JanardanBhagatShikshanPrasarakSanstha's
CHANGU KANA THAKUR
ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL (AUTONOMOUS)

Re-accredited 'A+' Grade by NAAC
'College with Potential for Excellence' Status Awarded by UGC
'Best College Award' by University of Mumbai

Program: M.Sc.
Revised Syllabus of M.Sc.-II Computer Science
Choice Based Credit & Grading System (60:40)
w.e.f. Academic Year 2020-21

Preamble

This syllabus is an extension of the syllabus for semester - I and semester – II of MSc Computer Science, which came into existence in the academic year 2019-2020. As mentioned in the syllabus of semester I and II, the intended philosophy of the new syllabus is to meet following guidelines:

- Give strong foundation on core Computer Sciencesubjects.
- Expose student to emerging trends in a gradual and incrementalway.
- Prepare student community for the demands of ICT industry.
- Offer specialization on a chosenarea.
- Create research temper among students in the wholeprocess.

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 two core compulsory subjects in semester III. The student has to continue with the tracks they have taken in the semester II as elective subjects. The syllabus also includes project proposal as part of the practical course in elective subjects.

The semester – IV will have one compulsory subject. Student can choose one subject as specialization out of the two electives he or she has been pursuing since the semester – II. That means, there will be four specializations in the semester IV as mentionedbelow:

- CloudComputing
- Cyber and InformationSecurity
- Business Intelligence and Big DataAnalytics
- MachineLearning

The syllabus also offers an internship and project implementation in the semester – IV, each of which has weights equivalent to a full course. By introducing different electives as tracks in semester –II, espousing more of that tracks in the semester –III and offering

the opportunity to choose the specialization based on the tracks pursed in semester –IV will give the student the added advantage of high level competency in the advanced and emerging areas of computer science. This will definitely equip the student with industry readiness as 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 andacademia.

As one can easily notice, the syllabus offers lots of emphasis on student driven learning and learning through experience. Research is embedded in the course structure. By introducing Researching Computing in semester – I, Case study in semester – II, Project Proposal in semester – III and Project Implementation insemester– IV (which together has a weightage equivalent to almost two theory courses), the syllabus prepares a strong army of budding computer science researchers. The syllabus designed on the firm believe that by 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 thesyllabus.

We thank all our colleagues in the University of Mumbai for their inputs, suggestions and critical observations. We acknowledge the contributions of experts from premier institutions and industry for making the syllabus more relevant. We thank the chairperson and members of the present and previous Adhoc Board of Studies in Computer Science of University for their constant support. Thanks to one and all who have directly or indirectly helped in this venture.

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- **Objectives of the Course:**
    - Offer specialization on a chosen area.
    - Promote research based projects/activities in the emerging areas of technology convergence.
    - To develop the confidence to the learners to face and adapt to the changing trends and requirements of industry and academia.
    - Offer provision for internship and field work.

- **Course Outcomes:**
    - Gain the knowledge of current technologies by internship.
    - Hands on training on specialized subjects.
    - Can get job opportunities like Software Developer, Network administrator, IT expert etc.
    - Prepares strong army of budding computer science researchers.

Scheme of examination for Each Semester:

I. Continuous Internal Examination: 40 Marks

Sr. No.	Particular		Marks
01	One periodical class test / online examination to be conducted in the given semester		20 Marks
02	One case study /review / project with presentation based on curriculum to be assessed by the teacher concerned		15 Marks
	Presentation	10 Marks	
	Written Document	05 Marks	
03	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities		05 Marks

II. External Examination: 60 Marks

- There shall be five questions each of 12 marks.
- All questions shall be compulsory with internal options.
- Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.

Question	Based on	Marks
Q.1	Unit I	12
Q.2	Unit II	12
Q.3	Unit III	12
Q.4	Unit IV	12
Q.5	Unit I,II,III,IV	12

III. Practical Examination: 50 Marks

Sr. No.	Particulars of External	Marks
1	Laboratory Work	40
2	Journal	05
3	Viva	05
	TOTAL	50

M.Sc. Computer Science Syllabus
Credit Based System and Grading System
Academic year 2020-21
SEMESTER - III

CODE	COURSE TYPE	SUBJECT	SCHEME OF INSTRUCTION (PERIOD PER WEEK)		SCHEME OF EXAMINATION (MAX MARKS)			NO. OF CREDITS
			TH	LAB	CA	EA	TOTAL	
PCS3UBI	CORE	Ubiquitous Computing	4	-	40	60	100	4
PCS3SNA	CORE	Social Network Analysis	4	-	40	60	100	4
PCS3E1A	Elective-I	Track A: Cloud Computing – II (Cloud Computing Technologies)	4	-	40	60	100	4
PCS3E1B	Elective-I	Track B: Cyber and Information Security- II (Cyber Forensics)						
PCS3E2C	Elective-II	Track C: Business Intelligence and Big Data Analytics –II (Mining Massive Data sets)	4	-	40	60	100	4
PCS3E2D	Elective-II	Track D: Machine Learning –II (Advanced Machine Learning)						
PCS3PPR1	CORE SUBJECT PRACTICAL	PCS3UBI+ PCS3SNA	-	4			100	4
PCS3PPR2	ELECTIVE SUBJECT PRACTICAL	PCS3E1A/ PCS3E1B+ PCS3E2C/ PCS3E2D	-	4			100	4
TOTAL							600	24

SEMESTER - IV

CODE	COURSE TYPE	SUBJECT	SCHEME OF INSTRUCTION (PERIOD PER WEEK)		SCHEME OF EXAMINATION (MAX MARKS)			NO. OF CREDITS
			TH	LAB	CA	EA	TOTAL	
PCS4SIM	CORE	Simulation and Modeling	4	-	40	60	100	4
PCS4S1A	Elective	Specialization - Track A: Cloud Computing –III (Building Clouds and Services)	4	-	40	60	100	4
PCS4S2B		Specialization - Track B: Cyber and Information Security-II (Cryptography and Crypt Analysis)						
PCS4S3C		Specialization - Track C: Business Intelligence and Big Data Analytics –III (Intelligent Data Analysis)						
PCS4S4D		Specialization - Track D: Machine Learning –III (Computational Intelligence)						
PCS4PPR1	Practical of Simulation & Modeling and Specialization	PCS4SIM+PCS4S1A/ PCS4S2B/ PCS4S3C/ PCS4S4D	4				100	4
PCS4PPR2	Internship with industry		6				150	6
PCS4PPR3	Project Implementation		6				150	6
TOTAL							600	24

Structure of the syllabus

This is the syllabus for the semester–III and semester–IV of MSc Computer Science program of University of Mumbai to be implemented from the year 2020-21

Semester-III

The syllabus offers four theory courses and two practical courses in semester-III. Of the four theory courses, two are compulsory courses. The remaining two are electives. Each elective course has two tracks (track A and track B for elective I and track C and track D for elective II). A student is expected to continue with the track they have chosen in semester-II.

The syllabus proposes four subjects in semester-III. Each subject has theory and practicalcomponents.

Semester–III: Theory courses

The four theory courses offered in semester-III are:

(i) UbiquitousComputing

(ii) Social NetworkAnalysis

(iii) Elective -I

- (a) Track A: Cloud Computing – II (Cloud ComputingTechnologies)
- (b) Track B: Cyber and Information Security – II (CyberForensics)

(iv) Elective –II

- (a) Track C: Business Intelligence and Big Data Analytics – II (Mining Massive Data sets)
- (b) Track D: Machine Learning – II (Advanced MachineLearning)

A student is expected to continue with the same tracks he or she has taken in semester-II for elective –I and elective –II. Each of these theory courses (compulsory as well as elective) is of four credits each and is expected to complete in 60 hours. The details are shown in the following table.

Semester III – Theory courses

Course Code	Course Nomenclature	Lecture In Hours	Credits
PCS3UBI	Ubiquitous Computing	60	4
PCS3SNA	Social Network Analysis	60	4
PCS3E1A	Elective I - Track A: Cloud Computing –II (Cloud Computing Technologies)	60	4
PCS3E1B	Elective I -Track B: Cyber and Information Security- II (CyberForensics)		
PCS3E2C	Elective II - Track C: Business Intelligence and Big Data Analytics –II (Mining Massive Data sets)	60	4
PCS3E2D	Elective II - Track D: Machine Learning –II (Advanced Machine Learning)		
Total Credits for Theory courses in Semester III			16

Semester–III: Practical Laboratory Courses

The syllabus proposes two laboratory courses of 4 credits each. The laboratory experiments from the first two theory courses (PSCS301 and PSCS302) are combined together and are proposed as the first practical course (PSCSP5). Similarly, the laboratory experiments from the elective courses are combined together and taken as the second practical course (PSCSP6). The following table summarizes the details of the practical courses in the semester –III.

Semester-III: Practical Laboratory Courses

Course Code	Course Title	No of hours	Credits
PCS3PPR1	Ubiquitous Computing and Social Network Analysis	60+60= 120	04
PCS3PPR2	Elective I and Elective II	60+60= 120	04
Total Credits for Practical Laboratory courses in Semester–III			08

Project Proposal: The syllabus introduces a project proposal in the semester-III under lab course PSCSP6. As per this, a student is expected to select a topic for project based on the specialization he or she is planning to take in the semester-IV. Needless to say, the project proposal will be based on a topic related to the elective the student has been pursuing in semester –II and semester-III and intends to continue in semester- IV asspecialization.

The proposal will contain introduction, related works, objectives and methodology. The implementation, experimental results and analysis will be part of the Project implementation in the semester-IV.

Semester –IV

The syllabus proposes two subjects in semester-IV, each with theory and practical components. In addition, there will be internship with industry and a project implementation. The important feature of the semester-IV is the specialization a student can choose. A student can choose a specialization based on the electives one has been pursuing since semester–II. Since there are two electives in semester-III, a student can drop one and choose the other as the specialization in semester–IV.

Semester–IV: Theory courses

The two theory courses offered in semester-IV are:

(i) Simulation andModeling

(ii) Specialization

(a) Track A: Cloud Computing – III (Building Clouds andServices)

(b) Track B: Cyber and Information Security–III (Cryptography and Crypt Analysis)

(c) Track C: Business Intelligence and Big Data Analytics – III (Intelligent Data Analysis)

(d) Track D: Machine Learning – III (ComputationalIntelligence)

Each of these courses (core as well as the specialization) is expected to complete in 60 hours. The details are given in the following table.

Semester-IV: Theory courses

Course Code	Course Nomenclature	Lecture In Hours	Credits
PCS4SIM	Simulation and Modeling	60	4
PCS4S1A	Specialization - Track A: Cloud Computing –III (Building Clouds and Services)	60	4
PCS4S2B	Specialization -Track B: Cyber andInformation Security- II (Cryptography and Crypt Analysis)		
PCS4S3C	Specialization - Track C: Business Intelligence and Big Data Analytics –III (Intelligent Data Analysis)		
PCS4S4D	Specialization - Track D: Machine Learning –III (Computational Intelligence)		
Total Credits for Theory courses in Semester-IV			08

Semester–IV: Practical Laboratory courses

The syllabus proposes one laboratory course of 4 credits. The laboratory experiments from the two theory courses are combined together and are proposed as the first practical course (PSCSP7).

Semester-IV: Practical course

Course Code	Course Title	No of hours	Credits
PCS4PPR1	Simulation & Modeling and Specialization	60+60= 120	04

Semester–IV: 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 oneself with 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 thedocumentation.

Semester–IV: Internship

Course Code	Course Title	No of hours	Credits
PCS4PPR2	Internship with industry	300	06

Semester–IV: Project Implementation

The syllabus proposes project implementation as part of the semester–IV. The project implementation is continuation of the project proposal the students has submitted and evaluated in semester-III. The student is expected to continue with the proposal made and examined in the semester-III and implement the same in the semester–IV. In addition, experimental set up, analysis of results, comparison with results of related works, conclusion and future 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:

Semester–IV: Project Implementation

Course Code	Course Title	No of hours	Credits
PCS4PPR3	Project Implementation	200	06

Detailed syllabus of semester– III

Course Code	Course Title	Credits
PCS3UBI	**Ubiquitous Computing**	**04**

Unit I: Basics of **Ubiquitous Computing**

Examples of Ubiquitous Computing Applications, Holistic Framework for UbiCom: Smart DEI, Modeling the Key Ubiquitous Computing Properties, Ubiquitous System Environment Interaction, Architectural Design for UbiCom Systems: Smart DEI Model, Smart Devices and Services, Service Architecture Models, Service Provision Life Cycle.

Unit II: Smart Mobiles, Cards and Device Networks

Smart Mobile Devices, Users, Resources and Code, Operating Systems for Mobile Computers and Communicator Devices, Smart Card Devices, Device Networks.

Human–Computer Interaction (HCI): Explicit HCI, Implicit HCI, User Interfaces and Interaction for Devices, Hidden UI Via Basic Smart Devices, Hidden UI Via Wearable

and Implanted Devices, Human Centered Design (HCD).

Unit III: Smart Environments

Tagging, Sensing and Controlling, Tagging the Physical World, Sensors and Sensor Networks, Micro Actuation and Sensing: MEMS, Embedded Systems and Real Time Systems, Control Systems.

Unit IV: Ubiquitous Communication

Audio Networks, Data Networks, Wireless Data Networks, Universal and Transparent Audio, Video and Alphanumeric Data Network Access, Ubiquitous Networks, Network Design Issues.

Text book:

- Ubiquitous Computing Smart Devices, Environments and Interactions, Stefan Poslad, Wiley,2009.

References:

- Ubiquitous Computing Fundamentals. John Krumm, Chapman & Hall/CRC2009.
- Ambient intelligence, wireless networking and ubiquitous computing, Vasilakos, A., &Pedrycz, W. ArtechHouse, Boston, 2006.
- http://www.eecs.qmul.ac.uk/~stefan/ubicom.

Practical Course on Ubiquitous Computing	
Sr. No.	**List of practical Experiments on Ubiquitous Computing**
1	Design and develop location based messaging app
2	Design and develop chat messaging app which is a location-based
3	Design and develop app demonstrating Simple Downstream Messaging
4	Design and develop app demonstrating Send Upstream Messages
5	Design and develop app for Device Group Messaging
6	Implementing GCM Network Manager
7	Demonstrate use of OpenGTS (Open Source GPS Tracking System)
8	Context-Aware system Context-awareness is a key concept in ubiquitous computing. The Java Context-Awareness Framework (JCAF) is a Java-based context-awareness infrastructure and programming API for creating context-aware applications
9	Develop application demonstrating Human Computer Interaction
10	Write a Java Card applet

Course Code	Course Title	Credits
PCS3SNA	**Social Network Analysis**	**04**

Unit I: Introduction to social network analysis (SNA)

Introduction to networks and relations- analyzing relationships to understand people and groups, binary and valued relationships, symmetric and asymmetric relationships, multimode relationships, Using graph theory for social networks analysis- adjacency matrices, edge-lists, adjacency lists, graph traversals and distances, depth-first traversal, breadth-first traversal paths and walks, Dijkstra's algorithm, graph distance and graph diameter, social networks vs. link analysis, ego-centric andsocio-centric

density.

Unit II: Networks, Centrality and centralization in SNA

Understanding networks- density, reachability, connectivity, reciprocity, group-external and group-internal ties in networks, ego networks, extracting and visualizing ego networks, structural holes, Centrality- degree of centrality, closeness and betweenness centrality, local and global centrality, centralization and graph centers, notion of importance within network, Google pagerank algorithm, Analyzing network structure- bottom-up approaches using cliques, N-cliques, N-clans, K-plexes, K-cores, F-groups and top-down approaches using components, blocks and cut-points, lambda sets and

bridges, and factions.

Unit III: Measures of similarity and structural equivalence in SNA

Approaches to network positions and social roles- defining equivalence or similarity, structural equivalence, automorphic equivalence, finding equivalence sets, brute force and Tabu search, regular equivalence, equivalence of distances: Maxsim, regular equivalence, Measuring similarity/dissimilarity- valued relations, Pearson correlations covariance and cross-products, Understanding clustering- agglomerative and divisive clusters, Euclidean, Manhattan, and squared distances, binary relations, matches: exact, Jaccard,Hamming,

Unit IV: Two-mode networks for SNA

Understanding mode networks- Bi-partite data structures, visualizing two-mode data, quantitative analysis using two-mode Singular value decomposition (SVD) analysis,

two-mode factor analysis, two-mode correspondence analysis, qualitative analysis using two-mode core-periphery analysis, two-mode factions analysis, affiliation and attribute networks.

Text book:

- Introduction to Social Network Methods: Robert A. Hanneman, MarkRiddle, University of California, 2005 [Published in digital form and available at http://faculty.ucr.edu/~hanneman/nettext/index.html].
- Social Network Analysis for Startups- Finding connections on the social web: MaksimTsvetovat, Alexander Kouznetsov, O'Reilly Media,2011.
- Social Network Analysis- 3rd edition, John Scott, SAGE Publications,2012.

Reference book:

- Exploratory Social Network Analysis with Pajek, Second edition: Wouter de Nooy, Andrej Mrvar, Vladimir Batagelj, Cambridge University Press,2011.
- Analyzing Social Networks, Stephen P Borgatti, Martin G.Everett, Jeffrey C. Johnson, SAGE Publications,2013.
- Statistical Analysis of Network Data with R: Eric D. Kolaczyk, GáborCsárdi, Springer,2014.
- Network Analysis: Methodological Foundations, (Editors) UlrikBrandes, Thomas Erlebach. Springer,2005.
- ModelsandMethodsinSocialNetworkAnalysis:(Editors)PeterJ.Carrington, John Scott,Stanley Wasserman, Cambridge University Press, 2005.

Practical Course on Social Network Analysis	
Sr No	**List of Practical Experiments on Social Network Analysis**
1	Write a program to compute the following for a given a network: (i) number of edges, (ii) number of nodes; (iii) degree of node; (iv) node with lowest degree; (v) the adjacency list; (vi) matrix of the graph.
2	Perform following tasks: (i) View data collection forms and/or import one-mode/two-mode datasets; (ii) Basic Networks matrices transformations
3	Compute the following node level measures: (i) Density; (ii) Degree; (iii) Reciprocity; (iv) Transitivity; (v) Centralization; (vi) Clustering.
4	For a given network find the following: (i) Length of the shortest path from a given node to another node; (ii) the density of the graph; (iii) Draw egocentric network of node G with chosen configuration parameters.
5	Write a program to distinguish between a network as a matrix, a network as an edge list, and a network as a sociogram (or “network graph”) using 3 distinct networks representatives of each.
6	Write a program to exhibit structural equivalence, automatic equivalence, and regular equivalence from a network.
7	Create sociograms for the persons-by-persons network and the committee-by-committee network for a given relevant problem. Create one-mode network and two-node network for the same.
8	Perform SVD analysis of a network.
9	Identify ties within the network using two-mode core periphery analysis.
10	Find “factions” in the network using two-mode faction analysis.

Course Code	Course Title	Credits
PCS3E1A	**Elective I- Track A: Cloud Computing -II** **(Cloud Computing Technologies)**	**04**

Unit I: Parallel and Distributed Computing

Elements of parallel computing, elements of distributed computing, Technologies for distributed computing: RPC, Distributed object frameworks, Service oriented computing

Virtualization – Characteristics, taxonomy, virtualization and cloud computing.

Unit II: Computing Platforms

Cloud Computing definition and characteristics, Enterprise Computing, The internet as a platform, Cloud computing services: SaaS, PaaS, IaaS, Enterprise architecture, Types of clouds.

Unit III: Cloud Technologies

Cloud computing platforms, Web services, AJAX, mashups, multi-tenant software, Concurrent computing: Thread programming, High-throughput computing: Task programming, Data intensive computing: Map-Reduceprogramming.

Unit IV: Software Architecture

Dev 2.0 platforms, Enterprise software: ERP, SCM, CRM

Custom enterprise applications and Dev 2.0, Cloud applications.

Text book:

- Enterprise Cloud Computing Technology, Architecture, Applications, GautamShroff, Cambridge University Press, 2010
- Mastering In Cloud Computing, RajkumarBuyya, Christian VecchiolaAnd ThamariSelvi S, Tata Mcgraw-Hill Education,2013
- Cloud Computing: A Practical Approach, Anthony T Velte, Tata Mcgraw Hill, 2009

References:

- Architecting the Cloud: Design Decisions for Cloud Computing ServiceModels (SaaS, PaaS, and IaaS), Michael J. Kavis, Wiley CIO,2014
- Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business Models,Mobile, Security and More, Kris Jamsa, Jones & Bartlett Learning,2013

Practical Course on Elective I-Track A:Cloud Computing-II (Cloud Computing Technologies)	
Sr. No.	**List of Practical Experiments on Elective I-Track A:Cloud Computing-II (Cloud Computing Technologies)**
1	Execute & check the performance of existing algorithms using CloudSim.
2	Install a Cloud Analyst and Integrate with Eclipse/Netbeans. Monitor the performance of an Existing Algorithms.
3	Build an application on private cloud.
4	Demonstrate any Cloud Monitoring tool.
5	Evaluate a Private IAAS Cloud using TryStack.
6	Implement FOSS-Cloud Functionality - VDI (Virtual Desktop Infrastructure)
7	Implement FOSS-Cloud Functionality VSI (Virtual Server Infrastructure) Infrastructure as a Service (IaaS)
8	Implement FOSS-Cloud Functionality - VSI Platform as a Service (PaaS)
9	Implement FOSS-Cloud Functionality - VSI Software as a Service (SaaS)
10	Explore FOSS-Cloud Functionality- Storage Cloud

Course Code	Course Title	Credits
PCS3E1B	**Elective I- Track B: Cyber and Information Security- II (Cyber Forensics)**	**04**

Unit I: Computer Forensic Fundamentals: Introduction to Computer Forensics and objective, the Computer Forensics Specialist, Use of Computer Forensic in Law Enforcement, Users of Computer Forensic Evidence, Case Studies, Information Security Investigations. Types of Computer Forensics Technology: Types of Military Computer Forensic Technology, Types of Law Enforcement Computer Forensic Technology, Types of Business Computer Forensic Technology, Specialized Forensics Techniques, Hidden Data, Spyware and Adware, Encryption Methods and Vulnerabilities, Protecting Data from Being Compromised, Internet Tracing Methods, Security and Wireless Technologies. Types of Computer Forensics Systems: Study different Security System: Internet, Intrusion Detection, Firewall, Storage Area, Network Disaster Recovery, Public Key Infrastructure, Wireless Network, SatelliteEncryption,
Instant Messaging (IM), Net Privacy, Identity Management, Biometric, Identity Theft.

Unit II: Data Recovery: Data Recovery and Backup, Role of Data Recovery, Hiding and Recovering Hidden Data. Evidence Collection: Need to Collect the Evidence, Types of Evidences, The Rules of Evidence, Collection Steps. Computer Image Verification and Authentication: Special Needs of Evidence Authentication. Identification of Data: Timekeeping, Forensic Identification and Analysis of Technical Surveillance Devices,
ReconstructingPastEvents:HowtoBecomeaDigitalDetective,UseableFileFormats,
Unusable File Formats, Converting Files.

Unit III: Network Forensics: Sources of Network Based Evidence, Principles of Internetworking, Internet Protocol Suite. Evidence Acquisition: Physical Interception, Traffic Acquisition Software, Active Acquisition. Traffic Analysis: Protocol Analysis, Packet Analysis, Flow Analysis, Higher-Layer Traffic analysis. Statistical Flow Analysis: Sensors, Flow Record Export Protocols, Collection and Aggregation, Analysis. Wireless: theIEEELayer2ProtocolSeries,WirelessAccessPoint,WirelessTrafficCaptureand Analysis, Common Attacks, Locating Wireless Devices. Network Intrusion Detectionand

Analysis: NIDS/NIPS Functionality, Modes of Detection, Types of NIDS/NIPS, NIDS/NIPS Evidence Acquisition.

Unit IV: Network Devices and Mobile Phone Forensics: Sources of Logs, Network Architecture, Collecting and Analyzing Evidence, switches, routers, firewalls, interfaces Web Proxies: Need to Investigate Web Proxies, Functionality, Evidence, Squid, Web Proxy Analysis, EncryptedWebTraffic. MobilePhoneForensics: Crime and Mobile Phones, Voice, SMS and Identification of Data Interception in GSM, MobilePhone Tricks, SMS Security, Mobile Forensic.

Text book:

- Computer Forensics Computer Crime Scene Investigation, John R. Vacca, Second Edition,2005.
- Network Forensics, Sherri Davidoff, Jonathan HAM, Prentice Hall,2012.
- Mobile Phone Security and Forensic: A Practical Approach, Second Edition,Iosif I. Androulidkis, Springer,2012.

References:

- Digital forensics: Digital evidence in criminal investigation",Angus M.Marshall, John – Wiley and Sons,2008.
- Computer Forensics with FTK, Fernando Carbone, PACKT Publishing,2014.
- Practical Mobile Forensics, SatishBommisetty, RohitTamma, Heather Mahalik, PACKT Publishing,2014.

Practical Course on Elective I-Track B: Cyber and Information Security- II (Cyber Forensics)	
Sr. No.	**List of Practical Experiments on Elective I-Track B: Cyber and Information Security- II (Cyber Forensics)**
1	Write a program to take backup of mysql database
2	Write a program to restore mysql database
3	Use Drive Image XML to image a hard drive
4	Write a program to create a log file
5	Write a program to find a file in a directory
6	Write a program to find a word in a file
7	Create forensic images of digital devices from volatile data such as memory using Imager for: (i) Computer System; (ii) Server; (iii) MobileDevice
8	Access and extract relevant information from Windows Registry for investigation process using Registry View, perform data analysis and bookmark the findings with respect to: (i) Computer System; (ii) Computer Network; (iii) Mobile Device; (iv) Wireless Network
9	Generate a report based on the analysis done using Registry View for different case scenario of the following: (i) Computer System; (ii) Computer Network; (iii) Mobile Device; (iv) Wireless Network
10	Create a new investigation case using Forensic Tool: (i) Computer System; (ii) Computer Network; (iii) Mobile Device ;(iv) Wireless Network.

Course Code	Course Title	Credits
PCS3E1C	**Elective I- Track C: Business Intelligence and Big Data Analytics –II (Mining Massive Data sets)**	**04**

Unit I: Introduction To Big Data

Big data: Introduction to Big data Platform, Traits of big data, Challenges of conventional systems, Web data, Analytic processes and tools, Analysis vs Reporting, Modern data analytic tools, Statistical concepts: Sampling distributions, Re-sampling, Statistical Inference, Prediction error. Data Analysis: Regression modeling, Analysis of time Series: Linear systems analysis, Nonlinear dynamics, Rule induction, Neural networks: Learning and Generalization, Competitive Learning, Principal Component AnalysisandNeuralNetworks,FuzzyLogic:ExtractingFuzzyModelsfromData,Fuzzy Decision Trees, Stochastic Search Methods.

Unit II: MAP REDUCE

Introduction to Map Reduce: The map tasks, Grouping by key, The reduce tasks, Combiners, Details of MapReduce Execution, Coping with node failures. Algorithms Using MapReduce: Matrix-Vector Multiplication, Computing Selections and Projections, Union, Intersection, and Difference, Natural Join. Extensions to MapReduce: Workflow Systems, Recursive extensions to MapReduce, Common map reduce algorithms.

Unit III: SHINGLING OF DOCUMENTS

Finding Similar Items, Applications of Near-Neighbor Search, Jaccard similarity of sets, Similarity of documents, Collaborative filtering as a similar-sets problem, Documents, k- Shingles, Choosing the Shingle Size, Hashing Shingles, Shingles built from Words. Similarity-Preserving Summaries of Sets, Locality-Sensitive hashing for documents. The Theory of Locality-Sensitive functions. Methods for high degrees of similarity.

Unit IV: MINING DATA STREAMS

Introduction to streams concepts – Stream data model and architecture, Stream computing, Sampling data in a stream, Filtering streams, Counting distinct elements in a stream, Estimating moments, Counting oneness in a Window, Decaying window, Real time analytics Platform(RTAP).

Text book:

- Mining of Massive Datasets, AnandRajaraman and Jeffrey David Ullman, Cambridge University Press,2012.
- BigData,BigAnalytics:EmergingBusinessIntelligenceandAnalyticTrendsfor Today's Businesses, Michael Minelli, Wiley, 2013

References:

- Big Data for Dummies, J. Hurwitz, et al., Wiley,2013
- Understanding Big Data Analytics for Enterprise Class Hadoop and Streaming Data, Paul C. Zikopoulos, Chris Eaton, Dirk deRoos, Thomas Deutsch, George Lapis, McGraw-Hill,2012.
- Big data: The next frontier for innovation, competition, and productivity, James Manyika,Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh, Angela Hung Byers, McKinsey Global Institute May2011.
- Big Data Glossary, Pete Warden, O'Reilly,2011.
- Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques,NoSQL,andGraph,DavidLoshin,MorganKaufmannPublishers, 2013

Practical Course on Elective II-Track C: Business Intelligence and Big Data Analytics - II (Mining Massive Data sets -I)	
Sr. No	**List of Practical Experiments on Elective II-Track C: Business Intelligence and Big Data Analytics – II (Mining Massive Data sets -I)**
1	Generate regression model and interpret the result for a given data set.
2	Generate forecasting model and interpret the result for a given data set.
3	Write a map-reduce program to count the number of occurrences of each alphabetic character in the given dataset. The count for each letter should be case-insensitive (i.e., include both upper-case and lower-case versions of the letter; Ignore non-alphabetic characters).
4	Write a map-reduce program to count the number of occurrences of each word in the given dataset. (A word is defined as any string of alphabetic characters appearing between non-alphabetic characters like nature's is two words. The count should be case-insensitive. If a word occurs multiple times in a line, all should be counted)
5	Write a map-reduce program to determine the average ratings of movies. The input consists of a series of lines, each containing a movie number, user number, rating and a timestamp.
6	Write a map-reduce program: (i) to find matrix-vector multiplication; (ii) to computeselectionsandprojections;(iii)to find union, intersection,difference, natural Join for a given dataset.
7	Write a program to construct different types of k-shingles for given document.
8	Write a program for measuring similarity among documents and detecting passages which have been reused.
9	Write a program to compute the n- moment for a given stream where n is given.
10	Write a program to demonstrate the Alon-Matias-Szegedy Algorithm for second moments.

Note: The experiments may be done using software/tools like Hadoop / WEKA / R / Java etc.

Course Code	Course Title	Credits
PCS3E1D	**Elective I- Track D: Machine Intelligence - II (Advanced Machine Learning Techniques)**	**04**

Unit I: Probability

A brief review of probability theory, Some common discrete distributions, Some common continuous distributions, Joint probability distributions, Transformations of random variables, Monte Carlo approximation, Information theory. Directed graphical models (Bayes nets): Introduction, Examples, Inference, Learning, Conditional independence properties of DGMs. Mixture models and EM algorithm: Latent variable models, Mixture models, Parameter estimation for mixture models, The EM algorithm.

Unit II: Kernels

Introduction, kernel function, Using Kernel inside GLMs, kernel trick, Support vector machines, Comparison of discriminative kernel methods.

Markov and hidden Markov models: Markov models, Hidden Markov Models (HMM), Inference in HMMs, Learning for HMMs. Undirected graphical models (Markov random fields): Conditional independence properties of UGMs, Parameterization of MRFs, Examples of MRFs, Learning, Conditional random fields (CRFs), applications of CRFs.

Unit III: Monte Carlo inference

Introduction, Sampling from standard distributions, Rejection sampling, Importance sampling, Particle filtering, Applications: visual object tracking, time series forecasting, Rao-Blackwellised Particle Filtering (RBPF). Markov chain Monte Carlo (MCMC) inference: Gibbs sampling, Metropolis Hastings algorithm, Speed and accuracy ofMCMC.

Unit IV: Graphical model structure learning

Structure learning for knowledge discovery, Learning tree structures, Learning DAG structure with latent variables, Learning causal DAGs, Learning undirected Gaussian graphical models, Learning undirected discrete graphical models. Deep learning: Deep generative models, Deep neural networks, Applications of deep networks.

Text book:

- Machine Learning: A Probabilistic Perspective: Kevin P Murphy, The MIT Press Cambridge(2012).

References:

- Introducing Monte Carlo Methods with R, Christian P. Robert, George Casella, Springer,2010
- Introduction to Machine Learning (Third Edition): EthemAlpaydın, The MIT Press (2015).
- Pattern Recognition and Machine Learning: Christopher M. Bishop,Springer (2006)

- Bayesian Reasoning and Machine Learning: David Barber, Cambridge University Press (2012).
- Statistical And Machine Learning Approaches For Network Analysis, Edited By Matthias Dehmer, Subhash C. Basak: John Wiley & Sons, Inc(2012)
- Practical Graph Mining with R: Edited by Nagiza-F-Samatova et al, CRC Press (2014)
- https://class.coursera.org/pgm/lecture/preview

Note:

OnemayuseprogramminglanguageslikeR,Python,Pajeketc and open software/ toolslike(i)EGONet;(ii)Ora;(iii)Netlogo;(iv)Pajek;and(v)NetDraw;todothe practical experiments.

Practical Course on Elective II- Track D:Machine Intelligence-II(Advanced Machine Learning Techniques)	
Sr. No	**List of Practical Experiments on Elective II- Track D:Machine Intelligence-II(Advanced Machine Learning Techniques)**
1	Find probability density function or probability mass function, cumulative distribution function and joint distribution function to calculate probabilities andquantiles for standard statistical distributions.
2	Create a Directed Acyclic Graph (DAG) using (i) set of formulae (ii) set of vectors and (iii) set of matrices. Find parents and children of nodes. Read conditional independence from DAG. Add and remove edges from graph.
3	Create a Bayesian network for a given narrative. Set findings and ask queries [One may use narratives like 'chest clinic narrative' and package gRain for the purpose].
4	Implement EM algorithm.
5	Use string kernel to find the similarity of two amino acid sequence where similarity is defined as the number of a substring incommon.
6	Demonstrate SVM as a binary classifier.
7	Create a random graph and find its page rank.
8	Apply random walk technique to a multivariate time series.
9	Implement two stage Gibbs Sampler.
10	Implement Metropolis Hastings algorithm.

Detailed syllabus of semester – IV

Course Code	Course Title	Credits
PCS4SIM	**Simulation and Modeling**	**04**

Unit I: Introduction

Introduction to Simulation, Need of Simulation, Time to simulate, Inside simulation software: Modeling the progress of Time, Modeling Variability, Conceptual Modeling: Introduction to Conceptual modeling, Defining conceptual model, Requirements of the conceptual model, Communicating the conceptual model, Developing the Conceptual Model: Introduction, A framework for conceptual modeling, methods of model simplification.

Unit II: Model Verification and Validation

Data Collection and Analysis: Introduction, Data requirements, Obtainingdata, Representing unpredictable variability, Selecting statistical distributions. Obtaining Accurate Results: Introduction, The nature of simulation models and simulation output, Issues in obtaining accurate simulation results, example model, dealing with initialization bias: warm-up and initial conditions, Selecting the number of replications and run-length. Searching the Solution Space: Introduction, The nature of simulation experimentation, Analysis of results from a single scenario, Comparing alternatives, Search experimentation, and Sensitive analysis. Verification, Validation and Confidence: Introduction, Defining Verification and Validation, The difficulties of verification and validation, Methods of verification and validation,Independent verification and validation.

Unit III: Modeling and simulation modeling

Types of models, Analytical vs Simulation modeling, Application of simulation modeling, Level of abstraction, Simulation Modeling. Methods, System Dynamics, Discrete Event Modeling, Agent Based modeling: Introduction to Agent, Agent-based modeling**,** Time in agent based models, Space in agent based models, Discrete space, Continuous space movement in continuous space, Communication between agents, Dynamic creation and destruction of agents, Statics on agent population, Condition triggered events and transitioninagents.Buildingagentsbasedmodels:Theproblemstatement,Phasesof

modeling, Assumptions, 3 D animation. Dynamics Systems: Stock and flow diagrams, examples of stock and flow diagrams. Multi-method modeling: Architecture, Technical aspects of combining modeling methods, Examples.

Unit IV: Design and behavior of models

Designing state-based behavior: Statecharts, State transitions, Viewing and debugging Statecharts at runtime, Statecharts for dynamic objects. Discrete events and Event model object: Discrete event, Event-the simplest low level model object, Dynamic events, and Exchanging data with external world. Presentation and animation: Working with shapes, groups and colors, Designing interactive models: using controls, Dynamic properties of controls, 3D Animation. Randomness in Models: Probability distributions, sources of randomness in the model, randomness in system dynamics model, random number generators, Model time, date and calendar: Virtual and real time: The model time, date and calendar, Virtual and real-time execution modes.

Text book:

- Simulation: The Practice of Model Development and Use by Stewart Robinson, John Wiley and Sons, Ltd,2004.
- TheBigBookofSimulationModeling:MultiMethodModelingbyAndrei Borshchev, 2013.

References:

- Agent Based Modeling and Simulation, Taylor S,2014.
- Simulation Modeling Handbook: A Practical Approach, Christopher A. Chung, 2003.
- Object Oriented Simulation: A Modeling and Programming Perspective, Garrido, José M,2009.
- Simulation, Modeling and Analysis, Averill M Law and W. David Kelton, "Tata McGraw Hill, Third Edition,2003.
- Process Control: Modeling, Design and Simulation, Wayne Bequette W,Prentice Hall of India, 2003.

Practical course on Simulation and modeling	
Sr. No	**List of Practical Experiments on Simulation and modeling**
1	Design and develop agent based model by • Creating the agentpopulation • Defining the agentbehavior • Add a chart to visualize the modeloutput. [Use a case scenario like grocery store, telephone call center etc for the purpose].
2	Design and develop agent based model by • Creating the agentpopulation • Defining the agentbehavior • Adding a chart to visualize the modeloutput • Adding word of mouthеffect • Considering productdiscards
3	Design and develop agent based model by • Creating the agentpopulation • Defining the agentbehavior • Adding a chart to visualize the modeloutput • Adding word of mouthеffect • Considering productdiscards • Consider deliverytime • Simulating agentimpatience • Comparing model runs with different parameter values [Use a scenario like marketmodel]

4	Design and develop System Dynamic modelby • Creating a stock and flowdiagram • Adding a plot to visualizedynamics • ParameterVariation • Calibration [Use a case scenario like spread of contagious disease for the purpose]
5	Design and develop a discrete-event model that will simulate process by: • Creating a simplemodel • Addingresources • Creating 3Danimation • Modelingdelivery [Use a case situation like a company's manufacturing and shipping].
6	Design and develop time-slice simulation for a scenario like airport model to design how passengers move within a small airport that hosts two airlines, each with their own gate. Passengers arrive at the airport, check in, pass the security checkpoint and then go to the waiting area. After boarding starts, each airline's representatives check their passengers' tickets before they allow them to board.
7	Verify and validate a model developed like bank model or manufacturing model
8	Create defense model to stimulate aircraft behavior
9	Stimulate the travelling sales man problem to compute the shortest path.
10	Stimulate the Urban dynamics to address the scenarios like: (a) The problem of public transportline (b) To compute the time taken for train to enter thestation

Course Code	Course Title	Credits
PCS4S1A	**Specialization: Cloud Computing -III (Building Clouds and Services)**	**04**

Unit I: Specialized Cloud Mechanisms: Automated Scaling listener, Load Balancer, SLA monitor, Pay-per-use monitor, Audit monitor, fail over system, Hypervisor, Resource Centre, Multi device broker, State Management Database.

Unit II: Fundamental Cloud Architectures: Workload Distribution Architecture, Resource Pooling Architecture, Dynamic Scalability Architecture, Elastic Resource Capacity Architecture, Service Load Balancing Architecture, Cloud Bursting Architecture, Elastic Disk Provisioning Architecture, Redundant Storage Architecture. Advanced
Cloud Architectures: Hypervisor Clustering Architecture, Load Balanced Virtual Server Instances Architecture, Non-Disruptive Service Relocation Architecture, Zero Downtime Architecture, Cloud Balancing Architecture, Resource Reservation Architecture, Dynamic Failure Detection and Recovery Architecture, Bare-Metal Provisioning Architecture, Rapid Provisioning Architecture, Storage Workload Management Architecture

Unit III: Cloud Management: System Center 2012 and Cloud OS, Provisioning Infrastructure: Provisioning Infrastructure with Virtual Machine Designing, Planning and Implementing. Managing Hyper-V Environment with VMM 2012. Provisioning Self-service with App Controller.

Unit IV: Implementing Monitoring: Real-time monitoring with Operations Manager, Proactive monitoring with Advisor, Operations Design, Planning, Implementation, Administration, Monitoring, Alerting, Operations and Security reporting. Building private clouds: Standardization with service manager, Service Manager 2012: Design, Planning, Implementing, Incident Tracking, Automation with orchestrator, System Orchestrator 2012.

Text book:

- Cloud Computing Concepts, Technology & Architecture, Thomas Erl, ZaighamMahmood, and Ricardo Puttini, Prentice Hall,2013.
- Cloud Security - A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley Publishing, Inc.,2010.
- Open Stack Cloud Computing Cookbook, Kevin Jackson, Cody Bunch,Egle Sigler, Packt Publishing, Third Edition, 2015.

Reference:

- Tom Fifield, Diane Fleming, Anne Gentle, Lorin Hochstein, Jonathan Proulx, Everett Toews, and Joe, Topjian,OpenStack Operations Guide, O'Reilly Media, Inc, 2014.
- NIST Cloud Computing Standards Roadmap, Special Publication 500-291, Version 2, NIST, July 2013, http://www.nist.gov/itl/cloud/upload/NIST_SP-500- 291_Version-2_2013_June18_FINAL.pdf
- https://www.openstack.org
- http://cloudstack.apache.org
- http://www.foss-cloud.org/en/wiki/FOSS-Cloud
- http://www.ubuntu.com/cloud/openstack/autopilot

Practical Course on Cloud Computing -III (Building Clouds and Services)	
Sr. No	**List of Practical Experiments on Cloud Computing -III (Building Clouds and Services)**
1	Managing private cloud with App Controller
2	Perform the practical Using Orchestrator for automation
3	Implement Windows Azure Pack
4	Implement VMWAreESXi Server

5	Managing and working of XEN for server virtualization
6	Implement Hyper-V server virtualization using server 2012
7	Managing vmware ESXi with vCentre server
8	Perform Practical to Manage xen server or Xen center
9	Design and Understanding blade server with cisco UCS/HP eva simulator
10	Perform Provisioning Self-service with App Controller

Course Code	Course Title	Credits
PCS4S2B	**Specialization: Cyber and Information Security (Cryptography and Crypt Analysis)**	**04**

Unit I: Introduction to Number Theory

Topics in Elementary Number Theory: O and notations, time estimates for doing arithmetic-divisibility and the Euclidean algorithm, Congruence: Definitions and properties, linear congruence, residue classes, Euler's phi function, Fermat's Little Theorem, Chinese Reminder Theorem, Applications to factoring, finite fields, quadratic residues and reciprocity: Quadratic residues, Legendre symbol, Jacobi Symbol. (proofs of the theorems are not expected to cover).

Unit II: Simple Cryptosystems

Shift Cipher, Substitution Cipher, Affine Cipher, Vigenère Cipher, Vermin Cipher, Hill Cipher, Permutation Cipher, Stream Cipher, Cryptanalysis of Affine Cipher, Substitution Cipher, Vigenère Cipher and Hill Cipher, Block Ciphers, Algorithm Modes, DES, Double DES, Triple DES, Meet-in-Middle Attack, AES, IDEA algorithm. Cryptographic Hash Functions: Hash Functions and Data Integrity, Security of Hash Functions, Secure Hash

Algorithm, Message Authentication Code, Nested MACs, HMAC.

Unit III: RSA Cryptosystem

The RSA Algorithm, Primarily Testing, Legendre and Jacobi Symbols, The Solovay- Strassen Algorithm, The Miller-Rabin Algorithm, Factoring Algorithm: The pollard p-1 Algorithm, Dixon's Random Squares Algorithm, Attacks on RSA, The Rabin Cryptosystem. Public Key Cryptosystems: The idea of public key Cryptography, The Diffie-Hellman Key Agreement, ElGamal Cryptosystem, The Pollard Rho Discrete

Logarithm Algorithm, Elliptic Curves, Knapsack problem.

Unit IV: Key Distribution and Key Agreement Scheme

Diffie-Hellman Key distribution and Key agreement scheme, Key Distribution Patterns, Mitchell-Piper Key distribution pattern, Station-to-station protocol, MTI Key Agreement

scheme. Public-Key Infrastructure:What is PKI?, Secure SocketLayer, Certificates, Certificate Life cycle, Trust Models: Strict Hierarchy Model, Networked PKIs, The web browser Model, Pretty Good Privacy.

Text book:

- Discrete Mathematics and Its Applications, Kenneth H. Rosen, 7th Edition, McGraw Hill,2012.
- Cryptography Theory and Practice, 3rd Edition, Douglas R. Stinson,2005.

Reference:

- Network Security and Cryptography, AtulKahate, McGraw Hill,2003.
- Cryptography and Network Security: Principles and Practices, William Stalling, Fourth Edition, Prentice Hall, 2013.
- Introduction to Cryptography with coding theory, second edition, Wade Trappe, Lawrence C. Washington, Pearson, 2005.

	Practical Course on Specialization: Cyber & Information Security (Cryptography and Crypt Analysis)
Sr. No	**List of Practical Experiments on Specialization: Cyber & Information Security (Cryptography and Crypt Analysis)**
1	Write a program to implement following: • Chinese ReminderTheorem • Fermat's LittleTheorem
2	Write a program to implement the (i) Affine Cipher (ii) Rail Fence Technique (iii) Simple Columnar Technique (iv) Vermin Cipher (v) Hill Cipher to perform encryption and decryption.
3	Write a program to implement the (i) RSA Algorithm to perform encryption and decryption.
4	Write a program to implement the (i) Miller-Rabin Algorithm (ii) pollard p-1 Algorithm to perform encryption and decryption.
5	Write a program to implement the ElGamal Cryptosystem to generate keys and perform encryption and decryption.
6	Write a program to implement the Diffie-Hellman Key Agreement algorithmto generate symmetric keys.
7	Write a program to implement the MD5 algorithm compute the message digest.
8	Write a program to implement different processes of DES algorithm like (i) Initial Permutation process of DES algorithm, (ii) Generate Keys for DES algorithm, (iii) S-Box substitution for DES algorithm.
9	Write a program to encrypt and decrypt text using IDEA algorithm.
10	Write a program to implement HMAC signatures.

Course Code	Course Title	Credits
PCS4S3C	**Specialization: Business Intelligence and Big Data Analytics (Intelligent Data Analysis)**	**04**

Unit I: Clustering

Distance/Similarity, Partitioning Algorithm: K-Means; K-Medoids, Partitioning Algorithm for large data set: CLARA; CLARANS, Hierarchical Algorithms: Agglomerative (AGNES); Divisive (DIANA), Density based clustering: DBSCAN, Clustering in Non- Euclidean Spaces, Clustering for Streams andParallelism.

Unit II: Classification

Challenges, Distance based Algorithm: K nearest Neighbors and kD-Trees, Rules and Trees based Classifiers, Information gain theory, Statistical based classifiers: Bayesian classification, Document classification, Bayesian Networks. Introduction to Support

Vector Machines, Evaluation: Confusion Matrix, Costs, Lift Curves, ROC Curves, Regression/model trees: CHAID (Chi Squared Automatic Interaction Detector). CART (Classification And Regression Tree).

Unit III: Dimensionality Reduction

Introduction to Eigen values and Eigen vectors of Symmetric Matrices, Principal- Component Analysis, Singular-Value Decomposition, CUR Decomposition.

Unit IV: Link Analysis And Recommendation Systems

Link analysis: PageRank, Efficient Computation of PageRank, Topic-Sensitive PageRank, Link Spam. Recommendation Systems: A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction.

Text book:

- Mining of Massive Datasets, AnandRajaraman and Jeffrey David Ullman, Cambridge University Press,2012.
- DataMining:IntroductoryandAdvancedTopics,MargaretH.Dunham,Pearson, 2013.

Reference:

- Big Data for Dummies, J. Hurwitz, et al., Wiley,2013.
- Networks, Crowds, and Markets: Reasoning about a Highly Connected World, David Easley and Jon Kleinberg, Cambridge University Press, 2010.
- Lecture Notes in Data Mining, Berry, Browne, World Scientific,2009.
- Data Mining: Concepts and Techniques third edition, Han and Kamber, Morgan Kaufmann,2011.
- Data Mining Practical Machine Learning Tools and Techniques, Ian H. Witten, Eibe Frank, The Morgan Kaufmann Series in Data Management Systems,2005.
- Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques,NoSQLandGraph,DavidLoshin,MorganKaufmannPublishers, 2013.

Practical Course on Specialization: Business Intelligence & Big Data Analytics (Intelligent Data Analysis)	
Sr. No.	**List of Practical Experiments on Specialization: Business Intelligence & Big Data Analytics (Intelligent Data Analysis)**
1	Pre-process the given dataset and hence apply clustering techniques like K-Means, K-Medoids. Interpret the result.
2	Pre-process the given data set and hence apply partition clustering algorithms. Interpret the result
3	Pre-process the given data set and hence apply hierarchical algorithms and density based clustering techniques. Interpret the result.

4	Pre-process the given data set and hence classify the resultant data set using tree classification techniques. Interpret the result.
5	Pre-process the given data set and hence classify the resultant data set using Statistical based classifiers. Interpret the result.
6	Pre-process the given data set and hence classify the resultant data set using support vector machine. Interpret the result.
7	Write a program to explain different functions of Principal Components.
8	Write a program to explain CUR Decomposition technique.
9	Write a program to explain links to establish higher-order relationships among entities in Link Analysis.
10	Write a program to implement step-by-step a Collaborative Filtering Recommender System.
The experiments may be done using software/ tools like R/Weka/Java etc.	

Course Code	Course Title	Credits
PCS4S4D	**Specialization: Machine Learning -III (Computational Intelligence)**	**04**

Unit I: Artificial Neural Networks

The Artificial Neuron, Supervised Learning Neural Networks, Unsupervised Learning Neural Networks, Radial Basis Function Networks, Reinforcement Learning, Performance Issues.

Unit II: Evolutionary Computation

Introduction to Evolutionary Computation, Genetic Algorithms, Genetic Programming, Evolutionary Programming, Evolution Strategies, Differential Evolution, Cultural Algorithms, Co-evolution.

Unit III: Computational Swarm Intelligence

Particle Swarm Optimization(PSO) - Basic Particle Swarm Optimization, Social Network Structures, Basic Variations and parameters, Single-Solution PSO. Advanced Topics and applications. Ant Algorithms- Ant Colony Optimization Meta-Heuristic, Cemetery Organization and Brood Care, Division of Labor, Advanced Topics and applications.

Unit IV: Artificial Immune systems, Fuzzy Systems and Rough Sets

Natural Immune System, Artificial Immune Models, Fuzzy Sets, Fuzzy Logic andReasoning, Fuzzy Controllers, Rough Sets.

Text book:

- Computational Intelligence- An Introduction (Second Edition): Andries P. Engelbrecht, John Willey & Sons Publications(2007).

Reference:

- Computational Intelligence And Feature Selection: Rough And Fuzzy Approaches, Richard Jensen QiangShen, IEEE Press Series On Computational Intelligence, A John Wiley & Sons, Inc., Publication,2008.
- Computational Intelligence And Pattern Analysis In Biological Informatics, (Editors).UjjwalMaulik,SanghamitraBandyopadhyay,JasonT.L.Wang,John Wiley & Sons, Inc, 2010.

- Neural Networks for Applied Sciences and Engineering: From Fundamentals to Complex Pattern Recognition 1st Edition, SandhyaSamarasinghe, Auerbach Publications,2006.
- Introduction to Evolutionary Computing (Natural Computing Series) 2nd ed, A.E. Eiben , James E Smith, Springer;2015.
- Swarm Intelligence, 1st Edition, Russell C. Eberhart, Yuhui Shi, James Kennedy, Morgan Kaufmann,2001
- Artificial Immune System: Applications in Computer Security, Ying Tan, Wiley- IEEE Computer Society,2016.
- Computational Intelligence and Feature Selection: Rough and FuzzyApproaches 1st Edition, Richard Jensen, QiangShen, Wiley-IEEE Press, 2008

Practical Course on Specialization: Machine Intelligence (Computational Intelligence)	
Sr No	**List of Practical Experiments on Specialization: Machine Intelligence (Computational Intelligence)**
1	Implement feed forward neural network for a given data.
2	Implement Self Organizing Map neural network.
3	Implement Radial Basis Function neural network with gradient descent.
4	Implement a basic genetic algorithm with selection, mutation and crossover as genetic operators.
5	Implement evolution strategy algorithm.
6	Implement general differential evolution algorithm.
7	Implement gbest and lbest of PSO.
8	Implement simple Ant colony optimization algorithm.
9	Implement basic artificial immune system algorithm.
10	Apply different defuzzification methods for centroid calculation of a given fuzzy rule base.
Note: The above practical experiments may use programming languages like C, Java, R etc.	

Scheme of Examination for Theory Courses

There will be internal and external examination for the theory courses. The weightage of internal/external and scheme of examination will be as per common guidelines provided by the University for the PG courses in the faculty of Science.

Scheme of Examination for Practical Courses

There will not be any internal examination for practical courses.

External Examination for practical courses:

The evaluation of the external examination of practical course is given below:

Sr No	Semester	Course Code	Particular		No of questions	Marks per question	Total Marks
1	III	PCS3PPR1	Laboratory experiment Question		2	40	80
			Journal		-	10	10
			Viva		-	10	10
		Marks for each course			100		
2	III	PCS3PPR2	Laboratory experiment Question		2	25	50
			Journal		-	10	10
			Viva		-	10	10
			viva on Project Proposal	Documentation		10	30
				Presentation		10	
				Viva		10	
		Total Marks			100		

Sr No	Semester	Course Code	Particular			No of questions	Marks per question	Total Marks
1	IV	PCS4PPR1	Laboratory experiment question			2	40	80
			Journal			-	10	10
			Viva			-	10	10
			Total Marks				100	
2	IV	PCS4PPR2	Intern-ship	Internship conduct	Quality and relevance		40	100
					Documentation		30	
					Presentation		30	
				Internship Viva			50	50
			Total Marks				150	
3	IV	PCS4PPR3	Project Implem entation	Project conduct	Quality and relevance		40	100
					Documentation		30	
					Presentation		30	
				Project viva			50	50
			Total Marks				150	

Guide lines for maintenance of journals:

A student should maintain a journal with at least six practical experiments for each part of the practical course. Certified journals need to be submitted at the time of the practical examination.

Guidelines for Project Proposal in Semester - III

- Student should take a topic related to the specialization he or she is planning to take inSemester-IV.
- Should have studied the related topics in the elective he or she has chosen in semester-II and semester-III
- A student is expected to devote at least 2 to 3 months of study as part of topic selection and itsdocumentation.
- The student should be comfortable to implement the proposal in the semester – IV.

Guidelines for Documentation of Project Proposal in Semester –III

Student is expected to make a project proposal documentation which should contain the following:

- **Title:** A suitable title giving the idea about what work isproposed.
- **Introduction:** An introduction to the topic of around 3-5 pages, giving proper back ground of the topicdiscussed.
- **Related works:** A detailed survey of the relevant works done by others in the domain. Student is expected to refer at least 5 research papers in addition to text books and web-links in the relevant topic. It may be around 7 to 10pages.
- **Objective:** A detailed objective of the proposal is needed. It may be of 1 to 2 pages.
- **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. It shall be of around 3 to 5pages.

The report may be of around 20 pages, which needs to be signed by the teacher in charge and head of the Department. Students should submit the signed project proposal documentation at the time of viva as part of the Universityexamination.

Guidelines for internship in Semester - IV

- Internship should be of 2 to 3 months with 8 to 12 weeksduration.
- A student is expected to find internship by himself or herself. However, the institution should assist their students in getting internship in goodorganizations.
- The home institution cannot be taken as the place ofinternship.
- A student is expected to devote at least 300 hours physically at theorganization.
- Internship can be on any topic covered in the syllabus mentioned in the syllabus, not restricted to the specialization.
- Internship can be done, in one of the following, but not restrictedto, types of organizations:
    - Software developmentfirms
    - Hardware/ manufacturingfirms
    - Any small scale industries, service providers likebanks
    - Clinics/ NGOs/professional institutions like that of CA, Advocateetc
    - Civic Depts like Ward office/post office/police station/punchayat.
    - Research Centres/ University Depts/ College as research Assistant for research projects or similarcapacities.

Guidelines for making Internship Report in Semester –IV

A student is expected to make a report based on the internship he or she has done in an organization. It should contain thefollowing:

- **Certificate:** A certificate in the prescribed Performa (given in appendix 1) from the organization where the internshipdone.
- **Evaluation form:** The form filled by the supervisor or to whom the intern was reporting, in the prescribed Performa (given in appendix2).

- **Title:** A suitable title giving the idea about what work the student has performed during theinternship.
- **Description of the organization:** A small description of 1 to 2 pages on the organization where the student hasinterned
- **Description about the activities done by the section where the intern has worked**: A description of 2 to 4 pages about the section or cell of the organization where the intern actually 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 actually done by the intern:** A detailed description of the work allotted and actual work performed by the intern during the internship period. Intern may give a weekly report of the work by him or her if needed. It shall be of around 7 to 10pages.
- **Self assessment:** A self assessment by the intern on what he or she has learnt during the internship period. It shall contain both technical as well as inter personal skills learned in the process. It shall be of around 2 to 3pages.

The internship report may be around 15 pages and this needs to be submitted to the external examiner at the time of University examination.

Guidelines for Research Implementation in Semester - IV

- Student should continue with topic proposed and evaluated at the semester –III.
- The topic has to be related with the specialization he or she has chosen in the semester – IV.
- A student is expected to devote at least 3 to 4 months of efforts for the implementation.
- Student 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 project implementation report with following details:

- **Title:** Title of the project (Same as the one proposed and evaluated at the semester IIexamination).
- **Implementation details:** A description of how the project has beenimplemented. It shall be of 2 to 4pages.
- **Experimental set up and results:** A detailed explanation on how experiments were conducted, what software used and the results obtained. Details like screen shots, tables and graphs can come here. It shall be of 6 to 10pages.
- **Analysis of the results:** A description on what the results means and how they have been arrived at. Different performing measures or statistical tools used etc may be part of this. It shall be of 4 to 6pages.
- **Conclusion:** A conclusion of the project performed in terms of its outcome (May be half apage).
- **Future enhancement:** A small description on what enhancement can be done when more time and resources are available (May be half apage).
- **Program code:** The program code may be given asappendix.

The report may be of around 20 pages (excluding program code), which needs to be signed by the teacher in charge and head of the Department. Student should submit the signed project implementation report along with evaluated copy of the project proposal documentation (of semester –III) at the time of Project evaluation and viva as part of the University examination.

Appendix 1

(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 her MSc course in Computer Science of University of Mumbai. The particulars of internship are givenbelow:

Internshipstartingdate: _____

Internshipendingdate:_____

Actual number of daysworked:_____

Tentative number ofhoursworked:_____Hours

Broad area of work:_____

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

_____

_____

_____

_____

_____

_____

Signature:

Name:

Designation:

Contact number:

Email:

(seal of the organization)

Appendix 2

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

Professional Evaluation of intern

Nameofintern:_____

College/institution:_____

[Note: Give a score in the 1-5 scale by putting √ in the respectivecells]

Sr No	Particular	Excellent	Very Good	Good	Moderate	Satisfactory
1	Attendance					
2	Punctuality					
3	Adaptability					
4	Ability to shoulder responsibility					
5	Ability to work in a team					
6	Written and oral communication skills					
7	Problem solving skills					
8	Ability to grasp new concepts					
9	Ability to complete task					
10	Quality of work done					

Comments:

_____

_____

_____

Signature:

Name:

Designation:

Contact number:

Email:

(seal of the organization)