Donald, 5th Edition, 2021, Pearson Education
4. Introduction to Linear Regression Analysis by Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining (Wiley), 6th Edition, 2024.
5. Mathematics for Machine learning, Marc Peter Deisennroth, A. Aldo Faisal, Cheng Soon Ong, 2020, Cambridge University Press.

Reference books / Manuals:

1. S. S. Rao, Engineering Optimisation: Theory and Practice, Wiley, 2008.
2. K. Deb, Optimization for Engineering design algorithms and Examples, Prentice Hall, 2nd edition 2012.
3. Jorge Nocedal and Stephen J. Wright, Numerical Optimization, 2nd Edition, Springer, 2006.
4. Linear Algebra and its Applications, Gilbert Strang, 4th edition, 2005, Brooks Cole.
5. Linear Algebra: An Introduction, Richard Bronson & Gabriel B. Costa, 2nd edition, Academic press.
6. Linear Models and Generalizations - Least Squares and Alternatives by C.R. Rao, H. Toutenburg, Shalabh, and C. Heumann (Springer, 2008)

Web links and Video Lectures (e-Resources):

1. Statistics Made Easy: https://numiqo.com/assets/Statistics_made_easy_8_sample.pdf
2. Convex Optimization: https://web.stanford.edu/~boyd/cvxbook/bv_cvxbook.pdf

Assessment Structure (both CIE and SEE)

The weightage assigned to Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) shall be **50% each**. A student shall secure a minimum of 50% of the maximum marks prescribed for CIE and a minimum of **40%** of the maximum marks prescribed for SEE to be eligible for passing.

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to a subject/course only if he/she secures not less than **50% of the aggregate marks** obtained in CIE and SEE taken together.

Continuous Internal Evaluation:

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted. Each test shall be conducted for a maximum of **25 marks**. The average of the two test marks shall be the marks secured by a student in IA.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.