University of Mumbai

No. AAMS UGS/ICC/2024-25/ 101

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office circular No. AAMS UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Computer Science** at its meeting held on 01st July, 2024 and subsequently passed by the Board of Deans at its meeting held on 10th July, 2024 **vide** item No. 6.2 (N) have been accepted by the Academic Council at its meeting held on 12th July, 2024 **vide** item No.6.2 (N) and that in accordance therewith **syllabus** for the **M.Sc (Computer Science) (Sem. III & IV)** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The circular is available on the University's website www.mu.ac.in).

Baliram

MUMBAI – 400 032
22nd August, 2024

(Prof.(Dr) Baliram Gaikwad)
I/c Registrar

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Department.

A.C/6.2(N)/12/07/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science & Technology,
3) The Chairman, **Ad-hoc Board of Studies in Computer Science**,
4) The Director, Board of Examinations and Evaluation,
5) The Director, Board of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari.
8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentre@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

1	The Chairman, Board of Deans
2	The Dean, Faculty of Humanities,
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology,
7	The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari, director@idol.mu.ac.in

AC – 12/07/2024
Item No. – 6.2 (N)

As Per NEP 2020

University of Mumbai

Title of the program

M.Sc. (Computer Science)

Syllabus for

Semester – Sem.- III & IV

Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr.No.	Heading	Particulars
1	**Title of program** **O:_____ B**	**M.Sc. (Computer Science)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	Standards of Passing **R: _____**	**40%**
4	Credit Structure **R: SP-95A** **R: SP-95B**	**Attached herewith**
5	Semesters	**Sem. III & IV**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Sign of the BOS Chairperson
Dr. Jyotshna Dongardive
Ad-hoc Board of Studies in Computer Science

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Credit Distribution Structure for Two Years/ One Year PG (M.Sc. Computer Science)

R: SP-95B

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum.Cr.	Degree
			Mandatory			Electives					
2	6.5	Sem III	2*4+2*2+2			4	-	-	RP (607) 4	22	PG Degree after 3-yr UG
			Web3Technologies (601)	TH	4	Social Network Analysis (606a) 2 TH +2PR **(OR)** Data Visualization (606b) 2 TH+2 PR **(OR)** Fuzzy Systems (606c) 2 TH +2PR					
			Web3 Technologies Practical (602)	PR	2						
			Cyber Security and Risk Assessment (603)	TH	4						
			Cyber Security and Risk Assessment Practical (604)	PR	2						
			Ethical & Responsible AI (605)	TH	2						
		Sem IV	2*4+2*2			4	-	-	RP (616)	22	
			Deep Learning(611)	TH	4	Trends in cloud computing (615a) 2 TH +2PR **(OR)** Remote Sensing (615b) 2 TH +2PR **(OR)** Server Virtualization (615c) 2 TH +2PR					
			Deep Learning Practical (612)	PR	2						
			Big Data Analytics (613)	TH	4						
			Big Data Analytics Practical (614)	PR	2						
Cum.Cr. For 1 Yr PG Degree			26			8			10	44	
Cum.Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Semester- III

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Web3 Technologies
Total Credits: 04	**Total Marks:** 100
College assessment: 50	**University assessment:** 50

Prerequisite: Fundamental knowledge of mathematics, blockchain technologies.

Course Outcome:

The learner will be able to

- Understand and apply the fundamentals of Web3 Technologies and bitcoin.
- Develop skills in smart contracts and Ethereum development environment.
- Understand and apply concept of Ethereum framework, serenity and Tokenization
- Apply Solidity programming for Smart contracts and tokenization

Course Code	Course Title	Total Credits
PSCS601	**Web3 Technologies**	**04**
MODULE I **Unit 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 **Unit 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		**02**

MODULE II **Unit 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 **Unit 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.	**02**

Text Books:

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.

Reference Books:

1. Josh Thompson, „Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming‟, Create Space Independent Publishing Platform, First Edition - 2017.

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Web3 Technologies
Total Credits: 02	**Total Marks:** 50
	University assessment: 50

Prerequisite: Knowledge of Solidity, NodeJS

Course Outcome:

The learner will be able to

- Implement the concept of the docker with respect to BlockChain Applications
- Implement smart contracts and Ethereum development environment.
- Implement the concept of Ethereum framework, serenity and Tokenization
- Apply Solidity programming for Smart contracts and tokenization.

Course Code	Course Title	Credits
PSCS602	**Web3 Technologies Practical**	**02**
Note: - The following practical can be performed using Solidity, NodeJS. Ethereum and any other suitable platform		
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.	

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Cyber Security and Risk Assessment
Total Credits: 04	**Total Marks: 100**
College assessment: 50	**University assessment: 50**

Prerequisite: Basic Security Concepts, Cyber Security issues.

Course Outcome:

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

Course Code	Course Title	Total Credits
PSCS603	**Cyber Security and Risk Assessment**	**04**
MODULE I **Unit 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 **Unit 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		**02**

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	
MODULE II **Unit 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 **Unit 4: Exploiting System Vulnerabilities** **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	**02**

Text Books:

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, Nessus, Nmap, And Wireshark, Glen D. Singh, Packt, 2019

Reference Books: -

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

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Cyber Security and Risk Assessment Practical
Total Credits: 04	**Total Marks: 100**
College assessment: 50	**University assessment: 50**

Prerequisite: Virtualization, Kali Linux

Course Outcome:

The learner will be able to

- Implement the penetration testing and analyse the result.
- Use Kali Linux in performing penetration tests against networks, systems, and applications
- Understand ways to protect system and digital assets
- Selecting the most effective tools, to rapidly compromising network security to highlighting the techniques used to avoid detection

Course Code	Course Title	Credits
PSCS604	**Cyber Security and Risk Assessment Practical**	**02**
Note: The Practical to be performed preferably on Kali Linux		
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.	

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Ethical & Responsible AI
Total Credits: 02	**Total Marks: 50**
College assessment: 25	**University assessment: 25**

Prerequisite: Programming Language concepts, Security and Artificial Intelligence

Course outcomes:

- Gain an understanding of ethical frameworks and principles relevant to AI, including fairness, transparency, accountability, and privacy.
- Learn to identify ethical issues and challenges that arise in the development, deployment, and use of AI technologies.

Course Code	Course Title	Total Credits
PSCS605	**Ethical & Responsible AI**	**02**
MODULE I **Unit 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, Explainability through causality Model agnostic Interpretation **Unit 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, Data Compliance Data Protection Policies and rights of the data subjects. Roles of the Controller, Processor and Data Protection Officer (DPO) Planning for compliance - privacy compliance frameworks and gap analysis. Data Protection Impact Assessment (DPIA) Data breaches, notification and incident response.		**02**

Text Books:

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

ELECTIVES

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Social Network Analysis
Total Credits: 02	**Total Marks: 50**
College assessment: 25	**University assessment: 25**

Prerequisite: Basic understanding of Graph Theory, Social Networking Concepts

Course Outcome:

The learner will be able to

- Gain a comprehensive understanding of social network concepts, including nodes, edges, centrality, clustering, and network dynamics.
- Develop skills in visualizing social network data using appropriate tools and techniques, including node-link diagrams, matrix plots, and network layouts.

Course Code	Course Title	Total Credits
PSCS606a	**Social Network Analysis**	**02**
MODULE I **Unit 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. **Unit 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.		**02**

Text Books:

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.

Reference Books:

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.

Programme Name: M.Sc. Computer Science Semester III	**Course Name:** Social Network Analysis Pratical
Total Credits: 02	**Total Marks: 50**
	University assessment: 25

Prerequisite: Basic understanding of R Programming or Python

Course Outcome:

The learner will be able to

- Gain a comprehensive understanding of social network concepts, including nodes, edges, centrality, clustering, and network dynamics.
- Develop skills in visualizing social network data using appropriate tools and techniques, including node-link diagrams, matrix plots, and network layouts

Course Code	Course Title	Credits
PSCSP606a	**Social Network Analysis Practical**	**02**
Note: The Practical to be performed preferably in R Studio or Python		
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.	

Programme Name: M.Sc. Computer Science Semester III	Course Name: Data Visualization
Total Credits: 02	Total Marks: 50
College assessment: 25	University assessment: 25

Pre requisite: Knowledge of Basic concepts of Databases

Course Outcome:

The learner will be able to

- Work with data analysis tools and perform data wrangling for practical purposes.
- Use of Tableau to handle data from various sources and perform analysis of data.

Course Code	Course Title	Total Credits
PSCS606b	Data Visualization	02
MODULE I **Unit 1: Basics of Power BI** Introduction to Power BI, Creating POWER BI Reports, Auto Filters, Report Visualization And Properties, Chart And Map Report Properties, Hierarchies And Drilldown Reports, Power Query & M Language, DAX EXPRESSIONS – Level 1, DAX EXPRESSIONS – Level 2, Power BI Deployment & Cloud, Power BI Cloud Operations, Power BI Integration Elements **Unit 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. //Tableau		02

Text Books:

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

Programme Name: M.Sc. Computer Science Semester III	**Course Name: Data Visualization Practical**
Total Credits: 02	**Total Marks: 50**
	University assessment: 50

Pre requisite: Knowledge of Power BI and Tableau

Course Outcome:

- Work with data analysis tools and perform data wrangling for practical purposes.
- Use Tableau to handle data from various sources and perform analysis of data.

Course Code	**Course Title**	**Credits**
PSCSP606b	**Data Visualization Practical**	**02**
Note: Following practical can be performed using Python and simulators, Raspberry Pi, and other hardware devices.		
1	Create Charts and Reports in Power BI.	
2	Time Intelligence and data analysis Functions with DAX	
3	Operations on Pinned Reports and Visuals using Power BI	
4	Create one-dimensional data using series and perform various operations on it	
5	Perform Reshaping of the hierarchical data and pivoting data frame data	
6	Connecting and extracting with various data resources in tableau and Perform 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.	

Programme Name: M.Sc. Computer Science Semester III	Course Name: Fuzzy Systems
Total Credits: 02	Total Marks: 50
College assessment: 25	University assessment: 25

Prerequisite: Basic understanding of Probability and Fuzzy Concepts

Course Outcome:

- 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.
- Learn the neural networks for classification, regression and to give design methodologies for artificial neural networks

Course Code	Course Title	Total Credits
PSCS606c	Fuzzy System	02
MODULE I **Unit 1:** Introduction to Fuzzy System: Historical Background, Comparison between Classical and Fuzzy Logic, Applications of Fuzzy Logic Fuzzy Sets: Definition and Examples of Fuzzy Sets, Membership Functions, Types of Membership Functions (Triangular, Trapezoidal, Gaussian, etc.), Operations on Fuzzy Sets (Union, Intersection, Complement) Fuzzy Relations: Definition and Types of Fuzzy Relations, Composition of Fuzzy Relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations Fuzzy Rule-Based Systems: Fuzzy If-Then Rules, Fuzzy Inference Systems, Mamdani vs. Sugeno Fuzzy Models, Applications in Control Systems Fuzzy Arithmetic: Fuzzy Numbers, Arithmetic Operations on Fuzzy Numbers,Extension Principle, Applications of Fuzzy Arithmetic Fuzzy Logic Control: Basic Concepts of Fuzzy Control, Design of Fuzzy Controllers, Stability Analysis of Fuzzy Control Systems, Real-World Applications **Unit 2:** Fuzzy Decision Making: Fuzzy Decision-Making Process, Multi-Criteria Decision Making, Fuzzy Optimization Techniques, Case Studies Fuzzy Clustering: Introduction to Clustering, Fuzzy C-Means Clustering, Evaluation of Clustering Results, Applications in Image Processing and Data Mining Fuzzy Pattern Recognition: Fuzzy Pattern Recognition Systems, Fuzzy Neural Networks Hybrid Systems (Fuzzy Logic and Neural Networks), Practical Examples and Applications Fuzzy Logic in Artificial Intelligence: Integration of Fuzzy Logic in AI, Fuzzy Expert Systems, Fuzzy Logic in Machine Learning, Case Studies		02

Text Books:

1. Timothy Ross, "Fuzzy Logic with Engineering Applications", John Wiley and Sons, Second Edition.
2. An Introduction to Fuzzy Logic Applications in Intelligent Systems by Ronald R. Yager and Lotfi A. Zadeh
3. Fuzzy Sets and Fuzzy Logic: Theory and Applications by George J. Klir and Bo Yuan

Programme Name: M.Sc. Computer Science Semester III	**Course Name: Fuzzy System Practical**
Total Credits: 02	**Total Marks: 50**
	University assessment: 50

Prerequisite: Knowledge of Python and matlab

Course Outcome:

The learner will be able to

- Understand the implementation of Fuzzy logic .
- Develop small fuzzy models for purpose of implementation

Course Code	**Course Title**	**Credits**
PSCSP606c	**Fuzzy System Practical**	**02**
Note : Programs can be performed with python or matlab		
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	

Programme Name: M.Sc. Data Science Semester III **Total Credits:** 04 **College assessment:** 50	**Course Name:** Research Project **Total Marks:** 100 **University assessment:** 50

Guidelines for Research Project Proposal in Semester – III

Total Credits	Total Hours	Marks	
		Internal	External
04	120	50	50

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 in the domain. The student is expected to refer to at least 30 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 be quantitative, qualitative, or mixed-methods. Explain the rationale behind the chosen design and how 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.
- **Significance / Scope of the work**
- **Conclusion**
- **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**		
Internal Viva 1		25		
Topic Weightage	Introduction	Objectives	Literature Survey	Total
05	05	05	10	25
Internal Viva 2				
Proposed Methodology	Significance / Scope and Conclusion	Documentation		Total
10	05	10		25

External Examination

B) External Evaluation:

Method				**Marks**			
External Viva				**50**			
Topic Weightage	Introduction	Objectives	Literature Review	Proposed Methodology	Documentation	Presentation/ Viva	Total
02	04	04	10	10	10	10	50

Semester IV

Programme Name: M.Sc. Computer Science Semester IV	**Course Name:** Deep Learning
Total Credits: 04	**Total Marks: 100**
College assessment: 50	**University assessment: 50**

Prerequisite: Fundamental concepts of Machine Learning and Neural Network

Course Outcome:

- Develop a solid understanding of the fundamentals of Neural Network.
- Gain proficiency in using CNN models
- Explore the fundamentals of semi supervised deep learning and artificial neural networks, including their architecture and activation functions.
- Acquire practical skills in implementing machine learning algorithms using the TensorFlow framework and analysing performance measures for model evaluation

Course Code	Course Title	Total Credits
PSCS611	**Deep Learning**	**04**
MODULE I **Unit 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 **Unit 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		**02**
MODULE II **Unit 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		**02**

Generative Adversarial Networks (GANs): Introduction, training algorithms, Conditional GANs, applications, Deep convolutional generative adversarial networks **Unit 4: Deep Learning Application** **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	

Text Books:

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

Programme Name: M.Sc. Computer Science Semester IV	**Course Name: Deep Learning Practical**
Total Credits: 02	**Total Marks: 50**
	University assessment: 25

Prerequisite: Basic understanding of machine learning concepts, familiarity with Python programming language, knowledge of common datasets (e.g., Iris, MNIST), proficiency in using machine learning libraries (e.g., scikit-learn, TensorFlow).

Course Outcome:

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

Course Code	**Course Title**	**Credits**
PSCS612	**Deep Learning Practical**	**02**
Note: All the Practical's should be implemented using Python and TensorFlow. Link:Python :https://www.python.org/downloads/ TensorFlow :https://www.tensorflow.org/install		
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. 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.	

Programme Name: M.Sc. Computer Science Semester IV	**Course Name: Big Data Analytics**
Total Credits: 04	**Total Marks: 100**
College assessment: 50	**University assessment: 50**

Prerequisite: Basic knowledge of programming and Python, understanding of data structures and algorithms, familiarity with probability and statistics.

Course Outcome:

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

Course Code	Course Title	Total Credits
PSCS613	**Big Data Analytics**	**04**
MODULE I **Unit 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. **Unit 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.		**02**
MODULE II **Unit 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		**02**

Unit 4: Tools for Data Analytics 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.	

Text Books:

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

Programme Name: M.Sc. Computer Science Semester IV	**Course Name:** Big Data Practical
Total Credits: 02	**Total Marks: 50**
	University assessment: 50

Prerequisite: Basic knowledge of programming and Python, understanding of data structures and algorithms, familiarity with probability and statistics.

Course Outcome:

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

Course Code	Course Title	Credits
PSCS614	**Big Data Analytics Practical**	**02**
Note: - The following set of Practical can be performed using any Python Libraries for NLP such as NLTK, spaCy, genism: Link:-https://www.python.org/downloads/		
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.	
	Write a Pig Script for solving counting problems.	
9	Use Flume and transport the data from the various sources to a centralized data store	
10	Installing and setting environment variables for Working with Apache Hadoop	

ELECTIVES

Programme Name: M.Sc. Computer Science Semester IV	**Course Name:** Trends in Cloud Computing
Total Credits: 02	**Total Marks: 50**
College assessment: 25	**University assessment: 25**

Prerequisite: Basic concepts of Virtualization

Course outcomes:

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

Course Code	Course Title	Total Credits
PSCS616a	**Trends in Cloud Computing**	**02**
MODULE I **Unit 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 **Unit 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		**02**

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	

Text Books:

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

Programme Name: M.Sc. Computer Science Semester IV	**Course Name:** Trends in Cloud Computing Practical
Total Credits: 02	**Total Marks: 50**
	University assessment: 50

Course Code	**Course Title**	**Credits**
PSCSP616a	**Trends in Cloud Computing Practical**	**02**
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	

Programme Name: M.Sc. Computer Science Semester IV	**Course Name:** Remote Sensing and GIS
Total Credits: 02	**Total Marks: 50**
College assessment: 25	**University assessment: 25**

Prerequisite: Basic electronics knowledge (components, microcontrollers), understanding of wireless sensor networks, familiarity with IoT concepts and architectures.

Course Outcome:

- Understand basic of remote sensing
- Learn techniques used in GIS applications

Course Code	Course Title	Total Credits
PSCS616b	**Remote Sensing & GIS**	**04**
MODULE I **Unit 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**,** GPS- Coordinate and time systems, Satellite orbital motions, GPS observables, Estimation procedures **Unit 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. GIS Operation Layers and Operations.		**02**

Text Books:

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
5. Scientists, I.R. Robinson, Ellis Horwood series marine sciences.

Programme Name: M.Sc. Computer Science Semester IV	**Course Name: Remote Sensing and GIS Practical**
Total Credits: 02	**Total Marks: 50**
College assessment: 25	**University assessment: 25**

Pre requisite: Knowledge of IoT Systems

Course Outcome: -

- The course is designed to enable students, to understand and implement IoT in industry.
- Design and executive projects in IoT with Automatic Identification and Data Capture.

Course Code	Course Title	Credits
PSCSP616b	**Remote Sensing and GIS Practical**	**02**
Note: - The following set of practicals should be implemented in CodeVisionAVR, Proteus8, Cisco Packet Tracer, Keli V5, Python Link: -Python:https://www.python.org/downloads/ CodeVisionAVR :https://www.codevision.be/ Proteus8:https://www.labcenter.com/downloads/ Cisco Packet Tracer:https://www.netacad.com/courses/packet-tracer Keli V5: https://www.keil.com/download/		
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.	

Programme Name: M.Sc. Computer Science Semester IV	Course Name: Server Virtualization
Total Credits: 02	Total Marks: 50
College assessment: 25	University assessment: 25

Prerequisite: Basic concepts of Virtualization

Course Outcome:

- Understand and apply the Virtualization infrastructure
- Learn basic concept in network virtualization

Course Code	Course Title	Total Credits
PSCS616c	Server Virtualization	02
MODULE I **Unit 1: Virtualized IT Infrastructure: Concepts & Trends** **Virtualized IT Infrastructure: Concepts & Trends** Physical Vs Virtual IT Infrastructure, machines, Data Centres, Types of Virtualizations, 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 **Unit 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)		02

Text Books:

1. Mickey Iqbal 2010, IT Virtualization Best Practices: A Lean, Green Virtualized Data Center Approach, MC Press [ISBN: 978-1583473542]

2. Mike Laverick, VMware vSphere 4 Implementation [ISBN: 978-0071664523]

3. Jason W. McCarty, Scott Lowe, Matthew K. Johnson, VMware vSphere 4 Administration Instant Reference [ISBN: 978-0470520727]

4. Brian Perry, Chris Huss, Jeantet Fields, VCP VMware Certified Professional on vSphere 4 Study Guide [ISBN: 978-0470569610]

5. Brian Perry, Chris Huss, Jeantet Fields, VCP VMware Certified Professional on vSphere 4 Study Guide [ISBN: 978-0470569610]

6. Jason Kappel, Anthony Velte, Toby Velte, Microsoft Virtualization with Hyper-V: Manage Your Datacenter with Hyper-V, Virtual PC, Virtual Server, and Application Virtualization [ISBN: 978-0071614030]

Programme Name: M.Sc. Computer Science Semester IV	Course Name: Server Virtualization Practical
Total Credits: 02	**Total Marks: 50**
	University assessment: 50

Prerequisite: Basic understanding of virtualization

Course Outcome:

- Learn virtualization concepts
- Learn security features and application of Virtualization

Course Code	Course Title	Credits
PSCSP616c	**Server Virtualization Practical**	**02**
Note: - The following set of practical's should be implemented in Scrape, python: Link:-Python : https://www.python.org/downloads/		
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.	

Programme Name: M.Sc. Data Science Semester IV **Total Credits:** 06 **College assessment:** 75	**Course Name:** Research Project **Total Marks:** 150 **University assessment:** 75

Guidelines for Research Project Implementation in Semester – IV

Total Credits	Total Hours	Marks	
		Internal	External
06	180	75	75

Guidelines for Documentation of Research Project Implementation in Semester –IV

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:**
- **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 30 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.

Scheme of Examination for Research Project

Internal Examination

A) Continuous Internal Evaluation:

Method			**Marks**
Internal Viva 1			**40**
Implementation	**Experimental setup and results**		**Total**
20	20		40
Internal Viva 2			**35**
Analysis of the results	**Code**	**Documentation**	**Total**
10	15	10	35

External Examination

A) External Evaluation:

Method				**Marks**			
External Viva				**75**			
Introduction	**Objectives**	**Methodology**	**Implementation**	**Experimental setup and results**	**Documents**	**Viva**	**Total**
05	05	05	15	15	15	15	75

EVALUATION SCHEME

A. Evaluation for Mandatory Theory Courses (4 Credit Courses)

I. Internal Evaluation for Mandatory Theory Courses – 50 Marks

(i) Mid-Term Class Test – 30 Marks

(ii) Assignment/ Case study– 20 Marks

II. External Examination for Mandatory Theory Courses – 50 Marks

- Duration: **2 Hours**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	*Any 2 out of 4*	10
Q.2	Unit II	*Any 2 out of 4*	10
Q.3	Unit III	*Any 2 out of 4*	10
Q.4	Unit IV	*Any 2 out of 4*	10
Q.5	Unit I, II, III & IV	*Any 2 out of 4*	10

B. Evaluation for Elective Theory Courses (2 Credit Courses)

I. Internal Evaluation for Elective Theory Courses – 25 Marks

(i) Mid-Term Class Test – 15 Marks

(ii) Assignment/ Case study– 10 Marks

II. External Examination for Mandatory Theory Courses – 25 Marks

- Duration: **1 Hour**
- Theory question paper pattern:

	All questions are compulsory.		
Question	**Based on**	**Options**	**Marks**
Q.1	Unit I	*Any 2 out of 4*	10
Q.2	Unit II	*Any 2 out of 4*	10
Q.3	Unit I & II	*Any 1 out of 2*	5

C. Evaluation for Mandatory & Elective Practical Courses (2 Credit Courses)

- Each Practical Course carries 50 Marks
  - **40 marks + 05 marks (journal) + 05 marks (viva)**
- 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.**

Sign of the BOS Chairperson Dr. Jyotshna Dongardive Ad-hoc Board of Studies in Computer Science	**Sign of the Offg. Associate Dean Dr. Madhav R. Rajwade Faculty of Science & Technology**	**Sign of the Offg. Dean Prof. Shivram S. Garje Faculty of Science & Technology**