University of Mumbai

No. AAMS_UGS/ICC/2022-23/1 04

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head of the University Departments in Faculty of Science & Technology is invited to this office circular No. UG/ 36 of 2016-17 dated 30th July, 2016 relating to the M.Sc. (Computer Science) (Sem.III & IV) (CBCS).

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in **Computer Science** at its meeting held on 02nd June, 2022 and subsequently passed in the faculty and by the Board of Deans at its meeting held on 05th July, 2022 **vide** item No. 6.7 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 **vide** item No. 6.7 (R) and that in accordance therewith, the revised syllabus of M.Sc. (Computer Science) (Sem.III & IV) (CBCS), has been brought into force with effect from the academic year 2022-23. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
11th October, 2022

(Dr. Shailendra Deolankar)
I/c. REGISTRAR

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head of the University Departments in Faculty of Science & Technology.

A.C/6.7(R) /11/07/2022

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No. AAMS_UGS/ICC/2022-23/ 1 04   11th October, 2022
Copy forwarded with Compliments for information to:-
1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies Life Science,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Computer Science ,
6) The Co-ordinator, MKCL.

(Dr. Shailendra Deolankar)
I/c. REGISTRAR

py for information and necessary action :-

1. The Deputy Registrar, College Affiliations & Development Depart (CAD),
2. College Teachers Approval Unit (CTA),
3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),
4. The Deputy Registrar, Academic Appointments & Quality Assur (AAQA)
5. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),
6. The Deputy Registrar, Executive Authorities Section (EA)
   He is requested to treat this as action taken report on the conce resolution adopted by the Academic Council referred to the a circular.
7. The Deputy Registrar, PRO, Fort, (Publication Section),
8. The Deputy Registrar, Special Cell,
9. The Deputy Registrar, Fort Administration Department (FAD) Record Section,
10. The Deputy Registrar, Vidyanagari Administration Department (VAD),

Copy for information :-

1. The Director, Dept. of Information and Communication Techn (DICT), Vidyanagari,
   He is requested to upload the Circular University Website
2. The Director of Department of Student Development (DSD),
3. The Director, Institute of Distance and Open Learning (IDOL Admi Vidyanagari,
4. All Deputy Registrar, Examination House,
5. The Deputy Registrars, Finance & Accounts Section,
6. The Assistant Registrar, Administrative sub-Campus Thane,
7. The Assistant Registrar, School of Engg. & Applied Sciences, Kaly
8. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,
9. P.A to Hon'ble Vice-Chancellor,
10. P.A to Pro-Vice-Chancellor,
11. P.A to Registrar,
12. P.A to All Deans of all Faculties,
13. P.A to Finance & Account Officers, (F & A.O),
14. P.A to Director, Board of Examinations and Evaluation,
15. P.A to Director, Innovation, Incubation and Linkages,
16. P.A to Director, Department of Lifelong Learning and Extension (DLLE),
17. The Receptionist,
18. The Telephone Operator,

Copy with compliments for information to :-

19. The Secretary, MUASA
20. The Secretary, BUCTU.

University of Mumbai

Revised Syllabus for

Masters of Science (Computer Science)

Semester – III & IV

(Choice Based Credit System)

(With effect from the academic year 2022-23)

University of Mumbai

O: _____	**Title of Course**	**M.Sc. (Computer Science)**
O: _____	**Eligibility**	As per University regulations
Passing Marks		40%
Ordinances /Regulations (if, any)		As applicable for all M.Sc. Courses
No. of years/Semesters:		Two years – Four Semesters
Level:		P.G. / ~~U.G./~~ ~~Diploma / Certificate~~
Pattern:		~~Yearly~~ / Semester
Status:		~~New~~ / Revised
To be implemented from Academic Year :		From the Academic Year 2022 – 2023

Date:

Signature:
Name:
Chairman of Ad-hoc/BoS of

Signature: 03/08/2022
Dr. Anuradha Majumdar
Dean, Science and Technology

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5. SCHEME OF EXAMINATION AND DISTRIBUTION PATTERN OF MARKS

1. PREAMBLE

This syllabus is an extension of the syllabus for the semester - I and semester – II of M.Sc. Computer Science of the University of Mumbai, which came into existence in the academic year 2021-2022. As mentioned in the syllabus forthe semester I and II, the intended philosophy of the new syllabus is to meet the following guidelines:

- 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.

This syllabus for the semester - III and semester – IV has tried to continue the steps initiated in the semester- I and semester –II to meet the goals set. This proposes Four Tracks in semester-III. The student must select one paper from each track.

The Four Elective in semester- III is mentioned below:
- Data Science
- Advanced Computing
- Security
- Computer Networking

Semester- IV will have two papers which shall be conducted in ONLINE MODE. A ratio of 70:30 needs to be followed i.e. 70% percent of lectures and practicals shall be in ONLINE MODE and the remaining 30% of lectures and practicals will be conducted purely in OFFLINE MODE.

The syllabus also offers an internship with industry and project implementation in semester IV, each of which has weights equivalent to a full course. Introducing different Electives in Tracks in semester –III and offering the opportunity to choose those Electives will give the student added advantage of high-level competency in the advanced and emerging areas of computer science. This will equip the student with industry readiness as an internship in an IT or IT-related organization gives a practical exposure to what is learned and what is practiced. The strong foundation given in the core courses in different semesters will give enough confidence to the learner to face and adapt to the changing trends and requirements of industry and academia.

The syllabus prepares a strong army of budding computer science researchers. The syllabus was designed on the firm belief that focusing on student-driven research on cutting edge and

emerging trends with lots of practical experience will make the learning more interesting and stimulating. It is hoped that the student community and teacher colleagues will appreciate the thrust, direction, and treatment given in the syllabus.

2. PROGRAMME STRUCTURE

SEMESTER - III

The syllabus proposes Four Tracks with Two Electives each in semester -III with theory and practical components. Each of these courses is of Four Credits and Two credits respectively.

The following table gives the details of the Theory Courses in Semester -III.

Semester - III: Theory courses

Course Code	Course Title	No of Hours	Credit
Track-A: Advanced Computing **Select Any one from the courses listed below along with corresponding practical course**			
PSCS3011	Elective-1: Advanced Computing (Web3 Technologies)	60	04
PSCS3012	Elective-2: Advanced Computing (Trends in Cloud Computing)		
Track-B: Security **Select Any one from the courses listed below along with corresponding practical course**			
PSCS3021	Elective-1: Security (Cryptography and Cryptanalysis)	60	04
PSCS3022	Elective-2: Security (Cyber Security and Risk Assessment)		
Track-C: Computer Networking **Select Any one from the courses listed below along with corresponding practical course**			
PSCS3031	Elective-1: Computer Networking (Server and Data Centric Networking)	60	04
PSCS3032	Elective-2: Computer Networking (Wireless Networking)		
Track-D: Data Science **Select Any one from the courses listed below along with corresponding practical course**			
PSCS3041	Elective-1: Data Science (Data Visualization)	60	04
PSCS3042	Elective-2: Data Science (Big Data Analytics)		
Total Credits for Theory courses in Semester - III		**240**	**16**

Semester - III: Practical Lab courses

The syllabus proposes Four laboratory courses of 02 Credits each. As far as the practical is concerned, equal weightage similar to that of theory courses have been given in terms of the number of hours.

The following table gives the details of the Practical Courses in Semester –III

Course Code	Course Title	No of Hours	Credit
Track-A: Advanced Computing **Select Any one from the courses listed below along with corresponding practical course**			
PSCSP3011	Elective-1: Advanced Computing (Web3 Technologies)	60	02
PSCSP3012	Elective-2: Advanced Computing (Trends in Cloud Computing)		
Track-B: Security **Select Any one from the courses listed below along with corresponding practical course**			
PSCSP3021	Elective-1: Security (Cryptography and Cryptanalysis)	60	02
PSCSP3022	Elective-2: Security (Cyber Security and Risk Assessment)		
Track-C: Computer Networking **Select Any one from the courses listed below along with corresponding practical course**			
PSCSP3031	Elective-1: Computer Networking (Server and Data Centric Networking)	60	02
PSCSP3032	Elective-2: Computer Networking (Wireless Networking)		
Track-D: Data Science **Select Any one from the courses listed below along with corresponding practical course**			
PSCSP3041	Elective-1: Data Science (Data Visualization)	60	02
PSCSP3042	Elective-2: Data Science (Big Data Analytics)		
Total Credits for Theory courses in Semester - III		**240**	**08**

SEMESTER - IV

The syllabus proposes Two subjects in Semester – IV, and each subject has a Theory and Practical components. In addition, there will be an Internship with Industry and Project Implementation.

The following table gives the details of the Theory Courses in Semester - IV.

Semester - IV: Theory courses

Course Code	Course Title	No of Hours	Credit
PSCS401	Robotics (Online Mode)	60	04
PSCS402	Advanced Deep Learning (Online Mode)	60	04
Total Credits for Theory courses in Semester - IV		**120**	**08**

Semester - IV: Practical Lab courses

The syllabus proposes Two laboratory courses of 2 Credits each. As far as the practical is concerned, equal weightage similar to that of Theory courses have been given in terms of the number of hours.

The following table summarizes the details of the Practical Courses in the Semester-IV

Course Code	Course Title	No of Hours	Credit
PSCSP401	Robotics (Online Mode)	60	02
PSCSP402	Advanced Deep Learning (Online Mode)	60	02
Total Credits for Practical courses in Semester - IV		**120**	**04**

Internship with industry

The syllabus proposes an internship for about 8 weeks to 12 weeks to be done by a student. It is expected that a student chooses an IT or IT-related industry and formally works as a full-time intern during the period. The student should subject himself/herselfto an internship evaluation with proper documentation of the attendance and the type of work he or she has done in the chosen organization. Proper certification (as per the guidelines given in Appendix 1 and 2) by the person, to whom the student was reporting, with Organization's seal should be attached as part of the documentation.

Course Code	Course Title	No of Hours	Credit
PSCSP403	Internship with Industry	300	06

Project Implementation

The syllabus proposes project implementation as part of the semester–IV. The student is expected to submit the proposal and implement the same in the semester–IV. In addition, experimental setup, analysis of results, comparison with results of related works, conclusion, and prospects will be part of the project implementation. A student is expected to make a project implementation report and appear for a project viva. He or she needs to spend around 200 hours for the project implementation, which fetches 6 credits. The details are given below:

Course Code	Course Title	No of Hours	Credit
PSCSP404	Project Implementation	200	06

3. DETAILED SYLLABUS FOR SEMESTER - III & SEMESTER - IV

SEMESTER- III

Course Code	Course Title	Credits
PSCS3011	Elective-1: Advanced Computing (Web3 Technologies)	04

Course Outcome: -

- To cover the technical aspects of cryptocurrencies, blockchain technologies, and distributed consensus.
- To familiarize potential applications for Bitcoin-like cryptocurrencies
- To Basics of smart contracts, decentralized apps, and decentralized anonymous organizations (DAOs)
- To know Solidity programming

Course Specific Outcome: -

- Understand blockchain technology.
- Develop blockchain-based solutions and write smart contracts using Hyperledger Fabric and Ethereum frameworks.
- Build and deploy blockchain applications for on-premise and cloud-based architecture.
- Integrate ideas from various domains and implement them using blockchain technology from different perspectives.

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	**15L**
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	**15L**
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	**15L**
UNIT 4: Solidity Programming (Skill Enhancement) **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.	**15L**

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.

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.

Course Code	Course Title	Credits
PSCSP3011	**Practical Course on Elective-1: Advanced Computing (Web3 Technologies)**	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 Build a web app that uses Hyperledger Fabric to track and trace member rewards
6	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 resultsand data in the starter plan
7	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
8	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
9	Develop a voting application using Hyperledger and Ethereum. Build a decentralized app that combines Ethereum's Web3 and Solidity smart contracts with Hyperledger's hosting Fabric and Chaincode EVM
10	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

Course Code	Course Title	Credits
PSCS3012	**Elective-2: Advanced Computing (Trends in Cloud Computing)**	**04**

Course Outcome: -

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

Course Specific Outcome: -

- Design, develop & deploy real-world applications in the cloud computing platforms
- Demonstrate the ability to access the various cloud platforms
- Describe the standardization process of the cloud platform and various API's used in Cloud Computing
- Describe the methods for managing the data in the cloud
- Analyze and use of an appropriate framework and APIs for the task
- Design dashboards for management across cloud-based service

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	**15L**
UNIT 2: Cloud Service Delivery Environment and API **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	**15L**

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 3: 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	**15L**
UNIT 4: Azure & GCP Essentials (Skill Enhancement) **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 clouds	**15L**

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

REFERENCE BOOKS:

1. JJ GEEWAX, Google Cloud Platform in Action, Manning Publications Co, 2018
2. Haishi Bai, Dan Stolts, Santiago Fernández Muñoz, Exam Ref 70-535 Architecting Microsoft Azure Solutions, Pearson Education, 2018
3. Dr. Kumar Saurabh, Cloud Computing, 4ed: Architecting Next-Gen Transformation Paradigms, Wiley, 2017

Course Code	Course Title	Credits
PSCSP3012	**Practical Course on Elective-2: Advanced Computing (Trends in Cloud Computing)**	**02**

Note: Learners are expected to create free accounts with various Cloud Computing providers and try to explore different technologies.

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

Course Code	Course Title	Credits
PSCS3021	Elective-1: Security (Cryptography and Cryptanalysis)	04

Course Outcome: -

- To develop the foundation for the study of cryptography and its use in security.
- To understand the application of Number Theory and Algebra for the design of cryptographic algorithms
- To understand the role of cryptography in communication over an insecure channel.
- To analyze and compare symmetric-key encryption and public-key encryption schemes based on different security models

Course Specific Outcome: -

- Insights related to cryptography and cryptanalysis.
- Analyze and use methods for cryptography.
- Implement some of the prominent techniques for public-key cryptosystems and digital signature schemes
- Understand the notions of public-key encryption and digital signatures and sketch their formal security definitions.

UNIT 1: Classic Cryptography Techniques **Cryptosystems and Basic Cryptographic Tools:** Introduction, Secret-key Cryptosystems, Public-key Cryptosystems, Block and Stream Ciphers, Hybrid Cryptography, Hybrid Cryptography, Message Integrity, Message Authentication Codes, Signature Schemes, Nonrepudiation, Certificates, Hash Functions, Cryptographic Protocols, Security **Classical Cryptography:** Introduction to Some Simple Cryptosystems, Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Ciphers, Cryptanalysis, Cryptanalysis of the Affine Cipher, Cryptanalysis of the Substitution Cipher, Cryptanalysis of the Vigenere Cipher, Cryptanalysis of the Hill Cipher, Cryptanalysis of the LFSR Stream Cipher. **Perfect Secrecy:** Introduction, Perfect Secrecy, Entropy, Properties of Entropy, Spurious Keys, and Unicity Distance	**15L**
UNIT 2: Advanced Encryption, Integrity, and Authentication **Block Ciphers and Stream Ciphers:** Substitution-Permutation Networks, Linear Cryptanalysis, Differential Cryptanalysis, Data Encryption Standard, Advanced Encryption Standard, Modes of Operation, Stream Ciphers **Hash Functions and Message Authentication:** Hash Functions and Data Integrity, Security of Hash Functions, Iterated Hash Functions, Sponge Construction, Message Authentication Codes, Unconditionally Secure MACs	**15L**

RSA Cryptosystem and Factoring: Public-key Cryptography, Number Theory-Euclidean Algorithm, Chinese Remainder Theorem, Other Useful Facts, RSA Cryptosystem, Primality Testing, Square Roots Modulo n, Factoring Algorithms, Rabin Cryptosystem, Semantic Security of RSA	
UNIT 3: Public-Key Cryptography and Identity Verification **Public-Key Cryptography and Discrete Logarithms:** Introduction, ElGamal Cryptosystem, Shanks' Algorithm, Pollard Rho Discrete Logarithm Algorithm, Finite Fields, Elliptic Curves, Discrete Logarithm Algorithms in Practice, Security of ElGamal Systems **Signature Schemes:** Introduction to RSA Signature Scheme, Security Requirements, ElGamal Signature Scheme, Variants of the ElGamal Signature Scheme, Full Domain Hash, Certificates, Signing and Encrypting **Identification Schemes and Entity Authentication:** Passwords and Secure Identification Schemes, Challenge-and-Response in the Secret-key Setting, Challenge-and-Response in the Public-key Setting, Schnorr Identification Scheme, Feige-Fiat-Shamir Identification Scheme	**15L**
UNIT 4: Key Management (Skill Enhancement) **Key Distribution:** Attack Models and Adversarial Goals, Diffie-Hellman Key Predistribution, Blom Scheme, Key Predistribution in Sensor Networks, Session Key Distribution Schemes-Needham-Schroeder Scheme, Kerberos, Threshold Schemes-Shamir Scheme **Key Agreement Schemes:** Transport Layer Security (TLS), , Diffie-Hellman Key Agreement, Known Session Key Attacks, Key Derivation Functions, MTI Key Agreement Schemes, Deniable Key Agreement Schemes, Conference Key Agreement Schemes **Other Security Issues:** Cocks Identity-based Cryptosystem, Copyright Protection, Fingerprinting, Identifiable Parent Property, 2-IPP Codes, Tracing Illegally Redistributed Keys	**15L**

TEXTBOOKS:

1. Cryptography Theory and Practice Douglas R. Stinson, , Fourth Edition, CRC Press, 2019
2. Applied Cryptanalysis, Breaking Ciphers in Real World, John Wiley, 2015

REFERENCE BOOKS:

1. Implementing Cryptography, Shannon W. Bray, John Wiley, 2020
2. Algorithmic Cryptanalysis, Antoine Joux, CRC Press, 2017
3. Modern Cryptography: Applied Mathematics for- Encryption and Information Security, William Easttom, Springer, 2021

Course Code	Course Title	Credits
PSCSP3021	**Practical on Elective-1: Security (Cryptography and Cryptanalysis)**	**02**

	Note: The practical can be performed in C/C++/Java/Python
1	Program to implement password salting and hashing to create secure passwords.
2	Program to implement various classical ciphers-Substitution Cipher, Vigenère Cipher, and Affine cipher
3	Program to demonstrate cryptanalysis (e.g., breaking Caesar or Vigener Cipher)
4	Program to implement AES algorithm for file encryption and decryption
5	Program to implement various block cipher modes
6	Program to implement Steganography for hiding messages inside the image file.
7	Program to implement HMAC for signing messages.
8	Program to implement Sending Secure Messages Over IP Networks
9	Program to implement RSA encryption/decryption
10	Program to implement (i) El-Gamal Cryptosystem (ii) Elliptic Curve Cryptography

Course Code	Course Title	Credits
PSCS3022	Elective-2: Security (Cyber Security and Risk Assessment)	04

Course Outcome: -

- Learn about an advanced concept related to penetration testing
- Use of 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 Specific Outcome: -

- Develop skills to use kali Linux for penetration testing
- Use open-source tools for Reconnaissance
- Perform vulnerability assessment using popular tools
- Learn about advanced ways to exploit web apps and cloud security
- Apply techniques for privilege escalation and use exploitation tools.

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	**15L**
UNIT 2: Vulnerabilities and Advanced Attacks **Vulnerability Assessment:** Local and online vulnerability databases, Vulnerability 8scanning with Nmap, Web application vulnerability scanners, Vulnerability scanners for mobile applications, OpenVAS network vulnerability scanner, Commercial vulnerability scanners, Specialized scanners, Threat modeling	**15L**

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

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	**15L**
UNIT 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	**15L**

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, 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

Course Code	Course Title	Credits
PSCSP3022	**Practical Course on Elective-2: Security (Cyber Security and Risk Assessment)**	**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	Wireless Network threats (sniff wifi hotspots, analyze strength, discover wireless access points)

Course Code	Course Title	Credits
PSCS3031	**Elective-1: Computer Networking (Server and Data-Centric Networking)**	**04**

Course Outcome:

- Identify important requirements to design and support a data center.
- Determine a data center environment's requirements including systems and network architecture as well as services.
- Evaluate options for server farms, network designs, high availability, load balancing, data center services, and trends that might affect data center designs.

- Design a data center infrastructure integrating features that address security, performance, and availability.

Course Specific Outcome:

- Learners will be able to know basic concepts of Server and Data-Centric Networking
- Learners will be able to know about the infrastructure of Data Centers.
- Learners will be able to know about the security measures of Data Centers.
- Learners will be able to know about network designing and virtualization.

UNIT 1: Virtualization History and Definitions **Data Center:** Essential Definition, Data Center Evolution, thernet Protocol, The Humble Beginnings of Network Virtualization,Resource Sharing Control and Management Plane, Concepts from the Routing World, Overlapping Addresses in a Data Center **Virtual Routing and Forwarding:**Defining and Configuring VRFs, VRFs and Routing Protocols, VRFs and the Management Plane VRF-Awareness, VRF Resource Allocation Control, Use Case: Data Center Network Segmentation	**15L**
UNIT 2: ACE Virtual Contexts **Application Networking Services:** The Use of Load Balancers, Load-Balancing Concepts, Security Policies, Suboptimal Traffic, Application Environment Independency, ACE Virtual Contexts, Application Control Engine Physical Connections, Connecting an ACE Appliance, Bridged Design, One-Armed Design, **Managing and ConfiguringACE:** Virtual Contexts, Allowing Management Traffic to a Virtual Context, Allowing Load Balancing Traffic Through a Virtual Context, Controlling Management Access to Virtual Contexts, ACE Virtual Context Additional Characteristics, Sharing VLANs Among Contexts, Virtual Context Fault Tolerance, Instant Switches, MPLS Basic Concepts	**15L**
UNIT 3: Virtualization in Server Technologies **Server virtualization:** Operational Policies, Configuration, External IPMI Management Configuration, Management IP Address, The Virtual Data Center and Cloud Computing, The Virtual Data Center **Automation and Standardization:**Cloud Implementation Example, Journey to the Cloud, Networking in the Clouds, Software-Defined Networks, OpenStack, Network Overlays	**15L**
UNIT 4: Intelligent Disk Subsystems (Skill Enhancement)	**15L**

Disk Subsystem: The architecture of Intelligent Disk Subsystems Hard Disks and Internal I/O Channels JBOD: The Physical I/O Path from the CPU to the Storage System, SCSI, Fibre Channel SAN, SCSI via InfiniBand and RDMA,Fibre Channel over Ethernet (FCoE) I/O Consolidation based on Ethernet,FCoE Details,Data Center Bridging (DCB), File Systems and Network Attached Storage (NAS)

File system Management: Local File Systems File systems and databases Journaling;, Snapshots Volume manager Network File Systems and File Servers, Network Attached Storage (NAS)

TEXTBOOKS:

1. Data Center Virtualization Fundamentals by Gustavo Alessandro Andrade Santana,Cisco Press, 2018
2. Storage Networks Explained Wiley Publishing, 2019

REFERENCE BOOKS:

1. Information Storage and Management Wiley Publishing, 2016
2. Storage Networks: The Complete Reference, 2019

Course Code	Course Title	Credits
PSCSP3031	**Practical Course on Elective-1: Computer Networking (Server and Data-Centric Networking)**	**02**
Note: Practical can be implemented using GNS3, CISCO packet tracer 7.0 and above		

01	Installation of - Vmware Esxi - Citrix Xen - Microsoft Hyper-V
02	Create and manage the inter connectivity of Virtual Machine on - Vmware Esxi - Citrix Xen - Microsoft Hyper-V
03	Configuring Trunks between switches and VTP Pruning Suggested Topology
04	Configuring EtherChannels Suggested Topology

05	● Configure Secure DMVPN Tunnels ● Implement a DMVPN Phase 1 Hub-to-Spoke Topology ● Implement a DMVPN Phase 3 Spoke-to-Spoke Topology
06	● Implement BGP Path Manipulation ● Implement BGP Communities
07	● Control Routing Updates ● Path Control Using PBR
08	● Implement Route Redistribution Between Multiple Protocols ● Configure Route Redistribution Within the Same Interior Gateway Protocol
09	● Implement GLBP ● Implement VRRP ● Implement HSRP
10	Implement MPLS

Course Code	Course Title	Credits
PSCS3032	**Elective-2: Computer Networking (Wireless Networking)**	**04**

Course Outcome: -

- To understand basic concepts of wireless networking.
- To understand 4G, 5G Technologies and their working.
- To implement Wireless architecture practically.
- To gain knowledge about sensors and their working.

Course Specific Outcome: -

- Learners will be able to know advanced concepts of wireless technologies and recent trends in them.
- Learners will be able to implement wireless architecture practically.
- Learners will achieve the basic knowledge required as per industry standards.
- Learners will be able to know about wireless optical communication.

UNIT 1: Basic Principles of Wireless Networking **Introduction to Wireless Sensor Networks:**Terminologies, Advantages, Challenges and Applications, Types of wireless sensor networks.	**15L**

Wireless Communication Technologies: Mobile Ad-hoc Networks (MANETs) and Wireless Sensor Networks, Enabling technologies for Wireless Sensor Networks.	
UNIT 2: Wireless Optical Communication(WOC) **Optical Communication:** Introduction to wireless optical communication (WOC), wireless optical channels, atmospheric channel, underwater optical channel, atmospheric losses **WOC and Applications:** Weather condition influence, atmospheric turbulence effects i.e. scintillation, beam spreading, etc. wireless optical communication application areas, WOC challenges and applications	**15L**
UNIT 3: Fourth Generation Systems and New Wireless Technologies **4G Vision:** 4G Features and Challenges, Applications of 4G; 4G Technologies - LTE FDD vs TDD comparison; frame structure and its characteristics; Smart Antenna Techniques, OFDM **Trends in Wireless Technology:** MIMO Systems, Adaptive Modulation and Coding with Time-Slot Scheduler - Bell Labs Layered Space Time (BLAST) System , Software-Defined Radio, Cognitive Radio	**15L**
UNIT 4: Recent Trends in Wireless Networking (Skill Enhancement) **5G Technology:** Understand 5GPP & NGMN, 5G architecture and design objective, 5G spectrum requirements, ITU-R IMT-2020 vision for 5G, 5G RAN & Dynamic CRAN **Architecture and applications:** 5G Mobile Edge Computing & Fog computing, 5G Protocol Stack, 5G Ultra-dense networks, 5G Air interface, Applications	**15L**
TEXTBOOK: 1. Anurag Kumar, D.Manjunath, Joy kuri, ―Wireless Networking‖, third Edition, Elsevier 2018.	
REFERENCE BOOKS: 1. Jochen Schiller, ‖Mobile Communications‖, Second Edition, Pearson Education 2019. 2. Vijay Garg, ―Wireless Communications and networking‖, First Edition, Elsevier 2012.	

Course Code	Course Title	Credits
PSCSP3032	**Practical Course on Elective-2: Computer Networking (Wireless Networking)**	02

Note: Practical can be implemented using GNS3, CISCO packet tracer 7.0 and above

1	Configuring WEP on a Wireless Router
2	Demonstrating Distribution Layer Functions
3	Placing ACLs
4	Planning Network-based Firewalls
5	Configure Auto Profiles ACU Utilities
6	Creating an Adhoc Network
7	Configuring Basic AP Settings
8	Configure Ethernet/Fast Ethernet Interface
9	Configure Radio Interfaces through the GUI
10	Configure Site-to-Site Wireless Link

Course Code	Course Title	Credits
PSCS3041	**Elective-1: Data Science (Data Visualization)**	04

Course Outcome: -

- Familiarity with working with data analysis tools.
- Ability to perform data wrangling for practical purposes.
- Ability to solve real-world data analysis problems with thorough, detailed examples.
- Ability to use Tableau to handle data from various sources and perform analysis of data.

Course Specific Outcome: -

- Understands the fundamentals of Visualization.

- Working with different Data Collection Structures.
- Efficiently handle various source data using Tableau.
- Data Visualization and Analysis can be performed using Tableau.
- Handling and customizing Geospatial data using Tableau.
- Creating a story using the dashboard to analyze data

UNIT 1: Preparing and Storing Data **Series**: Creating a Series with index, creating a Series from a Dictionary, Creating a Series from a Scalar Value, Vectorized Operations and Label Alignment with Series, Name Attribute. Accessing Data from a Series with a Position, Exploring and Analysing a Series, Operations on a Series. **Data Frames**: Creating a Data Frame from a Dict of Series or Dicts, Creating Data Frames from a Dict of Ndarrays, Creating Data Frames from a Structured or Record Array, Creating Data Frames from a List of Dicts, Creating Data Frames from a Dict of Tuples, Selecting, Adding, and Deleting Data Frame Columns, Assigning New Columns in Method Chains, Row Selection, Row Addition, Row Deletion, Exploring and Analysing a Data Frame, Indexing and Selecting Data Frames, Transposing a Data Frame, Data Frame Interoperability with Numpy Functions. **Visualizing Data:** Data visualization in Business Intelligence, Data visualization techniques. Data visualization libraries in Python	**15L**
UNIT 2: Data Cleaning and Data Wrangling **Data Gathering and Cleaning:** Cleaning Data, Checking for Missing Values, Handling the Missing Values, Reading and Cleaning CSV Data, Merging and Integrating Data, Reading Data from the JSON Format, HTML Format, XML Format. **Data Transformation Removing Duplicates:** Replacing Values, Renaming Axis Indexes **Hierarchical Indexing:** Reordering and Sorting Levels Summary' Statistics by Level Indexing with a DataFrame's columns. Combining and Merging Datasets Database-Style, DataFrame Joins Merging on Index Concatenating Along with an Axis Combining Data with Overlap **Reshaping and Pivoting:** Reshaping with Hierarchical Indexing Pivoting "Long" to "Wide" Format Pivoting "Wide" to "Long" Format **Statistical Analysis, Data Aggregation:** Data Grouping, Iterating Through Groups, Aggregations, Transformations, Filtration.	**15L**

UNIT 3: Basics of Tableau **Tableau:** Introduction, connecting to data, Visualizing Data using Tableau, Graphs, charts, and reports **Connecting to Data:** Connecting various data sources, Managing data source metadata, Extract Data, Filtering data. Moving beyond basic visualization. **Calculations:** Introduction to Calculation, Row-level Calculations, Aggregate calculations, parameters, Leveraging level of Detail Calculations. **Telling Data Story with Dashboards:** Designing Dashboards in tableau, Designing for different displays and devices.	**15L**
UNIT 4: Data Visualization (Skill Enhancement) **Trend Visualization:** Trend Models, Analysing Trend Models. Clustering, Distributions, and Forecasting, Different Charts and Visualization. **Dynamic Dashboards:** Sheet Swapping, Automatically Showing and hiding controls. **Exploring Mapping and Advanced Geospatial Features:** Rendering maps with Tableau. Using Geospatial Data Creating custom territories. **Structuring Messy Data to Work Well in Tableau:** Structuring data for Tableau. **Taming data with Tableau Prep:** Cleaning, Transforming, Filtering, and Calculating data. Sharing Data story.	**15L**

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.

REFERENCE BOOKS:
1. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly, 2017
2. Visual Data Storytelling with Tableau, Linda Ryan, Pearson Addison Wesley Data & Analytics Series, 2018
3. Visual Analytics with Tableau, Alexander Loth, Wiley, 2019

Course Code	Course Title	Credits
PSCSP3041	**Practical Course on Elective-1: Data Science (Data Visualization)**	**02**

Note: Practical can be implemented using Python / R studio.

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 CSV files 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.

Course Code	Course Title	Credits
PSCS3042	**Elective-2: Data Science (Big Data Analytics)**	**04**

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 Specific Outcome: -

- Understands big data and the technologies associated with it.
- Identify Big Data and its Business Implications.
- List and understands the components of Hadoop and the Hadoop Ecosystem.
- Understands Map-Reduce Technology and its applications.
- Understands handling of data using Spark Technology.
- Understands the Hive, Sqoop, and Pig Technology.

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 DataAnalytics, Need of big data frameworks, Types and Sources of Big Data.Exploring the Use of Big Data in Business Context

Hadoop Framework: Requirement of Hadoop Framework, Design principle of Hadoop, Hadoop Components, Hadoop Ecosystem, Hadoop 2 architecture, Hadoop YARN Architecture, Advantage of YARN, YARN Command. HDFS: Design of HDFS, Benefits and Challenges, HDFS Commands.

15L

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.

15L

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.	**15L**
UNIT 4: Tools for Data Anlytics (Skill Enhancement) **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.	**15L**

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

REFERENCE BOOKS:
1. Big Data in Practice: How 45 Successful Companies Used Big Data Analytics to Deliver Extraordinary Results, Wiley, 1st edition, 2016
2. Hadoop – TheDefinitive Guide by Tom White, OReilly, 2012
3. Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data, McGrawHill, 2012
4. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Michael Minelli, Wiley, 2013

Course Code	Course Title	Credits
PSCSP3042	**Practical Course on Elective-2: Data Science (Big Data Analytics)**	**02**

Note: Following practical can be performed on Windows or Linux

1	Installing and setting environment variables for Working with Apache Hadoop.
2	Implementing Map-Reduce Program for Word Count problem,
3	Download and install Spark. Create Graphical data and access the graphical data using Spark.
4	Write a Spark code for the given application and handle error and recovery of data.
5	Write a Spark code to Handle the Streaming of data.
6	Install Hive and use Hive Create and store structured databases.
7	Install HBase and use the HBase Data model Store and retrieve data.
8	Perform importing and exporting of data between SQL and Hadoop using Sqoop.
9	Write a Pig Script for solving counting problems.
10	Use Flume and transport the data from the various sources to a centralized data store.

SEMESTER – IV

Course Code	Course Title	Credits
PSCS401	**Robotics (Online Mode)**	**04**

Course Outcome: -

- Leverage the features of the Raspberry Pi OS
- Discover how to configure a Raspberry Pi to build an AI-enabled robot

- Interface motors and sensors with a Raspberry Pi
- Code robot to develop engaging and intelligent robot behavior
- Explore AI behavior such as speech recognition and visual processing

Course Specific Outcome: -

- Knowledge about the fundamentals of Robotics and its applications
- Ability to use Raspberry Pi for programming Robotics
- Ability to apply robotics in speech and vision problems

UNIT 1: Introduction to Robotics **Introduction to Robotics:** What is a robot? Examples of Advanced and impressive robots, Robots in the home, Robots in industry **Robotics in Action:** Exploring Robot Building Blocks - Code and Electronics Technical requirements, Introducing the Raspberry Pi - Starting with Raspbian Technical requirements, Raspberry Pi controller on a robot	**15L**
UNIT 2: Building Robot Basics **Technical requirements**: Robot chassis kit with wheels and motors, a motor controller, Powering the robot, Test fitting the robot, Assembling the base. **Robot Programming:** Programming technique, adding line sensors to our robot, creating line-sensing behavior, and Programming RGB Strips in robot.	**15L**
UNIT 3: Servo Motors Use and control of servo motors, pan, and tilt mechanism.Distance sensors, Introduction to distance sensors and their usage Connecting distance sensors to robot and their testing. Creating a smart object avoidance behavior. Creating a menu to select different robot behaviors, Distance and speed measuring sensors—encoders and odometry	**15L**
UNIT 4: Robot Vision and Voice Communication (Skill Enhancement) **Robotics setup:** Setting up a Raspberry Pi Camera on the robot (software and hardware), Check the robot vision on a phone or laptop, Mask images with RGB strips	**15L**

Robotics for Vision and Voice Applications: Colors, masking, and filtering – chasing colored objects, Detecting faces with Haar cascades, Finding objects in an image, Voice Communication with a robot

TEXTBOOKS:

1. Danny Staple, Robotics Programming, Packt Publishing, 2nd edition, Feb 2021

REFERENCE BOOKS:

1. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, Wiley, 3rd Edition, 2019
2. D. K. Pratihar, FUNDAMENTALS OF ROBOTICS. Narosa Publication, 2016
3. Lentin Joseph, Learning Robotics Using Python, Packt Publishing Ltd., May 2015

Course Code	Course Title	Credits
PSCSP401	**Practical Course on Robotics (Online Mode)**	**02**

Note: Following practical can be performed using Python and simulators, Raspberry Pi, and other hardware devices.

1	Making a Raspberry Pi headless, and reaching it from the network using WiFi and SSH.
2	Using sftp upload files from PC.
3	Write Python code to test motors.
4	Write a script to follow a predetermined path.
5	Develop Python code for testing the sensors.
6	Add the sensors to the Robot object and develop the line-following behavior code.
7	Using the light strip develop and debug the line follower robot.
8	Add pan and tilt service to the robot object and test it.
9	Create an obstacle avoidance behavior for robot and test it.
10	Detect faces with Haar cascades.
11	Use the robot to display its camera as a web app on a phone or desktop, and then use the camera to drive smart color and face-tracking behaviors.
12	Use a Raspberry Pi to run the Mycroft environment and connect it to a speaker/microphone combination

Course Code	Course Title	Credits
PSCS402	**Advanced Deep Learning (Online Mode)**	**04**

Course Outcome: -

- Understand the context and use of neural networks and deep learning
- Understand the tools and libraries for deep learning
- Have a working knowledge of neural networks and deep learning
- Explore the parameters for neural networks
- Identify emerging applications of deep learning

Course Specific Outcome: -

- Knowledge of implementing neural network architectures for deep learning.
- Skill to implement regularization and optimization of neural network
- Ability to implement advanced networks like CNN, RNN and GAN
- Implement deep learning for advanced applications like object identification, speech, and language

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	**15L**
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	**15L**

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 **Generative Adversarial Networks (GANs):**Introduction, training algorithms, Conditional GANs, applications, Deep convolutional generative adversarial networks	**15L**
UNIT 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**	**15L**

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

REFERENCE BOOKS:

1. Advanced Deep Learning with Keras, Rowel Atienza, Packt Publication, 2018
2. Python Deep Learning Cookbook, Indra den Bakker, Packt Publication, 2017
3. Deep Learning with Keras, Antonio Gulli, Packt Publication, 2017

Course Code	Course Title	Credits
PSCSP402	**Practical Course on Advanced Deep Learning (Online Mode)**	**02**

	Note: Following practical can be performed using python
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.
	
	   a. 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
	   b. LSTM for sentiment analysis on datasets like UMICH SI650 for similar.

9	Write a program for object detection from the image/video.
10	Write a program for object detection using pre-trained models to use object detection.

Course Code	Course Title	Credits
PSCSP403	**Internship with Industry**	**06**

Context:

An internship offers an environment for the student to apply what he or she has learned in the classroom in a real-world setup. It also equips the student with the technical and non-technical skills required by the industry. An organization, in turn, gets an opportunity to understand and appreciate the curriculum of the program and will be in a position to offer constructive feedback on the course and industry requirements. Faculty will get first-hand exposure to understand the industry and the type of work they do, which will help to improve the pedagogy and delivery. Internship details:

- Internship should be of 2 to 3 months with 8 to 12 weeks duration.
- The student is expected to devote at least 300 hours physically at the organization.

- The student is expected to find an internship by himself or herself. However, the institution should assist their students in getting an internship in good organizations.
- The home institution cannot be taken as the place of internship.
- Internship can be on any topic covered in the syllabus.

Interning organization: Internship can be done, in one of the following, but not restricted to, types of organizations:

- Software development firms
- Hardware/ manufacturing firms
- Any small-scale industries, service providers like banks
- Clinics/ NGOs/professional institutions like that of CA, Advocate, etc
- Civic Depts like Ward office/post office/police station/ panchayat.
- Research Centres/ University Depts/ College as research Assistants for research projects or similar capacities.

Internship mentors:

To ensure the rigor of the MSc program, a student will be provided with a faculty mentor provided by the institution and an industry mentor, to be provided by the organization where the student is interning with.

- The industry mentor ensures that the requirements of the organization and the demands of the project are done by the internee.
- The faculty mentor is the overall in charge of the internship. He or she could evaluate the quality of the internship in a uniform manner across all students and within the demand of the program.

Documentation of the internship:

The student will make two documents as part of the internship.

- **Online diary:** This ensures that the student updates daily activity, which could be accessed by both the mentors. Daily entry can be of 3- 4 sentences giving a very brief account of the learning/activities/interaction taken place. The faculty mentor will be monitoring the entries in the diary regularly.
- **Internship report:** A student is expected to make a report based on the internship he or she has done in an organization. It should contain the following:
- **Certificate**: A certificate in the prescribed Performa (given in appendix 1) from the organization where the internship was done.
- **Title**: A suitable title giving the idea about what work the student has performed during the internship.
- **Evaluation form:** The form filled by the supervisor or to whom the intern was reporting, in the prescribed Performa (given in appendix 2).
- **Description of the organization**: A small description of the organization where the student has interned
- **Description of the activities** done by the section where the intern has worked: A description of the section or cell of the organization where the intern worked. This

should give an idea about the type of activity a new employee is expected to do in that section of the organization.

- ▪ **Description of work allotted** and done by the intern: A detailed description of the work allotted, and actual work performed by the intern during the internship period. It shall be the condensed and structured version of the daily report mentioned in the online diary.
- ▪ **Self-assessment**: A self-assessment by the intern on what he or she has learned during the internship period. It shall contain both technical as well as interpersonal skills learned in the process.

The internship report needs to be submitted to the external examiner at the time of the University examination.

Interaction between mentors:
To ensure the smooth conduct of the internship a meet-up involving the intern, industry mentor, and the faculty mentor will be scheduled as a mid-term review. The meeting can preferably be online to save time and resources. The meeting ensures the synergy between all stakeholders of the internship. A typical meeting can be of around 15 minutes where at the initial stage the intern brief about the work and interaction goes for about 10 minutes. This can be followed by the interaction of the mentors in the absence of the intern. This ensures that issues between the intern and the organization, if any, are resolved amicably.

Internship workload for the faculty:
Every student is provided with a faculty member as a mentor. So, a faculty mentor will have a few students under him/her. A faculty mentor is the overall in charge of the internship of the student. He/she constantly monitors the progress of the internship by regularly overseeing the diary, interacting with the industry mentor, and guiding on the report writing etc. Considering the time and effort involved, a faculty mentor who is in-charge of 20 students shall be provided by a workload of 3 hours.

Course Code	Course Title	Credits
PSCSP404	**Project Implementation**	**06**

Guidelines for Project Implementation in Semester - IV

- ● A student is expected to devote at least 3 to 4 months of effort to the implementation.

- ● Students should submit a detailed project implementation report at the time of viva.

Guidelines for Documentation of Project Proposal in Semester –IV

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

- **Title:** Title of the project.

- **Objective:** A detailed objective of the proposal is needed.

- **Related works:** A detailed survey of the relevant works done by others in the domain. The student is expected to refer to at least 15 recent (last five years) research papers in addition to textbooks and web links in the relevant topic.

- **Methodology:** A proper and detailed procedure of how to solve the problem discussed. It shall contain the techniques, tools, software, and data to be used.

- **Implementation details:** A description of how the project has been implemented.

- **Experimental setup and results:** A detailed explanation of how experiments were conducted, what software was used, and the results obtained. Details like screenshots, tables, and graphs can come here.

- **Analysis of the results:** A description of what the results mean and how they have been arrived at. Different performing measures or statistical tools used etc may be part of this.

- **Conclusion:** A conclusion of the project performed in terms of its outcome

- **Future enhancement:** A small description of what enhancement can be done when more time and resources are available

- **Program code:** The program code may be given as an appendix.

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

4. EVALUATION

The evaluation of each paper shall contain two parts:
Internal Assessment - 40 Marks.
External Assessment - 60 Marks.
The Internal to External assessment ratio shall be **2:3.**

5. SCHEME OF EXAMINATIONS AND DISTRIBUTION PATTERN OF MARKS

Theory Examination (Semester-III)

a. **Scheme of Internal Evaluation (40 Marks)**
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 30% syllabus is completed and the second class test when an additional 70% syllabus is completed. The duration of each test shall be one hour. The test should be conducted in online mode on the LMS system in the institute's premises.

b. Scheme of External Examination (60 Marks)

The External Theory examination of all semesters shall be conducted by the University at the end of each semester.

Q.1	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.2	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.3	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.4	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.5	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**

Practical Examination (Semester-III)

a. Scheme of Internal Evaluation

There will not be any internal examination for practical courses of Semester- III.

b. Scheme of External Examination

The particulars of the external examination for each practical course of Semester- III will be of TWO hours. The details of the same are given below:

No	Semester	Course Code	Particular	No of Questions	Marks	Total Marks
1	III	PSCSP3011 / PSCSP3012	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	
2		PSCSP3021/ PSCSP3022	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	
3		PSCSP3031/ PSCSP3032	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	
4		PSCSP3041/ PSCSP3042	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	

Theory Examination (Semester-IV)

a. Scheme of Internal Evaluation (40 Marks)

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and the second class test when an additional 40% syllabus is completed. The duration of each test shall be one hour. The test should be conducted in online mode on the LMS system on the institute's premises.

b. Scheme of External Examination (60 Marks)
The External Theory examination of all semesters shall be conducted by the University at the end of each semester.

Q.1	Attempt **<u>any two</u>** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.2	Attempt **<u>any two</u>** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.3	Attempt **<u>any two</u>** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**
Q.4	Attempt **<u>any two</u>** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**

Q.5	Attempt **any two** of the following	**(12)**
a)		**6**
b)		**6**
c)		**6**
d)		**6**

Practical Examination (Semester-IV)

a. Scheme of Internal Evaluation

There will not be any internal examination for practical courses of Semester- IV.

Sr. No.	Semester	Course Code	Particulars		Marks	Total Marks
1.	IV	PSCSP403	Internship with Industry	Online diary	30	60
				Mid-term interaction	30	
2.	IV	PSCSP404	Project Implementation	Documentation	30	60
				Presentation	30	

b. Scheme of External Examination

The particulars of the external examination for each practical course of Semester- IV will be of TWO hours. The details of the same are given below:

No	Semester	Course Code	Particular	No of Questions	Marks	Total Marks
1.	IV	PSCSP401	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	
2.		PSCSP402	Laboratory experiment question with internal choice	02	40	50
			Journal		05	
			VIVA		05	

3.		PSCSP403	Quality & Relevance		40	90
			Internship VIVA		50	
4.		PSCSP404	Quality & Relevance		40	90
			Project VIVA		50	

Guidelines of Journals:

A student should maintain a Journal with Practical experiments reported for each of the practical courses of Semester- III and Semester - IV. Related theories/algorithms need to be explained in a journal.

Certified Journal with at least 70% of the list of the Practical need to be submitted at the time of the practical examination.

Appendix-I

(Proforma for the certificate for internship in official letter head)

This is to certify that Mr/Ms_____ of _____College/Institution worked as an intern as part of his/her M.Sc. course in Computer Science of University of Mumbai. The particulars of internship are given below:

Internship starting date: _____

Internship ending date: _____

Actual number of days worked: _____

Tentative number of hours worked: _____ Hours

Broad area of work: _____

A small description of work done by the intern during the period:

_____
_____

Signature: _____

Name: _____

Designation: _____

Contact number: _____

Email: _____

Appendix-II

(Proforma for the Evaluation of the intern by the industry mentor /to whom the intern was reporting in the organization)

Professional Evaluation of intern

Name of intern: _____

College/institution: _____

[Note: Give a score in the 1 to 5 scale by putting √ in the respective cells]

No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming etc					
7	Ability to complete the task					
8	Quality of overall work done					

Comments: _____

_____

Signature: _____

Name: _____

Designation: _____

Contact number: _____

Email: _____

(Seal of the organization)

Appendix-III

Maintain the weekly online diary for each week in the following format.

	Day	Date	Name of the Topic/Module Completed	Remarks
WEEK No	MONDAY			
	TUESDAY			
	WEDNESDAY			
	THRUSDAY			
	FRIDAY			
	SATURDAY			

Signature of the Faculty mentor: _____

Seal of the University/College

----xxxx----