SYLLABUS

2024-2025

M. TECH. (Computational Mathematics)

DEPARTMENT OF APPLIED SCIENCES AND HUMANITIESFACULTY OF ENGINEERING AND TECHNOLOGY
JAMIA MILLIA ISLAMIA, NEW DELHI-110025.

Brief About the Program:

The field of computer simulation is of great importance in high-tech industry as well as in scientific and technological research. Familiar examples are virtual processing, climate studies, advanced materials, data structures, data science, machine learning and big data analytics. Thus, computational science and engineering promote appropriate technology as well scientific advancement which is helpful in engineering design. Activities involved are mathematical modeling, numerical analysis, computer algorithms, high-speed computing and visualization. The remarkable development in large scale computing in recent decades has transformed computational science and technology into an indispensible tool. It complements theory and lab experimentations leading to new insights. Computational Mathematics is primarily concerned with mathematical foundations of computational science and technology.

Career Possibilities:

M.Tech. program in computational mathematics is designed to meet the needs of sophisticated users; especially in the context of scientific investigations and technological innovation. Computational mathematics combines mathematics with computer science to produce useful techniques. The syllabus would cover relevant areas which are in demand. The program is comprehensive and would (for instance) meet the needs of ISRO, DRDO, DOS, BARC, research bodies and industry. Graduates would participate in research & development as well as computational activities. Their training would equip them with computational techniques; suited to conditions in India. Our country needs talented scholars with strong background in theory, modeling and computation. The government organizations, industry, multinational companies may face shortage of trained Scientists and computing experts if such programs are not promoted. India may play a key role on the world science with its technical manpower trained in computational methods and techniques. India is poised to become world leader Soft- computing Mathematics.

The M.Tech. Program would provide students with comprehensive theoretical knowledge and impart practical training with focus on computer science, numerical computing and mathematical finance. This programme has been introduced to motivate youth towards sophisticated mathematics needed for modern scientific investigations and technological progress. The program would strive to equip students with comprehensive theoretical background. Graduates of M.Tech. programme in Computational Mathematics will acquire skills in applied mathematics; they would be well-prepared for advanced industrial positions or they may continue higher studies.

Prospects:

The M.Tech. Program is designed to meet present and future needs of relevant mathematics in industry and research. The three components viz mathematics, computing and financial engineering need to be blended together as integrated components to ensure relevance their mutual links are emphasized in the curriculum. Along with technical aspects of computing, the scope for development is pointed out. The program would be managed by a team of committed faculty members. They would impart skills and guide students in innovative ways.

If you are aiming for higher studies, and wish to explore deep insights available in mathematics and computing, the curriculum of this program offers a good opportunity. Skills and information can be put to good use in diverse research projects. Some relevant fields include data mining, big data (map reduction), stochastic processes, data science, machine learning, big data analytics, recommended systems and computer graphics. You may join applied Mathematics research or learn advanced Computer Science & Engineering.

Placements:

On successful completion of the program, students would have job opportunities in software industry, financial institutions and government organizations. The employment possibilities include job in Consulting Engineering firms, Pharmaceutical Industry, Telcom industry, Banks Insurance companies.

Program Education Objectives (PEOs):

The objectives of the M. Tech. program (Computational Mathematics) are to empower and enable students to develop advanced knowledge and skills in order to become leaders and efficient managers in the computational sector. Specifically,

- ✓ Students will have a comprehensive understanding of the science and technology related to data structures, data science, machine learning and big data analytics.
- ✓ Students will understand the engineering design , mathematical modeling, numerical analysis, computer algorithms, high-speed computing and visualization.
- ✓ Student will learn basic to advanced aspects of mathematical foundations of computational science and technology.
- ✓ Students will develop their research and communication abilities to be effective leaders in the Computational Science & Technology sectors.
- ✓ To provide students with an academic environment aware of excellence, leadership, ethical codes and guidelines and the life-long learning needed for a successful professional career.

Programme Specific Outcomes (PSO):

On successful completion of the programme,

- ✓ Graduates will demonstrate knowledge of the sciences and technology related to energy production, conversion, utilization, and conservation.
- ✓ Graduates will demonstrate the understanding of data science, machine learning , artificial intelligence and big data analytics.
- ✓ Graduate will demonstrate the knowledge of basic to advanced aspects of mathematical foundations of computational science and technology.
- ✓ Graduates will demonstrate an ability to develop the research and communication abilities to be the effective leaders in the computational science industry.
- ✓ Graduate will develop confidence for self-education and ability for life-long learning. scientific investigations and technological innovation.

Programme Outcomes (POs):

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering and scientific problems**.**
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering & data sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including scientific investigations and technologicalinnovation.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools & softwares including prediction and modelling to complex scientific & engineering activities with an understanding of the limitations.
6. **The engineer, scientist and society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to professional engineering practice.
7. **Environment and sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Total Intake: 18

COURSE STRUCTURE

M.TECH. (COMPUTATIONAL MATHEMATICS)
SEMESTER-I

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
FIRST SEMESTER									
THEORY & LAB									
01	CM-101	Computational Methods for Differential Equations	4	4	-	-	40	60	100
02	CM-102	Discrete Mathematics and its Applications	4	4	-	-	40	60	100
03	CM-103	Computer Programming using Python	4	4	-	-	40	60	100
04	CM-104	Database Management System(DBMS)	4	4	-	-	40	60	100
05	CM-105	Neural Networks & Optimization Techniques	4	4	-	-	40	60	100
06	CM-106	Python Lab (Lab–I)	2	-	2	-	30	20	50
07	CM-107	ORACLE/ Mysql Lab (Lab –II)	2	-	2	-	30	20	50
TOTALCREDITS:24								TOTALMARKS:600	

COURSE STRUCTURE

M.TECH. (COMPUTATIONAL MATHEMATICS)
SEMESTER-II

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
THEORY & LAB									
01	CM-201	Seminar	4	4	-	-	40	60	100
02	CM-202	Scientific Computing	4	4	-	-	40	60	100
03	CM-203	Data Warehouse and Data Mining	4	4	-	-	40	60	100
04	CM-204	Big Data Analytics	4	4	-	-	40	60	100
05	CM-205	Machine Learning	4	4	-	-	40	60	100
06	CM-206	LAB-III (Big Data Analytics Lab)	2	-	2	-	30	20	50
07	CM-207	Lab--IV(Machine Learning Lab)	2	-	2	-	30	20	50
TOTALCREDITS:24									**TOTALMARKS:600**

COURSE STRUCTURE

M.TECH. (COMPUTATIONAL MATHEMATICS)

SEMESTER-III

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
Minor Project									
1.	CM-301	Minor Project (Dissertation)	8	-	-	-	80	120	200
MOOC Courses: (Total: 8 Credits)									
1.	CM-302	Introduction to Machine Learning (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs101/preview	3	3	-	-	30	45	75
2.	CM-303	Deep Learning for Computer Vision (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs89/preview	3	3	-	-	30	45	75
3.	CM-304	Social Network Analysis (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs90/preview	3	3	-	-	30	45	75
4.	CM-305	Big Data Computing (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs130/preview	2	2	-	-	20	30	50
5.	CM-306	Computational Complexity (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs106/preview	3	3	-	-	30	45	75
6.	CM-307	The Joy of Computing using Python (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs113/preview	3	3	-	-	30	45	75
7.	CM-308	Introduction To Machine Learning (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs81/preview	2	2	-	-	20	30	50
8.	CM-309	Introduction to Internet of Things (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs115/preview	3	3	-	-	30	45	75
9.	CM-310	Statistical Learning for Reliability Analysis (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs107/preview	3	3	-	-	30	45	75
10.	CM-311	Deep Learning (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs114/preview	3	3	-	-	30	45	75
11.	CM-312	Data Science for Engineers (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs133/preview	2	2	-	-	20	30	50

12.	CM-313	Responsible & Safe AI Systems (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs132/preview	3	3	-	-	30	45	75
13.	CM-314	Design & Implementation of Human-Computer Interfaces (MOOC) https://onlinecourses.nptel.ac.in/noc24_cs126/preview	3	3	-	-	30	45	75
14.	CM-315	Foundations of R Software (MOOC) https://onlinecourses.nptel.ac.in/noc24_ma95/preview	3	3	-	-	30	45	75
15.	CM-316	Introduction to Abstract and Linear Algebra (MOOC) https://onlinecourses.nptel.ac.in/noc24_ma58/preview	2	2	-	-	20	30	50
Note: Students are required to choose total of 8 credits out of 15 MOOC courses.									
TOTALCREDITS:16									**TOTALMARKS:400**

COURSE STRUCTURE

M.TECH. (COMPUTATIONAL MATHEMATICS)
SEMESTER-IV

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTE R EXAM	TOTAL
						CWS	MST		
THEORY									
01	CM-401	Major Project (Dissertation)	12	-	-	-	-	300	300
TOTAL CREDITS:12								**TOTALMARKS: 300**	

Semester	I	II	III	IV	Grand Total
Total no. of Credits	24	24	16	12	76
Total no. of marks	600	600	400	300	1900

Detailed Syllabus

I Semester

CM 101: Computational Methods for Differential Equations

CM 102: Discrete Mathematics with Applications

CM 103: Computer Programming using Python

CM 104: Database Management System

CM 105: Neural Networks and Optimization Techniques

CM 106: Lab-I (Python Lab)

CM 107: Lab -II (ORACLE/ Mysql Lab)

CM 101: Computational Methods for Differential Equations

Course Outcomes of Computational Methods for Differential Equations (CM-101):

CO1	Understanding Existence and uniqueness theorem, General theory of homogenous and non-homogenousdifferential equations with constant and variable coefficients, Method of variation of parameters, method of undetermined coefficients and the formula for particular integral in terms of wronskian, Solution of simultaneous differential equations.
CO2	Study on Series solution for second order linear differential equations near an ordinary point, Singularity and the solution of differential equation in the neighborhood of regular singular point using method of Frobenious, Solution of Legendre, Bessel, Hypergeometric, Hermite and Lagurre differential equation.
CO3	Solving of partial differential equations using Lagrange's method of undetermined multipliers, Charpit's method; Complete solution of homogeneous and non-homogeneous L.P.D.E. of higher order with constant and variable coefficients. Formulation of Heat conduction equation and its solution by variable separation method, Steady state condition and the solution of heat conduction problem with non-zero end conditions. Formation of wave equation and their solution.
CO4	Study on Linear homogeneous Boundary Value Problems, Eigen values and Eigen functions, Sturm- Liouville Boundary Value Problems, Non-homogeneous Boundary Value Problems, Non homogeneous heat conduction problems.
CO5	Basic Understanding of Green's functions and the solution of Boundary Value Problems in terms of Green's functions, Concept of stability, asymptotic stability and instability of a solution of the autonomous system $dx/dt = F(x, y)$, $dy/dt = G(x, y)$.

CM 101: Computational Methods for Differential Equations

Unit-1 Existence & uniqueness theorem; General theory of homogenous and non-homogenous differential equations with constant and variable coefficients; Method of variation of parameters, method of undetermined coefficients and the formula for particular integral in terms of wronskian; Solution of simultaneous differential equations.

Unit-2 Series solution for second order linear differential equations near an ordinary point; Singularity and the solution of differential equation in the neighborhood of regular singular point using method of Frobenious; Solution of Legendre, Bessel, Hyper geometric, Hermite and Lagurre differential equation.

Unit-3 Solution of partial differential equations using Lagrange's method of undetermined multipliers, Charpit'smethod; Completesolutionofhomogeneousandnon-homogeneous L.P.D.E. of higher order with constant and variable coefficients. Formulation of Heat conduction equation and its solution by variable separation method, Steady state condition and the solution of heat conduction problem with non-zero end conditions. Formation of wave equation and their solution.

Unit-4 Linear homogeneous Boundary Value Problems, Eigen values and Eigen functions, Sturm- Liouville Boundary Value Problems, Non-homogeneous Boundary Value Problems, Non- homogeneous heat conduction problems.

Unit-5 Green's functions and the solution of Boundary Value Problems in terms of Green's functions, Concept of stability, asymptotic stability and instability of a solution of the autonomous system.

Books Recommended

1. Earl A. Coddington, An Introduction to Ordinary Differential Equation,DoverPublications, INC.,2012.
2. Boyce and Diprime, Elementary Differential Equations and Boundary ValueProblems,Wiley, 2008.
3. H. F. Weinberger, A First Course in Partial Differential Equations: with ComplexVariablesand Transform Methods (Dover Books on Mathematics), Dover Publications,1995.
4. M. D. Raisinghania, Advanced Differential Equations, S. Chand Publications,20

CM 102: Discrete Mathematics with Applications

Course Outcomes of Discrete Mathematics with Applications (CM-102):

CO1	Understanding theory of sets, combination of sets, power sets, finite and infinite sets, principle of inclusion and exclusion, Relations and Functions, Equivalence Relations, Partial Order, PropositionalCalculus.
CO2	Study on Linear recurrence relations with constant coefficients (homogeneous case), discussion of allthe three sub-cases. Linear recurrence relations with constant coefficients (non-homogeneous case), discussion of several special cases to obtain particular solutions. Solution of linear recurrence, relations using generating functions.
CO3	Study on Lattices and Boolean algebra, Boolean Functions, Connonical Form (Disjunctive NormalForm) of a Boolean function, Karnaugh Maps.
CO4	Study on Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, ConnectedGraphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.
CO5	Study on Linear codes, Hamming Code, Generator and parity check matrix, Hamming distance standard array and Syndrome decoding, introduction to cyclic codes.

CM 102: Discrete Mathematics with Applications

Unit 1. Introduction to the theory of sets, combination of sets, power sets, finite and infinite sets, principle of inclusion and exclusion, Relations and Functions, Equivalence Relations, Partial Order, Propositional Calculus.

Unit 2. Linear recurrence relations with constant coefficients (homogeneous case); discussion of all the three sub-cases. Linear recurrence relations with constant coefficients (non- homogeneous case); discussion of several special cases to obtain particular solutions. Solution of linear recurrence relations using generating functions

Unit 3. Lattices and Boolean algebra, Boolean Functions, Canonical Form (Disjunctive Normal Form) of a Boolean function, Karnaugh Maps.

Unit 4. Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, Connected Graphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.

Unit 5. Linear codes, Hamming Code, Generator and parity check matrix, Hamming distance standard array and Syndrome decoding, introduction to cyclic codes.

Books Recommended

1. K.A. Ross, Charles R.W. Wright, Discrete Mathematics, 5th edition, PHI,2002.
2. Bernard Kolman, Robert C. Busby, Discrete Mathematical Structure for ComputerSciences, Prentice Hall of India, 1987.

3. F.J. Mac. Williams, N. J. A. Sloane, Theory of Error Correcting Codes, North HollandPub. Co., 1978.
4. Narsingh Deo, Graph Theory with Applications to Engineering and ComputerScience,Prentice Hall of India, 1979.
5. Liu C. L. , Elements of Discrete Mathematics, Second Edition, Mc Graw Hill1985.
6. Mott J. L. , Kandel A. and Baker T. P., Discrete Mathematics for ComputerScientistsand Mathematicians, Second Edition, Prentice Hall India,1986.

CM 103: Computer Programming using Python

Course outcomes Computer Programming using Python:

CO1	Understanding the Python Basics And Flow Control. Introduction to various scriptinglanguage, to Python GUI and Command line Interface. Variables and Data types in python. Input and output functions. Commenting and Indentation requirement.
CO2	Accessing list and Tuples data values with loops. Working with various inbuilt methods of list and tuples. Working with Python Dictionary data type. Modifying andanalysing Dictionary entries. Creating Data base using Dictionary.
CO3	Using try and except. Using Final Statement. Raising Exceptions. Assert statement. Basics of File handling in Python.
CO4	creating Layouts. pack method. Label, Button. Radio button. Check button.Entry. Tkinter variables
CO5	Introduction to OOPs. The Class Statements. Constructor. Class Inheritance. Overriding, Inherited Methods. Multiple Inheritance. Multilevel Inheritance. Method Overloading.Data Hiding.

CM 103: Computer Programming using Python

UNIT 1 (PYTHON BASICS AND FLOW CONTROL)
Introduction to various scripting language. Benefits of scripting language over structured language. Introduction to Python GUI and Command line Interface. Using Editor. Variables and Data types in python. Input and output functions. Commenting and Indentation requirement. If conditions. if-else. Nested if-else conditions. For loop. While loop. Break and continue statements. Problem statement solving using the flow control. Algorithm designing using flowcontrol

Unit 2. (PYTHON DATA STRUCTURES)
Accessing list and Tuples data values with loops. Working with various inbuilt methods of list and tuples. Comparison and concatenation in lists and tuples. Modifying list and tuple values. Creating user defined functions in python. Variable Argument passing with functions. Working with Python Dictionary data type. Modifying and analysing Dictionary entries.

Creating Data base using Dictionary. Working with string. Accessing, modifying and manipulating strings. Working with string functions. Creating array in Numpy. Matrix operations in Numpy. Predefined method calling using Numpy. Matplotlib Module. 2D plotting using Matplotlib.subplot using matplotlib. ineractive plotting using matplotlib

Unit 3. (FILE HANDLING AND EXCEPTION HANDLING)
Types of exceptions. Using try and except. Using Final Statement. Raising Exceptions. Assert statement. except v/s else block. Opening the files with user defined permissions. Reading from files. Writing to files. Renaming and removing files. Binary mode for fileoperations

UNIT 4 (GRAPHICAL USER INTERFACE WITH PYTHON)
GUI widgets. creating Layouts. pack method. Label, Button. Radiobutton. Checkbutton. Entry.Tkinter variable

Unit 5. (OBJECT ORIENTED PROGRAMMING WITH PYTHON)
Introduction to OOPs. The Class Statements. Constructor. Class Inheritance. Overriding, Inherited Methods. Multiple Inheritance. Multilevel Inheritance. Method Overloading. Data Hiding.

Books Recommended

1. E. Balagrurusamy, Object Oriented Programming with C++, TMH,2008.
2. Deitel and Deitel, C++ How to program, PHI, 4th Ed,2003.
3. Robert Lafore, Object-oriented programming in C++, 4th Ed,Sams Publishing,2002.

CM 104: Database Management System

Course outcomes of Database Management System (CM-104) :

CO1	Introduction to Data basemanagement system and Classification of DBMS, Three Schema Architecture and Data Independence. Client Server Architecture for DBMS
CO2	Data modeling, functional dependency and relational database. Relational Algebra and Relational Calculus, Introduction to Tuple Relational Calculus and Domain Relational Calculus, Codd's Rule for Relational Database, Indexes and Hash Indexes.
CO3	First, second and third normal forms and BCNF. Design Guidelines for Relational Schemas, Functional Dependency, Normal Forms Based on Primary Keys.
CO4	Higher normal forms and data base security. Multivalued Dependency and Fourth Normal Form, Join Dependency and Fifth Normal Form. . Inclusion Dependency, Transaction Processing Concepts, Locks, Serializability and Concurrency Control, Database Security.
.CO5	Introduction and applications of structural query language. Introduction of QBE. Introduction of PL/SQL, Programming Constructs, Procedures, Functions, Exceptionhandling, Cursors.

CM 104: Database Management System

Unit 1. Introduction to Database – Characteristics, Advantages & Disadvantages, Applications. Schemas and Instances. Difference Between Hierarchical, Network and Relational Model. Three Schema Architecture and Data Independence. Client Server Architecture for DBMS. Classification of DBMS.

Unit 2. Data Modeling and Functional Dependency: Data Model, Types, Data Modeling Using E-R Diagram, Entity Type, Entity Sets, Attribute and Keys, Weak Entity. Relational Model Concepts, Relational Database Schemas, Constraint Violations. Relational Algebra and Relational Calculus, Introduction to Tuple Relational Calculus and Domain Relational Calculus, Codd's Rule for Relational Database, Indexes and Hash Indexes.

Unit 3. Functional Dependency and Normalization: Design Guidelines for Relational Schemas, Functional Dependency, Normal Forms Based on Primary Keys. Definition of First Normal Form, Second Normal Form, Third Normal Form and BCNF.

Unit 4. Higher Normal Forms and Transaction Management: Multivalued Dependency and Fourth Normal Form, Join Dependency and Fifth Normal Form. Inclusion Dependency,Transaction Processing Concepts, Locks, Serializability and Concurrency Control, Database Security.

Unit 5. SQL: Table Creation, Deletion and Modification in SQL, Defining Constraints, Basic Structure of SQL for Data Extraction from Database, Insert, Delete & Update Statements in SQL, Views in SQL, Aggregate Functions , Nested Queries, Introduction of QBE. PL/SQL: Introduction of PL/SQL, Programming Constructs, Procedures, Functions, Exception handling, Cursors, Triggers and Packages.

Books Recommended:

1. Elmasri, Navathe, Fundamentals of Database Systems, Pearson Education,2008.
2. Henry F. Korth, Abraham Silberschatz, S. Sudurshan,Database System Concepts,McGraw-Hill, 2005.
3. C. J. Date, An Introduction to Database Systems, Pearson,2006.
4. Ramakrishna, Gehrke, Database Management Systems, Mcgraw-Hill,2014.
5. S. K. Singh, Database Systems Concepts, Design and Applications, Pearson,2011.
6. Jeffrey D. Ullman, Jennifer Widom, A first course in Database Systems, Pearson,2014.

CM-105 Neural Networks & Optimization Techniques

Course outcomes of Neural Networks & Optimization Techniques (CM-105):

CO1	Introduction to neurons, working of biological neurons, Artificial neuron, Brain vs Computer, Neural networks architectures, classifications and characteristics, Basic model of ANN: connections, weights, bias, and activation functions. McCulloch- Pitts Neuron, Threshold logic units, McCulloch-Pitts neuron as logic gates andmemory elements.
CO2	Hebb neuron: training algorithm and applications, Linear separability, ANN Learning rules, Supervised learning: Perceptron, ADALINE, XOR problem, MADALINE. Multi-layer Neural networks, Back-propogation derivation & training algorithm. Working examples of BP algorithms for training Multi-layer neural networks.
CO3	Unsupervised learning Kohonen Self-organizing feature map, Feedback Networks: Hopfield Networks, storage and retrieval of information in Hopfield neural networks (HNN), Bidirectional associatve memory (BAM), Adaptive resonance theory (ART) neural networks etc. Working examples on HNN, BAM & ART, Some applications ofANNs.
CO4	Introduction to optimization: basics, classifications &charateristics, Linear programming: concepts, solving method, applications. Nonlinear programming: Concepts, solving methods, examples. Dynamic programming method. Traveling salesman problem, Transportation problem.
CO5	Introduction to Genetic algorithm: working principle, encoding methods, fitness function, reproduction, Roulette Wheel, Tournament Selection, Rank Selection etc,cross-over and mutation operators, Applications of genetic algorithm, Recent optimization techniques.

CM-105 Neural Networks & Optimization Techniques

Unit 1. Introduction to neurons, working of biological neurons, Artificial neuron, Brain vs Computer, Neural networks architectures, classifications and characteristics, Basic model of ANN: connections, weights, bias, and activation functions. McCulloch-Pitts Neuron, Threshold logic units, McCulloch-Pitts neuron as logic gates and memory elements.

Unit 2. Hebb neuron: training algorithm and applications, Linear separability, ANN Learning rules, Supervised learning: Perceptron, ADALINE, XOR problem, MADALINE. Multi-layer Neural networks, Back-propogation derivation & training algorithm. Working examples of BP algorithms for training Multi-layer neural networks.

Unit 3. Unsupervised learning Kohonen Self-organizing feature map, Feedback Networks: Hopfield Networks, storage and retrieval of information in Hopfield neural networks (HNN), Bidirectional associatve memory (BAM), Adaptive resonance theory (ART) neural networks etc. Working examples on HNN, BAM & ART, Some applicationsofANNs.

Unit 4. Introduction to optimization: basics, classifications &charateristics, Linear programming: concepts, solving method, applications. Nonlinear programming: Concepts, solving methods, examples. Dynamic programming method. Traveling salesman problem, Transportation problem

Unit 5. Introduction to Genetic algorithm: working principle, encoding methods, fitness function, reproduction, Roulette Wheel, Tournament Selection, Rank Selection etc, cross-over and mutation operators, Applications of genetic algorithm, Recent optimization techniques

Books Recommended:

1. S Haykin, "Neural Networks: A Comprehensive Foundations"Pearson,
2. Rajasekaran& Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms:Synthesis and Applications", PHI,2011.
3. David E Goldberg, "Genetic Algorithm in Search, Optimization & Machine Learning",Pearson, 2011.
4. N P Padhy& S P Simon, "Soft Computing with MATLAB Programming", OxfordPublication, 2015.

CM 106: Lab-I (Python Lab)
CM 107: Lab-II (ORACLE/ Mysql Lab)

II Semester

CM 201: Seminar
CM 202: Scientific Computing(Numerical techniques)
CM 203: Data Warehouse and Data Mining
CM 204: Big Data Analytics
CM 205: Machine Learning
CM 206: Big Data Analytics Lab(Lab-III)
CM 207: Machine Learning Lab(Lab-IV)

CM 201: Seminar

CM 202: Scientific Computing.

Course outcomes of Scientific Computing (CM-202):

CO1	Roots of non-linear equations, ; Rate of convergence and error analysis of the method; Newton-Raphson method for solution of a pair of non-linear equations.
CO2	Solution of system of linear equations: Direct methods and Iterative Methods. Jacobi and Gauss-Seidel methods, Curve fitting using method of least squares.
CO3	Finite difference operator and their relationships ; Difference tables; Newton, Besseland Sterling's interpolation formulae; Divided differences; Lagrange interpolation and Newton's divided difference interpolation.
CO4	First and second order derivatives by various interpolation formulae; Numerical integration: Trapezoidal, Simpsons 1/3 and 3/8 rules, Booles Rule, Weddle Rule, Radau Rule; Errors in quadrature formulae; Gauss Legendre 2-points and 3-points Formulae; Numerical Integration and Double Integration using Romberg's Rule.
CO5	Solution of simultaneous, first and second orders ordinary differential equations: Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methods and Milne's method.

CM 202: Scientific Computing.(Numerical Techniques):

Unit 1. Roots of non-linear equations: Bisection method, Regula-Falsi method, Iterative method, Newton-Raphson Method, Graeffe's Root Squaring Method; Rate of convergence and error analysis of the method; Newton-Raphson method for solutionof a pair of non-linear equations.

Unit 2. Solution of system of linear equations: (i) Direct methods: Gauss Elimination Method without Pivoting and with Pivoting, LU-decomposition method; Ill conditioned linear system; (ii) Iterative Methods: Jacobi and Gauss-Seidel methods, Curve fitting using method of least squares.

Unit 3. Finite difference operator and their relationships; Difference tables; Newton, Bessel and Stirling's interpolation formulae; Divided differences; Lagrange interpolation and Newton's divided difference interpolation.

Unit 4. Numerical differentiation: first and second order derivatives by various interpolation formulae; Numerical integration: Trapezoidal, Simpsons 1/3 and 3/8 rules, Booles Rule, Weddle Rule, Radau Rule; Errors in quadrature formulae; Gauss Legendre 2- points and 3-points Formulae; Numerical Integration and Double Integration using Romberg's Rule.

Unit 5. Solution of simultaneous, first and second order ordinary differential equations: Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methodsand Milne's method.

Books Recommended:

1. Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley.2002.
2. Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific andEngineering Computation", New Age Pvt. Pub, New Delhi.2000.
3. Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGrawHill Publisher1982
4. Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East WestPublication. 1998.

CM 203: Data Warehouse and Data Mining

Course outcomes of Data Warehouse and Data Mining (CM-203.):

CO1	Introduction to Data ware housing, Data warehouse life cycle and Data Warehousing architecture.
CO2	Introduction to Data Mining, Data Transformation, Data DiscretizationAnd Concept Hierarchy Generation.
CO3	Apriori Algorithm, FP-Growth Algorithm and Correlation Analysis.
CO4	Introduction to Classification and Prediction, Bagging and Boosting.
CO5	Introduction to Cluster Analysis, Agglo merative and Divisive Methods.

CM 203: Data Warehouse and Data Mining

Unit 1. Introduction to Data Warehousing; Evolution of Decision Support Systems; Modeling a Data Warehouse; Granularity in the Data Warehouse; Data Warehouse Life Cycle; Building a Data Warehouse; Data Warehousing Components; Data Warehousing Architecture.

Unit 2. Introduction to Data Mining: KDD (Knowledge Discover from Databases) Process and Data Mining; KDD Steps; Types of Data for Data Mining, Data Mining Functionalities, Classification of Data Mining Systems; Data Mining Task Primitives; Major Issues in Data Mining. Introduction to Data Preprocessing, Descriptive Data Summarization: Measuring and Central Tendency and Dispersion of Data; Visualization of Descriptive Data Summaries; Data Cleaning: Handling Missing Values, Filtering Noisy Data – Binning Method; Data Integration; Data Transformation: Smoothing, Aggregation, Generalization, Normalization and Feature Selection; Data Reduction; Data Discretization and Concept HierarchyGeneration.

Unit 3. Association Rule Mining: Market basket Analysis; Frequent Item sets, Closed Item sets, and Association Rules; Support and Confidence; Apriori Algorithm for Mining Frequent Item sets using Candidate Generation; Generating Association Rules from Frequent Item sets; Improving the Efficiency of Apriori Algorithm; FP-Growth Algorithm for Mining Frequent Item sets without Candidate Generation; Mining Closed Frequent Item sets; Correlation Analysis.

Unit 4. Classification Rule Mining: Introduction to Classification and Prediction; Classification
by Decision Induction; Attribute Selection Measures: Information Gain, Gain Ratio, and Gini Index; Tree Pruning; Bayesian Classification: Bayes' Theorem, Naïve Bayesian Classification, Bayesian Belief Networks; Classifier Accuracy Measures: Sensitivity, Specificity, Precision, and Accuracy; Predictor Error Measures; Accuracy Evaluation Methods: Holdout, Random Subsampling, Cross-validation, and Bootstrap; Accuracy Enhancement Methods: Bagging and Boosting.

Unit 5. Introduction to Clustering, Features Required for Clustering Algorithms, Data Types and Dissimilarity Measures in Cluster Analysis; Categorization of Clustering Methods; Partitioning- Based Clustering: k-means Algorithms, k-medoids algorithms (PAM, CLARA, CLARANS); Hierarchical Clustering: Agglomerative and Divisive Methods (AGNES, DIANA, BIRCH; Density-Based Clustering: DBSCAN.

Books Recommended:

1. J. Han & M. Kamber, Data Mining Concepts and Techniques, 2nd Ed., Morgan Kaufman,2011.
2. Witten & E. Frank, Data Mining – Practical Machine Learning Tools and Techniques,Morgan Kaufman, 2011.
3. Michael Berry & Gordon Linoff, Data Mining Techniques, 3rd Edition,2011.

CM 204: Big Data Analytics

Course outcomes of Big Data Analytics (CM-204):

CO1	Introduction to Big data analytics, Big data applications and AlgorithmsUsing Map Reduce.
CO2	Introduction to Apache Hadoop & Hadoop Ecosystem and DataSerialization.
CO3	Hadoop Architecture, Hadoop Storage and Hadoop ecosystem
CO4	Basic nomenclature, Analytics process model, Standardizing Data,Categorization and Segmentation.
CO5	Predictive Analytics, Linear Regression, Decision Trees and NeuralNetworks

CM 204: Big Data Analytics

Unit 1. Introduction – Big Data and its importance, Four Vs, Drivers for Big data, Introduction to Big data analytics, Big data applications. Algorithms using Map Reduce, Matrix- Vector Multiplication by Map Reduce.

Unit 2. Introduction to Apache Hadoop & Hadoop EcoSystem - Data handling in Hadoop, Datahandling in MapReduce, DataSerialization.

Unit 3. Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., NameNode, Secondary Name Node, and Data Node, Hadoop Map Reduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering -Monitoring & Maintenance. Hadoop ecosystem components - Schedulers - Fair and Capacity, Hadoop

2.0 New Features NameNode High Availability, HDFS Federation, MRv1, MRv2, YARN, Running MRv1 in YARN.

Unit 4. Basic nomenclature - Analytics process model - Analytics model requirements - Types ofdata sources - Sampling - types of data elements - Visual Data Exploration and Exploratory Statistical Analysis - Missing Values - Outlier Detection and Treatment - Standardizing Data – Categorization - weights of evidence coding - Variable selection -Segmentation.

Unit 5. Predictive Analytics: Target Definition - Linear Regression - Logistic Regression - Decision Trees - Neural Networks - Support Vector machines - Ensemble Methods - Multiclass Classification Techniques-Evaluating Predictive Models. Descriptive Analytics: Association Rules - Sequence Rules - Segmentation. Survival Analysis:Survival Analysis Measurements - Parametric Survival Analysis.

Books Recommended:

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional HadoopSolutions”,Wiley, ISBN: 9788126551071, 2015.
2. Chris Eaton, Dirk derooset al. , “Understanding Big data ”, McGraw Hill,2012.
3. Tom White, “HADOOP: The definitive Guide” , O Reilly2012.
4. Vignesh Prajapati, “Big Data Analytics with R and Haoop”, Packet Publishing2013.
5. Tom Plunkett, Brian Macdonald et al, “Oracle Big Data Handbook”, Oracle Press,2014.
6. Jy Liebowitz, “Big Data and Business analytics”,CRC press,2013.
7. Baesens, 2014, Analytics in a Big Data World: The Essential Guide to DataScience andIts applications, Wiley India PrivateLimited.
8. Michael Minelli, Michele Chambers, 2013, Big Data, Big Analytics: EmergingBusiness Intelligence and Analytic Trends for Today’s Businesses,WileyCIO
9. Stephan Kudyba, 2014, Big Data, Mining and Analytics: Components of StrategicDecision Making, CRCPress.
10. Frank J. Ohlhorst, 2013, Big data Analytics: Turning Big Data into Big Money, WileyandSAS Business Series.
11. Foster Provost, Tom Fawcett, 2013, Data Science for Business,SPD.

CM 205 Machine Learning

Course outcomes of Machine Learning (CM-205):

CO1	Basic concepts of machine learning, Perspectives and Issues in MachineLearning.
CO2	Multi-layer Perceptron, Curse of Dimensionality, Interpolations andBasis Functions and Support Vector Machines.
CO3	Decision Trees, Probability and Learning and Self Organizing FeatureMap.
CO4	Linear Discriminant Analysis, Least Squares Optimization and MarkovDecision Process.
CO5	Markov Chain, Monte Carlo Methods, Online learning and SequencePrediction.

CM 205: Machine Learning

Unit 1. Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spacesand the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability– Linear Regression. .

Unit 2. Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi- layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back- Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

Unit 3. Learning with Trees – Decision Trees – Constructing Decision Trees – Classification andRegression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map .

Unit 4. Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

Unit 5. Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields –Hidden Markov Models – Tracking Methods. Model and Symbols- Bagging and Boosting, Multitask learning, Online learning and Sequence Prediction, Data Streams andActive Learning, Deep Learning, Reinforcement Learning.

Books Recommended:

1. Peter Flach: Machine Learning: The Art and Science of Algorithms that Make Senseof Data, Cambridge University Press, Edition2012.
2. Hastie, Tibshirani, Friedman: Introduction to Statistical Machine Learning withApplications in R, Springer, 2ndEdition-2012.
3. ParagKulkarni : Reinforcement and Systematic Machine Learning forDecisionMaking, WileyIEEE Press, Edition July2012.
4. EthemAlpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation andMachine Learning Series)‖, Third Edition, MIT Press,2014.

CM 206: Lab-III (Big Data Analytics Lab)
CM 207: Lab-IV (Machine Learning Lab)

SEMESTER-III

CM 301: Minor Research Project &
8 Credits MOOC Courses

SEMESTER-IV

CM 401 Major Project work