AC: 02.06.2025 ITEM NO: 1.4

Deccan Education Society's

Kirti M. Doongursee College of Arts, Science and Commerce (AUTONOMOUS)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Masters of Science
Course: M.Sc Part-I
Subject: Computer Science

Choice Based Credit System (CBCS)
with effect from
Academic Year 2025-2026

PROGRAM OUTCOMES

PO	Description
A student completing Master Degree in **Science** Program will be able to	
PO1	Demonstrate an in-depth understanding of the relevant science discipline. Recall, explain, extrapolate, and organize conceptual scientific knowledge for execution and application and also to evaluate its relevance
PO2	Critically evaluate, analyze, and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
PO3	Access, evaluate, understand, and compare digital information from various sources and apply it for scientific knowledge acquisition as well as scientific data analysis and presentation.
PO4	Articulate scientific ideas, put forth a hypothesis, design and execute testing tools and draw relevant inferences. Communicate the research work in appropriate scientific language
PO5	Demonstrate initiative, competence, and tenacity at the workplace. Successfully plan and execute tasks independently as well as with team members. Effectively communicate and present complex information accurately and appropriately to different groups
PO6	Use an objective, unbiased and non-manipulative approach in the collection and interpretation of scientific data and avoid plagiarism and violation of Intellectual Property Rights. Appreciate and be sensitive to environmental and sustainability issues and understand its scientific significance and global relevance
PO7	Translate academic research into innovation and creatively design scientific solutions to problems. Exemplify project plans, use management skills, and lead a team in the planning and execution of a task
PO8	Understand the cross-disciplinary relevance of scientific developments and relearn and reskill to adapt to technological advancements.

Deccan Education Society's

Kirti M. Doongursee College

(Autonomous) Proposed

Curriculum as per NEP-2020

Year of implementation- 2025-2026

Name of the Department-Computer Science

Semester	Course Code	Course Title	Vertical	Credit
I	25CSMJ711	Algorithm for Optimization	Major 1	4
	25CSMJP71	Practical- Algorithm for Optimization	Major Practical	2
	25CSMJ712	Advanced Database Techniques	Major 2	4
	25CSMJP72	Practical-Advanced Database Techniques	Major Practical	2
	25CSMJ713	Principles of Compiler Design	Major 3	2
	25CSEL721 25CSEL722 25CSEL723	a. Software Defined Networking [OR] b. NoSQL Technologies [OR] c.Image Processing	Elective 1	2
	25CSELP71 25CSELP72 25CSELP73	Practical Software Defined Networking [OR] Practical NoSQL Technologies OR] Practical Image Processing	Elective Practical	2
	25CSMJ714	Research Methodology	RESEARCH METHODOLOGY	4
II	25CSMJ811	Big Data Analytics	Major 1	4
	25CSMJP81	Practical- Big Data Analytics	Major Practical	2
	25CSMJ812	Natural Language Processing	Major 2	4
	25CSMJP82	Practical- Natural Language Processing	Major Practical	2
	25CSMJ813	Micro Service Architecture	Major 3	2
	25CSEL821 25CSEL822 25CSEL823	a. Web Data Analytics [OR] b. Introduction to Robotics [OR] c. Bioinformatics	Elective	2
	25CSELP81 25CSELP82 25CSELP83	PRACTICAL-Web Data Analytics [OR] Robotics [OR] Bioinformatics	Elective Practical	2
	25CSOJT83	Internship PROJECT	OJT	4

SEMESTER-I

Course Code	Major 1	Credits	Lectures/Week
25CSMJ711	**Algorithm for Optimization**	4	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define fundamental concepts of optimization algorithms and key optimization techniques.
CO2: Explain the principles behind optimization methods and their applications in various domains
CO3: Implement optimization algorithms.
CO4: Access the impact of various optimization methods/techniques on the performance of algorithms.

Unit	Topics	No of Lectures
I	**Ability Enhancement** Introduction to Optimization Process Basic Optimization Problem, Constraints, Critical Points, Conditions for Local Minima, Contour Plots. Unimodality, Fibonacci Search, Golden Section Search, Quadratic Fit Search.	15
II	**Order Methods** First-Order Methods, Gradient Descent, Conjugate Gradient, Adagrad, RMSProp, Adadelta, Adam, Hypergradient Descent. Second-Order Methods, Newton's Method, Secant Method, QuasiNewton Methods.	15
III	**Sampling and Surrogate Models** Sampling Plans, Full Factorial, Random Sampling, Uniform Projection Plans, Stratified Sampling, Space-Filling Metrics. Surrogate Models, Fitting Surrogate Models, Linear Models, Basis Functions, Fitting Noisy Objective Functions, Model Selection, Probabilistic Surrogate Models, Gaussian Distribution, Gaussian Processes, Prediction	15
IV	**Skill Enhancement** Optimization and Uncertainty Optimization under Uncertainty, Uncertainty, Set-Based Uncertainty, Probabilistic Uncertainty. Uncertainty Propagation, Sampling Methods, Taylor Approximation, Polynomial Chaos, Bayesian Monte Carlo. Dynamic Programming, Ant Colony Optimization. Expression Optimization, Grammars, Genetic Programming, Grammatical Evolution, Probabilistic Grammars, Probabilistic Prototype Trees	15

REFERENCE BOOKS:

- Algorithms for Optimization Mykel J. Kochenderfer, Tim A. Wheeler, The MIT Press 2019.
- Think Julia: How to Think Like a Computer Scientist by Allen B. Downey and Ben Lauwens 1st Edition 2019 O'reilly.
- Decision Making Under Uncertainty: Theory and Application by Mykel J. Kochenderfer MIT Lincoln Laboratory Series 2015.
- Introduction to Algorithms, By Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein 3Ed. (International Edition) (MIT Press) 2009.

Course Code	**Major 1**	**Credits**	**Practicals/Week**
25CSMJP71	**Algorithm for Optimization – Practical**	**2**	**4**

Course Outcome -

After successful completion of this course, students would be able to

CO1: Remember and Explain Integer programming techniques and apply different optimization techniques to solve various models arising from engineering areas.
CO2: Understand or Use classical optimization techniques and numerical methods of optimization.
CO3: Implement different evolutionary algorithms.
CO4: Enumerate fundamentals of Integer programming technique and apply different techniques to solve various optimization problems arising from engineering areas.

Note: All the Practical's should be implemented using Julia
Link: Julia:https://julialang.org/

1	Implement Contour Plots.
2	Implement Fibonacci and Golden section search.
3	Implement Quadratic Fit Search.
4	Implement Gradient descent.
5	Implement quasi-Newton methods to find the local maxima.
6	Implement the Adagrad method with application, RMSprop and Adadelta.
7	Implement radial basis functions using surrogate modelling.
8	Apply Random Forest in surrogate Model.
9	Implement Gaussian Process and its application.
10	Path finding using Ant Colony Optimization with an application.

Course Code	Major 2	Credits	Lectures/Week
25CSMJ712	Advanced Database Techniques	4	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall the fundamentals of relational database systems including: data models, database architectures and ER features.

CO2: Explain the advanced topics of databases to become more proficient.

CO3: Interpret and use theoretical knowledge and practical skills in advanced topics in database systems, big data and modern data-intensive systems.

CO4: Analyze the relational database systems and execute it with NOSQL .

Unit	Topics	No of Lectures
I	**Enhanced Database Models** **Object–Oriented Databases**: Need of Object-oriented databases, Complex Data Types, Structured Types and Inheritance, Object-Identity and Reference, ODL and OQL, Implementing O-R Features, Persistent Programming Languages, Object-Oriented versus Object-Relational, Example of Object oriented and object relational database implementation, comparison of RDBMS, OODBMS, ORDBMS. **XML Databases:** Structured Semi structure and unstructured data, XML hierarchical tree data model, Documents DTD and XML schema, XML Documents & Database, XML query and transformation, Storage of XML data, Xpath. XQuery, Join and Nesting Queries, XML database applications. **Spatial Databases:** Types of spatial data, Geographical Information Systems (GIS), Conceptual Data Models for spatial databases, Logical data models for spatial databases: Raster and vector model. Physical data models for spatial databases: Clustering methods (space filling curves), Storage methods (R-tree). Query processing.	15
II	**Cooperative Transaction Model** **Parallel and Distributed Databases:** Architecture of parallel databases, Parallel query evaluation, Parallelizing individual operations, Sorting Joins **Distributed Databases:** Concepts, Data fragmentation, Replication and allocation techniques for distributed database design, Query processing, Concurrency control and recovery in distributed databases. **Architecture and Design:** Centralised versus non centralized Databases, Homogeneous and Heterogeneous DDBMS, Functions and Architecture, Distributed database design, query processing in DDBMS, Distributed concurrency management, deadlock	15

	management, Distributed Commit Protocols: 2 PC and 3 PC, Concepts of replication servers. **Temporal Databases**: Time ontology, structure, and granularity, Temporal data models, Temporal relational algebra.	
III	**Learning the NoSQL Basics** **Introduction to NoSQL:** Characteristics of NoSQL, NoSQL Storage types, Advantages and Drawbacks, NoSQL Products. **Interfacing and interacting with NoSQL:** Storing Data In and Accessing Data from MongoDB, Redis, HBase and Apache Cassandra, Language Bindings for NoSQL Data Stores. **Understanding the storage architecture:** Working with Column-Oriented Databases, HBase Distributed Storage Architecture, Document Store Internals.	**15**
IV	**Gaining Proficiency With NoSQL** **Querying NoSQL Stores:** Similarities Between SQL and MongoDB Query Features, Accessing Data from Column-Oriented Databases Like HBase, Querying Redis Data Stores. **Handling Datasets with MongoDB:** Indexing And Ordering Data Sets, Essential Concepts Behind a Database Index, Indexing and Ordering in MongoDB, CouchDB and Apache Cassandra. **Managing Transactions And Data Integrity:** RDBMS and ACID, Distributed ACID Systems, Upholding CAP, Consistency Implementations.	**15**

REFERENCE BOOKS:

- Database Management Systems by Raghu Ramakrishnan and Johannes Gehrke, McGraw Hill, 3rd Edition, 2014
- Professional NoSQL By Shashank Tiwari, Wrox-John Wiley & Sons, Inc, 2011
- Getting Started with NoSQL, Gaurav Vaish, Packt Publishing Ltd, 2013

Course Code	Major 2	Credits	Lectures/ Week
25CSMJP72	**Advanced Database Techniques – Practical**	**2**	**4**

Course Outcome: -

After successful completion of this course, students would be able to

CO1: Recall the basics of query processing, object-oriented, distributed databases.
CO2: Understand the roles that databases play in organizations and familiarize with basic database storage, file organization, and database accessing techniques.
CO3: Demonstrate theoretical knowledge and practical skills in advanced topics in database systems, big data and modern data-intensive systems.
CO4: Analyze non-relational database systems and structures and XML.

Note: All the Practical's should be implemented using NoSQL Link: https://www.oracle.com/database/technologies/nosql-databaseserver-downloads.html

1	Create different types that include attributes and methods. Define tables for these types by adding a sufficient number of tuples. Demonstrate insert, update and delete operations on these tables. Execute queries on them.
2	Create an XML database and demonstrate insert, update and delete operations on these tables. Issue queries on it.
3	Demonstrate distributed databases environment by dividing given global conceCreate a table that stores spatial data and issue queries on it. ptual schema, into vertical and Horizontal fragments and place them on different nodes. Execute queries on these fragments.
4	Create a table that stores spatial data and issues queries on it
5	Create a temporal database and issue queries on it.
6	Demonstrate the Accessing and Storing and performing CRUD operations in 1. MongoDB 2. Redis
7	Demonstrate the Accessing and Storing and performing CRUD operations in 1. HBase 2. Apache Cassandra
8	Demonstrating MapReduce in MongoDB to count the number of female (F) and male (M) respondents in the database.
9	Demonstrate the indexing and ordering operations in 1. MongoDB 2. CouchDB 3. Apache Cassandra
10	Demonstrate the use of data management and operations using NoSQL in the Cloud.

Course Code	Major 3	Credits	Lectures/Week
25CSMJ713	**Principles of Compiler Design**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Learn the fundamental concepts of compiler design.
CO2: Summarize the phases of compilation and their significance.
CO3: Apply parsing techniques, and implement code optimization techniques to improve execution efficiency.
CO4: Evaluate the impact of compiler design choices on performance and memory management. and Analyze various optimization strategies for efficient code generation.

Unit	Topics	No of Lectures
I	**Introduction to Compilers** Definition and role of a compiler, Phases of compilation,Difference between interpreters and compilers **Lexical Analysis** Tokens, lexemes, and patterns, Regular expressions, finite automata, NFA, conversion to NFA to DFA, minimization of DFA, Lexical analyzer design. **Syntax Analysis** Context-free grammars and parse trees, Top-down and bottom-up parsing techniques, LL(1), elimination of Left Recursion, Left factorization and LR parsing methods **Semantic Analysis** Syntax-directed translation,Type checking and error handling, Symbol tables and scope resolution	**15**
II	**Intermediate Code Generation** Abstract syntax trees and three-address code, Translation of expressions and control structures, Storage allocation strategies	**15**

	Run-time Environment Memory management and activation records, Parameter passing mechanisms **Code Optimization** Peephole optimization and loop optimization, Data-flow analysis and constant folding, Register allocation and instruction scheduling **Code Generation** Target machine architecture, Generating assembly/machine code, Error recovery strategies	

REFERENCE BOOKS:

- "Compilers: Principles, Techniques, and Tools" by Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman 2nd Edition, Pearson Publication, 2006 ISBN-13: 978-0321486813
- "Modern Compiler Implementation in C" by Andrew W. Appel, 3rd Edition, Cambridge University Press, 2020, ISBN-13: 978-1108426631
- "Principles of Compiler Design" by D. M. Dhamdhere, 2 nd Edition Publisher: McGraw-Hill Education, 2017, ISBN-13: 978-9339204608

Course Code	Elective SEM I	Credits	Lectures/Week
25CSEL721	**Software Defined Networking**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define and remember the basics concepts of computer networks.
CO2: Summarize the knowledge of Software defined networks
CO3: Determine the knowledge of Software defined networks and virtualization for industry standard solutions.
CO4: Implement network virtualization and Software Defined Network (SDN).

Unit	Topics	No of Lectures
I	**Introduction to Computer Networking** Basic Concepts and Definitions: LAN, MAN, WAN, AD-Hoc, Wireless Network, Understanding the layered architecture of OSI/RM and TCP-IP Model, Concepts and implementation of IPV4 and IPV6, Study of various network Routing protocols, Introduction to Transport layer and Application layer protocols.	**15**

	Software Defined Networking Elements of Modern Networking, Requirements and Technology, SDN: Background and Motivation, SDN Data Plane and OpenFlow, SDN Control Plane, SDN Application Plane	
II	**Network Functions Virtualization** Concepts and Architecture, NFV Functionality, Network Virtualization Quality of Service, MODERN NETWORK ARCHITECTURE: CLOUDS AND FOG, Cloud Computing, The Internet of Things: Components **Design and implementation of Network** Understand and implement Layer 2/3 switching techniques (VLAN /TRUNKING/ Managing Spanning Tree), Implementation of OSPF V2 and V3, Implementation BGP, Implementation Multicast Routing, Implementation of MPLS, Implementation of Traffic Filtering by using Standard and Extended Access Control List, Implementation of Routing redistribution, Implementation of Policy Based Routing/ Load Balancing /QOS/Natting /VRF	**15**

REFERENCE BOOKS:

- Behrouz A Forouzan ―TCP/IP Protocol Suite‖ Fourth Edition 2010
- William Stallings, ―Foundations of Modern Networking‖ , Pearson Ltd.,2016.
- Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014
- SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013

Course Code	Elective SEM – I	Credits	Practical/Week
25CSELP72	SOFTWARE DEFINED NETWORKING Practical	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall and Describe the fundamental concepts and purpose of IP SLA operations.
CO2: Describe the mechanisms and advanced modifications used in STP. Understand the concepts behind EtherChannel, OSPF routing, and BGP operation and path selection.
CO3: Configure and Implement various IP SLA operations based on given network scenarios.
CO4: Analyze and Interpret the results of IP SLA operations to identify network performance metrics and potential issues.

Note: All the Practical's should be implemented using GNS3/EVENG/CISCO VIRL
Link: GNS3:https://www.gns3.com/software/download EVE-NG: https://www.eve-ng.net/index.php/download/CISCO VIRL:
https://learningnetwork.cisco.com/s/question/0D53i00000Kswpr/virl15-download

1	Implement IP SLA (IP Service Level Agreement)
2	Implement IPv4 ACLs a) Standard ACL b) Extended ACL
3	a) Implement SPAN Technologies (Switch Port Analyzer) b) Implement SNMP and Syslog c) Implement Flexible NetFlow
4	a) Implement a GRE Tunnel b) Implement VTP c) Implement NAT
5	Implement Inter-VLAN Routing
6	Observe STP Topology Changes and Implement RSTP a) Implement Advanced STP Modifications and Mechanisms b) Implement MST
7	a) Implement EtherChannel b) Tune and Optimize EtherChannel Operations
8	OSPF Implementation a) Implement Single-Area OSPFv2 b) Implement Multi-Area OSPFv2 c) OSPFv2 Route Summarization and Filtering d) Implement Multiarea OSPFv3

9	a) Implement BGP Communities b) Implement MP-BGP c) Implement eBGP for IPv4 d) Implement BGP Path Manipulation
10	a) Implement IPsec Site-to-Site VPNs b) Implement GRE over IPsec Site-to-Site VPNs c) Implement VRF Lite
11	Simulating SDN with a) OpenDaylight SDN Controller with the Mininet Network Emulator b) OFNet SDN network emulator
12	Simulating OpenFlow Using MININET

Course Code	**Elective SEM I**	**Credits**	**Lectures/Week**
25CSEL722	**NoSQL Technologies**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall the concepts of MongoDB, Redis, HBase, and Apache Cassandra effectively. Comprehend storage architecture in NoSQL, including column-oriented, document stores, and key/value stores.

CO2: Summarize NoSQL characteristics, storage types, and advantages/drawbacks.

CO3: Use CRUD operations proficiently, including data creation, access, update, and deletion. Query NoSQL stores using MongoDB features, accessing HBase data, and querying Redis.

CO4: Analyze indexing and ordering concepts in NoSQL databases like MongoDB, CouchDB, and Cassandra.Manage transactions and ensure data integrity in NoSQL, including distributed ACID systems.

Unit	**Topics**	**No of Lectures**

I	**Introduction to NoSQL and Interfacing with NoSQL Data Stores** **Basics Introduction to NoSQL:** Characteristics of NoSQL, NoSQL Storage types, Advantages and Drawbacks, NoSQL Products Interfacing and interacting with NoSQL: Storing Data in and Accessing Data from MongoDB, Redis, HBase and Apache Cassandra, Language Bindings for NoSQL Data Stores **Understanding the storage architecture:** Working with ColumnOriented Databases, HBase Distributed Storage Architecture, Document Store Internals, Understanding Key/Value Stores in Memcached and Redis, Eventually Consistent Non-relational **Databases Performing CRUD operations:** Creating Records, Accessing Data, Updating and Deleting Data	**15**
II	**Querying, Indexing, and Data Management in NoSQL Databases** **Querying NoSQL Stores:** Similarities Between SQL and MongoDB Query Features, Accessing Data from Column-Oriented Databases Like HBase, Querying **Redis Data Stores Indexing and Ordering Data Sets:** Essential Concepts Behind a Database Index, Indexing and Ordering in MongoDB, ouchDB and Apache Cassandra **Managing Transactions and Data Integrity:** RDBMS and ACID, Distributed ACID Systems, Upholding CAP, Consistency Implementations Using NoSQL in The Cloud: Google App Engine Data Store, Amazon SimpleDB	**15**

REFERENCE BOOKS-

- QL & NoSQL Databases, Andreas Meier · Michael Kaufmann, Springer Vieweg, 2019
- Professional NoSQL by Shashank Tiwari, Wrox-John Wiley & Sons, Inc, 2011
- SQL & NoSQL Databases, Andreas Meier · Michael Kaufmann, Springer Vieweg, 2019
- NoSQL: Database for Storage and Retrieval of Data in Cloud, Ganesh Chandra Deka, CRC Press, 2017
- Demystifying NoSQL by Seema Acharya, Wiley, 2020

Course Code	Elective SEM I	Credits	Lectures/Week
25CSELP73	**NoSQL Technologies Practical**	**02**	**4**

Course Outcome:

After successful completion of this course, students would be able to

CO1: Recall the concept of NoSQL
CO2: Understand the storage architecture and internal workings of different NoSQL databases, such as column-oriented databases, document stores, and key/value stores.
CO3: Perform CRUD operations and retrieve data from different NoSQL databases using appropriate query languages and commands, Implement data indexing and explore its impact on query performance in MongoDB and other NoSQL databases.
CO4: Analyze the application of NoSQL technologies in real-world scenarios, such as caching with Redis, data storage in Google App Engine Data Store, and Amazon SimpleDB data management.

1	Lab Exercise: Setting up and Exploring MongoDB a) Install MongoDB on your local machine or lab server. b) Create a new MongoDB database and collection. c) Insert sample data into the collection. d) Retrieve and display data from the collection using MongoDB queries
2	Interacting with Redis a) Install Redis on your lab server or local machine. b) Store and retrieve data in Redis using various data structures like strings, lists, and sets. c) Implement basic Redis commands for data manipulation and retrieval
3	Working with HBase a) Set up an HBase cluster in a lab environment. b) Create an HBase table and define column families. c) Insert sample data into the table. d) Perform CRUD operations and retrieval of data in HBase.
4	Apache Cassandra Operations a) Install and configure Apache Cassandra in a lab environment. b) Create a keyspace and define a table schema. c) Insert data into the table. d) Perform CRUD operations and query data from Apache Cassandra.
5	Querying MongoDB and HBase a) Write and execute MongoDB queries to retrieve specific data from a collection. b) Perform queries on HBase tables using HBase shell commands.

6	Redis Data Manipulation a) Use Redis commands to manipulate and modify data stored in different data structures. b) Retrieve specific data using Redis query operations.
7	Implementing Indexing in MongoDB a) Create an index on a specific field in a MongoDB collection. b) Measure the impact of indexing on query performance.
8	Data Storage in Redis a) Implement caching functionality using Redis as a cache store. b) Store and retrieve data from Redis cache using appropriate commands.
9	Using Google App Engine Data Store a) Create a project in Google App Engine and set up the Data Store. b) Store and retrieve data from the Data Store using the provided API.
10	Amazon SimpleDB Data Management a) Task 1: Set up an Amazon SimpleDB domain for data storage. b) Task 2: Store and retrieve data from the SimpleDB domain using appropriate commands or APIs.

Course Code	**Elective SEM I**	**Credits**	**Lectures/Week**
25CSEL723	**Image Processing**	**2**	**2**

Course Outcome:

After successful completion of this course, students would be able to

CO1: Recall the fundamental concepts of digital image processing and techniques.
CO2: Explain and interpret the principles behind image enhancement, noise reduction, edge detection, morphological operations, and segmentation methods.
CO3: Utilize image processing techniques such as intensity transformations, histogram processing, filtering, edge detection, and morphological operations to analyse and enhance digital images.
CO4: Assess the effectiveness of different image processing techniques in improving image quality, extracting features, and segmenting regions according to the application requirements.

Unit	Topics	No of Lectures
I	**Fundamentals of Digital Image Processing** **Basics of Image Processing:** Digital image representation- pixels, resolution, and intensity; Image file formats- BMP, PNG, JPEG, and TIFF; Tools and libraries: OpenCV, Pillow, scikit-image **Image Intensity Transformations**: Logarithmic and Power-law Transformations, Contrast Stretching and Thresholding **Histogram Processing:** Histogram Equalization, Histogram Matching **Noise and Image Smoothing:** Noise types-Gaussian, Salt-and-Pepper, Speckle; Noise reduction- Mean, Gaussian, and Median Filtering	**15**
II	**Advanced Image Processing Techniques** **Edge Detection**: Sobel, Prewitt, Roberts, and Canny Techniques **Morphological Operations:** Erosion, Dilation, Opening, Closing; Skeletonization, Boundary Extraction **Image Segmentation & Feature Extraction**: Thresholding, Region-based Segmentation, feature extraction using Difference of Gaussians (DoG)	**15**

REFERENCE BOOKS-

- Understanding Digital Image Processing, Vipin Tyagi, CRC Press, 2018
- Digital Signal and Image Processing by Tamal Bose, John Wiley 2010
- Hands-On Image Processing with Python by Sandipan Dey,Packt Publishing, 2018
- Fundamentals of Digital Images Processing by A K Jain, Pearson, 2010

Course Code	Elective SEM I	Credits	Practical/Week
25CSELP74	Image Processing Practical	02	4

Course Outcome:

After successful completion of this course, students would be able to

CO1: Recall and demonstrate basic image operations such as intensity transformations, histogram equalization, and basic smoothing techniques using programming tools.
CO2: Interpret the role of different filters and morphological operations in enhancing image quality and preparing images for further processing.
CO3: Implement edge detection and image enhancement techniques using software tools to extract features and improve visual interpretation.
CO4: Analyze images for object and shape detection using segmentation techniques and evaluate the suitability of algorithms for different scenarios.

1	Write a program to implement point/pixel intensity transformations such as 1. Log and Power-law Transformations. 2. Contrast Adjustments.
2	Write program to implement Histogram Equalization
3	Write a program to implement Linear and Non-Linear noise smoothing on suitable image.
4	Write a program to apply various image enhancement using image directives by implementing smoothing filters for generating suitable images for specific application requirements.
5	Write a program to apply various image enhancement using image directives by implementing sharpening, and unsharp masking filters for generating suitable images for specific application requirements.
6	Write a program to apply edge detection techniques to extract meaningful information from the given image samples. 1. Sobel Image 2. Canny Edge
7	Write a program to implement morphological image processing techniques on binary images 1. Dilation and erosion. 2. Opening and closing.
8	Write a program to implement morphological image processing techniques on gray scale images 1. Dilation and erosion. 2. Opening and closing.
9	Write a Program to apply Various Enchantments on Images using images directives by Implementing Gradient and Laplacian Operations.

10	Write the program to apply segmentation for detecting lines, circles, and other shapes/objects. Also, implement edge-based and region-based segmentation.

Course Code	RESEARCH METHODOLOGY SEM – I	Credits	Lectures/Week
25CSMJ714	**RESEARCH METHODOLOGY**	**4**	**4**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Learn the application of Research in different Business Sectors
CO2: Describe business research with an understanding of all the latest theories.
CO3: Develop the ability to explore research techniques used for solving any real world or innovative problem.
CO4: Analyze the data to help the decision makers in innovative business process

Unit	Topics	No of Lectures
I	Introduction: Role of Business Research, Information Systems and Knowledge Management, Theory Building, Organization ethics and Issues Beginning Stages of Research Process: Problem definition, Qualitative research tools, Secondary data research	**15**
II	Research Methods and Data Collection: Survey research, communicating with respondents, Observation methods, Experimental research	**15**
III	Measurement Concepts, Sampling and Field work: Levels of Scale measurement, attitude measurement, questionnaire design, sampling designs and procedures, determination of sample size.	**15**
IV	Data Analysis and Presentation: Editing and Coding, Basic Data Analysis, Univariate Statistical Analysis and Bivariate Statistical analysis and differences between two variables. Multivariate Statistical Analysis.	**15**

REFERENCE BOOKS-

- Business Research Methods William, G.Zikmund, B.J, Babin, J.C. Carr, Atanu Adhikari, M.Griffin Cengage 8e 2016
- Business Analytics, Albright Winston, Cengage 5e 2015
- Research Methods for Business Students Fifth Edition, Mark Saunders 2011

SEMESTER-II

Course Code	MAJOR 1	Credits	Lectures/Week
25CSMJ811	Big Data Analytics	4	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define fundamental concepts of Big Data, including structured, semi-structured, and unstructured data, define key technologies such as Hadoop, Spark, NoSQL databases, and MapReduce and Recall different types of analytics: descriptive, predictive, and prescriptive analytics.

CO2: Explain the architecture and components of Hadoop Distributed File System (HDFS), MapReduce, Hbase, Spark and Interpret the role of data preprocessing, cleaning, and transformation in Big Data analytics.

CO3: Implement various tools of big data Analytics.

CO4: Analyze the use of various technologies for performing big data analytics in industry today.

Unit	Topics	No of Lectures
I	**Big Data:** Characteristics of Big Data, Big Data importance, and Applications, Big Data Analytics, Typical Analytical Architecture, Requirement for new analytical architecture, Challenges in Big DataAnalytics, Need of big data frameworks, Types and Sources of Big Data.Exploring the Use of Big Data in Business Context **Hadoop Framework:** Requirement of Hadoop Framework, Design principle of Hadoop, Hadoop Components, Hadoop Ecosystem, Hadoop 2 architecture, Hadoop YARN Architecture, Advantage of YARN, YARN Command. HDFS: Design of HDFS, Benefits and Challenges, HDFS Commands.	15
II	**Map Reduce and HBASE** **MapReduce Framework and Basics:** Working of Map Reduce, Developing Map Reduce Application, I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs. Processing data using Map Reduce. **HBASE:** Role of HBase in Big Data Processing, Features of HBase. HBase Architecture, Zookeeper. HBase Commands for creating, listing, and Enabling data tables.	15
III	**Spark Framework and Applications** **Introduction to Spark:** Overview of Spark, Hadoop vs Spark, Cluster Design, Cluster Management, performance, Application Programming Interface (API): Spark Context, Resilient Distributed Datasets, Creating RDD, RDD Operations, Saving RDD - Lazy Operation, Spark Jobs. **Writing Spark Application** – Compiling and Running the Application. Monitoring and debugging Applications. Spark Programming	15
IV	**Tools for Data Anlytics (Skill Enhancement)** **Spark SQL:** SQL Context, Importing and Saving data, Data frames, using SQL, GraphX overview, Creating Graph, Graph Algorithms.	15

	Spark Streaming: Overview, Errors and Recovery, Streaming Source, Streaming live data with spark **Hive:** Hive services, Data Types, and Built-in functions in Hive. **Pig:** Working with operators in Pig, Working with Functions and Error Handling in Pig. **Flume and Sqoop:** Flume Architecture, Sqoop, Importing Data. Sqoop2 vs Sqoop.	

REFERENCE BOOKS-

- Big Data Analytics, Introduction to Hadoop, Spark, and Machine-Learning, Raj Kamal, Preeti Saxena, McGraw Hill, 2019
- Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization, Dreamtech Press; 1st edition, 2016
- Big Data Analytics with Spark, A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Apress, 2015
- Hadoop MapReduce v2 Cookbook - Second Edition, Packt Publishing, 2015
- Big Data in Practice: How 45 Successful Companies Used Big Data Analytics to Deliver Extraordinary Results, Wiley, 1st edition, 2016
- Hadoop – TheDefinitive Guide by Tom White, OReilly, 2012
- Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data, McGrawHill, 2012
- Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Michael Minelli, Wiley, 2013

Course Code	Major 1	Credits	Practicals/Week
25CSMJP81	**Big Data Analytics– Practical**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define fundamental concepts of Big Data, including structured, semi-structured, and unstructured data, define key technologies such as Hadoop, Spark, NoSQL databases, and MapReduce and Recall different types of analytics: descriptive, predictive, and prescriptive analytics.
CO2: Explain the architecture and components of Hadoop Distributed File System (HDFS), MapReduce, Hbase, Spark and Interpret the role of data preprocessing, cleaning, and transformation in Big Data analytics.
CO3: Implement various tools of big data Analytics.
CO4: Analyze the use of various technologies for performing big data analytics in industry today.
Note: Following practical can be performed on Windows or Linux

1	Installing and setting environment variables for Working with Apache Hadoop.
2	Implementing Map-Reduce Program for Word Count problem,

3	Download and install Spark. Create Graphical data and access the graphical data using Spark.
4	Write a Spark code for the given application and handle error and recovery of data.
5	Write a Spark code to Handle the Streaming of data.
6	Install Hive and use Hive Create and store structured databases.
7	Install HBase and use the HBase Data model Store and retrieve data.
8	Perform importing and exporting of data between SQL and Hadoop using Sqoop
9	Write a Pig Script for solving counting problems
10	Use Flume and transport the data from the various sources to a centralized data store.

Course Code	MAJOR 2	Credits	Lectures/Week
25CSMJ812	Natural Language Processing	4	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall fundamental concepts of NLP, key NLP techniques and different language models.

CO2: Explain the role of morphological analysis, part-of-speech tagging, and parsing in NLP, the significance of word embeddings and Compare different NLP approaches.

CO3: Applying algorithms, text preprocessing techniques available for the processing of linguistic information and computational properties of natural languages.

CO4: Evaluate and analyze the efficiency of NLP algorithms.

Unit	Topics	No of Lectures
I	**Introduction to Natural Language Processing (NLP) and Language Modelling** Introduction to NLP: Introduction and applications, NLP phases, Difficulty of NLP including ambiguity; Spelling error and Noisy Channel Model; Concepts of Parts-of speech and Formal Grammar of English. Language Modelling: N-gram and Neural Language Models Language Modelling with N-gram, Simple N-gram models, smoothing (basic techniques), Evaluating language models; Neural Network basics, Training; Neural Language Model, Case study: application of neural language model in NLP system development Python Libraries for NLP: Using Python libraries/packages such as NaturalLanguage Toolkit (NLTK), spaCy, genism	15
II	**Morphology & Parsing in NLP** Computational morphology & Parts-of-speech Tagging: basic concepts; Tagset; Lemmatization, Early approaches: Rule-based and TBL; POS tagging using HMM, Introduction to POS Tagging using Neural Model. Parsing Basic concepts: top-down and bottom-up parsing, treebank; Syntactic parsing: CKY parsing; Statistical Parsing basics: Probabilistic Context-Free Grammar (PCFG); Probabilistic CKY Parsing of PCFGS.	15
III	**Semantics and Word Embedding** Semantics Vector Semantics: Words and Vector; Measuring Similarity; Semantics with dense vectors; SVD and Latent Semantic Analysis Embeddings from prediction: Skip-gram and Continuous Bag of words; Concept of Word Sense; Introduction to WordNet.	15
IV	**NLP Applications and Case Studies**	15

	Intelligent Work Processors: Machine Translation; User Interfaces; man-machine Interfaces: Natural language Querying Tutoring and Authoring Systems. Speech Recognition Commercial use of NLP: NLP in customer Service, Sentiment Analysis, Emotion Mining, Handling Frauds and SMS, Bots, LSTM & BERT models, Conversations	

REFERENCE BOOKS:

- Speech and Language Processing, Jurafsky Dan and Martin James H., 3rd Edition, Pearson, 2018
- Natural Language Processing with Python, Steven Bird, Ewan Klein, and Edward Loper, 2nd Edition, O'Reilly, 2016.
- Practical NaturalLanguage Processing with Python, Mathangi Sri, Apress, 2021
- Handbook of Computational Linguistics and Natural Language Processing, Martin Whitehead, Clanrye International, 2020
- Handbook of Natural Language Processing,NitinIndurkhya, and Fred J. Damerau, Pearson; 2nd edition, 2008
- Foundations of Statistical Natural Language Processing‖ , Manning, Christopher and Heinrich, Schutze, MIT Press, 1997

Course Code	Major 2	Credits	Practicals/Week
25CSMJP82	Natural Language Processing– Practical	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Learn how to apply basic algorithms & design and implement applications based on natural language processing
CO2: Understand current methods for statistical approaches to machine translation.
CO3: Apply and design an innovative application system who uses NLP components
CO4: Analyze and apply NLP techniques design real-world NLP applications

Note: - The following set of practicals can be performed using any Python Libraries for NLP such as NLTK, spaCy, genism:
Link:-https://www.python.org/downloads/

1	Write a program to implement sentence segmentation and word tokenization
2	Write a program to Implement stemming and lemmatization
3	Write a program to Implement a tri-gram model
4	Write a program to Implement PoS tagging using HMM & Neural Model
5	Write a program to Implement syntactic parsing of a given text
6	Write a program to Implement dependency parsing of a given text
7	Write a program to Implement Named Entity Recognition (NER)
8	Write a program to Implement Text Summarization for the given sample text

CASE STUDIES:

Apply the concepts and techniques of Natural language processing learned for real-life applications. A suitable application can be modelled which demonstrates the NLP skills.
Some of the concepts/themes for lab exercises (not limited to the following) are described.

9	Consider a scenario of applying NLP in Customer Service. Design and develop an application that demonstrates NLP operations for working with tasks and data like voice calls, chats, Ticket Data, Email Data. Process the data to understand the voice of the Customer (intent mining, Top words, word cloud, classify topics). Identify issues, replace patterns and gain insight into sales chats
10	Consider a scenario of Online Review and demonstrate the concept of sentiment analysis and emotion mining by applying various approaches like lexicon-based approach and rule-based 28 approaches.
11	Apply NLP in Banking, Financial Services, and Insurance. Design Application to detect frauds and work with SMS data.
12	Demonstrate the use of NLP in designing Virtual Assistants. Apply LSTM, build conversational Bots.

Course Code	Major-3	Credits	Lectures/Week
25CSMJ813	MICROSERVICE ARCHITECTURE	2	2

Course Outcome:

After successful completion of this course, students would be able to

CO1: Recall the fundamental principles, architecture, and key features of web applications developed using ASP.NET Core MVC.
CO2: Describe how microservices can improve scalability, fault isolation, and independent deployment, compared to monolithic architectures.
CO3: Use service discovery tools like Consul or Eureka to enable microservices to dynamically discover and communicate with each other.
CO4: Differentiate the potential performance bottlenecks in the system, such as inefficient inter-service communication or database contention

Unit	Topics	No of Lectures
I	**Microservices:**Understanding Microservices Adopting Microservices, The Microservices Way. Microservices Value Proposition: DerivingBusiness Value, defining a Goal-Oriented, Layered Approach,Applyingthe Goal-Oriented, Layered Approach. **Designing Microservice Systems**: The Systems Approach to Microservices, A MicroservicesDesign Process, Establishing a Foundation: Goals and Principles,Platforms, Culture.	15
II	**Service Design**: Microservice Boundaries, API design for Microservices, Data and Microservices, Distributed Transactions and Sagas, Asynchronous Message-Passing and Microservices, dealing with Dependencies, **System Design and Operations:** Independent Deployability, More Servers, Docker and Microservices, Role of Service Discovery, Need for an API Gateway, Monitoring and Alerting. Adopting Microservices in Practice: Solution Architecture Guidance, Organizational Guidance, Culture Guidance, Tools and Process Guidance, Services Guidance.	15

Reference Books:

- Microservice Architecture:Aligning Principles,Practices, and CultureIrakli Nadareishvili,Ronnie Mitra,Matt McLarty, and Mike Amundse O'Reilly First Edition 2016
- Building Microservices with ASP.NET Core Kevin Hoffman O'Reilly First 2017
- Building Microservices: Designing Fine-Grained Systems, O'Reilly
  IBM CE - MicroServices Architecture and Implementation
- MicroService Architecture by Irakli Nadareishvili, Ronnie Mitra, Matt McLarty, Mike Amundsen, O'REILLY
- Docker Cookbook - Solutions and Examples for Building Distributed Applications By Sébastien Goasguen, , O'REILLY
- Play with Docker : https://www.docker.com/play-with-docker
- Kubernetes and Container Concepts https://e5.onthehub.com/WebStore/

Course Code	ELECTIVE -SEM II	Credits	Lectures/Week
25CSEL821	**Web Data Analytics**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able

CO1: Learn about opinion mining and sentiment classification in web information retrieval.

CO2: Understand the concepts and techniques of web mining, including sequential pattern mining , rule generation, the discovery and analysis of web usage patterns, and the use of recommender systems and query log mining.

CO3: Execute social network analysis, link analysis, and the implementation of web page crawlers.

CO4: Analyse knowledge of information retrieval models, text preprocessing, and web search techniques.

Unit	Topics	No of Lectures
I	**Introduction to Web Mining** **Web Mining**-Data Mining, Basic Concepts, Difference, Mining Sequential Patterns on Prefix Span, Generating Rules from Sequential Patterns. Basic Concepts of Information Retrieval, Information Retrieval Models, Relevance feedback, Evaluation measures Text and Web Page Preprocessing, Inverted Index and Its Compression, latent semantic indexing, Web Search, Web Spamming	**15**

	Opinion Mining and Web Usage Mining: Web Information Retrieval, Sentiment Classification, Feature based Opinion Mining and summarization, Comparative Sentence and Relation Mining, Opinion Search and Opinion Spam. Web Usage Mining.	
II	**Social Network & Link Analysis** **Social Network-**Link Analysis, Scrapy using python (without pipelining), Social Network Analysis, Co-Citation and Bibliographic Coupling, PageRank, HITS, Community Discovery **Webpage crawlers and usage mining:** Basic Crawler Algorithm, Implementation Issues, Universal Crawlers, Focused Crawlers, Topical Crawlers, Crawler Ethics and Conflicts, Data modelling and webpage usage mining., Discovery and analysis of web usage patterns, Recommender systems and collaborative filtering, query log mining	**15**

Reference Books:

- Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data by Bing Liu (Springer Publications) 2017 publication
- Data Mining: Concepts and Techniques, Second Edition Jiawei Han, MichelineKamber (Elsevier Publications),2017
- Web Mining: Applications and Techniques by Anthony Scime,2010
- Mining the Web: Discovering Knowledge from Hypertext Data by SoumenChakrabarti 2010

Course Code	ELECTIVE -SEM II	Credits	Lectures/Week
25CSELP81	**Web Data Analytics Practical**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able

CO1: Recall key concepts and terminology related to web scraping, including the use of proxies, handling scraping restrictions, and interacting with MySQL databases.

CO2: Summarize the role of proxies and techniques for handling scraping restrictions when working with websites like Amazon.

CO3: Use web scraping techniques to extract product data from an E-commerce site like Amazon, focusing on product details and storing the scraped data in a MySQL database using pipelines.

CO4: Analyze the performance and effectiveness of scraping pipelines by evaluating the accuracy and completeness of the scraped product data stored in a MySQL database.	
1	Scrape an online E-Commerce Site for Data. 1.Extract product data from Amazon - be it any product and put these details in the MySQL database. One can use a pipeline. Like 1 pipeline to process the scraped data and other to put data in the database and since Amazon has some restrictions on scraping of data, ask them to work on small set of requests otherwise proxies and all would have to be used. 2.Scrape the details like color, dimensions, material etc. Or customer ratings by features
2	Scrape an online Social Media Site for Data. Use python to scrape information from twitter.
3	Page Rank for link analysis using python Create a small set of pages namely page1, page2, page3 and page4 apply random walk on the same
4	Perform Spam Classifier
5	Demonstrate Text Mining and Webpage Pre-processing using meta information from the web pages (Local/Online).
6	Apriori Algorithm implementation in case study.
7	Develop a basic crawler for the web search for user defined keywords.
8	Develop a focused crawler for local search
9	Develop a programme for deep search implementation to detect plagiarism in documents online.
10	Sentiment analysis for reviews by customers and visualize the same.

Course Code	**ELECTIVE -SEM II**	**Credits**	**Lectures/Week**
25CSEL822	**Introduction to Robotics**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able

CO1: Leverage the features of the Raspberry Pi OS
CO2: Discover how to configure a Raspberry Pi to build an AI-enabled robot, Interface motors and sensors with a Raspberry Pi
CO3: Write code to develop engaging and intelligent robot behavior.
CO4: Explore AI behavior such as speech recognition and visual processing.

Unit	**Topics**	**No of Lectures**

I	**Introduction to Embedded System Design,** Categories of ES, Overview of Embedded System Architecture, Recent Trends in Embedded Systems, Hardware Architecture of Embedded System, Real Time Embedded Systems, Robots and Robotics, Microprocessors and Microcontrollers, Microcontroller or Embedded Controller. **Robot Vision and Voice Communication:** Setting up a Raspberry Pi Camera on the robot (software and hardware), Check the robot vision on a phone or laptop, Mask images with RGB strips, Colours, masking, and filtering – chasing coloured objects, detecting faces with Haar cascades, Finding objects in an image, Voice Communication with a robot	**15**
II	**Robotics:** Classification of Robots, Links and Joint, Degree of freedom, Motors-DC motors, Stepper Motors, Servo Motors; Power Transmission Type of Gears, Robotic Sensors, Applications of Robot, S/w used for Robot programming. **AI In Robotics:** Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks far Artificial intelligence in robotics.	**15**

REFERENCE BOOKS-

- "Embedded Systems & Robots", Subrata Ghoshal, Cengage Learning, 2009
- “Artificial Intelligence: A modern approach”, Stuart Russell, Peter Norvig, Pearson Education, India 2020
- Robotics Programming,Danny Staple, Packt Publishing, 2nd edition, Feb 2021

Course Code	ELECTIVE SEM -II	Credits	Lectures/Week
25CSELP822	**Introduction to Robotics- Practical**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall the proper steps for hardware preparation and installation of a Raspberry Pi.
CO2: Summarize the basic logic for controlling a line follower robot using light strip data
CO3: Perform the physical setup and initial configuration of a Raspberry Pi for embedded system development.
CO4: Analyze the performance of different motor control algorithms.

1	Raspberry pi Hardware Preparation and Installation.
2	Develop Python code for testing the sensors.
3	Interface a Stepper motor and rotate it in clockwise and anti-clockwise Direction.
4	Interface and Control a DC Motor.
5	Interface GPS Module with Raspberry pi. Display the latitude and longitude on the 16X12 LCD Display.
6	Interface Pi Camera.
7	Using the light strip develop and debug the line follower robot
8	Fingerprint Sensor Interfacing With Raspberry pi.
9	Visitor Monitoring with Raspberry pi and pi camera.
10	Distance Measurement Using ultrasonic Sensor.

Course Code	Elective SEM – II	Credits	Lectures/Week
25CSEL823	**Bioinformatics**	**2**	**2**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall key concepts and terminologies in molecular biology, including the structure and function of DNA, RNA, and proteins, as well as genetic variation and mutation.

CO2: Understand the process of phylogenetic analysis and the construction of evolutionary trees based on biological data.

CO3: Apply knowledge of genetic variation and mutation to identify potential biomarkers for diseases using bioinformatics tools.

CO4: Analyze biological data from multiple sources, applying sequence alignment techniques to interpret genetic relationships and structural properties.

Unit	Topics	No of Lectures
I	**Biological Data Analysis** Biological Foundations: Introduction to molecular biology concepts and terminology, DNA, RNA, and protein structure and function, Genetic variation and mutation Introduction to Bioinformatics: Overview of bioinformatics and its applications in biology and medicine, Introduction to biological databases and data formats, Introduction to sequence analysis, structure analysis Sequence Analysis: Sequence alignment algorithms (pairwise and multiple sequence alignment), Sequence database searching (BLAST, FASTA), Hidden Markov Models (HMMs) for sequence analysis, Phylogenetic analysis and evolutionary tree construction Structure Analysis: Protein structure prediction methods (homology modeling, ab initio methods), Protein structure visualization and analysis tools, Drug discovery	**15**
II	**Computational Tools and Methods** **Genomics and Transcriptomics**: Analyzing and manipulating genomic sequences, working with genome annotations and gene features, Analyzing gene expression data **Machine Learning and Data Mining in Bioinformatics**: Introduction to machine learning algorithms and techniques, Feature selection and	**15**

	dimensionality reduction in biological data, Predictive modeling for biological data (classification, regression) **Ethical, Legal, and Social Implications**: Ethical considerations in bioinformatics research, Privacy and data security in genomic data, social and policy issues in bioinformatics and personalized medicine	

Reference Books:

- Bioinformatics: Sequence and Genome Analysis by David W. Mount Publisher: Cold Spring Harbor Laboratory Press Publication (4th edition), 2021,
- Python for Bioinformatics by Tiago Antao, Packt Publishing Publication, 2015
- Python for Biologists: A complete programming course for beginners" by Martin Jones CreateSpace Independent Publishing Platform, 2013,
- Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases, and Analytical Tools by SupratimChoudhuri, Academic Press Publication, 2014
- Bioinformatics Programming Using Python: Practical Programming for Biological Data by Mitchell L. Model, O'Reilly Media, 2009

Course Code	**Elective SEM – II**	**Credits**	**Lectures/Week**
25CSELP83	**Bioinformatics Practical**	**2**	**4**

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Recall key concepts in biological sequence manipulation, including DNA, RNA, and protein sequence formats and structures.
CO2: Understand the principles behind pairwise and multiple sequence alignment algorithms, and their applications in evolutionary studies and homology analysis.
CO3: Apply basic sequence manipulations like reverse complementing and translating DNA sequences to obtain the corresponding protein sequences.
CO4: Analyze genomic variant data and interpret the biological significance of identified variants, including their potential impact on gene function or disease.

1	Sequence Manipulation ● Read and parse sequence data from files ● Perform basic sequence manipulations (e.g., reverse complement, translation)
2	Sequence Alignment ● Perform pairwise sequence alignment using algorithms like Needleman-Wunsch or Smith-Waterman

	● Implement multiple sequence alignment using methods such as ClustalW or MUSCLE
3	Database Searching ●Perform sequence searches against databases (e.g., BLAST or FASTA) ●Retrieve and analyze search results
4	Protein Structure Analysis ● Retrieve protein structures from databases like PDB ● Calculate structural properties (e.g., secondary structure, solvent accessibility) ● Perform structure visualization and analysis
5	Genomic Data Analysis ● Retrieve genomic data from databases (e.g., NCBI) ● Analyze gene annotations, promoter regions, or regulatory elements ● Perform genomic variant analysis
6	Data Preprocessing ● Cleaning and preprocessing biological data (e.g., gene expression data, DNA sequences) ● Handling missing values, outliers, and normalization of data ● Feature selection and dimensionality reduction techniques
7	Classification ● Applying machine learning algorithms (e.g., decision trees, random forests, support vector machines) to classify biological samples or sequences ● Evaluating model performance using metrics such as accuracy, precision, recall,and F1-score
8	Regression ● Building regression models to predict quantitative biological properties (e.g., protein structure, gene expression levels) ● Assessing model performance using metrics such as mean squared error or R- squared
9	Clustering ● Applying clustering algorithms (e.g., k-means, hierarchical clustering) to group similar biological samples or sequences ● Assessing clustering quality using metrics such as silhouette coefficient or Rand index
10	Visualizing clusters and analyzing their biological significance ● Data Visualization: ● Generate plots, graphs, and figures to visualize bioinformatics results ● Use libraries like Matplotlib, Seaborn, or ggplot in Python or R for visualization ● Create interactive visualizations using tools like D3.js or Plotly

Course Code	OJT SEM – II	Credits	Lectures/Week
25CSOJT83	Internship Project	4	4

Course Outcome:

CO1: Learn the process of project implementation
CO2: Understand the system, submit the proposal and implement the same in the semester–II.
CO3: Propose project implementation as part of the semester–II.
CO4: Experimental setup, analysis of results, comparison with results of related works, conclusion, and prospects will be part of the project implementation.
CO5: Evaluate the system
CO6: Create project implementation report and appear for a project viva

PROJECT IMPLEMENTATION

The syllabus proposes project implementation as part of the semester–II.
The student is expected to submit the proposal and implement the same in the semester–II.
In addition, experimental setup, analysis of results, comparison with results of related works, conclusion, and prospects will be part of the project implementation.
A student is expected to make a project implementation report and appear for a project viva.
He or she needs to spend around 133 hours for the project implementation, which fetches 4 credits.

Guidelines for Project Implementation in Semester - II

- A student is expected to devote at least 3 to 4 months of effort to the implementation.
- Students should submit a detailed project implementation report at the time of viva.

Guidelines for Documentation of Project Proposal in Semester –II

A student should submit a project implementation report with the following details:

- Title: Title of the project.
- Objective: A detailed objective of the proposal is needed.
- Related works: A detailed survey of the relevant works done by others in the domain. The student is expected to refer to at least 15 recent (last five years) research papers in addition to textbooks and web links in the relevant topic.
- Methodology: A proper and detailed procedure of how to solve the problem discussed. It shall contain the techniques, tools, software, and data to be used.
- Implementation details: A description of how the project has been implemented.
- Experimental setup and results: A detailed explanation of how experiments were conducted, what software was used, and the results obtained. Details like screenshots, tables, and graphs can come here.
- Analysis of the results: A description of what the results mean and how they have been arrived at. Different performing measures or statistical tools used etc may be part of this.
- Conclusion: A conclusion of the project performed in terms of its outcome
- Future enhancement: A small description of what enhancement can be done when more time and resources are available
- Program code: The program code may be given as an appendix.

The project documentation needs to be signed by the teacher in charge and head of the Department. Student should also attach the certified copy of the internal evaluation report (Appendix III) at the time of Project evaluation and viva as part of the University examination.

Evaluation Scheme for First Year (PG) under NEP (4 credits)

I. Internal Evaluation for Theory Courses – 40 Marks

1) Continuous Internal Assessment(CIA) Assignment - Tutorial/ Case Study/ Project / Presentations/ Group Discussion / Ind. Visit. – 20 marks

2) Continuous Internal Assessment(CIA) ONLINE Unit Test – 20 marks

II. External Examination for Theory Courses – 60 Marks

Duration: 2 Hours

Theory question paper pattern:

Question	Based on	Marks
Q.1	Unit I	15
Q.2	Unit II	15
Q.3	Unit III	15
Q.4	Unit IV	15

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be subdivided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

- **Paper Pattern of Theory Paper:(for 4 credits)**

DES's Kirti M. Doongursee College (AUTONOMOUS), Dadar (W), Mumbai-28			
Regular / Additional / ATKT Examination			
Duration: 2 Hour			**Max Marks: 60**
Date:		**Time:**	**Code:**
(For office use)			
N. B.	i)	*All Questions are compulsory.*	
	ii)	*Mixing of sub-questions is not allowed*	
	iii)	*Draw neat labeled diagrams wherever necessary.*	
Q. No.			**Marks**
Q.1 A			**07**
OR			
Q.1 B			**07**
Q.1 C			**08**
OR			
Q.1 D			**08**
Q.1 E			**07**
OR			

Q.1 F		**07**
Q.2 G		**08**
OR		
Q.2 H		**08**
Q.3 I		**07**
	OR	
Q.3 J		**07**
Q.3 K		**08**
	OR	
Q. 3 L		**08**
Q.4 M		**07**
	OR	
Q.4 N		**07**
Q.4 O		**08**
	OR	
Q.4 P		**08**

Evaluation Scheme for Second Year (PG) under NEP (2 credits)

I. Internal Evaluation for Theory Courses – 20 Marks

1) Continuous Internal Assessment(CIA) Assignment - Tutorial/ Case Study/ Project / Presentations/ Group Discussion / Ind. Visit. / – 10 marks

2) Continuous Internal Assessment(CIA) ONLINE Unit Test – 10 marks

II. External Examination for Theory Courses – 30 Marks

Duration: 1 Hours

Theory question paper pattern:

Question	Based on	Marks
Q.1	**Unit I**	**15**
Q.2	**Unit II**	**15**

- All questions shall be compulsory with internal choice within the questions.

- Each Question may be subdivided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.
- **Paper Pattern of Theory Paper:(for 2 credits)**

DES's Kirti M. Doongursee College (AUTONOMOUS), Dadar (W), Mumbai-28			
Regular / Additional / ATKT Examination			
Duration: 1 Hour			**Max Marks: 30**
Date: **Time:** **Code:** ***(For office use)***			
N. B.	i)	*All Questions are compulsory.*	
	ii)	*Mixing of sub-questions is not allowed*	
	iii)	*Draw neat labeled diagrams wherever necessary.*	
Q. No.			**Marks**
Q.1 A			**07**
OR			
Q.1 B			**07**
Q.1 C			**08**
OR			
Q.1 D			**08**
Q.1 E			**07**
OR			
Q.1 F			**07**
Q.2 G			**08**
OR			
Q.2 H			**08**

III. Practical Examination

- Each core subject carries 50 Marks
- Duration: 2 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is compulsory for appearing at the time of Practical Exam

NOTE: To pass the examination, attendance is compulsory in both Internal & External (Theory + Practical) Examinations.