VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS) MAJOR IN MATHEMATICS

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes (CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN MATHEMATICS
(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	2nd	III	SEMESTER-III							
			Major-3	MATHMJ03	T: Real Analysis;	4	3-1-0	15	60	75
			Major-4	MATHMJ04	T: Differential Equations & Vector calculus	4	3-1-0	15	60	75
			SEC	MATSEC03	P: Object Oriented Programming in C++ / Introduction to Python programming (Practical)	3	0-0-3	10	40	50
			AEC	AEC03	Communicative English -2 (***common for all programmes***)	2	2-0-0	10	40	50
			MDC	MDC03	Multidisciplinary Course -3 (***to be chosen from the list***)	3	3-0-0	10	40	50
			Minor-3 (Disc.-I)	MATMIN03	T: Algebra	4	3-1-0	15	60	75
					Semester-III Total	20				375
		IV	SEMESTER-IV							
			Major-5	MATHMJ05	T: Theory of Real Functions & Introduction to Metric	4	3-1-0	15	60	75
			Major-6	MATHMJ06	T: Group Theory – I	4	3-1-0	15	60	75
			Major-7	MATHMJ07	T: Numerical Methods; P: Lab	4	3-0-1	15	60	75
			AEC	AEC04	MIL-2 (***common for all programmes***)	2	2-0-0	10	40	50
			Minor-4 (Disc.-II)	MATMNI04	T: Calculus, Geometry & Ordinary Differential Equation	4	3-1-0	15	60	75
			Summer Intern.	INT	Internship/ Apprenticeship - activities to be decided by the Colleges following the guidelines	4	0-0-4	-	-	50
					Semester-IV Total	22				400
					TOTAL of YEAR-2	42				775

MJ = Major, MI = Minor Course, SEC = Skill Enhancement Course, AEC = Ability Enhancement Course, MDC = Multidisciplinary Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical, MIL = Modern Indian Language

MAJOR (MJ)

MJ-3: Real Analysis **Credits 04 (Full Marks: 75)**

MJ-3T: Real Analysis **Credits 04**

Course contents:

Unit 1:
Review of algebraic and order properties of R, ε-neighborhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima. Completeness property of R and its equivalent properties. The Archimedean property, density of rational (and Irrational) numbers in R, intervals. Limit points of a set, isolated points, open set, closed set, derived set, illustrations of Bolzano-Weierstrass theorem for sets, compact sets in R, Heine-Borel Theorem.

Unit 2:
Sequences, bounded sequence, convergent sequence, limit of a sequence, liminf, lim sup. Limit theorems. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.

Unit 3:
Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's nth root test, integral test. Alternating series, Leibniz test. Absolute and conditional convergence.

Unit 4:
Graphical Demonstration (Teaching aid)

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of in
5. finite series by plotting their sequences of partial sum.
6. Cauchy's root test by plotting nth roots.
7. Ratio test by plotting the ratio of nth and (n+1)th term.

Suggested Readings:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary

4. Real Analysis, Prentice Hall, 2001.
5. S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
6. T. Apostol, Mathematical Analysis, Narosa Publishing House
7. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer
8. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
9. Terence Tao, Analysis I, Hindustan Book Agency, 2006.
10. S. Goldberg, Calculus and mathematical analysis.

MJ-4: Differential Equations & Vector Calculus Credits 04 (Full Marks: 75)

MJ-4T: Differential Equations & Vector Calculus Credits 04

Course contents:

Unit 1
Lipschitz condition and Picard's Theorem (Statement only). The general solution of the homogeneous equation of second order, principle of superposition for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Unit 2
Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit 3
Equilibrium points, Interpretation of the phase plane, Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Unit 4
Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

Unit 5
Graphical demonstration (Teaching aid)
1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

Suggested Readings:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case
2. Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
3. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
4. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
5. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.

6. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
7. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
8. G.F.Simmons, Differential Equations, Tata Mc Graw Hill
9. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
10. Maity,K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
11. M.R. Speigel, Schaum's outline of Vector Analysis.

MJ-5: Theory of Real Functions& Introduction to Metric Space Credits 04 (75 marks)

MJ-5T: Theory of Real Functions& Introduction to Metric Space Credits 04

Course contents:

Unit 1

Limits of functions ($\varepsilon - \delta$ approach), the sequential criterion for limits, and divergence criteria.
Limit theorems, one-sided limits. Infinite limits and limits at infinity. Continuous functions, the sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

Unit 2

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials.

Unit 3

Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/(ax + b)$ and $(x+1)^n$. Application of Taylor's theorem to inequalities.

Unit 4

Metric spaces: Definition and examples. open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces.

Suggested Readings:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

8. Terence Tao, Analysis II, Hindustan Book Agency, 2006
9. SatishShirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006
10. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
11. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw- Hill, 2004.

MJ-6: Group Theory 1 **Credits 04 (Full marks 75)**

MJ-6T: Group Theory 1 **Credits 04**

Course contents:

Unit 1
Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.

Unit 2
Subgroups and examples of subgroups, centralizer, normalizer, centre of a group, product of two subgroups.

Unit 3
Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

Unit 4
The external direct product of a finite number of groups **(definition and examples only)**, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups **(only statement)**.

Unit 5
Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

Suggested Readings:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

MJ-7: Numerical Methods **Credits 04 (Full marks 75)**

MJ-7T: Numerical Methods **Credits 03**

Course contents:

Unit 1
Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

Unit 2
Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

Unit 3
System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss-Seidel method and their convergence analysis. LU decomposition

Unit 4
Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.
Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Unit 5
Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula.
The algebraic eigenvalue problem: Power method. Approximation: Least square polynomial approximation.

Unit 6
Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Suggested Readings:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
3. Computation, 6th Ed., New age International Publisher, India, 2007.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH

Publishing Co.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
9. Yashavant Kanetkar, Let Us C , BPB Publications.
10. M.Pal, Numerical Analysis for Scientists and Engineers: Theory and C Programs, Narosa. 2007.

MJ-7P: Numerical Methods Lab (Using MATLAB/C++/Python) Credits 01

List of problems (using any software):

1. Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 +----------+ 1/ N.
2. Enter 100 integers into an array and sort them in ascending order.
3. Solution of transcendental and algebraic equations by
   a) Bisection method
   b) Newton Raphson method.
   c) Secant method.
   d) Regula Falsi method.
4. Solution of a system of linear equations
   a) LU decomposition method
   b) Gaussian elimination method iii)
   c) Gauss-Jacobi method
   d) Gauss-Seidel method
5. Interpolation
   a) Lagrange Interpolation
   b) Newton Interpolation
6. Numerical Integration
   a) Trapezoidal Rule
   b) Simpson's one third rule
   c) Weddle's Rule
   d) Gauss Quadrature
7. Method of finding Eigenvalue by Power method
8. Fitting a Polynomial Function
9. Solution of ordinary differential equations
   a) Euler method
   b) Modified Euler method
   c) Runge Kutta method

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

MINOR (MI)

MI-3: Algebra **Credits 04 (Full Marks: 75)**

MI-3: Algebra **Credits 04**

Course contents:

UNIT-1:
Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.
Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation.
Inequality: The inequality involving AM ≥ GM ≥ HM, Cauchy-Schwartz inequality.

UNIT-2:
Equivalence relations. Functions, composition of functions, Invertible functions, one-to-one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical induction, statement of Fundamental Theorem of Arithmetic.

UNIT-3:
Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.

UNIT-4:
Definition of vector space of $R^{n:}$, introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, eigenvectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Suggested Readings:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. K.B. Dutta, Matrix and linear algebra.
5. K. Hoffman, R. Kunze, Linear algebra.
6. W.S. Burnstine and A.W. Panton, Theory of equations.

MI – 4: Calculus, Geometry & Ordinary Differential Equation **Credits 04**

MI – 4T: Calculus, Geometry & Ordinary Differential Equation **Full Marks: 75**

Course contents:

UNIT-1:
Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type e^{ax}+b sinx, e^{ax}+b cosx, $(ax+b)^n$ sinx, $(ax+b)^n$ cosx, concavity and inflection points, curvature, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

UNIT-2:
Reduction formulae, derivations and illustrations of reduction formulae of the type ∫sin nx dx, ∫cos nx dx, ∫tan nx dx, ∫sec nx dx, ∫$(\log x)^n$ dx, ∫ $\sin^n x \sin^m x$ dx, parametric equations, parameterizing a curve, arc length of a curve, the arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics.

UNIT-3:
Reflection properties of conics, rotation of axes and second-degree equations, classification of conics using the discriminant, polar equations of conics.
Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid.

UNIT-4:
General, particular, explicit, implicit and singular solutions of a differential equation. First order but not first degree. Exact differential equations and integrating factors, and equations reducible to this form, linear equation, Bernoulli equation and special integrating factors and transformations.

Suggested Readings:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
5. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
6. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
7. G.F.Simmons, Differential Equations, Tata Mcgraw Hill.
8. T. Apostol, Calculus, Volumes I and II.
9. S. Goldberg, Calculus and mathematical analysis.

SKILL ENHANCEMENT COURSE (SEC)

SEC 3: Object-Oriented Programming in C++/Introduction to Python programming

[Students will opt for either Object Oriented Programming in C++ or Introduction to Python programming]

Credits 03

SEC3P: Object Oriented Programming in C++ (Practical) **Full Marks: 50**

Course Outline of Object-Oriented Programming in C++:

Unit 1

Programming paradigms, characteristics of object-oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointers.

Unit 2

Objects, classes, constructors and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Unit 3

Working with files. Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

Unit 4: Problems to be solved:

1. Generate a list of 50 random numbers between 1 and 100. Find the maximum and minimum values in the list. Calculate the mean and variance of the numbers.
2. Write a function to determine if a given integer is prime or not.
3. Implement the following sorting algorithms:
    - Bubble Sort
    - Insertion Sort
    - Selection Sort
4. Write a program to calculate the sum of the sine, cosine, or exponential series up to a given number of decimal places.
5. Write a function to check if a given square matrix is an identity matrix.
6. Calculate and print the sum of each row and each column of a given matrix.
7. Write a function that checks whether a given string is a palindrome.
8. Count and display the frequency of each word in a given string.
9. Write a function that removes duplicate characters from a given string.
10. Write a program to compare two strings lexicographically and check if they are equal.
11. Write a function to check if a substring exists in a given string.
12. Write a program to find the longest word in a given sentence.
13. Reverse each word in a given string but keep the original word order intact.
14. Write a program to count the number of vowels and consonants in a given string.
15. Write a program to generate Fibonacci sequence using overloading of ++ operator.

16. Write a class for complex numbers and use it to find the sum, difference, multiplication and division of complex numbers. Use operator overloading.
17. Write a class for matrices and use it to find the sum, difference and multiplication matrices. Use operator overloading.

Suggested Readings:

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997.
2. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
3. Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, Object Oriented Programming with C++, BPB Publication.
5. Bjarne Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley.
6. E. Balaguruswami, Object Oriented Programming In C++, Tata McGraw Hill
7. Herbert Scildt, C++, The Complete Reference, Tata McGraw Hill.

OR

SEC3P: Introduction to Python programming (Practical) **Full Marks: 50**

Course Outline of Introduction to Python programming:

Unit 1:
Python interpreter as a calculator, variable types: int, float, complex, list, tuple, set, string, type() function, basic mathematical operations, logical conditions (if, elif, else), loops (for, while), user defined functions,, lambda function, importing modules with math, c math, random, help and dir commands, name spaces-local and global.

Python scripts, I/O operations, opening and writing to files.

Unit 2:
List: reading, changing elements, slicing, concatenation, list comprehension. 2D list.
range(), len(), sum(), min(), max(), append(), extend(), count(), index(), sort(), insert(), pop(), remove(), reverse().
Array: Difference between Python lists and arrays, array module, NumPy, Insertion, deletion, and modification.
Tuples: compare with lists, packing/unpacking.
Sets: update(), pop(), remove(), union, intersection, difference, symmetric difference.
Strings: single, double, triple quotes, len(). Indexing, slicing, concatenation, strip(), split), join(), find(), count(), replace(), matting with % operator
Dictionary: Make a dictionary, built-in functions, and dictionary methods.
NumPy library

Unit 3:
Matplotlib, basics of XY-plotting of function, exponential functions, trigonometric functions. Define a Python function, plot in a domain, bar chart, histograms, polar plots, pie plots, plot from data file, save, subplots, and multiple plots.

Unit 4: Problems to be solved:

1. Generate a List of Random Numbers:
    - Generate a list of 50 random numbers between 1 and 100.
    - Find the maximum and minimum values in the list.
    - Calculate the mean and variance of the numbers.
2. Prime Number Check:
    - Write a function to determine if a given integer is prime or not.
3. Sorting Algorithms:
    - Implement and compare the performance of the following sorting algorithms:
        - Bubble Sort
        - Insertion Sort
        - Selection Sort
4. Sum of Series (Trigonometric or Exponential Functions):
    - Write a program to calculate the sum of the sine, cosine, or exponential series up to a given number of decimal places. (Example: sin(x)\sin(x), cos(x)\cos(x), exe^x).
5. Matrix Operations using NumPy:
    - Perform matrix addition, multiplication, and find the inverse using NumPy.
6. Finding Determinant of a Matrix:
    - Use NumPy or implement your own logic to find the determinant of a square matrix.
7. Solving a System of Linear Equations:
    - Use the Gaussian elimination method or NumPy to solve a system of linear equations.
8. Checking Identity Matrix:
    - Write a function to check if a given square matrix is an identity matrix.
9. Sum of Each Row and Column of a Matrix:
    - Calculate and print the sum of each row and each column of a given matrix.
10. Matrix Rotation by 90 Degrees:
    - Write a program to rotate a matrix by 90 degrees clockwise.
11. Palindrome Check:
    - Write a function that checks whether a given string is a palindrome.
12. Word Frequency Counter in a String:
    - Count and display the frequency of each word in a given string.
13. Removing Duplicates from a String:
    - Write a function that removes duplicate characters from a given string.
14. String Comparison:
    - Write a program to compare two strings lexicographically and check if they are equal.
15. Substring Search:
    - Write a function to check if a substring exists in a given string.
16. Longest Word in a Sentence:
    - Write a program to find the longest word in a given sentence.
17. Reverse Each Word in a String:
    - Reverse each word in a given string but keep the original word order intact.
18. Counting Vowels and Consonants in a String:
    - Write a program to count the number of vowels and consonants in a given string.
19. Plotting a Polynomial Function:
    - Plot a polynomial (or any transcendental) function. Identify the real roots by plotting.
20. Plotting Sine and Cosine Functions:
    - Plot the graphs of sine and cosine functions for $x \in [0, 2\pi]$. Use different line styles, colors, and a legend.
21. Plotting $y = x$ and $y = \sqrt{x}$:
    - Plot the graphs of $y = x$ and $y = \sqrt{x}$ on the same figure for $x \in [0, 10]$. Use different colors and add a legend.

22. Bar Chart of Student Grades:
    - Create a bar chart to display the grades of five students in three subjects (Math, Science, and English). Label the axes and provide a title.
23. Market Share Pie Chart:
    - Represent the market share of five companies (A, B, C, D, E) as a pie chart. Use percentages and include labels for each slice.
24. Histogram of Exam Scores:
    - Generate random exam scores for 100 students between 0 and 100 and plot a histogram. Divide the scores into bins of size 10.

Suggested Readings:

1. M. Sundarrajan, Mani Deepak Choudhry, S. Jeevanandham, Akshya Jothi, Python Programming: Beginners Guide, 2024.
2. Dave Brueck. Stephen Tanner, Python 2.1 Bible, Hungry Minds, Inc, New York, 2001.
3. Abhijit Kar Gupta, Scientific Computing in Python, Techno World Computational Playsics, Mark Newman, Amazon Digital, 2022.
4. Ch Satyanarayana, M Radhika Mani and B N Jagadesh, *Programming, University Press, 2018.*
5. J.Elkner, C. Meyer, A Downey, Learning with Python- how to think like a computer scientist, Dreamtech Press, 2015.

INTERNSHIP/APPRENTICESHIP (INT)

Credit-04 Marks: 50 **(120 hours, 8 weeks)**

Guideline for internship/apprenticeship:

The internship program will commence at the beginning of the third semester and will be evaluated upon its completion at the end of the fourth semester.

1. Two or more neighbouring colleges can exchange students for internship programs. Mentors at the partnering colleges may offer these students courses related to their curriculum. The program content will vary depending on the mentor. It could include theoretical courses such as Mathematical Analysis, Numerical Analysis, Applied Mathematics, Financial Mathematics, or Industrial Mathematics, or hands-on training using programming techniques.
2. A student may visit an industry for industry-related issues or a research institution, laboratory, or university to engage in research-related activities under the guidance of an industry official, scientist, or professor.
3. A student may work at a company's outlet or similar type of office, hotel, hospital, nursing home, etc. to collect statistical data and analyse it with any statistical method under the supervision of the respective official or a faculty of his/her own college teacher or a teacher from another college/university/industry person.
4. A student may pursue an internship under the supervision of a teacher within their own college, focusing on allied subjects like Statistics, Economics, or Computer Science (for Mathematics majors).
5. Interns may engage in advanced learning in topics beyond their course curriculum, under the guidance of their respective mentor.
6. Interns may be assigned a complex problem to solve using C++, MatLab or Python and will be required to code and run these programs in the computer lab under the mentor's guidance.
7. Interns may be assigned to design a webpage for his/her own college or department under the mentor's guidance.
8. Interns may be assigned to prepare study materials in MS-Word or MS PowerPoint or LaTeX on topics assigned by their mentor.
9. Interns may be assigned to develop a video lecture on any topic of their own choice with a proper title page for the video under the mentor's guidance.
10. Interns may be allowed to work as quantitative researchers in financial institutions such as banks, insurance companies, or financial consulting firms.

General instructions:

a) Each intern must maintain a daily logbook of activities.
b) At the end of the internship, a completion certificate must be obtained from the mentor, supervisor, or concerned authority.
c) Interns are expected to strictly adhere to the assigned tasks and deadlines.