University of Mumbai

No. AAMS(UG)/ 90 of 2021-22

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, the Head of the University Departments and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to the syllabus uploaded by Academic Authority Meetings and Services which was accepted by the Academic Council at its meeting held on 10th February, 2012 **vide** item No. 4.43 the syllabus for the M.Sc. Part- I – Computer Science (CBSGS).

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Computer Science at its meeting held on 21st June, 2021 and subsequently passed by the Board of Deans at its meeting held on 28th June, 2021 vide item No. 6.40 (R) have been accepted by the Academic Council at its meeting held on 29th June, 2021 vide item No. 6.40 (R) and that in accordance therewith, the revised syllabus as per the (CBSGS) for the M.Sc. Computer Science – (Sem I &II) has been brought into force with effect from the academic year 2021-22 accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
30th September, 2021

(Dr. B.N.Gaikwad)
I/c REGISTRAR

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

A.C/6.40 (R) 29/06/2021

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No. AAMS(UG)/ 90 -A of 2021-22   MUMBAI-400 032   30th September, 2021

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Computer Science,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre,

(Dr. B.N.Gaikwad)
I/c REGISTRAR

Copy to :-
1. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
2. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
5. **The Deputy Registrar, Executive Authorities Section (EA),**
6. **The Deputy Registrar, PRO, Fort, (Publication Section),**
7. **The Deputy Registrar, (Special Cell),**
8. **The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
9. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **P.A to Hon'ble Vice-Chancellor,**
2. **P.A Pro-Vice-Chancellor,**
3. **P.A to Registrar,**
4. **All Deans of all Faculties,**
5. **P.A to Finance & Account Officers, (F.& A.O),**
6. **P.A to Director, Board of Examinations and Evaluation,**
7. **P.A to Director, Innovation, Incubation and Linkages,**
8. **P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
9. **The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
10. **The Director of Board of Student Development,**
11. **The Director, Department of Students Walfare (DSD),**
12. **All Deputy Registrar, Examination House,**
13. **The Deputy Registrars, Finance & Accounts Section,**
14. **The Assistant Registrar, Administrative sub-Campus Thane,**
15. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
16. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
17. **The Assistant Registrar, Constituent Colleges Unit,**
18. **BUCTU,**
19. **The Receptionist,**
20. **The Telephone Operator,**
21. **The Secretary MUASA**

for information.

UNIVERSITY OF MUMBAI

Syllabus
For the
Program: M.Sc. SEM-I & II CBCS
(REVISED)

Course: Computer Science

(Choice Based and Credit System with effect from the academic year 2021-22)

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1.	Title of the Course	**M.Sc. (Computer Science)**
2.	Eligibility for Admission	Circular No: No. PG/ Univ./VCD/ ICC / 2012-13/ 8, B.E/B.Sc. (Computer Science) / BCS / B.Sc. (I.T.) / B.sc. (Maths) / B.Sc. (Phy) with ancillary mathematics/ B.Sc. (Stats) with ancillary mathematics
3.	Passing Marks	40%
4.	Ordinances / Regulations (if, any)	As applicable for all M.Sc. Courses
5.	Number of years / Semesters	Two years – Four Semesters
6.	Level	P.G./ U.G. /Diploma / Certificate (Strike out which is not applicable)
7.	Pattern	Yearly / Semester, Choice Based (Strike out which is not applicable)
8.	Status	New /Revised
9.	To be implemented from Academic year	From the Academic Year **2021 – 2022**

Date: 28/06/2021

Dr. Jagdish Bakal   **Dr. Anuradha Majumdar**
BoS Chairperson in Computer Science   **Dean, Science and Technology**

CONTENTS

1. PREAMBLE

2. PROGRAM OUTCOME

3. PROGRAMME STRUCTURE

4. DETAILED SYLLABUS FOR SEMESTER - I & SEMESTER - II

5. EVALUATION

6. SCHEME OF EXAMINATIONS AND DISTRIBUTION PATTERN OF MARKS

1. PREAMBLE

M.Sc. in Computer Science is a two-year post-graduate programme with the objective to develop human resources with core competence in various thrust areas of Computer Science. It will provide students with opportunities to develop and hone core competency in the field of computer science and encourage them to make a mark in the much sought-after IT industry.

The Syllabus of this Course creates a unique identity for M.Sc. in Comp Science distinct from similar degrees in other related subjects, focuses on core Computer Science subjects, incorporate advanced and most recent trends, Identify and nurture research temper among students, Offer provision for internship with industry and Focus, as far as possible, only on open-source software

The syllabus for the semester I and semester II has tried to initiate steps to meet these goals. By extending the syllabus to semester III and semester IV, it is assumed that these goals will be met to a larger extent. The syllabus proposes to have four core compulsory courses in Semester I and Semester II. UNIT -1 of Paper I of Semester - I and Semester - II are ABILITY ENHANCEMENT UNITS and UNIT- 4 of all papers of Semester - I and Semester - II is SKILL ENHANCEMENT UNIT. Semester III and Semester IV proposes electives courses based on a recent and emerging area. Inclusion of Project as part of the internal assessment is an attempt to translate theory into practice. It is assumed that, with this back ground, a student can take up challenging research project in the semester III and semester IV and will be better fit for industry as he or she will have strong foundation on fundamentals and exposure to advanced and emerging trends.

We thank all the industry experts, senior faculties and our colleague's department of Computer Science of different colleges as well as University of Mumbai; who have given their valuable comments and suggestions, which we tried to incorporate. We thank the Chairperson and members of the Ad-hoc Board of Studies in Computer Science of University for their faith in us. Thanks to one and all who have directly or indirectly helped in this venture.

2. PROGRAM OUTCOMES

The M. Sc. Computer Science programme is designed to help the students to:

● To be fundamentally strong at core subject of Computer Science.

● To apply programming and computational skills for industrial solutions.

● Broad understanding of latest technological trends.

● To identify opportunities for establishing an enterprise for immediate Employment.

● Able to understand and apply fundamental research concepts.

● Able to use efficient soft skills for professional development.

● Engage in independent and life-long learning for continued professional development.

3. PROGRAMME STRUCTURE

A	Programme Duration	Four Semester (2 Years)
B	**Total Credits required for Successful Completion**	**96**
C	**Credits required from Core Courses**	**42**
D	**Credits required for the Ability Enhancement Courses**	**02**
E	**Credits required for the Skill Enhancement Courses**	**12**
F	**Credits required for the Practical Course**	**28**
G	**Project**	**06**
H	**Internship**	**06**
I	**Minimum Attendance per Semester**	**75%**

This is the syllabus for the Semester-I and Semester-II of M.Sc. Computer Science program of University of Mumbai to be implemented from the year 2021-22. The Syllabus offers four Theory Courses and Four Practical Courses each in each Semester.

SEMESTER - I

The syllabus proposes four subjects in Semester -I. Each subject has Theory and Practical components. Each of these Courses is of Four Credits each and is expected to complete in 60 hours.

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

Semester - I: Theory courses

Course Code	Course Title	No of Hours	Credit
PSCS101	Algorithm for Optimization	60	04
PSCS102	Software Defined Networking	60	04
PSCS103	Applied Signal and Image Processing	60	04
PSCS104	Advanced Database Techniques	60	04
Total Credits for Theory courses in Semester-I			16

Semester - I: Practical Lab courses

The syllabus proposes Four Laboratory courses of 2 Credits each. As far as the Practical are concerned, equal weightage similar to that of Theory courses has been given in terms of the number of hours.

The following table gives the details of the Practical Courses in Semester -I

Course Code	Course Title	No of Hours	Credit
PSCSP101	Algorithm for Optimization	60	02
PSCSP102	Software Defined Networking	60	02
PSCSP103	Applied Signal and Image Processing	60	02
PSCSP104	Advanced Database Techniques	60	02
Total Credits for Practical courses in Semester-I			08

SEMESTER - II

The Syllabus proposes four subjects in Semester - II also. As in the case of Semester-I, each subject has theory and practical components. Each of these courses is of Four Credits and Two credits respectively and is expected to complete in 60 hours.

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

Semester - II: Theory courses

Course Code	Course Title	No of Hours	Credit
PSCS201	Applied Machine and Deep Learning	60	04
PSCS202	Natural Language Processing	60	04
PSCS203	Web Mining	60	04
PSCS204	Embedded and IoT Technology	60	04
Total Credits for Theory courses in Semester -II			16

Semester - II: Practical Lab courses

The Syllabus proposes Four Laboratory courses of 2 Credits each. As far as the Practical are concerned, equal weightage similar to that of Theory courses has been given in terms of the number of hours.

The following table summarizes the details of the practical courses in the Semester - II.

Course Code	Course Title	No of Hours	Credit
PSCSP201	Applied Machine and Deep Learning	60	02
PSCSP202	Natural Language Processing	60	02
PSCSP203	Web Mining	60	02
PSCSP204	Embedded and IoT Technology	60	02
Total Credits for Practical Courses in Semester -II			08

4.DETAILED SYLLABUS FOR SEMESTER - I & SEMESTER - II

SEMESTER- I

Course Code	Course Title	Credits
PSCS101	**Algorithm for Optimization**	**04**

Course Outcome: -
- You will be able to effectively implement optimization techniques to the existing algorithm to improve its performance.
- You will be able to work in the areas of Machine Learning and Data Sciences Algorithms

Course Specific Outcome: -
- Optimization with a focus on practical algorithms for the design of engineering systems
- Exposure to multivariable calculus, linear algebra, and probability concepts.
- Learn a wide variety of optimization topics, introducing the underlying mathematical problem formulations and the algorithms for solving them.

UNIT 1: (Ability Enhancement) **Introduction to Optimization Process** Basic Optimization Problem, Constraints, Critical Points, Conditions for Local Minima, Contour Plots. Unimodality, Fibonacci Search, Golden Section Search, Quadratic Fit Search.	**15L**
UNIT 2: Order Methods First-Order Methods, Gradient Descent, Conjugate Gradient, Adagrad, RMSProp, Adadelta, Adam, Hypergradient Descent. Second-Order Methods, Newton's Method, Secant Method, Quasi-Newton Methods.	**15L**
UNIT 3: Sampling and Surrogate Models Sampling Plans, Full Factorial, Random Sampling, Uniform Projection Plans, Stratified Sampling, Space-Filling Metrics. Surrogate Models, Fitting Surrogate Models, Linear Models, Basis Functions, Fitting Noisy Objective Functions, Model Selection,	**15L**

	Probabilistic Surrogate Models, Gaussian Distribution, Gaussian Processes, Prediction	
UNIT 4: (Skill Enhancement) **Optimization and Uncertainty** Optimization under Uncertainty, Uncertainty, Set-Based Uncertainty, Probabilistic Uncertainty. Uncertainty Propagation, Sampling Methods, Taylor Approximation, Polynomial Chaos, Bayesian Monte Carlo. Dynamic Programming, Ant Colony Optimization. Expression Optimization, Grammars, Genetic Programming, Grammatical Evolution, Probabilistic Grammars, Probabilistic Prototype Trees	**15L**

TEXT BOOK:

1. Algorithms for Optimization Mykel J. Kochenderfer, Tim A. Wheeler, The MIT Press 2019.

REFERENCE BOOKS:

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

Course Code	Course Title	Credits
PSCSP101	**Practical Course on Algorithm Optimization**	**02**
Note: All the Practical's should be implemented using Julia **Link: Julia:https://julialang.org/**	
1	Implement Contour Plots.	
2	Implement Fibonacci and Golden section search.	
3	Implement Quadratic Fit Search.	
4	Implement Gradient descent.	
5	Implement quasi-Newton methods to find the local maxima.	

6	Implement the Adagrad method with application, RMSprop and Adadelta.
7	Implement radial basis functions using surrogate modelling.
8	Apply Random Forest in surrogate Model.
9	Implement Gaussian Process and its application.
10	Path finding using Ant Colony Optimization with an application.

Course Code	Course Title	Credits
PSCS102	**Software Defined Networking**	**04**

Course Outcome: -

- To make the students capable of understanding computer network basics.
- To Obtain the knowledge of Software defined networks with understanding of data plane, control plane and application plane.
- To apply network virtualization for industry standard solutions.
- To improve skills in implementing network virtualization and Software Defined Network (SDN).

Course Specific Outcome: -

- Learners will be able to understand basic concepts of Software Defined Networking and network virtualization.
- Learners will be able to explore OpenFlow specifications to build Software defined networks.
- Learners will be able to analyse and implement theories and practical related to Network management and Virtualization.
- Learners will be able to apply knowledge of Software Defined Networking as per industry standards.

Unit 1: Introduction to Computer Networking Basic Concepts and Definitions: LAN, MAN, WAN, AD-Hoc, Wireless Network, Understanding the layered architecture of OSI/RM and TCP-IP Model, Concepts and implementation of IPV4 and IPV6, Study of various network Routing protocols, Introduction to Transport layer and Application layer protocols.	**15L**

UNIT 2:Software Defined Networking Elements of Modern Networking, Requirements and Technology, SDN: Background and Motivation, SDN Data Plane and OpenFlow, SDN Control Plane, SDN Application Plane	**15L**
UNIT 3: Network Functions Virtualization Concepts and Architecture, NFV Functionality, Network Virtualization Quality of Service, MODERN NETWORK ARCHITECTURE: CLOUDS AND FOG, Cloud Computing, The Internet of Things: Components	**15L**
UNIT 4: (Skill Enhancement) **Design and implementation of Network** Understand and implement Layer 2/3 switching techniques (VLAN /TRUNKING/ Managing Spanning Tree), Implementation of OSPF V2 and V3, Implementation BGP, Implementation Multicast Routing, Implementation of MPLS, Implementation of Traffic Filtering by using Standard and Extended Access Control List, Implementation of Routing redistribution, Implementation of Policy Based Routing/ Load Balancing /QOS/Natting /VRF	**15L**

TEXT BOOK:

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

REFERENCE BOOKS:

1. Network Programmability and Automation-Jason Edelman, Matt Oswalt First Edition 2018.

Course Code	Course Title	Credits
PSCSP102	**Practical Course on Software Defined Networking**	02

Note: All the Practical's should be implemented using GNS3/EVE-NG/CISCO VIRL

Link: GNS3 :https://www.gns3.com/software/download
      EVE-NG: https://www.eve-ng.net/index.php/download/
     CISCO VIRL:https://learningnetwork.cisco.com/s/question/0D53i00000Kswpr/virl-15-download

1	Implement IP SLA (IP Service Level Agreement)

2	Implement IPv4 ACLs
	    1. Standard
	    2. Extended

3	1. Implement SPAN Technologies (Switch Port Analyzer) 2. Implement SNMP and Syslog 3. Implement Flexible NetFlow
4	1. Implement a GRE Tunnel 2. Implement VTP 3. Implement NAT
5	Implement Inter-VLAN Routing

6	Observe STP Topology Changes and Implement RSTP
	    1. Implement Advanced STP Modifications and Mechanisms
	    2. Implement MST

7	1. Implement EtherChannel 2. Tune and Optimize EtherChannel Operations

8	OSPF Implementation
	    1. Implement Single-Area OSPFv2
	    2. Implement Multi-Area OSPFv2
	    3. OSPFv2 Route Summarization and Filtering
	    4. Implement Multiarea OSPFv3

9	Implement BGP Communities
	    1. Implement MP-BGP
	    2. Implement eBGP for IPv4

	3. Implement BGP Path Manipulation

10	Implement IPsec Site-to-Site VPNs
	    1. Implement GRE over IPsec Site-to-Site VPNs
	    2. Implement VRF Lite

11	Simulating SDN with
	    1. OpenDaylight SDN Controller with the Mininet Network Emulator
	    2. OFNet SDN network emulator

12	Simulating OpenFlow Using MININET

Course Code	Course Title	Credits
PSCS103	**Applied Signal and Image Processing**	**04**

Course Outcome: -

- Introduce the concepts of signal processing terms and relate them to image processing
- Learn about basic image processing techniques (e.g., noise removal and image enhancement).
- Develop skills to design and implement algorithms for advanced image analysis
- Apply image processing to design solutions to real-life problems

Course Specific Outcome: -

- Understanding the terminologies of signal and digital image processing
- Ability to apply various images, intensity transformations, and spatial filtering.
- Knowledge of Perform frequency domain operations on images.
- Ability to apply image segmentation and extract image features.
- Apply image processing algorithms in practical applications.

UNIT 1: Fundamentals of Digital Signals Processing Periodic signals, Spectral decomposition, Signals, Reading and writing Waves, Spectrums, Wave objects, Signal objects Noise: Uncorrelated noise, Integrated spectrum, Brownian noise, Pink Noise, Gaussian noise; Autocorrelation: Correlation, Serial correlation, Autocorrelation, Autocorrelation of periodic signals, Correlation as a dot product Frequency domain Operations: Representing Image as Signals, Sampling and Fourier Transforms, Discrete Fourier Transform, Convolution and Frequency Domain Filtering, Smoothing using low-pass filters, Sharpening using high-pass filters. Fast Fourier Transforms.	**15L**
UNIT 2: Image Processing fundamentals and Pixel-Transformation Definition, Application of Image Processing, Image Processing Pipeline, Tools and Libraries for Image Processing, Image types and files formats. Intensity Transformations- Log Transform, Power-law Transform, Contrast Stretching, Thresholding Histogram Processing- Histogram Equalization and Histogram Matching; Linear and Non-linear smoothing of Images, Sharpening of images Image Derivative: Derivatives and gradients, Laplacian, the effect of noise on gradient computation	**15L**
UNIT 3: Structural and Morphological Operations Edge Detection: Sobel, Canny Prewitt, Robert edge detection techniques, LoG and DoG filters, Image Pyramids: Gaussian Pyramid, Laplacian Pyramid Morphological Image Processing: Erosion, Dilation, Opening and closing, Hit-or-Miss Transformation, Skeletonizing, Computing the	**15L**

convex hull, removing small objects, White and black top-hats, Extracting the boundary, Grayscale operations	
UNIT 4: (Skill Enhancement) **Advanced Image Processing Operations** Extracting Image Features and Descriptors: Feature detector versus descriptors, Boundary Processing and feature descriptor, Principal Components, Harris Corner Detector, Blob detector, Histogram of Oriented Gradients, Scale-invariant feature transforms, Haar-like features Image Segmentation: Hough Transform for detecting lines and circles, Thresholding and Otsu's segmentation, Edge-based/region-based segmentation Region growing, Region splitting and Merging, Watershed algorithm, Active Contours, morphological snakes, and GrabCut algorithms	**15L**

TEXT BOOK:

1. Digital Image Processing by Rafael Gonzalez & Richard Woods, Pearson; 4th edition, 2018
2. Think DSP: Digital Signal Processing in Python by Allen Downey, O'Reilly Media; 1st edition (August 16, 2016)

REFERENCE BOOKS:

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

Course Code	Course Title	Credits
PSCSP103	**Practical Course on Applied Signal and Image Processing**	**02**
Note: All the Practical's should be implemented using Python Link:https://www.python.org/downloads/		
1	Write program to demonstrate the following aspects of signal processing on suitable data 1. Upsampling and downsampling on Image/speech signal 2. Fast Fourier Transform to compute DFT	
2	Write program to perform the following on signal 1. Create a triangle signal and plot a 3-period segment. 2. For a given signal, plot the segment and compute the correlation between them.	
3	Write program to demonstrate the following aspects of signal on sound/image data 1. Convolution operation 2. Template Matching	
4	Write program to implement point/pixel intensity transformations such as 1. Log and Power-law transformations 2. Contrast adjustments 3. Histogram equalization 4. Thresholding, and halftoning operations	
5	Write a program to apply various enhancements on images using image derivatives by implementing Gradient and Laplacian operations.	
6	Write a program to implement linear and nonlinear noise smoothing on suitable image or sound signal.	

7	Write a program to apply various image enhancement using image derivatives by implementing smoothing, sharpening, and unsharp masking filters for generating suitable images for specific application requirements.
8	Write a program to Apply edge detection techniques such as Sobel and Canny to extract meaningful information from the given image samples
9	Write the program to implement various morphological image processing techniques.
10	Write the program to extract image features by implementing methods like corner and blob detectors, HoG and Haar features.
11	Write the program to apply segmentation for detecting lines, circles, and other shapes/objects. Also, implement edge-based and region-based segmentation.

Course Code	Course Title	Credits
PSCS104	**Advanced Database Techniques**	**04**

Course Outcome: -

- To cover advanced topics of databases to become more proficient.
- To provide students with theoretical knowledge and practical skills in advanced topics in database systems, big data and modern data-intensive systems.
- To Expand Students, view and introduce advanced topics and Business Intelligence.

Course Specific Outcome: -

- To form professional competencies related to design and implementation of non-relational databases, including object-oriented, parallel and Distributed.
- Learners will be able to explore XML, and Mobile databases.
- Learners will be able to deal with methods used for dealing with spatial and Temporal Databases.
- Learner will have a solid grasp on business intelligence tools and XML.

UNIT 1: Enhanced Database Models Object–Oriented Databases: Need of Object-oriented databases, Complex Data Types, Structured Types and Inheritance, Object-Identity and Reference, ODL and OQL, Implementing O-R Features, Persistent Programming Languages, Object-Oriented versus Object-Relational, Example of Object oriented and object relational database implementation, comparison of RDBMS, OODBMS, ORDBMS XML Databases: Structured Semi structure and unstructured data, XML hierarchical tree data model, Documents DTD and XML schema, XML Documents & Database, XML query and transformation, Storage of XML data, Xpath. XQuery, Join and Nesting Queries, XML database applications. Spatial Databases: Types of spatial data, Geographical Information Systems (GIS), Conceptual Data Models for spatial databases, Logical data models for spatial databases: Raster and vector model. Physical data models for spatial databases: Clustering methods (space filling curves), Storage methods (R-tree). Query processing. Temporal Databases: Time ontology, structure, and granularity, Temporal data models, Temporal relational algebra.	**15L**
UNIT 2: Cooperative Transaction Model Parallel and Distributed Databases: Architecture of parallel databases, Parallel query evaluation, Parallelizing individual operations, Sorting Joins Distributed Databases: Concepts, Data fragmentation, Replication and allocation techniques for distributed database design, Query processing, Concurrency control and recovery in distributed databases, Architecture and Design: Centralised versus non centralized Databases, Homogeneous and Heterogeneous DDBMS, Functions and Architecture, Distributed database design, query processing in DDBMS, Distributed concurrency management, deadlock management, Distributed Commit Protocols: 2 PC and 3 PC, Concepts of replication servers. Mobile Database: Overview, Features, Advantages and Disadvantages, Mobile databases in Android System	**15L**

UNIT 3: Learning the NoSQL Basics Introduction to NoSQL: Characteristics of NoSQL, NoSQL Storage types, Advantages and Drawbacks, NoSQL Products Interfacing and interacting with NoSQL: Storing Data In and Accessing Data from MongoDB, Redis, HBase and Apache Cassandra, Language Bindings for NoSQL Data Stores Understanding the storage architecture: Working with Column-Oriented Databases, HBase Distributed Storage Architecture, Document Store Internals, Understanding Key/Value Stores in Memcached and Redis, Eventually Consistent Non-relational Databases Performing CRUD operations: Creating Records, Accessing Data, Updating and Deleting Data	**15L**
UNIT 4: : (Skill Enhancement) **Gaining Proficiency With NoSQL** Querying NoSQL Stores: Similarities Between SQL and MongoDB Query Features, Accessing Data from Column-Oriented Databases Like HBase, Querying Redis Data Stores Indexing And Ordering Data Sets: Essential Concepts Behind a Database Index, Indexing and Ordering in MongoDB, ouchDB and Apache Cassandra Managing Transactions And Data Integrity: RDBMS and ACID, Distributed ACID Systems, Upholding CAP, Consistency Implementations Using NoSQL in The Cloud: Google App Engine Data Store, Amazon SimpleDB	**15L**
TEXT BOOK: 1. Database Management Systems by Raghu Ramakrishnan and Johannes Gehrke, McGraw Hill, 3rd Edition, 2014 2. Professional NoSQL By Shashank Tiwari, Wrox-John Wiley & Sons, Inc, 2011 3. Getting Started with NoSQL, Gaurav Vaish, Packt Publishing Ltd, 2013	

REFERENCE BOOKS:

1. Advanced Database Management System by byRini Chakrabarti and Shilbhadra Dasgupta, Dreamtech Press, 2017
2. SQL & NoSQL Databases, Andreas Meier · Michael Kaufmann, Springer Vieweg, 2019
3. Parallel and Distributed Systems by Arun Kulkarni, Nupur Prasad Giri, Wiley, Second edition, 2017
4. Practical Hadoop Migration: How to Integrate Your RDBMS with the Hadoop Ecosystem and Re-Architect Relational Applications to NoSQL By Bhushan Lakhe, Apress; 1st edition, 2016.

Course Code	Course Title	Credits
PSCSP104	**Practical Course on Advanced Database Techniques**	**02**
Note: All the Practical's should be implemented using NoSQL **Link: https://www.oracle.com/database/technologies/nosql-database-server-downloads.html**		
1	Create different types that include attributes and methods. Define tables for these types by adding a sufficient number of tuples. Demonstrate insert, update and delete operations on these tables. Execute queries on them.	
2	Create an XML database and demonstrate insert, update and delete operations on these tables. Issue queries on it.	
3	Demonstrate distributed databases environment by dividing given global conceCreate a table that stores spatial data and issue queries on it. ptual schema, into vertical and Horizontal fragments and place them on different nodes. Execute queries on these fragments.	
4	Create a table that stores spatial data and issues queries on it.	
5	Create a temporal database and issue queries on it.	
6	Demonstrate the Accessing and Storing and performing CRUD operations in	

	1. MongoDB **2.** Redis

7	Demonstrate the Accessing and Storing and performing CRUD operations in
	    1. HBase
	    2. Apache Cassandra

8	Demonstrating MapReduce in MongoDB to count the number of female (F) and male (M) respondents in the database.

9	Demonstrate the indexing and ordering operations in
	    1. MongoDB
	    2. CouchDB
	    3. Apache Cassandra

10	Demonstrate the use of data management and operations using NoSQL in the Cloud.

Course Code	Course Title	Credit
PSCS201	Applied Machine and Deep Learning	04

Course Outcome: -

- Developing projects in machine learning for industrial applications.
- Understanding and implementing algorithms and techniques of Machine Learning useful in the field of Data Science, Image Processing, NLP, etc.

Course Specific Outcome:

- Understand core concepts of ML through implementations in python.
- Working with diverse toolkits and packages useful for developing projects in ML
- Implement and understand deep learning and ANNs useful for industry today.

UNIT 1: (Ability Enhancement) **The Fundamentals of Machine Learning** What is Machine Learning? Why use Machine Learning? Types of Machine Learning, Supervised Learning, Unsupervised Learning & Reinforcement Learning. Challenges of Machine Learning, Testing and Validation A First Application: Classification, MNIST Dataset, Performance Measures, Confusion Matrix, Precision and Recall, Precision/Recall Tradeoff, The ROC Curve, Multiclass Classification, Error Analysis.	**15L**
UNIT 2: Training Models Linear Regression, Gradient Descent, Batch Gradient Descent, Stochastic Gradient Descent, Mini-batch Gradient Descent, Polynomial Regression, Learning Curves, The Bias/Variance Tradeoff, Ridge Regression, Lasso Regression, Early Stopping, Logistic Regression, Decision Boundaries, Softmax Regression, Cross Entropy.	**15L**

UNIT 3: Support Vector Machines Linear SVM Classification, Soft Margin Classification, Nonlinear SVM Classification, Polynomial Kernel, Gaussian RBF Kernel, SVM Regression, Decision Trees, Training and Visualizing a Decision Tree, Making Predictions, The CART Training Algorithm, Gini Impurity vs Entropy, Regularization Hyperparameters.	**15L**
UNIT 4: (Skill Enhancement) **Fundamentals of Deep Learning** What is Deep Learning? Need Deep Learning? Introduction to Artificial Neural Network (ANN), Core components of neural networks, Multi-Layer Perceptron (MLP), Activation functions, Sigmoid, Rectified Linear Unit (ReLU), Introduction to Tensors and Operations, Tensorflow framework.	**15L**

TEXT BOOK:

1. Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems by AurélienGéron, Second Edition, O'reilly 2019
2. Deep Learning with Python by François Chollet Published by Manning 2018
3. Reinforcement Learning: An Introduction by Richard S. Sutton and Andrew G. Barto, Second Edition 2014

REFERENCEBOOKS:

1. Introduction to Machine with Python - A Guide for Data Scientists by Andreas C. Müller & Sarah Guido O'reilly 2016
2. Artificial Neural Networks with TensorFlow 2 ANN Architecture Machine Learning Projects Poornachandra Sarang by Apress 2021

Course Code	Course Title	Credits
PSCSP201	**Practical Course onApplied Machine and Deep Learning**	**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 Linear Regression (Diabetes Dataset)	
2	Implement Logistic Regression (Iris Dataset)	
3	Implements Multinomial Logistic Regression (Iris Dataset)	
4	Implement SVM classifier (Iris Dataset)	
5	Train and fine-tune a Decision Tree for the Moons Dataset	
6	Train an SVM regressor on the California Housing Dataset	
7	Implement Batch Gradient Descent with early stopping for Softmax Regression	
8	Implement MLP for classification of handwritten digits (MNIST Dataset)	
9	Classification of images of clothing using Tensorflow (Fashion MNIST dataset)	
10	Implement Regression to predict fuel efficiency using Tensorflow (Auto MPG dataset)	

Course Code	Course Title	Credits
PSCS202	**Natural Language Processing**	**04**
Course Outcome: -		

Course Outcome: -

- Understanding the importance and concepts of Natural Language Processing (NLP)
- Applying algorithms available for the processing of linguistic information and computational properties of natural languages.
- Knowledge on various morphological, syntactic, and semantic NLP tasks.
- Introducing various NLP software libraries and data sets publicly available.

- Designing and developing practical NLP based applications

Course Specific Outcome: -

- The ability to describe the concepts of morphology, syntax, semantics, discourse & pragmatics of natural language
- Discover various linguistic and statistical features relevant to the basic NLP task, namely, spelling correction, morphological analysis, parts-of-speech tagging, parsing, and semantic analysis
- Assess and Evaluate NLP based systems
- Ability to choose appropriate solutions for solving typical NLP subproblems (tokenizing, tagging, parsing)
- Analyse NLP problems to decompose them inadequate independent components and develop real-life applications

UNIT 1: Introduction to Natural Language Processing (NLP) and Language Modelling Introduction to NLP: Introduction and applications, NLP phases, Difficulty of NLP including ambiguity; Spelling error and Noisy Channel Model; Concepts of Parts-of speech and Formal Grammar of English. Language Modelling: N-gram and Neural Language Models Language Modelling with N-gram, Simple N-gram models, smoothing (basic techniques), Evaluating language models; Neural Network basics, Training; Neural Language Model, Case study: application of neural language model in NLP system development Python Libraries for NLP: Using Python libraries/packages such as NaturalLanguage Toolkit (NLTK), spaCy, genism	**15L**
UNIT 2: Morphology & Parsing in NLP Computational morphology & Parts-of-speech Tagging: basic concepts; Tagset; Lemmatization, Early approaches: Rule-based and TBL; POS tagging using HMM, Introduction to POS Tagging using	**15L**

Neural Model. Parsing Basic concepts: top-down and bottom-up parsing, treebank; Syntactic parsing: CKY parsing; Statistical Parsing basics: Probabilistic Context-Free Grammar (PCFG); Probabilistic CKY Parsing of PCFGs.	
UNIT 3: Semantics and Word Embedding Semantics Vector Semantics: Words and Vector; Measuring Similarity; Semantics with dense vectors; SVD and Latent Semantic Analysis Embeddings from prediction: Skip-gram and Continuous Bag of words; Concept of Word Sense; Introduction to WordNet	**15L**
UNIT 4: (Skill Enhancement) **NLP Applications and Case Studies** Intelligent Work Processors: Machine Translation; User Interfaces; man-machine Interfaces: Natural language Querying Tutoring and Authoring Systems. Speech Recognition Commercial use of NLP: NLP in customer Service, Sentiment Analysis, Emotion Mining, Handling Frauds and SMS, Bots, LSTM & BERT models, Conversations	**15L**

TEXT BOOK:

1. ―Speech and Language Processing‖, Jurafsky Dan and Martin James H., 3rd Edition, Pearson, 2018.
2. ―Natural Language Processing with Python‖, Steven Bird, Ewan Klein, and Edward Loper, 2nd Edition, O'Reilly, 2016.

REFERENCE BOOKS:

1. ―Practical NaturalLanguage Processing with Python‖, Mathangi Sri, Apress, 2021
2. "Handbook of Computational Linguistics and Natural Language Processing‖, Martin Whitehead, Clanrye International, 2020
3. ―Handbook of Natural Language Processing‖, Nitin Indurkhya, and Fred J. Damerau, Pearson; 2nd edition, 2008

4. –Foundations of Statistical Natural Language Processing‖, Manning, Christopher and Heinrich, Schutze, MIT Press, 1997		

Course Code	Course Title	Credits
PSCSP202	**Practical Course on Natural Language Processing**	02

Note: - The following set of practicals can be performed using any Python Libraries for NLP such as NLTK, spaCy, genism:

Link:-https://www.python.org/downloads/

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

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

9	Consider a scenario of applying NLP in Customer Service. Design and develop an application that demonstrates NLP operations for working with tasks and data like voice calls, chats, Ticket Data, Email Data. Process the data to understand the voice of the Customer (intent mining, Top words, word cloud, classify topics). Identify issues, replace patterns and gain insight into sales chats.
10	Consider a scenario of Online Review and demonstrate the concept of sentiment analysis and emotion mining by applying various approaches like lexicon-based approach and rule-based

	approaches.
11	Apply NLP in Banking, Financial Services, and Insurance. Design Application to detect frauds and work with SMS data.
12	Demonstrate the use of NLP in designing Virtual Assistants. Apply LSTM, build conversational Bots.

Course Code	Course Title	Credits
PSCS203	**Web Mining**	**04**

Course Outcome: -

- To Understand the difference between Web Mining and Data mining.
- To Understand the Basics and Needs of Web Mining.
- To Understand Web-based Data.
- To Understand Opinion Mining and Sentiment classification.

Course Specific Outcome:

- Develop deep understanding of mining techniques exclusively for the Internet
- Understand and develop analytics for social media data.
- Design and implementation of various web analytical tool to understand complex unstructured data on the Internet for aiding individuals and Businesses to grow their business

UNIT 1: Introduction to Web Mining Web Mining, Data Mining, Basic Concepts, Difference, Mining Sequential Patterns on Prefix Span, Generating Rules from Sequential Patterns. Basic Concepts of Information Retrieval, Information Retrieval Models, Relevance feedback, Evaluation measures Text and Web Page Preprocessing, Inverted Index and Its Compression, latent semantic indexing, Web Search, Web Spamming	**15L**
UNIT 2: Opinion Mining and Web Usage Mining Web Information Retrieval, Sentiment Classification, Feature based	

Opinion Mining and Summarization, Comparative Sentence and Relation Mining, Opinion Search and Opinion Spam. Web Usage Mining.	**15L**
UNIT 3: Social Network & Link Analysis Link Analysis, Scrapy using python (without pipelining), Social Network Analysis, Co-Citation and Bibliographic Coupling, PageRank, HITS, Community Discovery	**15L**
UNIT 4: (Skill Enhancement) **Webpage crawlers and usage mining** Basic Crawler Algorithm, Implementation Issues, Universal Crawlers, Focused Crawlers, Topical Crawlers, Crawler Ethics and Conflicts, Data modelling and webpage usage mining., Discovery and analysis of web usage patterns, Recommender systems and collaborative filtering, query log mining	**15L**

TEXT BOOK:

1. Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data by Bing Liu (Springer Publications) 2017 publication

REFERENCE BOOKS:

1. Data Mining: Concepts and Techniques, Second Edition Jiawei Han, Micheline Kamber (Elsevier Publications),2017
2. Web Mining: Applications and Techniques by Anthony Scime,2010
3. Mining the Web: Discovering Knowledge from Hypertext Data by Soumen Chakrabarti 2010

Course Code	Course Title	Credits
PSCSP203	**Practical Course on Web Mining**	**02**
Note: - The following set of practical's should be implemented in Scrape, python: **Link:-Python : https://www.python.org/downloads/**		

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

Course Code	Course Title	Credits
PSCS204	**Embedded and IoT Technology**	**04**

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 Specific Outcome: -

- Understand basic components and functionalities of Embedded System including its hardware.
- Effectively achieve collaboration of various technologies in IoT and enable the same using software programming like Python, Embedded C etc.
- Understand case studies in IoT and replicate the same for more detailed analysis of the IoT development.

UNIT 1: Embedded System Basics Introduction to Embedded Systems, Design of Embedded Systems, Memory Architecture, Input/Output. Basic electronics: Semiconductors, Transistors, BJT, Flip Flops, Resistors, Capacitors, CMOS, MOSFET, FPGA, Relays. Microcontrollers, UART Communications, SPI-peripherals interface, I2C communication, Wireless Sensor Network (WSN)	**15L**
UNIT 2: Basics of IOT Introduction IoT:Evolution of the IoT concept, vision and definition of IoT, basic characteristics of IoT, distinguish the IoT from other related technologies, IoT enablers, IoT architectures, pros and cons of IoT, IoT architecture concepts for specific IoT applications. IoT Building Blocks -Hardware and Software:The basic IoT building blocks, smart thing components and capabilities, basics of Packet Tracer with reference to IoT, basics of IoT gateway, Cloud, and analytics Sensing Principles and Wireless Sensor Network:Sensor fundamentals and classification of sensors, physical principles of some common sensors, basics of WSNs, WSN architecture and types, layer-level functionality of WSN protocol stack.	**15L**
UNIT 3: Advanced IOT Technologies IoT Gateway:IoT architecture domains, IoT gateway architecture, IoT	**15L**

gateway functionalities, IoT gateway selection criteria, IoT gateway and edge computing, edge computing-based solution for specific IoT applications

IoT Protocol Stack:Mapping of IoT protocols to layered IoT architecture, functionality of infrastructure, service discovery, and application layer protocols of IoT protocol stack

IoT Cloud and Fog Computing:Components of IoT Cloud architecture, usage of application domains of IoT Cloud platforms, layered architecture of Fog computing, distinguish Fog computing from other related terms

IoT Applications:Main applications of IoT, Implementation details of various IoT application domains

UNIT 4: (Skill Enhancement) **Security, Communication and Data analytics in IOT** IoT Security: Security constraints in IoT systems, security requirements of IoT systems, IoT attacks, security threats at each layer of IoT architecture, design secure IoT system for specific application Social IoT: Nature of social relationships among IoT Devices, functionality of different components of social IoT architecture, social aspects of smart devices in IoT applications Packet Tracer and IoT: Basics of Packet Tracer and Blockly programming language, design simple IoT projects in Packet Tracer.	**15L**

TEXT BOOK:

1. Introduction to Embedded Systems – Cyber physical systems Approach Edward Ashford Lee &SanjitArunkumarSeshia Second Edition — MIT Press — 2017
2. Enabling the Internet of Things Fundamentals, Design and Applications by Muhammad Azhar Iqbal, Sajjad Hussain, Huanlai Xing, Muhammad Ali Imran Wiley Pub.1stEdition 2021

REFERENCE BOOKS:

1. Introduction Embedded Systems by K.V. Shibu Second Edition McGraw Hills–2017
2. Build your own IoT Platform Develop a Fully Flexible and Scalable Internet

of Things Platform in 24 Hours by Anand Tamboli 2019 Apress

Course Code	Course Title	Credits
PSCSP204	**Practical Course onEmbedded and IoT Technology**	**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	Design and implement basics embedded circuits 1. Automatic Alarm system- Alarm should get tigger by senor 2. Timer based buzzer 3. Sensor based Counting device	
2	Demonstrate communication between two embedded devices using UART port	
3	Built an IoT system to send ticket before entering the bus.	
4	Demonstrate an IoT based game which can be played between two player who are physically at a considerable distance.	
5	Develop a IoT application which will record the movement and orientation of your phone and give the data back to the PC	
6	Develop an IoT application that will raise an alarm whenever with going to rain outside based on the weather prediction data.	
7	Deploy an IoT application which will alert you by beeping or vibrating your phone whenever you get someone call your name.	
8	Develop an IoT application for monitoring water levels in tanks and automatically start the motor to fill the tank if the level goes below the critical level.	
9	Develop an IoT module to which measure the intensity of light and send the same to your PC/ Phone	
10	Develop an IoT application for Motion detection.	

5. EVALUATION

The evaluation of each paper shall contain two parts:
  (i) Internal Assessment- 40 Marks.
  (ii) External Assessment - 60 Marks.

The Internal to External assessment ratio shall be 2:3.

6. SCHEME OF EXAMINATIONS AND DISTRIBUTION PATTERN OF MARKS

SCHEME OF EXTERNAL EXAMINATIONOF SEMESTER- I AND SEMESTER – II

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

SCHEME OF INTERNAL EVALUATIONOF SEMESTER- I AND SEMESTER – II

Internal evaluation is to be done by continuous assessment which will consist of two components viz.

● Course Specific Project should be done for Each Course of Semester - I & II. The scope of the Course Specific Project may be within or beyond the scope of the 4 units and practical's prescribed for the Course.
● Assignments / QUIZ / Seminars / Case Studies.

The particulars of the Internal examination for each course of Semester- I and Semester – II are given below:

No	Semester	Course Code	Particular	Marks	Total Marks
1	I / II	PSCS101 / PSCS201	Course Specific Project	30	40
			Assignments / QUIZ / Seminars / Case Studies.	10	

No	Semester	Course Code	Particular	No of Questions	Marks	Total Marks
2		PSCS102 / PSCS202	Course Specific Project		30	40
			Assignments / QUIZ / Seminars / Case Studies.		10	
3		PSCS103 / PSCS203	Course Specific Project		30	40
			Assignments / QUIZ / Seminars / Case Studies.		10	
4		PSCS104 / PSCS204	Course Specific Project		30	40
			Assignments / QUIZ / Seminars / Case Studies.		10	

SCHEME OF EXAMINATION FOR PRACTICAL COURSES

There will not be any Internal examination for practical courses of Semester- I and Semester – II.

EXTERNAL EXAMINATION FOR PRACTICAL COURSES

The particulars of the external examination for each practical course of Semester- I and Semester – II are given below:

No	Semester	Course Code	Particular	No of Questions	Marks	Total Marks
1	I / II	PSCSP101 / PSCSP201	Laboratory experiment question with internal choice	01	40	50
			Journal		05	
			VIVA		05	
2		PSCSP102/ PSCSP202	Laboratory experiment question with internal choice	01	40	50

			Journal		05	
			VIVA		05	
3		PSCSP103/ PSCSP203	Laboratory experiment question with internal choice	01	40	50
			Journal		05	
			VIVA		05	
4		PSCSP104/ PSCSP204	Laboratory experiment question with internal choice	01	40	50
			Journal		05	
			VIVA		05	

GUIDELINES OF JOURNALS

A student should maintain a Journal with Practical experiments reported for each of the practical course of Semester- I and Semester - II. 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.

AUDIT COURSES

Students who have obtained Undergraduate Degree in subjects other than B.SC Computer science from a duly recognized University shall undertake **an Online Audit Courses provided below.**
They are supposed to submit the **online completion certificate** of the same to the concerned department at the end of each semester 1 and semester 2.

Semester I

Course Code	Course Name	Online Courses
PSCS101	Algorithm for Optimization	Design and analysis of algorithms https://onlinecourses.nptel.ac.in/noc21_cs68/preview
PSCS102	Software Defined Networking	Demystifying Networking https://onlinecourses.nptel.ac.in/noc21_cs94/preview
PSCS103	Applied Signal and Image Processing	Digital Signal Processing https://onlinecourses.nptel.ac.in/noc19_ee50/preview Digital Signal Processing and Applications https://onlinecourses.nptel.ac.in/noc21_ee20/preview
PSCS104	Advanced Database Techniques	Introduction to Database Systems https://nptel.ac.in/courses/106/106/106106220/ Introduction to Databases https://nptel.ac.in/courses/106/104/106104135/

Semester II

Course Code	Course Name	Online Courses
PSCS201	Applied Machine and Deep Learning	Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc21_cs85/preview
PSCS202	Natural Language	An Introduction to Artificial Intelligence https://onlinecourses.nptel.ac.in/noc21_cs42/preview

	Processing	The Joy of Computing using Python https://onlinecourses.nptel.ac.in/noc21_cs75/preview
PSCS203	Web Mining	Web Scraping without Scrapy https://www.udemy.com/course/webscraping-without-scrapy/
PSCS204	IoT Technology	Design for internet of things https://onlinecourses.nptel.ac.in/noc21_ee85/preview Introduction to Industry 4.0 and Industrial Internet of Things https://onlinecourses.nptel.ac.in/noc21_cs66/preview Introduction to internet of things https://onlinecourses.nptel.ac.in/ noc21_cs63/preview