

Programme	BSc Mathematics Honours			
Course Code	MAT4CJ203			
Course Title	REAL ANALYSIS I			
Type of Course	Major			
Semester	IV			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	3	2	75
Pre-requisites	1. Mathematical Logic and necessary exposure to set theory. 2. Basic Calculus			
Course Summary	After introducing the basic notions in set theory, the course develops into the construction of the Real number system. Thereafter Real functions are introduced and the notions of limit and continuity are developed.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Set Theory Fundamentals and Real Number Properties	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO2	Apply the completeness property of \mathbb{R} , and solve problems involving intervals and applications of the supremum property.	U	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
CO3	Analyse sequences and their limits, apply limit theorems, and demonstrate an understanding of concepts such as monotone sequences, sub-sequences, and the Cauchy Criterion, as well as their applications in solving problems related to sequences and limits.	An	C	Internal Exam/ Assignment/Seminar/ Viva/Report/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook		Introduction to Real Analysis, 4/e, Robert G Bartle, Donald R Sherbert John Wiley & Sons (2011)		
Module	Unit	Content	Hrs (45+30)	External Marks (70)
I	Introduction to Set theory		8	Min.15
	1	Section 1.1 - Sets and functions (for review only)		
	2	Section 1.2 - Mathematical Induction (Proofs of results included in practicum part).		
	3	Section 1.3 – Finite and Infinite sets.		
	4	Section 1.3 – Countable and Uncountable sets.		
II	The Real numbers		13	Min.15
	5	Section 2.1 – The algebraic properties of \mathbb{R} .		
	6	Section 2.1 – The order properties of \mathbb{R} .		
	7	Section 2.2 – Absolute value and the Real Line.		
	8	Section 2.3 – Completeness property of \mathbb{R} (Proofs included in Practicum).		
	9	Section 2.4 – Applications of the Supremum property - 2.4.3 to 2.4.6 and 2.4.8 to 2.4.9 (All other discussions included in Practicum).		
	10	Section 2.5 – Intervals – 2.5.2 to 2.5.4 (All other discussions included in Practicum).		
III	Sequences and Limits		12	Min.15
	11	Section 3.1 – Sequences and their limits.		
	12	Section 3.1 – Problems to find limits of sequence.		
	13	Section 3.2 – Limit theorems.		
	14	Section 3.2 – Problems using Limit theorems.		
	15	Section 3.3 – Monotone sequences – Monotone Convergence Theorem.		
	16	Section 3.3 – Applications of Monotone Convergence Theorem – Euler’s number introduction only.		
IV	Sequences and Limits (continued)		12	Min.10
	17	Section 3.4 – Sub sequences and the Bolzano Weierstrass theorem (Second proof of Theorem 3.4.8 is omitted for external exam and limits superior and inferior are included in practicum).		
	18	Section 3.4 – Problems using Divergence criteria.		
	19	Section 3.5 – The Cauchy Criterion (Examples 3.5.9, 3.5.11 and Corollary 3.5.10 are included in Practicum).		
	20	Section 4.1- Limits of functions (Proofs included in Practicum).		
	21	Section 4.2: Limit theorems of functions (Proofs included in Practicum).		

	22	Section 4.3: Some extensions of limit concepts (Proofs included in Practicum).		
V	Practicum: The goal is for the students to learn the following topics in 15 practicum sessions of two hours each via self-study and group activities. The lecturer may assist by running group discussions, supervising class seminars and referring library books for self-study and note preparation.		30	-
	1	Section 1.2 - for detailed discussions including proofs		
	2	Section 2.3 – re do it with all the proofs		
	3	Section 2.4 – Worked out examples for applying the ideas of supremum and infimum and the existence of square root of 2		
	4	Section 2.5 – Characterization theorem for intervals and representations of real numbers		
	5	Section 3.4 – discussions of limit inferior and limit superior with examples		
	6	Section 3.5 – Estimation of errors in contractive sequences with examples		
	7	Section 3.6 – Properly divergent Sequences		
	8	Section 3.7 – Introduction to Infinite Series – conditions for convergence – Harmonic Series		
	9	Section 3.7 – Comparison Tests with examples		
	10	Section 4.1 – Formulate a precise definition of limit and illustrate with examples		
	11	Section 4.1 – Sequential Criterion for Limits for convergence and divergence with examples		
	12	Section 4.2 – Limit theorems for functions in parallel to that of sequences.		
	13	Section 4.3 – One sided and infinite limits.		
	14	Section 11.1 – Open sets, their properties and characterization.		
	15	Section 11.1 - Closed sets, their properties and characterization.		
References				
<ol style="list-style-type: none"> 1. Tom.M. Apostol, Calculus I, Wiley & Sons. 2. Tom.M. Apostol, Mathematical Analysis, 2/e, Addison-Wesley. 3. Richard R Goldberg, Methods of Real Analysis, 2/e, Wiley 4. Raymond L Wilder, Introduction to the Foundations of Mathematics,2/e, John WileySons 				
Optional Programming References for Practicum:				
(1) SageMath Calculus Tutorial https://www.sagemath.org/calctut/limits.html				
(2) SageMath 2D plotting https://doc.sagemath.org/html/en/reference/plotting/sage/plot/plot.html#				

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	3	2	3	0	3	0	3	0	0
CO 2	1	3	2	2	3	0	3	0	3	0	0
CO 3	3	2	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Report
- Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/ Report	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Code	MAT4CJ204			
Course Title	BASIC LINEAR ALGEBRA			
Type of Course	Major			
Semester	IV			
Academic Level	200 – 299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	4	4	--	60
Pre-requisites	1.Familiarity with system of equations and their solutions 2. Knowledge about matrices and matrix operations.			
Course Summary	This course is a quick review of linear algebra, intended for students who have already taken a previous course in linear algebra or have some experience with vectors and matrices. It begins with the concepts of vector spaces, subspaces, bases and dimension. Linear transformations are introduced as ‘natural maps’ between vector spaces. The course opens up the classical finite dimensional inner product theory for the canonical reduction of a matrix as a special case of a self-adjoint operator.			

Course Outcomes:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and apply concepts related to vector spaces and subspaces, including determining whether a set forms a subspace and finding the span of a set	U	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO2	Demonstrate proficiency in analysing null spaces, column spaces, and linear transformations, including understanding the kernel and range of a linear transformation and contrasting the properties of null space and column space.	An	P	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
CO3	Evaluate and apply concepts related to bases, dimensionality, and rank of vector spaces, including understanding bases for null space and column space, determining dimensions of subspaces, and applying the rank theorem to systems of equations.	E	C	Internal Exam/Assignment/Seminar/Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Text Book	Linear Algebra and its Applications, Third Edition, David .C. Lay, Pearson Publications				
Module	Unit	Content	Hrs (48+ 12)	External Marks (70)	
I	Module I			14	Min 15
	1	Section 4.1: Vector Spaces and Subspaces Vector Spaces and Subspaces, Subspaces, A Subspace Spanned by a Set.			
	2	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. The Null Space of a Matrix, An Explicit Description of Nul A.			
	3	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. The Column Space of a Matrix, The Contrast Between Nul A and Col A.			
	4	Section 4.2: Null Spaces, Column Spaces, and Linear Transformations. Kernel and Range of a Linear Transformation.			
	5	Section 4.3: Linearly Independent Sets; Bases. Linearly Independent Sets; Bases, The Spanning Set Theorem.			
	6	Section 4.3: Linearly Independent Sets; Bases. Bases for Nul A and Col A, Two Views of a Basis.			
II	Module II			12	Min 15
	7	Section 4.4: Coordinate Systems. Coordinate Systems, A Graphical Interpretation of Coordinates, Coordinates in \mathbb{R}^n .			
	8	Section 4.4: Coordinate Systems. The Coordinate Mapping.			
	9	Section 4.5: The Dimension of a Vector Space. The Dimension of a Vector Space.			
	10	Section 4.5: The Dimension of a Vector Space. Subspaces of a Finite-Dimensional Space, The Dimensions of Nul A and Col A.			
	11	Section 4.6: Rank Rank, The Row Space.			
	12	Section 4.6: Rank The Rank Theorem, Applications to Systems of Equations (Topics up to and including Example 5).			
III	Module III			12	Min 15
	13	Section 6.1: Inner Product, Length and Orthogonality The Inner Product, The Length of a Vector, Distance in \mathbb{R}^n .			
	14	Section 6.1: Inner Product, Length and Orthogonality Orthogonal Vectors, Orthogonal Complements, Angles in \mathbb{R}^2 and \mathbb{R}^3 .			
	15	Section 6.2: Orthogonal Sets			

		Orthogonal Sets, An Orthogonal Projection (Topics up to and including Example 4).		
	16	Section 6.2: Orthogonal Sets Orthonormal Sets.		
	17	Section 6.4: The Gram-Schmidt Process The Gram -Schmidt Process, Orthonormal Bases.		
	18	Section 6.4: The Gram -Schmidt Process QR Factorization of Matrices.		
IV	Module IV			
	19	Section 7.1: Diagonalization of Symmetric Matrices Diagonalization of Symmetric Matrices.	10	Min 15
	20	Section 7.1: Diagonalization of Symmetric Matrices The Spectral Theorem. Spectral Decomposition.		
	21	Section 7.2: Quadratic Forms Quadratic Forms (Topics up to and including Example 3), Classifying Quadratic Forms.		
	22	Section 7.4: The Singular Value Decomposition The Singular Value Decomposition, The Singular Values of an $m \times n$ Matrix , The Singular Value Decomposition (Topics up to and including Example 4 only).		
V	OPEN ENDED		12	
	<p>Linear Algebra Lab Sessions</p> <p>Book: Mike Cohen, Practical Linear Algebra for Data Science, O'Reilly, 2019, ISBN 978-1-098-12061-0.</p> <p>Jupyter: https://github.com/mikexcohen/LinAlg4DataScience</p> <p>Choose lab demos and exercises for 12 hours as per lecturer's discretion.</p> <p>For Module I & II, Ch 2, 3, 5, 6 of book for Lab. For Module III, Ch 2 and Ch 9 of book for Lab. For Module IV, Ch 14 of book for Lab. Python and Jupyter review in Ch 16 of book.</p>			
References				
<ol style="list-style-type: none"> 1. Elementary Linear Algebra: Application Version, 11/e, Howard Anton & Chris Rorres Wiley 2. Algebra Done Right, 3/e, Sheldon Axler, Springer Nature, 2015. 3. Introduction to Linear Algebra, 6/e, Gilbert Strang, Wellesley-Cambridge Press. 4. Basic Linear Algebra, 2/e, T. S. Blyth and E.F. Robertson, Springer, 2002. 5. Linear Algebra, 2/e, Hoffman K and Kunze R, Prentice Hall of India, 1991. 6. Bretscher, Otto. <i>Linear algebra with applications</i>. Vol. 52. Eaglewood Cliffs, NJ: Prentice Hall, 1997. 7. Blyth, Thomas Scott, and Edmund F. Robertson. <i>Basic linear algebra</i>. Springer Science & Business Media, 2013. 				

***70 external marks are distributed over the first four modules subjected to a minimum of 15 marks from each module.**

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	2	2	3	0	3	0	3	0	0
CO 2	1	3	2	2	3	0	3	0	3	0	0
CO 3	3	2	3	3	3	0	3	0	3	0	0

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	B. Sc. Mathematics Honours			
Course Code	MAT4FV110(1)			
Course Title	STATISTICS AND MATHEMATICS WITH R			
Type of Course	VAC			
Semester	IV			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practicum per week	Total Hours
	3	3	-	45
Pre-requisites	1. Basic School (+2) Level Statistics 2. Basic Programming Experience			
Course Summary	The "Statistics and Mathematics with R" course is designed to provide an understanding of R programming for statistical analysis and mathematical computation. The curriculum begins with an introduction to R, covering basic features, data storage, and manipulation techniques. Subsequent modules explore graphical visualization, programming constructs such as flow control and functions, and computational linear algebra. Each unit offers hands-on exercises and references to relevant sections in the textbook by Braun and Murdoch, supplemented by further reading materials for deeper exploration. This course helps students with practical skills in utilizing R for statistical analysis and mathematical modeling.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate Proficiency in Basic and Intermediate R Programming	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam
CO2	Create and Interpret Various Types of Graphs Using R	C	C	Internal Exam/ Seminar/Assignment / End Sem Exam
CO3	Apply Advanced Mathematical and Statistical Functions in R	Ap	P	Internal Exam/ Seminar/Assignment / End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook		A First Course in Statistical Programming with R, , W. John Braun and Duncan J. Murdoch, Cambridge University Press, 3rd Ed., 2021, ISBN 978-1-108-99514-6.		
Module	Unit	Content	Hrs (36+9)	External Marks (50)
I	Introduction to R		12	Min 10
	1	R Studio. R Command Line. R as calculator. Named Storage. Quitting R.		
	2	Basic Features of R.		
	3	Vectors in R.		
	4	Data Storage in R. Packages,		
	5	Libraries and Repositories.		
	6	Getting Help. Useful Features of R.		
	7	Data Frames, tibbles, and lists		
	8	Data Input and Output		
Reference: Chapter 2, Sections 1 to 10				
II	Graphics with R		4	Min 10
	9	Bar Charts and Dot Charts. Pie Charts.		
	10	Histograms. Box Plots. Scatter Plots.		
	11	Plotting from Data Frames. Quantiles. QQ Plots.		
Reference: Section 3.1.				
III	Programming in R		13	Min 10
	12	Flow Control. For Loop. Examples 4.1 to 4.4.		
	13	If Statement. Examples.		
	14	Eratosthenes Sieve.		
	15	While Loop. Examples. Newton's Method.		

	16	Repeat loop. Break and Next Statements. Examples and Exercises.		
	17	Functions.		
	18	General Programming Guidelines		
Reference: Chapter 4, Sections 1-4.				
IV	Computational Linear Algebra		7	Min 10
	21	Vectors and Matrices in R		
	12	Matrix Multiplication and Inversion		
	19	Eigenvalues and Eigenvectors		
	20	Singular Value Decomposition		
Reference: Sections 7.1, 7.2, 7.3, 7.4.1.				
V	OPEN ENDED		9	
	<p>Suggestions:</p> <p>Section 3.2 - 3.4: Higher Level Graphics with ggplot</p> <p>Section 4.6: Debugging and Maintenance</p> <p>Section 4.7: Efficient Algorithms.</p> <p>Section 6.1: Monte Carlo, 6.2: Pseudo-Random Numbers</p> <p>Appendix A: Overview of Random Variables and Distributions</p> <p>Section 6.3: Simulation of Random Variables</p> <p>Section 8.3: Newton-Raphson</p> <p>Section 8.5: Linear Programming</p>			
Reference	<p>1. Roger D. Peng, R Programming for Data Science, LeanPub, 2022, ISBN 9781365056826. https://bookdown.org/rdpeng/rprogdatascience/</p> <p>2. Garrett Golemud, Hands-On Programming with R, O'Reilly, 2014, ISBN 1449359019. https://rstudio-education.github.io/hopr/</p> <p>3. Ruriko Yoshida, Linear Algebra and its Applications in R, Chapman and Hall, 2021, ISBN 9780367486846</p>			

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	1	2	2	2	2	2	2	1
CO 2	2	3	1	0	2	2	2	2	2	1	1
CO 3	1	1	3	2	2	2	2	2	2	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Programme	BSc Mathematics Honours			
Course Title	INTRODUCTION TO PYTHON AND SCIENTIFIC COMPUTING			
Type of Course	SEC – Double Major			
Semester	IV			
Academic Level	200-299			
Course Details	Credit	Lecture/Tutorial per week	Practical per week	Total Hours
	3	3	-	45
Pre-requisites	(1) Basic knowledge to start a desktop/laptop computer. (2) A basic course in calculus with an understanding of differential and integral calculus. (3) A basic course in matrix algebra (higher secondary level)			
Course Summary	This course introduces the fundamentals of Python with a focus towards mathematical programming. Getting started with Python, Various Interfaces, Variables, Modules, Loops, Lists, Tuples, Functions, Branching, Input and Output, Arrays and Plotting, Dictionaries and Strings and finally Classes and Object-Oriented Programming are introduced. Using the Python programming structure, an introduction to the advanced mathematics software SageMath is given in the last part of the course. Various practical problems making use of concepts from calculus and linear algebra are to be solved using the SageMath software in the open-ended practical part so that the students will come to know how to apply software to answer and compute typical problems from these subjects.			

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Basics of Python Programming.	U	C	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
CO2	Intermediate Level Concepts such as Object-Oriented Programming.	An	P	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
CO3	Scientific Computation using SageMath.	E	P	Internal Exam/ Assignment/ Practical Assessment / Viva/ End Sem Exam
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Textbook	<p>1. Introduction to Scientific Programming with Python, Joakim Sundnes, Simula SpringerBriefs on Computing, 2020, ISBN: 978-3-030-50356-7. Open Access: https://link.springer.com/book/10.1007/978-3-030-50356-7</p> <p>2. Sage for Undergraduates, 2nd Ed., Gregory V. Bard, 2022, American Mathematical Society, 2022. ISBN: 978-1470411114. 2014 Online Ed: http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf</p>			
Module	Unit	Content	Hrs (36+ 9)	Marks Ext: 50
I	Python Basics (Text 1, Ch. 1, 2, 3, 4.)		8	Min.10
	1	Getting Started (Ch 1). Programming Simple Mathematics (Sec 2.1). Variables and Variable Types (Sec 2.2).		
	2	Formatting Text Output. Importing Modules. (Sec 2.3, 2.4).		
	3	Loops and Lists. Loops for Automating Repeated Tasks. Using Lists to Store Sequences of Data. (Sec 3.1, 3.2, 3.3).		
	4	Iterating over a List with a for Loop.. Nested Lists and List Slicing. (Sec 3.4, 3.5).		
	5	Tuples. (Sec 3.6)		
II	Functions, Branching, I/O, Modules.		8	Min 10
	6	Programming with Functions.. Function Arguments and Local Variables. Default Arguments and Doc Strings. (Sec 4.1, 4.2, 4.3)		
	7	If Tests for Branching the Program Flow. Functions as arguments to Functions. (Sec 4.4, 4.5)		
	8	Solving Equations with Python Functions. (Sec 4.6)		
	9	Writing Test Functions to Verify Programs (Sec 4.7).		
	10	User Input and Error Handling. Reading Input User Data. Reading Data from Files. Writing Data to Files. (Sections 5.1, 5.3, 5.4. Section 5.2 omitted).		
	11	Handling Errors in Programs. (Sec 5.5)		
	12	Making Modules. (Sec 5.6)		

III	More Data Structures, Plotting (Text 1, Ch. 6, 7).		7	Min 10	
	13	Arrays and Plotting. Numpy and Array Computing. Plotting Curves with Matplotlib. (Sec 6.1, 6.2)			
	14	Plotting Discontinuous and Piecewise Defined Functions. (Sec 6.3).			
	15	Dictionaries and Strings. Examples: A Dictionary for Polynomials, Reading File Data to a Dictionary. (Sec 7.1 7.2, 7.3),			
	16	String Manipulation (Sec 7.4).			
IV	Classes and Object-Oriented Programming. (Text 1, Ch. 9, 10.)		7	Min 10	
	17	Basics of Classes. (Sec 8.1)			
	18	Protected Class Attributes, Special Methods. Example: Automatic Differentiation of Functions. (Sec 8.2, 8.3, 8.4).			
	19	Test Functions for Classes. Example: A Polynomial Class. (Sec 8.5, 8.6).			
	20	Class Hierarchies and Inheritance. Example: Classes for Numerical Differentiation, Integration. (Sec 9.1, 9.2, 9.3).			
V	<p>Open-Ended</p> <p>Lecturer's selections of 15 sessions of 2 hours each from below.</p> <p>Miscellaneous Python Exercises</p> <ol style="list-style-type: none"> 1. Pitfalls of Programming, Text 1, Section 2.5. 2. Familiarize various Python runtime environments and IDEs like IDLE, Spyder, VS Code, Virtual Environments, Jupyter Notebook, Google Colab, Anaconda/Miniconda/Mamba, Replit. 3. Familiarize various documentation websites and how to refer to the syntax and implementation of a Python concept or Package. 4. Case studies from Reference 2:, Income Tax Calculator (page 38), Investment Report (p. 73), Approximating Square Roots. (p. 92), Text Analysis (p. 126), Generating Sentences (p. 150). <p>Sagemath</p>				

1. Getting and installing sagemath in Windows, Ubuntu OS Using sagemath using cocalc (online).
2. Using Sage as a Calculator, Using Sage with Common Functions, Using Sage for Trigonometry (Text 2, sections 1.1, 1.2, 1.3).
3. Using Sage to Manipulate Polynomials (Text 2, section 1.7)
4. Matrices and Sage-A First Taste of Matrices, Doing the RREF in Sage (Text 2, section 1.5)
5. Using Sage for 2-D graphs (Text 2, section 1.4)
6. The Derivative, Slope of Tangent, Higher-Order Derivatives (Text 2, section 1.11))
7. Antiderivatives (Indefinite Integral), Definite Integrals, Improper Integrals (Text 2, sec 1.12, upto sec 1.12.6)

Sympy (Reference 3).

1. Sympy Introductory Tutorial.
2. Solve an equation algebraically.
3. Solve a system of equations algebraically.
4. Solve one or a system of equations numerically.
5. Find the roots of a polynomial symbolically or numerically.
6. Solve a matrix equation algebraically.
7. Solve a Diophantine equation algebraically.
8. Solve an ODE algebraically.

More Numpy and Data Visualization (Reference 1: Chapter 3, 4)

1. Numpy Functions: arange, linspace, zeros, ones, random.random, reshaping. (Sec 3.1.1 to 3.1.6). Copying, Saving and Restoring, Slicing, Arithmetic Operations. (Sec 3.1.7 to 3.1.10).
2. Matplotlib Module: 2D Plots, Polar Plots, Pie Charts, Multiple Plots. (Sec 4.1)
3. Sine function and friends, Circle, Parametric Plots, Error Bars. (Sec 4.2)
4. Simple 2D Animation (Reference 1, Section 4.4), Making a movie of a Plot (Text 1, Section 4.4)
5. Famous Curves: Astroids, Ellipse, Spirals of Archimedes and Fermat (Reference 1, Sec 4.5)
6. 2D Plots and Fractals (Reference 1, Section 4.6)
7. 3D Plots (Reference 1, Section 4.7)

Numerical methods using SageMath (Reference 5: Chapter 7)(7.1 - 7.10, 7.12)

- 1) Evaluate a Taylor series numerically.
- 2) Interpolate a function using
 - a) Newton's forward interpolation.
 - b) Newton's backward interpolation.
 - c) Lagrange's Interpolation.

- d) Newton's General Interpolation.
- 3) Find integral of function using
 - a. Trapezoidal Rule
 - b. Simpson's 1/3-rule
- 4) Find derivative of function numerically.
- 5) Solve first order differential equations numerically.
 - a) Euler method
 - b) Fourth order Runge-Kutta method
- 6) Solve algebraic equations numerically.
 - a) The Bisection method
 - b) Regula Falsi Method

References

1. Python for Education, Ajith Kumar B. P., 2023
<https://scischool.in/python/pythonForEducation.pdf>
2. Fundamentals of Python First Programs, Kenneth A Lambert, 2 Ed., Cengage, 2018.
3. Sympy Tutorial: <https://docs.sympy.org/latest/tutorials/intro-tutorial/index.html>
Solving Equations: <https://docs.sympy.org/latest/guides/solving/index.html>
4. Computational Mathematics with SageMath, Paul Zimmermann, Alexandre Casamayou,
<https://www.sagemath.org/sagebook/english.html>
5. SageMath Advice For Calculus, Tuan A. Le and Hieu D. Nguyen,
<https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf>
6. Sagemath Reference: <https://doc.sagemath.org/>

Programming Resources

1. Python official website: <https://www.python.org>
Documentation: <https://docs.python.org/>
2. Spyder official website and documentation, <https://www.spyder-ide.org/>
3. MIT Courseware, Getting Started: Python and IDLE,
<https://web.mit.edu/6.s189/www/handouts/GettingStarted.html>
4. Jupyter Notebook, <https://jupyter.org/>
5. Google Colaboratory (colab), <https://colab.google/>
6. Visual Studio Code: <https://code.visualstudio.com>,
Documentation: <https://code.visualstudio.com/docs>
VS Code for Web: <https://vscode.dev/>
7. Replit, <https://replit.com/>
8. Python Virtual Environments: <https://docs.python.org/3/tutorial/venv.html>
9. Anaconda, Miniconda and Mamba.
Anaconda: <https://docs.anaconda.com/free/anaconda/>

Miniconda: <https://docs.anaconda.com/free/miniconda>

Mamba: <https://mamba.readthedocs.io/en/latest/>

10. SageMathCloud at Cocalc: <https://cocalc.com>

Documentation: <https://doc.cocalc.com/>

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	2	1	3	2	3	3	2	1	2
CO 2	3	3	2	2	3	2	3	3	2	1	2
CO 3	3	3	3	3	3	1	3	3	3	1	3

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Seminar	Viva	End Semester Examinations
CO 1	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓

Assessment Rubrics:

- Assignment/ Seminar
- Internal Exam
- Viva
- Final Exam (70%)

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Course Title	Database Management System				
Type of Course	Major	Academic Level	200 - 299		
Pre-requisites	Discrete Mathematics, Data structures and Programming Basics				
Semester	IV				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Course Summary	This course provides an introduction to database management systems. The topics covered include the concept of Database Management System, ER Model, Relational model, SQL, Database design, Transactions, concepts of other data model-NoSQL and practical session to implement Database Concepts.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	A comprehensive understanding of fundamental concepts in database management systems and its application	U	C	Instructor-created exams / Quiz
CO2	Understand concepts of Relational Data Model and Normalization Techniques	U	C	Instructor-created exams / Quiz
CO3	Apply principles of entity-relationship modeling and normalization techniques to design efficient and well-structured databases that meet specified requirements.	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Acquire expertise in crafting and executing SQL queries for the retrieval, updating, and manipulation of data, showcasing adept skills in database querying and data manipulation	Ap	p	Practical Assignment / Observation of Practical Skills
CO5	Comprehend and apply strategies for managing transactions and implementing mechanisms for controlling concurrency, ensuring the database's consistency and reliability in environments with multiple users.	Ap	P	Practical Assignment / Observation of Practical Skills
CO6	Explore and analyze recent trends in database management systems, with a focus on unstructured databases, NoSQL technologies	An	P	Practical Assignment / Observation of Practical Skills

Detailed Syllabus:

Module	Unit	Content	Hrs	Mark
I	Database System- Concept		10	15
	1	Introduction, Characteristics of the Database Approach	2	

	2	Actors on the Scene, Workers behind the Scene, Advantages of Using the DBMS Approach, File system vs Database	2	
	3	Data Models, Schemas, and Instances , Three-Schema Architecture and Data Independence	3	
	4	Database Languages and Interfaces	2	
	5	Structured, Semi Structured and Unstructured Database	1	
II	Database Design		14	20
	6	ER Model- Basic concepts, entity set & attributes, notations	2	
	7	Relationships and constraints, cardinality, participation, notations, weak entities	2	
	8	Relational Model Concepts-Domains, Attributes, Tuples, and Relations, Values and NULLs in the Tuple	2	
	9	Relational Model Constraints and Relational Database Schemas	2	
	10	Relational Database Design- Atomic Domain and Normalization-1NF, 2NF,3NF,BCNF	4	
	11	4NF,5NF	2	
III	Query Languages		11	20
	12	SQL-, introduction to Structured Query Language (SQL)	1	
	13	Data Definition Language (DDL), Table definitions and operations	2	
	14	SQL DML (Data Manipulation Language) - SQL queries on single and multiple tables	4	
	15	Nested queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, Triggers, SQL data types.		
	16	Introduction to NoSQL Databases	2	
	17	Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB)	2	
IV	Transaction Processing,Concurrency Control		10	15
	18	Transaction Processing: Introduction, Transaction and System Concepts	3	
	19	Desirable Properties of Transactions	1	
	20	Characterizing Schedules Based on Recoverability & Serializability	2	
	21	Transaction Support in SQL.	1	
	22	Introduction to Concurrency Control: Two-Phase Locking Techniques	3	
V	DBMS LAB		30	
	1	Students should decide on a case study and formulate the problem statement.	3	
	2	Based on Identified problem Statement, Design ER Diagram (Identifying entities, attributes, keys and relationships between entities, cardinalities, generalization, specialization etc.) Note: Student is required to submit a document by drawing ER Diagram to the Lab teacher.	3	
	3	Converting ER Model to Relational Model (Represent entities and relationships in Tabular form, Represent attributes as columns, identifying keys) Note: Student is required to submit a document showing the database tables created from ER Model.	2	

	4	Normalization -To remove the redundancies and anomalies in the above relational tables, Normalize up to Third Normal Form	3	
	5	Creation of Tables using SQL- Overview of using SQL tool, Data types in SQL, Creating Tables (along with Primary and Foreign keys), Altering Tables and Dropping Tables	3	
	6	Practicing DML commands-Insert, Select, Update, Delete	2	
	7	Experiment 7:Practicing Queries using ANY, ALL, IN, EXISTS, NOT EXISTS, UNION, INTERSECT, CONSTRAINTS etc.	2	
	8	Practicing Sub queries (Nested, Correlated) and Joins (Inner, Outer and Equi).	2	
	9	Practice Queries using COUNT, SUM, AVG, MAX, MIN, GROUP BY, HAVING, VIEWS Creation and Dropping.	4	
	10	Install and Configure MongoDB to execute NoSQL Commands.	6	

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-						
CO 2	3	2	1	-	-	-						
CO 3	1	-	2	3	-	-						
CO 4	-	-	-	3	3	-						
CO 5	-	-	-	3	3	-						
CO 6	-	-	-	-	2	3						

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3		✓	✓	✓
CO 4		✓	✓	✓
CO 5	✓	✓		✓
CO 6		✓	✓	✓

Text books

1. Database System Concepts (Sixth Edition) Avi Silberschatz, Henry F. Korth, S. Sudarshan McGraw-Hill 2011 ISBN 978-0071325226/ 0-07-352332-1
2. Database Management Systems, Third Edition Raghu Ramakrishnan and Johannes Gehrke McGraw-Hill ©2003 ISBN: 978-0072465631/ 0-07-246563-8

Programme	B. Sc. Computer Science				
Course Title	Fundamentals of Python Programming				
Type of Course	Major				
Semester	IV				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. CSC2CJ101 – Fundamentals of Programming				
Course Summary	This course explores the versatility of Python language in programming and teaches the application of various data structures using Python. The course also gives an introduction to scientific computing using popular Python packages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts of Python programming language.	U	C	Instructor-created exams / Quiz
CO2	Apply problem-solving skills using the basic constructs in Python programming	Ap	P	Coding Assignments/ Code reading and review
CO3	Apply modular programming using functions in Python	Ap	P	Coding Assignments/ Code reading and review
CO4	Analyse the various data structures and operations on it using Python	An	C	Instructor-created exams / Case studies
CO5	Apply various packages available in Python	Ap	P	Coding Assignments/ Case studies
CO5	Apply visualization tools in Python	Ap	P	Coding Assignments/ Case studies

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
 # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)
 Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs
I	Fundamentals of Python (15 Marks)		12
	1	Features of Python, Identifiers, Keywords, Variables, Operators, Operands, Expressions and Data types	3
	2	Precedence and Associativity, Indentation, Comments	1
	3	Input, Output and Import functions, Mathematical functions, range function, Type Conversions	1
	4	Decision-making Structures	3
	5	Looping Structures	3
	6	Control Statements	1
II	Functions & Modules (15 Marks)		8
	7	Function Definition, Function Calling, Flow of Execution, Parameters and Arguments	2
	8	Types of Function Arguments – Required, Keyword, Positional and Variable length arguments	2
	9	Scope and lifetime of variables	1
	10	Types of Functions – Recursive, Anonymous, Functions with more than one return value, Void Functions	2
	11	Built in modules, User defined modules and packages	1
III	Data Structures in Python (20 Marks)		15
	13	Strings - Indexing, Traversal, Slicing, Joining, and Splitting of Strings, Formatting Strings, Operation and Methods of Strings	5
	14	Lists- Indexing and Traversal, Slicing, Joining, and Splitting of Lists, Operations and Methods of Lists	4
	15	Tuples – Indexing and Traversal, Operations and Methods of Tuples	2
	16	Dictionaries – Accessing and Modifying <i>key-value</i> pairs in Dictionary, Operations and Methods	3
	17	Sets - Creation and Operations of Sets	1
IV	Introduction to Scientific Computing in Python (20 Marks)		10
	18	Introduction to NumPy Arrays – Advantage of NumPy Arrays, Creation of NumPy Arrays	2
	19	Computation on NumPy Arrays - Universal Functions, Broadcasting, Fancy Indexing	3
	20	Introduction to Pandas - Pandas Series and Pandas Data Frames. Series - Construction from arrays, explicit indices, and dictionaries. Data Frames- Construction from arrays and dictionaries.	3
	21	Introduction to Matplotlib Basic plotting - Line plots, Scatter plots, Bar plots ,Histograms and Pie charts.	2
V	Hands-on Data Structures: Practical Applications, Case Study and Course Project		30

1	<p>Basics of Python</p> <ol style="list-style-type: none"> 1. Demonstrate basic data types in python using interactive Interpreter. 2. Write a Python script that reads two integers and perform all arithmetic operations on these two numbers. 3. Write a program to compute distance between two points. 4. Write a program to calculate the area of a circle. <p>Control Structures</p> <ol style="list-style-type: none"> 5. Write a program to check whether a number is odd or even. 6. Write a program that reads a positive integer, n, from the user and then displays the sum of the first n natural numbers. 	20
	<ol style="list-style-type: none"> 7. Write a Python program to check whether a given year is a leap year or not. 8. Develop a program that reads a four-digit integer from the user and displays the sum of the digits in the number. For example, if the user enters 2151 then your program should display $2+1+5+1=9$. <p>Function</p> <ol style="list-style-type: none"> 9. Write a program to find the largest of three numbers using functions. The program should pass three numbers as arguments and should return the result. 10. Write a function to check whether a given number is prime or not. 11. Write a recursive function to find the factorial of a number. <p>Python Data Structures: Strings, Sets, Lists , Tuples and Dictionaries</p> <ol style="list-style-type: none"> 12. Create a program that checks whether a given string is a palindrome or not. 13. Write a program to check whether an item exists in a tuple. 14. Write a program to create intersection, union, set difference, and symmetric difference of sets. 15. Write a program to create a telephone directory using a dictionary and display its contents. Also check for a specific phone number in the dictionary. <p>NumPy, Pandas and Matplotlib</p> <ol style="list-style-type: none"> 16. Write a program to implement matrix multiplication using NumPy. 17. Create a pandas series from a dictionary of values, and an ndarray. 18. Write a program to draw a line plot for the given heights and weights of a group of people. height=[145,155,165,175,185,195] weight=[43, 56, 60,69, 78,95] 	
2	Case Study	3
3	Capstone (/Course) Project: Build a practical application using any one package and demonstrate using visualization tools.	7

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-						
CO 2	2	-	2	-	1	-						
CO 3	2	-	2	1	-	-						
CO 4	1	-	1	-	-	-						
CO 5	-	2	2	2	2	2						
CO 6	-	2	2	-	2	2						

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Reference Books:

1. Jose, Jeeva. Taming Python By Programming. Khanna Book Publishing, 2017. Print.
2. S, Gowrishankar, and A, Veena. Introduction to Python Programming. Chapman & Hall/CRC Press, 2018.
3. Downey, Allen. Think Python. Green Tea Press, 2nd ed. 2009
4. VanderPlas, Jake. Python Data Science Handbook: Essential Tools for Working with Data. United States, O'Reilly Media, 2016.
5. Stephenson, Ben. *The Python Workbook*. SPRINGER INTERNATIONAL PU, 2016.

Programme	B. Sc. Computer Science				
Course Title	Introduction to Content Management Systems				
Type of Course	VAC				
Semester	IV				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	1. Familiarity with web content management systems (CMS). 2. Basic knowledge of internet technologies provides a foundation for learning web design.				
Course Summary	The course covers fundamental web design concepts including HTML and CMS principles, focusing on Drupal as a robust Content Management System. Students will learn to create and customize websites using Drupal, exploring its features such as content types, themes, and modules to build dynamic and interactive web pages.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Cultivate a robust understanding of web design fundamentals, laying a strong foundation for their journey into the dynamic world of digital design and development.	U	C	Assignment / Instructor-created exams / Quiz
CO2	Attain comprehensive knowledge and practical proficiency in Content Management Systems (CMS), empowering to navigate and excel in the ever-evolving landscape of digital content creation and management.	U	C	Assignment / Instructor-created exams / Quiz
CO3	Develop expertise in Drupal, a widely used CMS platform, gaining comprehensive understanding of its features, configuration, and installation processes, thus preparing them for proficient and innovative web development endeavors.	Ap	P	Practical Assignment / Instructor-created exams / Quiz
CO4	Impart a comprehensive understanding of website development using Drupal and facilitate the acquisition of expertise across various options within the Drupal ecosystem.	Ap	P	Practical Assignment / Instructor-created exams / Quiz
CO5	Gain an understanding of how to apply web design concepts to real-world scenarios, effectively designing and developing functional and aesthetically	C	P	Practical Assignment / Instructor-created exams /

	pleasing websites utilizing the Drupal CMS.			Quiz
CO6	Develop proficiency in advanced website management skills, including installing and configuring modules, managing menus, and more, to effectively navigate and optimize the functionality of websites built on the Drupal platform.	C	P	Practical Assignment / Instructor-created exams / Quiz
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus

Module	Unit	Content	Hrs	Marks
I	Introduction to Web Designing		8	10
	1	Basics of Web Designing -World Wide Web (WWW), W3C, Web Browser	1	
	2	Web Server, Web Hosting, Web Pages	1	
	3	DNS, URL	2	
	4	Overview of HTML (Concept only) and its role in Web Development	2	
	5	Open Source S/W, Open Source vs Closed Source Software, Open Source Licenses (Concept only)	2	
II	Introduction to CMS		6	10
	6	Introduction to Content Management Systems (CMS) - Features of CMS	2	
	7	Web Content Management System	2	
	8	Components of Content Management System	2	
III	Introduction to Drupal		10	15
	10	Drupal - Features, Advantages and Disadvantages	1	
	11	Installation and Configuration	1	
	12	Content types and Field	2	
	13	Drupal Architecture	1	
	14	User Management, Managing Comments	2	
	15	Creating and Customizing Themes	3	
IV	Building Website		12	15
	16	Website Development - Working with Templates and Template files	2	
	17	Articles, Creating Web Forms	2	
	18	Managing blocks, Add Links to Blocks, Moving Elements within Block	2	
	19	Blocks and Regions	2	
	20	Creating and Customizing Views	1	
	21	Installing and Configuring Modules	1	
	22	Static Pages, Creating Pages, Menu Management.	2	
V	Open Ended Module – Website Development		9	
	23	Develop a simple Website using Drupal.	9	

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	3	1	1	3	1						
CO 2	1	3	2	1	3	1						
CO 3	1	3	1	1	3	2						
CO 4	1	3	3	1	3	2						
CO 5	3	3	3	1	3	2						
CO 6	1	3	3	1	3	2						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓	✓		✓

References:

1. Jennifer Campbell, Jennifer T Campbell, Web Design: Introductory, Course Technology.
2. Jason Beard and Alex Walker, The Principles of Beautiful Web Design, SitePoint.
3. Bob Boiko, Content Management Bible, Wiley.
4. Daniel Sipos, Drupal 9 Module Development, Packt Publishing Limited.