R.P. Gogate College of Arts & Science and R.V. Jogalekar College of Commerce, Ratnagiri (Autonomous)

Master of Science (Computer Science) Programme
Two Year Integrated Programme
Four Semesters

Course Structure Syllabus

for MSc Semester III & IV

Under Choice Based Credit System (CBCS)

To be implemented from Academic Year- 2024-2025

Preamble

The syllabus extends from the M.Sc. Computer Science syllabus of the University of Mumbai for the academic year 2023-24. Building upon the framework established in the first and second semesters, the overarching aim remains consistent with the following principles:

- To be fundamentally strong at the core subject of Computer Science.
- To apply programming, computational skills, and the latest technological trends for industrial solutions.
- Offer specialization in a chosen area.
- Create research temper among students in the whole process.
- To encourage, motivate and prepare the Learners for Lifelong- learning.
- To inculcate professional and ethical attitude, good leadership qualities, and commitment to social responsibilities in the Learner's thought process.

The syllabus for semester III and IV builds upon the foundation laid in semester I and II, striving to further advance the objectives outlined in the earlier stages of the program. As an Extension Semester III and IV is not including any Internship or On job Training but it is focusing on Research Project which will take span of 10 months. As NEP structure Semester III syllabus is having 2 Major Mandatory along Practical and 1 Major Mandatory without practical component. One Major Electives is to be selected from 3 Options and One Research Project component. Semester IV is having 2 Major Mandatory along Practical and 1 Major Elective to be selected from 3 Options

The syllabus is designed to equip students with the practical skills and industry readiness necessary for success in the IT sector. Internships provide hands-on experience that bridges the gap between theory and practice, complementing the strong foundation laid in core courses across different semesters. This foundation instills confidence in students, enabling them to adapt to the evolving demands of both industry and academia.

Moreover, the syllabus fosters a cohort of aspiring computer science researchers by emphasizing student-driven research on cutting-edge topics. Practical experiences are integrated into the curriculum to enhance engagement and stimulate learning. We anticipate that both students and faculty will recognize and value the syllabus's emphasis on research and practical application.

We extend our gratitude and appreciation to all individuals who have directly or indirectly contributed to the development of this syllabus.

Name of Programme	**Masters of Science**
Level	PG
No of Semesters	04
Year of Implementation	**2024-25**
Programme Specific Outcomes (PSO)	At the end of the Programme, Learner will be able to 1. Develop a solid foundation in fundamental concepts, theories, and methodologies of Computer Science. 2. Offer opportunities for specialization in a chosen area of Computer Science. 3. Foster a research-oriented mindset and contribute to the advancement of Computer Science. 4. Prepare learners for lifelong learning, adapting to emerging technologies and industry requirements. 5. Inculcate professional attitudes, leadership qualities, and social responsibility. 6. Equip students with industry-relevant skills and experiences for successful careers. 7. Enhance critical thinking and innovative problem-solving abilities.
Relevance of PSOs to the local, regional, national, and global developmental needs	1. **Provide In-depth Knowledge:** The program aims to provide students with a comprehensive understanding of the key concepts, theories, and methodologies in Computer Science. It covers a range of topics including machine learning, data mining, data visualization, and data management, enabling students to develop a deep knowledge base in these areas. 2. **Develop Programming Skills:** The program aims to equip students with strong programming skills by providing hands-on experience with different tools and technologies. Students will gain proficiency in designing front-end and back-end solutions, enhancing their ability to develop robust and scalable applications. 3. **Foster Problem-solving Abilities:** The program aims to enhance students' problem-solving abilities by training them to approach real-world data challenges critically and creatively. Students will learn to identify problems, design appropriate data analysis strategies, and develop innovative solutions using their knowledge of Computer Science. 4. **Encourage Collaboration and Teamwork:** The program aims to foster collaboration and teamwork skills among students, recognizing that computer science projects often require interdisciplinary collaboration. Students will learn to effectively communicate, collaborate, and contribute as part of a team, preparing them for collaborative work environments. 5. **Foster Industry Relevance:** The program aims to stay

	up-to-date with industry trends and technologies to ensure graduates are well-prepared for the demands of the Computer Science job market. Through industry partnerships and internships, students will have the opportunity to gain practical experience and stay in touch with the latest advancements in the field. 6. **Professional Development:** The program aims to prepare students for successful careers in the field of Computer Science. In addition to technical skills, students will develop professional skills such as teamwork, project management, and leadership. The program may also provide networking opportunities, internships, or collaborations with industry partners to enhance students' industry readiness and employability. 7. **Cultivate Research Skills**: The program aims to cultivate research skills among students by providing a Research Methodology Course and encouraging participation in research projects. Students will learn to conduct literature reviews, design experiments, analyze data, and present their findings, fostering a research-oriented mindset and contributing to the advancement of Computer Science.

Master of Science (M.Sc) Programme

Under Choice Based Credit System (CBCS)

Course Structure

M.Sc. II

(To be implemented from Academic Year 2024-25)

No. of Courses	Semester III	Credits	No. of Courses	Semester IV	Credits
	Major Mandatory			Major Mandatory	
PSCS301	Applications of Web3 Technologies	4	PSCS401	Deep Learning	4
PSCS302	Applications of Web3 Technologies Practical	2	PSCS402	Deep Learning Practical	2
PSCS303	Cyber Security & Risk Assessment	4	PSCS403	Big Data Analytics	4
PSCS304	Cyber Security & Risk Assessment Practical	2	PSCS404	Big Data Analytics Practical	2
PSCS305	Ethical & Responsible AI	2			
	Major Electives			Major Electives	
PSCS306	Social Network Analysis	4	PSCS405	Trends in Cloud Computing	4
PSCS307	Data Visualization		PSCS406	Remote Sensing & GIS	
PSCS308	Fuzzy Systems & Neural Network		PSCS407	Server Virtualization	
PSCS309	Research Project	4	PSCS408	Research Project	6
Total Credits		22	Total Credits		22

Semester III				
1	Major Mandatory	4	PSCS301	Applications of Web3 Technologies
2	Major Mandatory	2	PSCS302	Applications of Web3 Technologies Practical
3	Major Mandatory	4	PSCS303	Cyber Security & Risk Assessment
4	Major Mandatory	2	PSCS304	Cyber Security & Risk Assessment Practical
5	Major Mandatory	2	PSCS305	Ethical & Responsible AI
6	Major Electives	4	PSCS306	Social Network Analysis
7			PSCS307	Data Visualization
8			PSCS308	Fuzzy Systems & Neural Network
9	RP	4	PSCS309	Research Project

Syllabus for Masters of Science in Computer Science for the year 2024-25

SEMESTER III

Nomenclature of the Course	Applications of Web3 Technologies
Class	MSc Computer Science
Semester	III
Course Code	PSCS301
No. of Credits	4
Nature	Theory
Type	Major Mandatory

Course Outcomes:
The learner will be able to **CO1:** Understand and apply the fundamentals of Web3 Technologies and bitcoin. **CO2**: Develop skills in smart contracts and Ethereum development environment. **CO3**: Understand and apply concept of Ethereum framework, serenity and Tokenization **CO4**: Apply Solidity programming for Smart contracts and tokenization.

Syllabus:		
Unit No.	**Unit Title**	**Sub titles (Learning Points)**
1	Introduction to Web3 Technologies	**Blockchain**: Growth of blockchain technology, Distributed systems, the history of blockchain and Bitcoin, Blockchain, Consensus, CAP theorem and blockchain,Decentralization using blockchain, Methods of decentralization,Routes to decentralization, Blockchain and full ecosystem decentralization, The consensus problem, Analysis and design, Classification, Algorithms, **Bitcoin**: Overview, Cryptographic keys, Transactions, Blockchain Mining, Bitcoin network, Wallets, Bitcoin payments, Innovation in Bitcoin, Advanced protocols, Bitcoin investment, and buying and selling Bitcoin
2	Smart Contracts & Ethereum	**Smart Contracts**: History, Definition Ricardian contracts, Smart contract templates, Oracles, Deploying smart contracts, The DAO **Ethereum**: Overview, Ethereum network, Components of the Ethereum ecosystem, The Ethereum Virtual Machine (EVM), Smart contracts, Blocks and Blockchain, Wallets and client software, Nodes and miners, APIs, tools, and DApps, Supporting protocols, Programming languages, **Ethereum Development Environment**: Overview, Test networks, Components of a private network, starting up the

		private network, mining on the private network, Remix IDE, MetaMask, Using MetaMask and Remix IDE to deploy a smart contract
3	Serenity, Ethereum, Hyperledger & Tokenization	**Web3**: Exploring Web3 with Geth, Contract deployment, interacting with contracts via frontends **Development frameworks**: Serenity, Ethereum 2.0—an overview, Development, phases, Architecture **Serenity**: Ethereum 2.0—an overview, Development phases, Architecture **Hyperledger**: Projects under Hyperledger, Hyperledger reference architecture, Hyperledger Fabric, Hyperledger Sawtooth, Setting up a sawtooth development environment. **Tokenization**: Tokenization on a blockchain, Types of tokens, Process of tokenization, Token offerings, Token standards, Trading and finance, DeFi, Building an ERC-20 token,emerging concepts
4	Solidity Programming	**Introduction to Solidity Programming:** Layout of a Solidity Source File, Structure of a Contract, Types, Units, and Globally Available Variables, Input Parameters and Output Parameters, Control Structures, Function Calls, Creating Contracts via new, Order of Evaluation of Expressions, Assignment, Scoping and Declarations, Error handling: Assert, Require, Revert and Exceptions **Smart Contracts:** Solidity Programming –Contracts, Creating Contracts, Visibility and Getters, Function Modifiers, Constant State Variables, Functions, Inheritance, Abstract Contracts, Interfaces, Libraries.

Other Learning Resources recommended:

Textbooks:

1. Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition 2020
2. Andreas M. Antonopoulos, Dr.Gavin wood “Mastering Ethereum” O‟Reilly Media Inc, 2019
3. Ritesh Modi, “Solidity Programming Essentials: A Beginner‟s Guide to Build Smart Contracts for Ethereum and BlockChain”, Packt Publishing.
4. Josh Thompson, „„Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming‟‟, Create Space Independent Publishing Platform, First Edition - 2017.

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures

1	Introduction to Web3 Technologies	Regular teaching and ICT	15
2	Smart Contracts & Ethereum	Regular teaching and ICT	15
3	Serenity, Ethereum, Hyperledger & Tokenization	Regular teaching and ICT	15
4	Solidity Programming	Regular teaching and ICT	15

Nomenclature of the Course	Applications of Web3 Technologies Practical
Class	MSc Computer Science
Semester	III
Course Code	PSCS302
No. of Credits	2
Nature	Practical
Type	Major Mandatory

Course Outcomes:

The learner will be able to

CO1: Implement the concept of the docker with respect to BlockChain Applications

CO2: Implement smart contracts and Ethereum development environment.

CO3: Implement the concept of Ethereum framework, serenity and Tokenization

CO4: Apply Solidity programming for Smart contracts and tokenization.

Syllabus:

Practical No.	Practical Title
Note: - The following set of practical should be implemented in Scrape, python: Link: -Python:	
1	Install and understand Docker container, Node.js, Java and Hyperledger Fabric, Ethereum and perform necessary software installation on local machine/create instance on Cloud to run.
2	Create and deploy a block chain network using Hyperledger Fabric SDK for Java
3	Interact with a block chain network. Execute transactions and requests against a block chain network by creating an app to test the network and its rules
4	Deploy an asset-transfer app using block chain. Learn app development within a Hyperledger Fabric network.
5	Use block chain to track fitness club rewards..
6	Build a web app that uses Hyperledger Fabric to track and trace member rewards.
7	Car auction network: A Hello World example with Hyperledger Fabric Node SDK and IBM Block chain Starter Plan. Use Hyperledger Fabric to invoke chaincode while storing results and data in the starter plan
8	Develop an IoT asset tracking app using Block chain. Use an IoT asset tracking device to improve a supply chain by using Block chain, IoT devices, and Node-RED.
9	Create a global finance block chain application with IBM Block chain Platform Extension for VS Code. Develop a Node.js smart contract and web app for a Global Finance with block chain use case
10	Develop a voting application using Hyperledger and Ethereum.
11	Build a decentralized app that combines Ethereum's Web3 and Solidity smart contracts with Hyperledger's hosting Fabric and Chaincode EVM
12	Create a block chain app for loyalty points with Hyperledger Fabric Ethereum Virtual Machine. Deploy Fabric locally with EVM and create a proxy for interacting with a

	smart contract through a Node.js web app

Learning Resources recommended:

Textbooks:

1. Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition 2020
2. Andreas M. Antonopoulos, Dr.Gavin wood "Mastering Ethereum" O"Reilly Media Inc, 2019
3. Ritesh Modi, "Solidity Programming Essentials: A Beginner"s Guide to Build Smart Contracts for Ethereum and BlockChain", Packt Publishing.
4. Josh Thompson, „Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming", Create Space Independent Publishing Platform, First Edition - 2017.

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Cyber Security and Risk Assessment
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS303
No. of Credits	4
Nature	Theory
Type	Major Mandatory

Course Outcomes:
The learner will be able to **CO1:** Learn about an advanced concept related to penetration testing **CO2**: Understand various vulnerabilities and various advanced attacks in cyber security **CO3**: Understand ways to protect system and digital assets **CO4**: Selecting the most effective tools, to rapidly compromising network security to highlighting the techniques used to avoid detection

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Introduction to Penetration Testing and Reconnaissance	**Goal-based penetration testing**: Introduction to Penetration Testing, Different types of threat actors, Conceptual overview of security testing, Common pitfalls of vulnerability assessments, penetration testing, and red team exercises, Objective-based penetration testing, The testing methodology Kali Linux & Red Team Tactics, Using CloudGoat and Faraday **Open-source Intelligence and Reconnaissance:** Basic Principles of Reconnaissance, Scraping, Google Hacking Database, creating custom wordlist for cracking password **Active Reconnaissance of External and Internal Networks:** Stealth scanning techniques, DNS reconnaissance, and route mapping, Employing comprehensive reconnaissance applications, Identifying the external network infrastructure, Mapping beyond the firewall, IDS/IPS identification, Enumerating hosts, port, operating system, and service discovery,Writing your port scanner using netcat, Large-scale scanning, Machine Learning for Reconnaissance
2	Vulnerabilities and Advanced Attacks	**Vulnerability Assessment**: Local and online vulnerability databases, Vulnerability scanning with Nmap, Web application vulnerability scanners, Vulnerability scanners for mobile applications, OpenVAS network vulnerability scanner, Commercial vulnerability scanners, Specialized scanners, Threat modeling

		Advanced Social Engineering and Physical Security: Common Methodology, Physical attacks at a console, creating rough physical devices, Social Engineering Toolkit, Hiding executables and obfuscating the attacker's URL, Escalating an attack using DNS redirection, Launching Phishing attack **Wireless and Bluetooth Attacks**: Wireless reconnaissance, Bypassing open SSID and MAC address authentication, attacking WPA and WPA2, Dos attacks against Wireless communication, Compromising enterprise implementations of WPA2, Evil Twin attack, using bettercap, WPA3, Bluetooth attacks
3	Web and Cloud Exploitations	**Exploiting Web-based applications**: Web app Hacking methodology, Reconnaissance of web apps, client-side proxies, application-specific attacks, Browser exploitation Framework **Cloud Security Exploitation**: Vulnerability scanning and application exploitation, Testing S3 bucket misconfiguration, exploiting security permission flaws, obfuscating Cloudtail logs **Bypassing Security Controls**: Bypassing Network Access Control and application-level controls, Bypassing antivirus, Bypassing Windows OS controls
4	Exploiting System Vulnerabilities (Skill Enhancement)	**Metasploit Exploitation:** Metasploit framework, exploiting single and multiple targets using MSF, using the public exploit, developing windows exploit **Privilege Escalation:** Escalation methodology, escalating from domain user to system administrator, local system escalation, escalating from administrator to system, credential harvesting, and escalating attacks, escalating access right in active directory **Embedded devices and RFID Hacking**: Firmware unpacking and updating, Introduction to RouterSploit Framework, UART, Cloning RFID using ChameleonMini

Learning Resources recommended:

Textbooks:

1. . Mastering Kali Linux for Advanced Penetration Testing Fourth Edition, Vijay Kumar Velu, Packt, 2022 2. Learn Kali Linux 2019:
2. Perform Powerful Penetration Testing Using Kali Linux, Metasploit, Nessus, Nmap, And Wireshark, Glen D. Singh, Packt, 2019

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Introduction to Penetration Testing and Reconnaissance	Regular teaching and ICT	15
2	Vulnerabilities and Advanced Attacks	Regular teaching and ICT	15

3	Web and Cloud Exploitations	Regular teaching and ICT	15
4	Exploiting System Vulnerabilities (Skill Enhancement)	Regular teaching and ICT	15

Nomenclature of the Course	Cyber Security and Risk Assessment Practical
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS304
No. of Credits	2
Nature	Practical
Type	Major Mandatory

Course Outcomes:

The learner will be able to

CO1: Implement the penetration testing and analyse the result.

CO2: Use Kali Linux in performing penetration tests against networks, systems, and applications

CO3: Understand ways to protect system and digital assets

CO4: Selecting the most effective tools, to rapidly compromising network security to highlighting the techniques used to avoid detection

Syllabus:

Practical No.	Practical Title
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	Exploring and building a verification lab for penetration testing (Kali Linux)
2	Use of open-source intelligence and passive reconnaissance
3	Practical on enumerating host, port, and service scanning.
4	Practical on vulnerability scanning and assessment
5	Practical on use of Social Engineering Toolkit
6	Practical on Wireless and Bluetooth attacks
7	Practical on Exploiting Web-based applications
8	Practical on using Metasploit Framework for exploitation
9	Practical on injecting Code in Data Driven Applications: SQL Injection
10	Sniff Wifi Hotspots in Wireless Network
11	Analyse strength Wifi Network Strength
12	Discover wireless access points in Wireless Networks.

Other Learning Resources recommended:

Textbooks:

1. Mastering Kali Linux for Advanced Penetration Testing Fourth Edition, Vijay Kumar Velu,Packt, 2022
2. Learn Kali Linux 2019: Perform Powerful Penetration Testing Using Kali Linux,

Metasploit,
3. Hands-on Penetration Testing for Web Applications: Run Web Security Testing on Modern Applications Using Nmap, Burp Suite and Wireshark, Richa Gupta, BPB, 2021
4. Advanced Penetration Testing, Wil Allsopp, Wiley, 2017

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practical's	Practical Demonstration	60

Nomenclature of the Course	Ethical & Responsible AI
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS305
No. of Credits	2
Nature	Theory
Type	Major Mandatory

Course Outcomes:

The learner will be able to

CO1: Gain an understanding of ethical frameworks and principles relevant to AI, including fairness, transparency, accountability, and privacy.

CO2: Learn to identify ethical issues and challenges that arise in the development, deployment, and use of AI technologies.

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Introduction to Responsible AI	Artificial Intelligence Fundamentals, Introduction to responsible AI. Need for ethics in AI. AI for Society and Humanity Fairness and Bias Sources of Biases Exploratory data analysis, limitation of a dataset Preprocessing, in processing and post processing to remove bias Group fairness and Individual fairness Counterfactual fairness Interpretability and explainability Interpretability through simplification and visualization Intrinsic interpretable methods Post Hoc interpretability Explain ability through causality Model agnostic Interpretation
2	Implementation of Responsible AI	Ethics and Accountability Auditing AI models, fairness assessment Principles for ethical practices Privacy preservation Attack models Privacy-preserving Learning Differential privacy Federated learning Case study Recommendation systems Medical diagnosis Hiring/ Education Computer Vision Natural Language Processing

Other Learning Resources recommended:

Textbooks:

1. Virginia Dignum, “Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way” Springer Nature, 04-Nov-2019;ISBN-10 : 3030303705, ISBN-13 : 978-3030303709
2. Christoph Molnar “Interpretable Machine Learning”.Lulu, 1st edition, March 24, 2019; eBook. ISBN-10 : 0244768528, ISBN-13 : 978-0244768522 [available online]

Teaching Plan:			
Unit No.	**Unit Title**	**Teaching Methods**	**No. of Lectures**
1	Introduction to Responsible AI	Regular teaching and ICT	15
2	Implementation of Responsible AI	Regular teaching and ICT	15

Nomenclature of the Course	Social Network Analysis
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS306
No. of Credits	2
Nature	Theory
Type	Major Elective

Course Outcomes:
The learner will be able to **CO1:** Gain a comprehensive understanding of social network concepts, including nodes, edges, centrality, clustering, and network dynamics. **CO2**: Develop skills in visualizing social network data using appropriate tools and techniques, including node-link diagrams, matrix plots, and network layouts.

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Introduction to social network analysis (SNA)	Understanding networks- density, reachability, connectivity, reciprocity, group-external and group-internal ties in networks, ego networks, extracting and visualizing ego networks, structural holes, Centrality- degree of centrality, closeness and betweenness centrality, local and global centrality, centralization and graph centers, notion of importance within network, Google pagerank algorithm, Analyzing network structure bottom-up approaches using cliques, N-cliques, N-clans, K-plexes, K-cores, F-groups and top-down approaches using components, blocks and cut-points, lambda sets and bridges, and factions.
2	Measures of similarity and structural equivalence in SNA	Measures of similarity and structural equivalence in SNA Approaches to network positions and social roles- defining equivalence or similarity, structural equivalence, automorphic equivalence, finding equivalence sets, brute force and Tabu search, regular equivalence, equivalence of distances: Maxsim, regular equivalence, Measuring similarity/dissimilarity- valued relations, Pearson correlations covariance and cross-products, Understanding clustering- agglomerative and divisive clusters, Euclidean, Manhattan, and squared distances, binary relations, matches: exact, Jaccard, Hamming Two-mode networks for SNA Understanding mode networks- Bi-partite data structures, visualizing two-mode data, quantitative analysis using two-mode Singular value decomposition (SVD) analysis.

Other Learning Resources recommended:

Textbooks:

1. Introduction to Social Network Methods: Robert A. Hanneman, Mark Riddle, University of California, 2005 [Published in digital form and available at http://faculty.ucr.edu/~hanneman/nettext/index.html].
2. Social Network Analysis for Startups- Finding connections on the social web: Maksim Tsvetovat, Alexander Kouznetsov, O'Reilly Media, 2011.
3. Social Network Analysis- 3rd edition, John Scott, SAGE Publications, 2012.
4. Exploratory Social Network Analysis with Pajek, Second edition: Wouter de Nooy, Andrej Mrvar, Vladimir Batagelj, Cambridge University Press, 2011.

Additional References:

1. Analyzing Social Networks, Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, SAGE Publications, 2013.
2. Statistical Analysis of Network Data with R: Eric D. Kolaczyk, Gábor Csárdi, Springer, 2014.
3. Network Analysis: Methodological Foundations, (Editors) Ulrik Brandes, Thomas Erlebach. Springer, 2005.
4. Models and Methods in Social Network Analysis: (Editors) Peter J. Carrington, John Scott,Stanley Wasserman, Cambridge University Press, 2005.

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Introduction to social network analysis (SNA)	Regular teaching and ICT	15
2	Measures of similarity and structural equivalence in SNA	Regular teaching and ICT	15

Nomenclature of the Course	Social Network Analysis Practical
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCSP306
No. of Credits	2
Nature	Practical
Type	Major Elective

Course Outcomes:

The learner will be able to

CO1: Gain a comprehensive understanding of social network concepts, including nodes, edges, centrality, clustering, and network dynamics.

CO2: Develop skills in visualizing social network data using appropriate tools and techniques, including node-link diagrams, matrix plots, and network layouts.

Syllabus:

Practical No.	Practical Title
Note : -Practical's should be implemented using MongoDB, Redis and Hbase	
1	Write a program to compute the following for a given a network: (i) number of edges, (ii) number of nodes; (iii) degree of node; (iv) node with lowest degree; (v)the adjacency list; (vi) matrix of the graph.
2	Perform following tasks: (i) View data collection forms and/or import onemode /two-mode datasets; (ii) Basic Networks matrices transformations
3	Compute the following node level measures: (i) Density; (ii) Degree; (iii) Reciprocity; (iv) Transitivity; (v) Centralization; (vi) Clustering.
4	For a given network find the following: (i) Length of the shortest path from a given node to another node; (ii) the density of the graph; (iii) Draw egocentric network of node G with chosen configuration parameters.
5	Write a program to distinguish between a network as a matrix, a network as an edge list, and a network as a sociogram (or "network graph") using 3 distinct networks representatives of each.
6	Write a program to exhibit structural equivalence, automatic equivalence, and regular equivalence from a network.
7	Create sociograms for the persons-by-persons network and the committee-bycommittee network for a given relevant problem.
8	Create one-mode network and two-node network for the same.
9	Perform SVD analysis of a network.
10	Identify ties within the network using two-mode core periphery analysis.
11	Find "factions" in the network using two-mode faction analysis.
12	Clean the data by removing duplicates, irrelevant information, and handling missing values.

Other Learning Resources recommended:

Textbooks:

1. Introduction to Social Network Methods: Robert A. Hanneman, Mark Riddle, University of California, 2005 [Published in digital form and available at http://faculty.ucr.edu/~hanneman/nettext/index.html].
2. Social Network Analysis for Startups- Finding connections on the social web: Maksim Tsvetovat, Alexander Kouznetsov, O'Reilly Media, 2011.
3. Social Network Analysis- 3rd edition, John Scott, SAGE Publications, 2012.
4. Exploratory Social Network Analysis with Pajek, Second edition: Wouter de Nooy, Andrej Mrvar, Vladimir Batagelj, Cambridge University Press, 2011.

Additional References:

1. Analyzing Social Networks, Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, SAGE Publications, 2013.
2. Statistical Analysis of Network Data with R: Eric D. Kolaczyk, Gábor Csárdi, Springer, 2014.
3. Network Analysis: Methodological Foundations, (Editors) Ulrik Brandes, Thomas Erlebach. Springer, 2005.
4. Models and Methods in Social Network Analysis: (Editors) Peter J. Carrington, John Scott,Stanley Wasserman, Cambridge University Press, 2005.

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practical's	Practical Demonstration	60

Nomenclature of the Course	Data Visualization
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS307
No. of Credits	2
Nature	Theory
Type	Major Elective

Course Outcomes:

The learner will be able to

CO1: Work with data analysis tools and perform data wrangling for practical purposes.

CO2: Use of Tableau to handle data from various sources and perform analysis of data.

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Preparing and Storing Data	Series,Data Frames,Visualizing Data, Data visualization techniques. Data visualization libraries in Python Data Gathering and Cleaning, Reading Data from the JSON , HTML and XML Format, Data Transformation Removing Duplicates, DataFrame Joins Merging on Index Concatenating Along with an Axis Combining Data with Overlap Reshaping and Pivoting Data Aggregation.
2	Basics of Tableau	Tableau, Managing data source metadata, Extract Data, Filtering data. Moving beyond basic visualization. Calculations, Trend Visualization, Dynamic Dashboards, Exploring Mapping and Advanced Geospatial Features, Structuring Messy Data to Work Well in Tableau, Taming data with Tableau Prep.

Other Learning Resources recommended:

Textbooks:

1. Dr. Ossama Embarak, Data Analysis and Visualization Using Python, Apress, 2018
2. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly, 2nd Edition, 2018.
3. Learning Tableau 2020, Create effective data visualizations, build interactive visual analytics, and transform your organization. Joshua Milligan, Fourth Edition, Packt, 2020
4. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly, 2017
5. Visual Data Storytelling with Tableau, Linda Ryan, Pearson Addison Wesley Data &

Analytics Series, 2018
6. Visual Analytics with Tableau, Alexander Loth, Wiley, 2019

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Preparing and Storing Data	Regular teaching and ICT	15
2	Basics of Tableau	Regular teaching and ICT	15

Nomenclature of the Course	Data Visualization Practical
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCSP307
No. of Credits	2
Nature	Practical
Type	Major Elective

Course Outcomes:
The learner will be able to **CO1:** Work with data analysis tools and perform data wrangling for practical purposes. **CO2**: Use Tableau to handle data from various sources and perform analysis of data.

Syllabus:	
Practical No.	**Practical Title**
Note: Following practical can be performed using Python and simulators, Raspberry Pi, and other hardware devices.	
1	Create one-dimensional data using series and perform various operations on it
2	Create Two-dimensional data with the help of data frames and perform different operations on it.
3	Write a code to read data from the different file formats like JSON, HTML, XML, and CSVfiles and check for missing data and outlier values and handle them.
4	Perform Reshaping of the hierarchical data and pivoting data frame data
5	Connecting and extracting with various data resources in tableau
6	Performing calculations and creating parameters in Tableau.
7	Designing Tableau Dashboards for different displays and devices
8	Create a Trend model using data, Analyse-it and use it for forecasting.
9	Creating Geospatial feature maps in Tableau using Geospatial Data.
10	Create Dashboard and Storytelling using tableau.
11	Create Sales Pipeline Dashboard.
12	Create Quarterly Forecast Dashboard.

Other Learning Resources recommended:
Textbooks:

1. Dr. Ossama Embarak, Data Analysis and Visualization Using Python, Apress, 2018

2. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly, 2nd Edition, 2018.
3. Learning Tableau 2020, Create effective data visualizations, build interactive visual analytics, and transform your organization. Joshua Milligan, Fourth Edition, Packt, 2020
4. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly, 2017
5. Visual Data Storytelling with Tableau, Linda Ryan, Pearson Addison Wesley Data & Analytics Series, 2018
6. Visual Analytics with Tableau, Alexander Loth, Wiley, 2019

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practical's	Practical Demonstration	60

Nomenclature of the Course	Fuzzy System and Neural Network
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCS308
No. of Credits	2
Nature	Theory
Type	Major Elective

Course Outcomes:

The learner will be able to

CO1: Improve Data Analysis Solutions and strengthen the dialogue between the statistics and soft computing research communities in order to cross-pollinate both fields and generate mutual improvement activities.

CO2: learn the neural networks for classification, regression and to give design methodologies for artificial neural networks.

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Introduction to Fuzzy System	Introduction, Classical Sets and Fuzzy Sets, Classical Relations and Fuzzy Relations, Membership Functions, Fuzzy-to-Crisp Conversions, Fuzzy Arithmetic Classical Logic and Fuzzy Logic, Fuzzy Rule- Based Systems, Fuzzy Decision Making, Fuzzy Classification
2	Introduction to Neural Network	What is Neural Network, Model of Artificial Neuron, Learning rules and various activation functions, Single layer Feed-forward networks. Multilayer Feed-forward networks. Recurrent Networks, Back propagation Networks

Other Learning Resources recommended:

Textbooks:

1. Timothy Ross, "Fuzzy Logic with Engineering Applications", John Wiley and Sons, Second Edition.
2. Neural Networks,Fuzzy Logic and Genetic Algorithms, by S.Rajasekaran and G.A.Vijayalakshmi Pai

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Introduction to Fuzzy System	Regular teaching and ICT	15
2	Introduction to Neural Network	Regular teaching and ICT	15

Nomenclature of the Course	Fuzzy System and Neural Network Practical
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCSP308
No. of Credits	2
Nature	Practical
Type	Major Elective

Course Outcomes:

The learner will be able to

CO1: Improve Data Analysis Solutions and strengthen the dialogue between the statistics and soft computing research communities in order to cross-pollinate both fields and generate mutual improvement activities.

CO2: learn the neural networks for classification, regression and to give design methodologies for artificial neural networks.

Syllabus:

Practical No.	Practical Title
1	Develope a Fuzzy Sets model for House Pricing example
2	Calculate support in fuzzy logic.
3	Calculate height and cross over in Fuzzy.
4	Create a triangular function in Matlab using trimf.
5	Implement fuzzy_trapezodial_membership-function
6	Implement fuzzy_gaussian_membership_function
7	Implement Fuzzy Sets Union Intersection
8	Implement fuzzy logic medical exam regarding the blood pressure and age
9	Implement Tipping Problem without Fuzzy Logic
10	Implement Water Level Control in a Tank using Fuzzy Logic
11	Design a single layer feed forward network for given data.
12	Design a multi layer feed forward network for given data.

Other Learning Resources recommended:

Textbooks:

1. Timothy Ross, "Fuzzy Logic with Engineering Applications", John Wiley and Sons, Second Edition.
2. Neural Networks,Fuzzy Logic and Genetic Algorithms, by S.Rajasekaran and G.A.Vijayalakshmi Pai

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practical's	Practical Demonstration	60

Nomenclature of the Course	Research Project
Class	M. Sc. Computer Science
Semester	III
Course Code	PSCSP309
No. of Credits	4
Nature	Practical
Type	-

Course Outcomes:
The learner will be able to **CO1:** Learn to define objectives of the problem. **CO2**: Learn doing research analysis and literature analysis. **CO3:** Learn to defined research methodology

Guidelines for Research Project Proposal in Semester – III

Total Credits	Total Hours	Marks	
		Internal	External
04	120	40	60

A student is expected to devote at least 2 to 3 months of effort to the Research Project Proposal. Students should submit a detailed research project proposal report at the time of viva.

Guidelines for Documentation of Research Project Proposal in Semester–III

Certified Spiral Bound Copy with Certificate is required to submit at the time of Viva Examination. A student should submit a Research Project Proposal report with the following details:

- **Title:** Title of the Research Project.
- **Objective:** A detailed objective of the proposal is needed.
- **Introduction/Background:**
- **Related works/Literature Survey:** A detailed survey of the relevant works done by others inthe domain. The student is expected to refer to at least 20 recent (last five years) research papers in addition to textbooks and web links in the relevant topic.
- **Proposed Methodology: -** Describe the overall research design, including whether it will bequantitative,qualitative,ormixed-methods.Explaintherationalebehindthechosendesignandhow it aligns with the research objectives. Explain the characteristics of the participants ,including demographics, sample size, selection criteria, and recruitment methods. Outline the methods used for data collection, such as surveys, interviews, observations, or document analysis.
- **Research Challenges: -** List All research challenges related to data collection, design and implementation
- **Conclusion/ Summary: -** Write one-page review or summary of your research proposal with respect to above points.

- **References:** List of References

Certified Spiral Bound Copy with Certificate is required to submit at the time of Viva Examination.

Scheme of Examination: -Internal Examination

A) Continuous Internal Evaluation:

Method		**Marks**	
InternalViva1		20	
Topic Weightage	Introduction	Objectives	Total
05	05	10	20
InternalViva2		20	
Proposed Methodology	Research Challenges &Conclusion	Documentation	Total
10	05	05	20

External Examination

A) External Evaluation:

Method				**Marks**			
External Viva				**60**			
Topic Weightage	Introduction	Objectives	Proposed Methodology	Research Challenges	Documents	Viva	Total
05	05	10	15	05	10	10	60

SEMESTER IV

S.N.	Type of the course	No. of Credits	Course Code	Nomenclature
1	Major Mandatory	4	PSCS401	Deep Learning
2	Major Mandatory	2	PSCS402	Deep Learning Practical
3	Major Mandatory	4	PSCS403	Big Data Analytics
4	Major Mandatory	2	PSCS404	Big Data Analytics Practical
5	Major Electives	4	PSCS405	Trends in Cloud Computing
6			PSCS406	Remote Sensing & GIS
7			PSCS407	Server Virtualization
8	RP	6	PSCS408	Research Project

Nomenclature of the Course	Deep Learning
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS401
No. of Credits	04
Nature	Theory
Type	Major Mandatory

Course Outcomes:

CO1. Develop a solid understanding of the fundamentals of Neural Network.

CO2. Gain proficiency in using CNN models

CO3 Explore the fundamentals of semi supervised deep learning and artificial neural networks, including their architecture and activation functions.

CO4. Acquire practical skills in implementing machine learning algorithms using the TensorFlow framework and analysing performance measures for model evaluation

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Neural Network for Deep Learning	Optimization and Neural Network: Review of Neural Network fundamentals, the problem of Learning, Implementing single Neuron-Linear and Logistic Regression, Deep Learning: Fundamentals, Deep Learning Applications, Popular open-source libraries for deep learning Feed-Forward Networks: Networks architecture and Matrix notation, Overfitting, Multiclass Classification with Feed-Forward Neural Networks, Estimating Memory requirement of Models
2	Convolutional and Recurrent Networks for Deep Learning	Regularization: Complex Network and Overfitting, Regularization and related concepts, Hyperparameter tuning Convolutional Neural Networks:Kernels and Filters,Building Blocks of CNN, Inception Network, Transfer Learning Recurrent Neural Network: Notation and Idea of recurrent neural networks, RNN Topologies, backpropagation through time, vanishing and exploding gradients
3	Advanced Concepts for Deep Learning	Autoencoders: Introduction, Network Design, Regularization in Autoencoders, Denoising autoencoders, Feed-Forward Autoencoders, spare and Contractive autoencoders Unsupervised Feature Learning: Hopfield networks and Boltzmann machines, restricted Boltzmann machine, Deep

		belief networks Generative Adversarial Networks (GANs):Introduction, training algorithms, Conditional GANs, applications, Deep convolutional generative adversarial networks.
4	Deep Learning Application(Skill enhancement)	Deep Learning for AI Games: AI Game Playing, Reinforcement learning, Maximizing future rewards, Q-learning, The deep Q-network as a Q-function, Balancing exploration with exploitation, Experience replay, or the value of experience Deep Learning for Object Localization and classification: Intersect Over Union (IoU), Sliding Window Approach, Region-Based CNN (R-CNN) Deep Learning for Language Modelling and Speech Recognition, Generative AI- Arts Generation, Content Generation

Learning Resources recommended:

A] Books and Textbooks:

1. Python Deep Learning, Valentino Zocca, Packt Publication, 2017
2. Applied Deep Learning, with TensorFlow 2, Umberto Michelucci, Apress, 2022
3. Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress, 2017
4. Advanced Deep Learning with Keras, Rowel Atienza, Packt Publication, 2018
5. Python Deep Learning Cookbook, Indra den Bakker, Packt Publication, 2017
6. Deep Learning with Keras, Antonio Gulli, Packt Publication, 2017

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Neural Network for Deep Learning	Regular teaching and ICT	15
2	Convolutional and Recurrent Networks for Deep Learning	Regular teaching and ICT	15
3	Advanced Concepts for Deep Learning	Regular teaching and ICT	15
4	Deep Learning Application(Skill enhancement)	Regular teaching and ICT	15

Nomenclature of the Course	Deep Learning Practical
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS402
No. of Credits	02
Nature	Practical
Type	Major Mandatory

Course Outcomes:

CO1: Implement diverse DL algorithms: Feed-forward Neural Network. autoencoder
CO2: Apply DL techniques to different datasets.
CO3: Utilize batch gradient descent with early stopping for softmax regression training.
CO4: Develop neural network models for problem solving
CO5: Use TensorFlow for image classification.
CO6: Implement regression models for fuel efficiency prediction using TensorFlow and Auto MPG dataset.

Syllabus:

Practical No	Practical
1	Implement Feed-forward Neural Network and train the network with different optimizers and compare the results.
2	Write a Program to implement regularization to prevent the model from overfitting.
3	Implement deep learning for recognizing classes for datasets like CIFAR-10 images for previously unseen images and assign them to one of the 10 classes.
4	Implement deep learning for the Prediction of the autoencoder from the test data (e.g. MNIST data set).
5	Implement Convolutional Neural Network for Digit Recognition on the MNIST Dataset.
6	Write a program to implement Transfer Learning on the suitable dataset (e.g. classify the cats versus dogs dataset from Kaggle).
7	Write a program for the Implementation of a Generative Adversarial Network for generating synthetic shapes (like digits)
8	Write a program to implement a simple form of a recurrent neural network. 1. E.g. (4-to-1 RNN) to show that the quantity of rain on a certain day also depends on the values of the previous day
9	Implement LSTM for sentiment analysis on datasets like UMICH SI650 for similar.
10	Write a program for object detection from the image/video.
11	Write a program for object detection using pre-trained models to use object detection.
12	Write a program for object movement from the image/video.

Learning Resources recommended:
A] Books and Textbooks:

1. Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems by AurélienGéron, Second Edition, O'reilly, 2019
2. Deep Learning with Python by François Chollet Published by Manning 2018
3. Reinforcement Learning: An Introduction by Richard S. Sutton and Andrew G. Barto, Second Edition ,2014
4. Introduction to Machine with Python - A Guide for Data Scientists by Andreas C. Müller & Sarah Guido O'reilly 2016
5. Artificial Neural Networks with TensorFlow 2 ANN Architecture Machine Learning Projects Poornachandra Sarang by Apress, 2021

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Big Data Analytics
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS403
No. of Credits	04
Nature	Theory
Type	Major Mandatory

Course Outcomes:

CO1: Exposure to the fundamentals of business intelligence and big data analytics.
CO2 : Understand basic concepts in Big Data analytics and parallel data processing and Map Reduce
CO3: Understand Hadoop Technology and its applications.
CO4: Exposure to real-life applications and solving them using big data toolkits

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Big Data and Hadoop	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 Data Analytics, 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.
2	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.
3	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
4	Tools for Data Anlytics	Spark SQL: SQL Context, Importing and Saving data, Data frames, using SQL, GraphX overview, Creating Graph, Graph Algorithms. 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.

Learning Resources recommended:

[A] Books and Textbooks:

1. Big Data Analytics, Introduction to Hadoop, Spark, and Machine-Learning, Raj Kamal, Preeti Saxena, McGraw Hill, 2019
2. Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization, Dreamtech Press; 1st edition, 2016
3. Big Data Analytics with Spark, A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Apress, 2015
4. Hadoop MapReduce v2 Cookbook - Second Edition, Packt Publishing, 2015

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Big Data and Hadoop	Regular teaching and ICT	15
2	Map Reduce and HBASE	Regular teaching and ICT	15
3	Spark Framework and Applications	Regular teaching and ICT	15
4	Tools for Data Anlytics	Regular teaching and ICT	15

Nomenclature of the Course	Big Data Analytics Practical
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS404
No. of Credits	02
Nature	Practical
Type	Major Mandatory

Course Outcomes:

CO1: Exposure to the fundamentals of business intelligence and big data analytics.
CO2: Understand basic concepts in Big Data analytics and parallel data processing.
CO3: Understand Hadoop Technology and its applications.
CO4: Exposure to real-life applications and solving them using big data toolkits

Syllabus:

Practical No	Practical
1	Installing and setting environment variables for Working with Apache Hadoop
2	Implementing Map-Reduce Program for Word Count problem,
3	Write a program to Implement a tri-gram model
4	Download and install Spark. Create Graphical data and access the graphical data using Spark
5	Write a Spark code for the given application and handle error and recovery of data
6	Write a Spark code to Handle the Streaming of data.
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
11	Implementing Spark Program for Word Count problem,
12	Implement Total Spent by Customer with DataFrames in Spark.

Learning Resources recommended:

Books and Textbooks:

1. Big Data Analytics, Introduction to Hadoop, Spark, and Machine-Learning, Raj Kamal, Preeti Saxena, McGraw Hill, 2019
2. Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization, Dreamtech Press; 1st edition, 2016
3. Big Data Analytics with Spark, A Practitioner's Guide to Using Spark for Large Scale Data Analysis, Apress, 2015
4. Hadoop MapReduce v2 Cookbook - Second Edition, Packt Publishing, 2015

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Trends in Cloud Computing
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS405
No. of Credits	02
Nature	Theory
Type	Major Elective

Course Outcomes:

CO1 : Learners will be able to develop and launch applications in the cloud environment

CO2 : Explore various frameworks ,Containers and APIs that are used for developing cloud-based applications

CO3 : Handling data in a Cloud environment

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Basic Concepts & Techniques for Cloud Application Development	Fundamentals of Cloud Application Development:Business case for implementing cloud application, Requirements collection for cloud application development, Cloud service models and deployment models, Open challenges in Cloud Computing: Cloud interoperability and standards, scalability and fault tolerance, security, trust, and privacy Application Development framework:Accessing the clouds: Web application vs Cloud Application, Frameworks: Model View Controller (MVC). Cloud platforms in Industry – Google AppEngine, Microsoft Azure, Openshift, CloudFoundry Sessions and API: Storing objects in the Cloud, Session management, Working with third party APIs: Overview of interconnectivity in Cloud ecosystems. Facebook API, Twitter API, Google API. Architecting for the Cloud: Best practices in architecture cloud applications in AWS cloud, Amazon Simple Queue Service (SQS), RabbitMQ Managing the data in the Cloud: Securing data in the cloud, ACL, OAuth, OpenID, XACML, securing data for transport in the cloud, scalability of applications and cloud services
2	DevOps and Containers in Cloud	**Basics of DevOps:** Introduction to DevOps, Continuous Deployment: Containerization with Docker, Orchestration (Kubernetes and Terraform), Automating

		Infrastructure on Cloud, Application Deployment and Orchestration using ECS, ECR & EKS, Application Deployment using Beanstalk, Configuration Management using OpsWorks **Application:** Designing a RESTful Web API, PubNub API for IoT to cloud, mobile device as IoT, Mobile cloud access **Azure essentials:** Azure Compute and Storage, Azure Database and Networking, Monitoring and Managing Azure Solutions, GCP Compute and Storage, GCP Networking and Security, Google App Engine (PaaS) **Cloud applications:** Amazon Simple Notification Service (Amazon SNS), multi-player online game hosting on cloud resources, building content delivery networks using cloud

Learning Resources recommended:

A] Books and Textbooks:

1. Kevin L. Jackson. Scott Goessling, Architecting Cloud Computing Solutions,Packt Publishing 2018
2. Shailendra Singh, Cloud Computing: Focuses on the Latest Developments in Cloud Computing, Oxford University Press; First edition, June 2018
3. JJ GEEWAX, Google Cloud Platform in Action, Manning Publications Co, 2018
4. Haishi Bai, Dan Stolts, Santiago Fernández Muñoz, Exam Ref 70-535 Architecting Microsoft Azure Solutions, Pearson Education, 2018
5. Dr. Kumar Saurabh, Cloud Computing, 4ed: Architecting Next-Gen Transformation Paradigms, Wiley, 2017

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Basic Concepts & Techniques for Cloud Application Development	Regular teaching and ICT	15
2	DevOps and Containers in Cloud	Regular teaching and ICT	15

Nomenclature of the Course	Trends in Cloud Computing Practical
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCSP405
No. of Credits	02
Nature	Practical
Type	Major Mandatory

Course Outcomes:

CO1 : Learners will be able to develop and launch applications in the cloud environment
CO2 : Explore various frameworks and APIs that are used for developing cloud-based applications
CO3: Handling data in a Cloud environment

Syllabus:

Practical No	Practical
1	Using the software like / API / Tools JDK 1.7/1.8, Eclipse IDE, Dropbox API, Apache tomcat server 7.0/8.0,Google AppEngine API, Servlets, Struts, Spring framework design and develop Web applications using MVC Framework
2	Installing and configuring the required platform for Google App Engine
3	Studying the features of the GAE PaaS model.
4	Creating and running Web applications (Guest book, MVC) on localhost and deploying the same in Google App Engine
5	Developing an ASP.NET based web application on the Azure platform
6	Creating an application in Dropbox to store data securely. Develop a source code using Dropbox API for updating and retrieving files.
7	Installing Cloud Foundry in localhost and exploring CF commands
8	Cloud application development using IBM Bluemix Cloud.
9	Installing and Configuring Dockers in localhost and running multiple images on a Docker Platform
10	Configuring and deploying VMs/Dockers using Chef/Puppet Automation tool
11	Access Azure Database and display the records.
12	Access AWS Database and display the records.

Learning Resources recommended:

A] Books and Textbooks:

1. Kevin L. Jackson. Scott Goessling, Architecting Cloud Computing Solutions,Packt Publishing 2018
2. Shailendra Singh, Cloud Computing: Focuses on the Latest Developments in Cloud Computing, Oxford University Press; First edition, June 2018
3. JJ GEEWAX, Google Cloud Platform in Action, Manning Publications Co, 2018
4. Haishi Bai, Dan Stolts, Santiago Fernández Muñoz, Exam Ref 70-535 Architecting Microsoft Azure Solutions, Pearson Education, 2018

5. Dr. Kumar Saurabh, Cloud Computing, 4ed: Architecting Next-Gen Transformation Paradigms, Wiley, 2017

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Remote Sensing & GIS
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS406
No. of Credits	02
Nature	Theory
Type	Major Elective

Course Outcomes:

CO1 : Understand basic of remote sensing

CO2 : Learn techniques used in GIS applications

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Basics of Remote Sensing	Overview of Remote sensing: Definition of Remote sensing Principles of Remote Sensing, Electromagnetic Radiation, Radiometric terms and definitions, Radiation Laws, EM spectrum, Sources of EM, Interaction of EM Radiation with atmosphere, and target, Atmospheric Widows, imaging spectrometry, Spectral signature of various land cove features Platform and Sensors :- • Platforms: Types of platforms, ground, airborne, and space born platforms, Orbit of satellites, Kepler's Law, satellite characteristics, satellites for Earth observations studies, and planetary missions (Chandrayana) • Sensors: Types and classification of sensors, imaging modes, Characteristics of optical sensors, sensor resolution-spectral, radiometric and temporal, Characteristics of detectors,
2	GIS	Introduction to GIS, Understand the difference between GIS and information system in general, GIS components and function of GIS: hardware software requirement of GIS, data types and spatial data models, idea of conceptual, logical and physical models, RDBMS, data base normalization Representation of real world via vector and raster representation model. Applications in land use and land cover analyses, Raster data structure, Vector data structures for geographical entities.

Learning Resources recommended:

A] Books and Textbooks:

Applied Remote Sensing, C.P. Lo, Longman, Scientific and Technical Publishers
2. Remote Sensing in hydrology, Engman, E.T. Gurney, R.J.
3. Remote Sensing in water management in command areas, Govardhan, V.
4. Satellite oceanography, An introduction for oceanographers and Remote Sensing Scientists, I.R. Robinson, Ellis Horwood series marine sciences.

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Basics of Remote Sensing	Regular teaching and ICT	15
2	GIS	Regular teaching and ICT	15

Nomenclature of the Course	Remote Sensing & GIS Practical
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCSP406
No. of Credits	02
Nature	Practical
Type	Major Elective

Course Outcomes:

CO1 : Understand basic of remote sensing

CO2 : Learn about GIS applications

Syllabus:

Practical No	Practical
1	Creating and Managing Vector Data a) Adding vector layer b) Setting properties c) Vector Layer Formatting
2	Write a program to Calculate line lengths and statistics
3	Write a program to Add raster layers, Raster Styling and Raster Mosaicking and Clipping.
4	Develop a map and download openstreetmap data.
5	Work with Terrain Data and Perform Hill shade analysis
6	Work with Projections and WMS Data
7	Generate Topo Sheets and Scanned Maps.
8	Perform spatial queries
9	Work with Interpolating Point Data.
10	Develop Automating Complex Workflows using Processing Modeler
11	Develop Automating Map Creation with Print Composer Atlas
12	Validate Map Data and note down observations.

Learning Resources recommended:

A] Books and Textbooks:

1.Applied Remote Sensing, C.P. Lo, Longman, Scientific and Technical Publishers

2. Remote Sensing in hydrology, Engman, E.T. Gurney, R.J.

3. Remote Sensing in water management in command areas, Govardhan, V.

4. Satellite oceanography, An introduction for oceanographers and Remote Sensing Scientists, I.R. Robinson, Ellis Horwood series marine sciences.

Teaching Plan:

Sr. No.	Title	Teaching Methods	No. of Lectures
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Server Virtualization
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCS407
No. of Credits	02
Nature	Theory
Type	Major Elective

Course Outcomes:

CO1. Understand and apply the Virtualization infrastructure
CO2. Learn basic concept in network virtualization

Syllabus:

Unit No.	Unit Title	Sub titles (Learning Points)
1	Virtualized IT Infrastructure: Concepts & Trends	**Virtualized IT Infrastructure: Concepts & Trends** Physical Vs Virtual IT Infrastructure, machines, Data Centers, Types of Virtualization, Desktop, Application, Server, Hardware, Storage, Memory and I/O virtualization, Need of Network and Storage Virtualization,Recent Trends & technologies in virtualized environments **Virtual Machine Management** Introduction to Hypervisors, Role of VMM. VM lifecycle, VM configurations, MVM migrations, Migration types and process, VM provisioning, Scaling, VM scheduling, Load balancing: Significance, Types and Algorithms, Comparing workstation products, QoS parameters – Performance, Functionality, Windows Vs Linux Hosting,Software Migration, Migrating workloads from Physical to Virtual Machines
2	Network Virtualization	Network Virtualization How to build guest OS, planning for automatic installations, Virtual Interfaces, VNIC profiles, Virtual Switches and Routers, TUN/TAP drivers and data flow between VMs, NAT, host-only approaches, Designing virtual networks, Bridged, NAT and host-only networking, Virtual Data Centers introduction, Data Center Virtualization with ESXi, Networking with Switches and port groups, Optimizing resource utilization Server Virtualization Server Partitioning, choosing virtual server hosts, Security implications, Server VMs, Interactive mode, deploying virtual servers, managing virtual servers remotely, Server

		health monitoring using vSphere Monitoring and Performance services, VM Cluster, Distributing workloads via Network Load Balancing (NLB)

Learning Resources recommended:

A] Books and Textbooks:

1. Chris Wolf and Erick M. Halter, "Virtualization" A press

2. LatifaBoursas (Editor), Mark Carlson (Editor), Wolfgang Hommel (Editor), Michelle Sibilla (Editor), KesWold (Editor), "Systems and Virtualization Management: Standards and New Technologies

Teaching Plan:

Unit No.	Unit Title	Teaching Methods	No. of Lectures
1	Virtualized IT Infrastructure: Concepts & Trends	Regular teaching and ICT	15
2	Network Virtualization	Regular teaching and ICT	15

Nomenclature of the Course	Server Virtualization Practical
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCSP407
No. of Credits	02
Nature	Practical
Type	Major Elective

Course Outcomes:

CO1 : Learn virtualization concepts
CO2 : Learn security features and application of Virtualization

Syllabus:

Practical No	Practical
1	Configure and use vCenter Server Appliance. Assign roles and permissions to Active Directory users to perform functions in vCenter Server Appliance
2	Create a standard switch and a port group.Configure access to an iSCSI datastore.
3	Create and manage VMFS datastores. Configure access to an NFS datastore. Deploy a new virtual machine from a template and clone a virtual machine.
4	Create a content library to clone and deploy virtual machines.Modify a virtual machine's hardware and add a raw LUN to a virtual machine
5	Use vSphere vMotion and vSphere Storage vMotion to migrate virtual machines.
6	In vCenter Server, create and use resource pools on an ESXi host. Use the system monitoring tools to reflect the CPU workload.
7	In vCenter Server, create and use resource pools on an ESXi host. Use the system monitoring tools to reflect the CPU workload.
8	Use the vCenter Server Appliance alarm feature.
9	Use vSphere HA functionality.
10	Implement a vSphere DRS cluster. b. Install, configure, and use vSphere Update Manager.
11	Develop Virtual Desktop Infrastructure/
12	Implement Virtual Machine and take snapshot.

Learning Resources recommended:

A] Books and Textbooks:

1. Chris Wolf and Erick M. Halter, "Virtualization" A press
2. LatifaBoursas (Editor), Mark Carlson (Editor), Wolfgang Hommel (Editor), Michelle Sibilla (Editor), KesWold (Editor), "Systems and Virtualization Management: Standards and New Technologies

Teaching Plan:			
Sr. No.	**Title**	**Teaching Methods**	**No. of Lectures**
1	10 Practicals	Practical Demonstration	60

Nomenclature of the Course	Research Project
Class	M. Sc. Computer Science
Semester	IV
Course Code	PSCSP408
No. of Credits	6
Nature	Practical
Type	-

Course Outcomes:
CO1 : Learn research implementation ethics
CO2 : Learn different methods of analysing results and making conclusion.

Guidelines for Research Project Implementation in Semester–IV

Total Credits	Total Hours	Marks	
		Internal	External
06	180	60	90

A student is expected to devote at least 3 to 4 months of effort to the Research Project Implementation on the proposal submitted in Semester III. Students should submit a detailed research project implementation report at the time of viva. Students are not permitted to change the project they submitted as a proposal in Semester III.

GuidelinesforDocumentationofResearchProjectImplementationinSemester –IV

Certified Spiral Bound Copy with Certificate is required to submit at the time of Viva Examination. A student should submit a Research Project Implementation report with the following details:

- **Title:** Title of the Research Project.
- **Objective:** A detailed objective of the proposal is needed.
- **Introduction/Background:** Introduction of the Topic
- **Related works/Literature Survey:** A detailed survey of the relevant works done by others in the domain. The student is expected to refer to at least 20 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 par 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 incharge 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.

Scheme of Examination: -Internal Examination

B) Continuous Internal Evaluation:

Method		**Marks**		
InternalViva1		**30**		
Methodology	**Implementation**	**Total**		
15	15	30		
InternalViva2		**30**		
Experimentalsetup andresults	**Analysisof the results**	**Code**	**Document**	**Total**
05	05	15	05	30

External Examination

B)External Evaluation:

Method				**Marks**			
ExternalViva				**90**			
Introduction	Objectives	Methodology	Code/Model	Results	Documents	Viva	Total
05	05	10	25	25	10	10	90

Evaluation Scheme

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

Theory Paper:-

A) Internal Assessment: 40 % (40 Marks)

Sr. No.	Particulars	4 credit subjects Marks	2 credit subjects Marks
01	One Class Test / Online Examination to be conducted in the given semester [Duration: 40 Minutes] [Duration: 20 Minutes]	20	10
02	One Assignment to be conducted in the given semester	10	05
03	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10	05
	Total	40	20

B) Semester End Examination: 60% of 100 (60 Marks) or 60% of 50 (30 Marks)

For 4 Credit Paper:-

Question No. and Sub questions (If any) (E.g. Q. 1 a) …	Unit and sub unit (with number and title)	Type of Question (Essay / short note / Objective / Diagram, etc.)	Marks
Q.1	Unit I	*Any 2 out of 4*	12
Q.2	Unit II	*Any 2 out of 4*	12
Q.3	Unit III	*Any 2 out of 4*	12
Q.4	Unit IV	*Any 2 out of 4*	12
Q.5	Unit I, II, III, IV	*Objective Based*	12

For 2 Credit Paper:-

	All questions are compulsory.			
Question	**Based on**	**Sub-Question**	**Options**	**Marks**
Q.1	Unit I	A	*Any 2 out of 4*	6
		B	*Any 1 out of 2*	4
Q.2	Unit II	A	*Any 2 out of 4*	6
		B	*Any 1 out of 2*	4
Q.3	Unit I, II	A	*Any 2 out of 4*	6
		B	*Any 1 out of 2*	4

Practical Paper:-

A. Continuous Internal Evaluation: Maximum Marks:

Method	Marks
Journals containing minimum 10 practical's which are timely completed with desired output	10
Attendance & Practical Performance	10

B. Semester End Examination: Maximum Marks:

Question No. and Sub questions (If any) (E.g. Q. 1 a) ...	Unit and sub unit (with number and title)	Type of Question (Essay / short note / Objective / Diagram, etc.)	Marks
1	All	Practical	25
2	All	VIVA	05

Standard of Passing

The learner to pass a course shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment & Semester End Examination. The learner shall obtain minimum of 40% marks (i.e. 16 out of 40 or 8 out of 20) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 out of 60 or 12 out of 30) separately, to pass the course and minimum of Letter Grade "P" in the project component, wherever applicable to pass a particular semester. A learner will be said to have passed the course if the learner passes the Internal Assessment & Semester End Examination together.

Performance Grading:

Letter Grades and Grade Points

Semester GPA/ Program CGPA Semester/Program	% of Marks	Alpha-Sign/ Letter Grade Result
9.00-10.00	90.0 -100	0(Outstanding)
8.00 ≤ 9.00	80.0 ≤ 90.0	A+(Excellent)
7.00 ≤ 8.00	70.0 ≤ 80.0	A (Very Good)
6.00 ≤ 7.00	60.0 ≤ 70.0	B+(Good)
5.50 ≤ 6.00	55.0 ≤ 60.0	B (Above Average)
5.00 ≤ 5.50	50.0 ≤ 55.0	C(Average)
4.00 ≤ 5.00	40.0 ≤ 50.0	P(Pass)
Below4.00	Below40	F(Fail)
Ab (Absent)	-	Absent

Date: 29-04-2024
Place: Ratnagiri

The Chairperson
BoS of Computer Science