Course Title: Mathematics for Data Science			
Course code:	**No. of credits:** 4	**L-T-P: 45-15-0**	**Learning hours: 60**
			L: Lectures; **T:** Tutorials**; P:** Practicals
Pre-requisite course code and title (if any): None			
Department: Natural and Applied Sciences			
Course coordinator:		**Course instructor:**	
Contact details:			
Course type: Core		**Course offered in:** Semester 1	

Course Description

The course is intended to act as a foundational course for other courses that are offered as part of the bachelor's degree in data science that require a strong mathematical background. It will give an overview of the fundamental mathematical methods used for investigating environmental data.

Course objectives

The course aims to build conceptual understanding and applied skills in said mathematical domains of linear algebra – matrices, determinants and vector spaces; calculus – differential and integral calculas; and differential equations.

Course content

	Topic	L	T	P
	Module 1: Introduction to mathematics for data science			
1	Introduction: Quantitative aspects in data driven decision making, tools available–deterministic (analytical and numerical), stochastic processes; mathematical modelling.	3		
2	Review of relations and functions, trigonometry, logarithms, quadratic equations.	5	1	
	Module 2: Linear algebra – matrices and determinants			
3	Matrices: Types of matrices, algebra of matrices, rank, transpose, and inverse of a matrix, symmetric, skew symmetric, and invertible matrices, square matrices, diagonal matrix, scalar matrix, orthogonal matrix.	5	2	
4	Determinants: Properties of determinants, singular and non-singular matrices, examples, finding an adjoint and inverse matrix, applications of determinants and matrices, definition of left/right eigenvalues and eigenvectors, Caley – Hamilton theorem, singular value decomposition, interpretation of eigenvalues/vectors, characteristic polynomial, diagonalization of a matrix, matrix factorization: Gauss elimination, row canonical form, Gauss-Jordan-LU decomposition.	5	2	
	Module 3: Linear algebra – vector spaces			
5	Introduction of vector spaces, subspaces, linear dependence, and independence of vectors, spanning set, basis and dimension, finite dimensional vector spaces and examples, linear transformation, kernel, range, matrix representation of a linear transformation, rank-nullity.	6	3	
6	Theorem, eigenvalues and eigenvectors, system of linear equations, consistency of a system of linear equations.	3		
	Module 4: Differential and integral calculus			

7	Differential calculus: Limits and continuity, derivatives and differentiation, logarithmic differentiation, successive differentiation, infinite series, applications of differential calculus, increasing and decreasing functions, the role of the Hessian maxima and minima and related extreme conditions, multivariable calculus.	7	3	
8	Integral calculus: Indefinite integrals, methods of integration – integration by substitution, by parts, decomposition into sums, applications. Definite integrals, theorems of definite integrals and evaluation of definite integrals, double integrals, applications of integrals and area under curves.	7	3	
	Module 5: Differential equations			
9	Linear and non-linear differential equations, solutions of differential equations, differential equations of first order and first degree, ordinary differential equations.	4	1	
	Total	**45**	**15**	

Evaluation criteria

- Minor 1: Written test [at the end of teaching of modules 1 and 2] -- 15%
- Minor 2: Written test [at the end of teaching of module 3] -- 15%
- Assignment: 20%
- Major Test: Written test [at the end of the semester, full syllabus] -- 50%

Learning outcomes

Upon completion of the course, the students will be able to

- understand deterministic and stochastic methods for analyzing data; and comprehend the basic mathematical concepts like relations and functions. [Module 1; Minor1]
- interpret the concepts of matrices and determinants in data science. [Module 2; Minor 1]
- apply linear and non-linear equations in real world problems. [Module 3; Minor 2]
- acquire the necessary background for advanced courses in Data Science such as coding theory, artificial intelligence, numerical computation. [Modules 1, 2, 3, 4 and 5; Major Test]

Pedagogical approach

- The course will be delivered through lectures and tutorials that will focus on developing necessary mathematical foundations for Data Science.
- The course will also focus on classroom discussions and assignments to improve the analytical and problem-solving capabilities of the students.

Reading Resources

Kreyszig, E. (2010). *Advanced Engineering Mathematics*. John Wiley.

Nield, T. (2022). *Essential Math for Data Science*. O'Reilly Media, Inc.

Prasad G. (2004). *Differential Calculus*. Pothishala Pvt. Ltd., Allahabad.

Prasad G. (2004). *Integral Calculus*. Pothishala Pvt. Ltd., Allahabad.

Ren, J., Wang, H. (2023). *Mathematical Methods in Data Science*. Elsevier.

Spivak, M. (2006). Calculus. Cambridge University Press.

Strang, G. (2006). *Linear Algebra and its Applications*. Belmont, CA: Thomson, Brooks/Cole.

Thomas, G.B., Fineey, R.L, Weir, M.D., Giordano, F.R. (203). *Thomas's Calculus*. Addison-Wesley.
Student Responsibilities The students are required to come prepared with readings that are suggested during the class and ensure timely submission of assignments. They are also expected to participate and further strengthen their understanding of concepts through classroom discussions.

Course Reviewers:

1. **Reviewer 1 – Dr Gurminder Singh,** Associate Professor, Department of Mathematics, Birla Institute of Technology (Mesra) Jaipur Campus
2. **Reviewer 2 – Prof. Shakir Ali**, Professor, Department of Mathematics, Aligarh Muslim University