BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
WORK INTEGRATED LEARNING PROGRAMMES

COURSE HANDOUT

Part A: Content Design

Course Title	Mathematical Foundations for Data Science
Course No(s)	

Course Description

Vector and matrix algebra, systems of linear algebraic equations and their solutions; eigenvalues, eigenvectors and diagonalization of matrices; graphs and digraphs; trees, lists and their uses; partially ordered sets and lattices; Boolean algebras and Boolean expressions;

Course Objectives

No	Objective- The course aims to
CO1	Introduce concepts in linear algebra and to use it as a platform to model physical problems.
CO2	Provide techniques for analytical and numerical solutions of linear equations and introduce the concept of convergence.
CO3	Introduce some of the mathematical structures, concepts and notations used in discrete mathematics.
CO4	Introduce some concepts from graph theory, partially ordered sets, Boolean algebras.

Text Book(s)

No	Author(s), Title, Edition, Publishing House
T1	Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India, 9 th Edition, 2011
T2	Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw Hill, 7th Ed., 2011.

Reference Book(s) & other resources

No	Author(s), Title, Edition, Publishing House
R1	K Hoffman and R Kunze, Linear Algebra, Pearson Education, 2nd Edition, 2005.
R2	Kolman, Busby, Ross and Rehman, Discrete Mathematical Structures for Computer Science, Pearson Education, 6th Edition, 2017

Content Structure

No	Title of the module	References
M1	1. Matrices, System of equations, determinants and inverse of a matrix	T1: Sec 7.1 – 7.3, 7.5, 7.8

	1.1. Matrix Algebra-Row-reduced echelon form of a matrix, Inverse of a matrix 1.2. System of linear equations, Consistency and inconsistency of system of linear equations	
M2	2. Vector spaces and Linear transformations 2.1 Vector space, subspace and span of a set, Linear dependence and independence of a set of vectors, basis and dimension 2.2. Linear transformation, rank and nullity	T1: Sec 7.4, 7.9, R1: Sec 3.2
M3	3. Eigenvalues and Eigenvectors 3.1. Eigenvalues 3.2. Eigenvectors	T1: Sec 8.2, 8.3
M4	4. Numerical linear algebra 4.1. Gauss elimination with partial pivoting and scaling 4.2. Iterative methods for solving linear system of equations	T1: Sec 20.1
M5	5. Matrix Eigenvalue Problems 5.1. Eigenvalue problems in linear system of equations 5.2. Power method for finding the dominant eigenvalue	T1: Sec 20.3, 20.8
M6	6. Sets, Functions and Relations, Boolean Algebra 6.1 Introduction to set theory, set relations, set operators, cardinality of sets, Cartesian product of sets 6.2 Fundamentals of functions – range, domain, injection, surjection, bijection of functions 6.3 Fundamentals of relations, reflexive, symmetric and transitive properties in relations, representing relations, applications of relations, equivalence relations, partial order relations, lattices. 6.4 Boolean functions, representing Boolean functions	T2: Sec 2.1, 2.2, 2.3, 7.1 – 7.6, 10.1, 10.2
M7	7. Graph Theory 7.1 Introduction to graph theory, directed and undirected graphs, handshaking theorem, special graph structures, graph representations and isomorphism of graphs, connectedness, components, Euler, Hamilton paths and cycles 7.2 Trees, binary trees, binary search tree, spanning trees, minimum spanning trees – Prim's and Kruskal's algorithms.	T2: Sec 8.1-8.5, 9.1-9.5

Learning Outcomes:

No	Learning Outcomes
LO1	Students will be able to effectively use matrix algebra tools to analyse and solve systems of linear equations.
L02	Students will be able to use some numerical methods to solve linear systems of equations
LO3	Students will be able to work with some of the mathematical structures, concepts and notations used in discrete mathematics
LO4	Students will be able to apply the concepts of sets, functions, relations and graph theoretic concepts to problems in computer science

Part B: Contact Session Plan

Academic Term	
Course Title	Mathematical Foundations for Data Science
Course No	
Lead Instructor	

Course Contents

Contact Hours	List of Topic Title	Text/Ref Book/external resource
1	Introduction to matrices, row-reduced echelon form of a matrix	T1: Sec 7.1 – 7.3
2	Consistency of linear systems, matrix inversion	T1: Sec 7.5, 7.8
3	Vector space, subspace and span, Linear dependence and independence, basis and dimension	T1: Sec 7.4
4	Linear transformation, rank and nullity	T1: Sec 7.9, R1: Sec 3.2
5	Eigenvalues of a matrix	T1: Sec 8.2
6	Eigenvectors of a matrix	T1: Sec 8.3
7	Gauss elimination with scaling and partial pivoting	T1: Sec 20.1
8	Iterative methods of solving linear systems; Matrix eigenvalue problems and Power method for finding the dominant eigenvalue	T1: Sec 20.3, 20.8
9	Introduction to set theory, set relations, set operators, cardinality of sets, Cartesian product of sets	T2: Sec 2.1, 2.2
10	Fundamentals of functions – range, domain, injection, surjection, bijection of functions	T2: Sec 2.3
11	Fundamentals of relations, reflexive, symmetric and transitive properties in relations	T2: Sec 7.1, 7.2
12	Representing relations, applications of relations, equivalence relations, partial order relations, lattices.	T2: Sec 7.3, 7.4, 7.5, 7.6

13	Introduction to graph theory, directed and undirected graphs, handshaking theorem, special graph structures, graph representations	T2: Sec 8.1, 8.2
14	Isomorphism of graphs, connectedness, components, Euler, Hamilton paths and cycles	T2: Sec 8.3, 8.4, 8.5
15	Trees, binary trees, binary search tree, Spanning trees, minimum spanning trees – Prim's and Kruskal's algorithms.	T2: Sec 9.1, 9.2, 9.3, Sec 9.4, 9.5
16	Boolean Algebra- Boolean Functions, Representing Boolean functions	T2: Sec 10.1, 10.2

 # The above contact hours and topics can be adapted for non-specific and specific WILP programs depending on the requirements and class interests.

Lab Details

Title	Access URL
Lab Setup Instructions	Not applicable
Lab Capsules	Not applicable
Additional References	Not applicable

Select Topics and Case Studies from business for experiential learning

Topic No.	Select Topics in Syllabus for experiential learning	Access URL
1	Assignment - linear algebra topics	
2	Assignment- discrete structures topics	

Evaluation Scheme

Legend: EC = Evaluation Component

No	Name	Type	Duration	Weight	Day, Date, Session, Time

Note *- Evaluation components can be tailored depending on the proposed model.*

Important Information

Syllabus for Mid-Semester Test (Closed Book): Topics in Weeks 1-8

Syllabus for Comprehensive Exam (Open Book): All topics given in plan of study

Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Announcements regarding the same will be made in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
3. For Open Book exams: Use of prescribed and reference text books, in original (not photocopies) is permitted. Class notes/slides as reference material in filed or bound form is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam. The genuineness of the reason for absence in the Regular Exam shall be assessed prior to giving permission to appear for the Make-up Exam. Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.