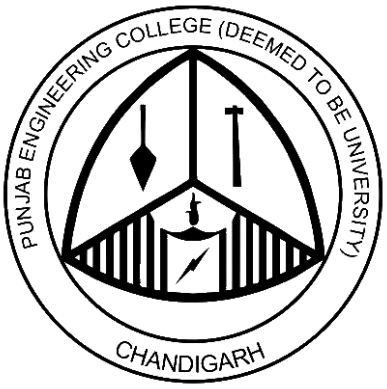
PG-Curriculum
(Structure and Course Contents)
M.Tech.- Computer Science & Engineering

With effect from July 2018



Computer Science & Engineering
Punjab Engineering College

(Deemed to be University)

Chandigarh

Index

M.Tech. Teaching Scheme

Semester I

Sr. No.	Course Stream	Course Code	Course Name	Credits	Segment Number
1.	Soft Computing	SCM5011	Internet of Things	1.5	1-3
		SCM5012	Machine Learning	1.5	4-6
2.	Design of Experiments and Research Methodology	DRM5011	Design of Experiments and Research Methodology	3	1-6
3.	Program Core-I	CSM5011	Advanced Data Structures	1.5	1-3
		CSM5012	Advanced Algorithms	1.5	4-6
4.	Program Core-II	CSM5021	Software Testing	1.5	1-3
		CSM5022	Cryptography and Computer Security	1.5	4-6
5.	Program Elective-I: E1	CSM5101	Information Retrieval	1.5	1-3
		CSM5102	Mobile and Wireless Network Security		
		CSM5103	Computer Vision		
		CSM5104	Distributed Algorithms and Computing System		
		CSM5105	Ad-hoc Networks		
		CSM5106	Advanced Computer Networks		
		CSM5107	Distributed Database Management System		
		CSM5108	Agile Software Development		
		CSM5109	Smartphones and Next Generation Computing		
		CSM5110	Cloud Computing and Security		
	Program Elective-II: E2	CSM5201	Recommender Systems	1.5	4-6
		CSM5202	Web Crawlers and Search Engines		
		CSM5203	Image and Video Processing		
		CSM5204	Mobile Computing		
		CSM5205	Wireless Sensor Networks		
		CSM5206	Advanced Data Warehouse and Data Mining		
		CSM5207	Crowd-Sensing and Pervasive Computing		
		CSM5208	Cryptocurrency and Blockchain Technology		
6.	Engineering Mathematics (EM)	EMM5014	EM1: Number Theory & Finite Fields	1	1-2
		EMM5015	EM2: Discrete Mathematics	1	3-4
		EMM5012	EM3: Optimization Techniques and Genetic Algorithm	1	5-6
			Total Credits	**18**	

Semester II

Sr. No.	Course Stream	Course Code	Course Name	Credits	Segment Number
1.	Soft Skills and Management	SSM5021	Communication Skills	1.5	1-2
		SSM5022	Management Entrepreneurship and IPR	1	3-4
		SSM5023	Professional Ethics	0.5	5-6
2.	Program Core III	CSM5031	Data Science	3	1-6
3.	Program Core-IV	CSM5041	Soft Computing	3	1-6
4.	Program Elective-III: E3	CSM5301	Social Network Analysis	1.5	1-3
		CSM5302	Image and Video Analytics		
		CSM5303	Convex Optimization		
		CSM5304	Performance Evaluation of Computer Systems and Networks		
		CSM5305	Business Analytics		
		CSM5306	Deep Learning		
	Program Elective-IV: E4	CSM5401	Big Data Analytics	1.5	4-6
		CSM5402	Medical Image Processing		
		CSM5403	Advanced Programming in Python, R, Weka		
		CSM5404	Bioinformatics		
		CSM5405	Architecture of Distributed CloudApplications		
		CSM5406	Information Warfare		
		CSM5407	Game Theory		
		CSM5408	Approximation Algorithms		
		CSM5409	High Performance Computing		
5.	Open Elective	CSO5001	Data Science	3	1-6
		CSO5002	Soft Computing	3	1-6
		CSO5003 CSO5006	Data Structures Business Analytics	1.5	1-3
		CSO5004 CSO5005	Digital Image Processing Cloud Computing	1.5	4-6
6.	Mini project/ Pre-dissertation	CSP5001		3	
			Total Credits	**18**	

Summer Term *

Sr. no.	Course Code	Course Name	Credits
1		Industrial Visit (3 days to 1 week of visit, Submission and presentation of visit report)	Satisfactory/ Non-satisfactory

*After Examination of second semester, in the first week of summer vacation industry visit can be undertaken.

Semester-III

Course No.	Course Name	Credits
1.	Dissertation/Industry Project	14

Semester-IV

Course No.	Course Name	Credits
1.	Dissertation/Industry Project	18

Total credits – 68

SEMESTER – I

SOFT COMPUTING

Course Name	**:**	**Internet of Things**
Course Code	**:**	**SCM5011**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	Understanding of core technology, applications, sensors used and IOT architecture along with the industry perspective.
2.	Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**Introduction to IOT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market , Privacy issues in IOT	2
2.	**Setting Up Raspberry Pi/Arduino to Create Solutions** Explore Raspberry Pi, setting up Raspberry Pi, showing working of Raspberry Pi using Secure Shell (SSH) Client and Team Viewer, Understand Sensing actions, Understand Actuators and Microelectromechanical Systems (MEMS).	3
3.	**Communication Protocols used in IoT** Types of wireless communication, Major wireless Short-range communication devices, properties, comparison of these devices (Bluetooth, Wireless Fidelity(WiFi), ZigBee, Low-power Wireless Personal Area Network(6LoWPAN)), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT, Low-Power Wide-Area Network(LPWAN))	3
4.	**IoT Applications** Industrial Internet 4.0, Applications such as: Smart Homes, Wearables, Smart City, Smart Grids, Connected Car, Connected digital health, telehealth, telemedicine), smart retail.	3
5.	**Sensors** Applications of various sensors: Google Maps, Waze, WhatsApp, Ola Positioning sensors: encoders and accelerometers, Image sensors: cameras Global positioning sensors: Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), Indian Regional Navigation Satellite System (IRNSS), Galileo and indoor localization systems,	3

	Motion & Orientation Sensors: Accelerometer, Magnetometer, Proximity Sensor, Gyroscope, Calibration, - noise modelling and characterization, and - noise filtering and sensor data processing, Privacy & Security	

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project based lab work: Design and build systems that will use sensors, communication protocols and actuators	14

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the concept of IOT
2.	Study IOT architecture and applications in various fields
3.	Study the security and privacy issues in IOT.
4.	Understand various applications of sensor in Industrial, healthcare, commercial, and building automation.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", VPT, 1st Edition	2014
2.	Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, 1st Edition	2013
3.	CunoPfister, "Getting Started with the Internet of Things", OReilly Media	2011
4.	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing	2015

Available MOOCS:

1. https://www.coursera.org/specializations/iot

2. https://www.edx.org/course/introduction-to-the-internet-of-things-iot

Course Name	**:**	**Machine Learning**
Course Code	**:**	**SCM5012**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To formulate machine learning problems corresponding to different applications.
2.	To understand a range of machine learning algorithms along with their strengths and weaknesses.
3.	To develop reasoning behind Model selection, model complexity, etc.

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	**BASICS OF MACHINE LEARNING:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, Real-life examples of Machine Learning.	2
2.	Artificial Intelligence and its applications in relevant engineering branch.	2
3.	**SUPERVISED LEARNING:** Classification and Regression: K-Nearest Neighbour, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2,confusionmatrix,precision,recall,F-Score,ROC-Curve.	5
4.	**UNSUPERVISED LEARNING:** Introduction to clustering, Types of Clustering: Hierarchical-Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering, Principal Component Analysis, ICA.	5

Lab Work:

Sr. No.	**Lab contents**	**No. of Hours**
1.	Python Introduction: Loops and Conditions and other preliminary stuff, Functions, Classes and Modules, Exceptions, Database access, Mathematical computing with Python packages like: numpy, Mat-plotLib, pandas Tensor Flow, Keras	8
2.	Application Oriented Project Work	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Design and implement machine learning solutions to classification, regression and clustering problems
2.	Evaluate and interpret the results of the different ML techniques
3.	Design and implement various machine learning algorithms in a range of Real-world applications.
4.	Use Python for various applications.

Bibliography:

Sr. No.	**Book Detail**	**Year of Publishing**
1.	Tom Mitchell, Machine Learning, McGraw Hill	2017
2.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer	2011
3.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e	2008
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packet Publishing Limited	2017

MOOCs on this course are available at:

1) Data Science: Machine Learning -https://www.edx.org/course/data-science-machine-learning
2) Machine Learning - https://www.coursera.org/learn/machine-learning

DESIGN OF EXPERIMENTS & RESEARCH METHODOLOGY

Course Name	**:**	**Design of Experiments and Research Methodologies**
Course Code	**:**	**DRM5011**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28
Total No. of Lab hrs. 28

Course Objectives:

The main objectives of this course are:	
1.	To develop an understanding of how to identify research topics, formulate research questions / hypotheses, select an appropriate research and, where applicable, experimental design.
2.	Provides a basis so the student can effectively develop a research proposal for either a capstone project, master's thesis, research project, or designed experiment.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction**: Types of Research and Their Purposes, Locating, Analysing, stating and evaluating research problem, need for literature review, steps in conducting literature review, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, research questions and hypothesis, types of hypothesis, evaluation of hypothesis.	**6**
2.	**Research Design and Sampling Design:** Concept of research design, features of a good research design, concept of population and sample, characteristics of sample design, types of sampling techniques	**4**
3.	**Methods of data collection and measurement:** Primary data and Secondary data, data collection techniques: observation, interview, questionnaires, schedules, case-study, levels of measurement, problems in measurement in research – validity, reliability.	**6**
4.	**Statistical Methods of Analysis:** Descriptive statistics: mean, median, mode, range, mean deviation and standard deviation, regression and correlation analysis, inferential statistics: t-tests, Chi-square tests. Correlation (rank difference and product moment), Analysis of variance (ANOVA) (one way)	**8**
5.	**Procedure for writing a research report and manuscript:** Types of research reports, steps of writing a report, layout of report, layout of research paper, ethical issues related to publishing, Plagiarism and Self-Plagiarism.	**4**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Select a problem from your area of interest, identifying the type of research	4

	problem it is and perform the SWOT analysis of the existing literature.	
2.	Generate research questions and hypotheses for a problem from your area of interest.	4
3.	Identify the population and sample for the study (highlighting the technique used for sample selection) for a problem from your area of interest.	4
4.	Design a questionnaire for the problem of interest.	4
5.	Utilizing software such as Statistical Package for the Social Sciences(SPSS), Mini Tab, etc. for the statistical analysis of the results obtained for the desired questionnaire.	6
6.	Preparing a research paper for the problem of interest	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Developed an understanding of how to identify research topics, formulate research questions and corresponding hypotheses, select an appropriate research and where applicable, experimental design.
2.	Perform required statistical analyses for any univariate application in a business / industrial setting, regardless of data form, and will be familiar with major indices for measuring correlation and association.
3.	Further, the underlying assumptions related to each statistical test and its interpretation will be thoroughly reviewed.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Probability and Statistics for Engineers and scientists by Anthony J. Hayter, Cencage Learning, 4th Edition	2016
2.	Probability and Statistics for Engineers and scientists by Walpole, Myers, Myers and Ye, 8th ed Pearson Education	2007
3.	Research Methodology - Methods and Techniques, C. K. Kothari, New Age International, 2nd Edition	2004
4.	English for writing research papers by Adrian Wallwork, 2nd Edition. Springer	2016
5.	Statistics: Concepts and Controversies by David S. Moore, William I. Notz, W. H. Freeman	2016

Available MOOCS:

1. https://www.coursera.org/learn/research-methods

2. https://www.lawctopus.com/certificate-course-on-research-methodology-online/

PROGRAM CORE

Course Name	**:**	**Advanced Data Structures**
Course Code	**:**	**CSM5011**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures:14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem.
2.	To understand the necessary mathematical abstraction to solve problems.
3.	To familiarize students with advanced paradigms and data structure used to solve algorithmic problems.
4.	To come up with analysis of efficiency and proofs of correctness.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Dictionaries and hashing:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries, Double Hashing, Rehashing, Extendible Hashing.	3
2.	**Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists	3
3.	**Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, Compressed Trees, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem.	5
4.	**Trees:** Red Black Trees, 2-3 Trees, B-Trees, Splay Trees	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project related to applications of hashing techniques	4
2.	Small text Processing application to compare different string processing algorithms	4
3.	Build application using tree data structures	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the implementation of symbol table using hashing techniques
2.	Develop and analyze algorithms for red-black trees, B-trees and Splay trees
3.	Develop algorithms for text processing applications

4.	Identify suitable data structures and develop algorithms for computational geometry

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson	2014
2.	M T Goodrich, Roberto Tamassia, Algorithm Design and Applications, John Wiley	2014
3.	Bradley N. Miller, David L. Ranum, Problem Solving with Algorithms and Data Structures Using Python, Franklin, Beedle & Associates	2011

Available MOOCS:

1. http://nptel.ac.in/courses/106106133/

2. https://www.edx.org/course/data-structures-fundamentals-uc-san-diegox-algs201x

Course Name	**:**	**Advanced Algorithms**
Course Code	**:**	**CSM5012**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures:14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand different classes of problems.
2.	To analyze and compare multiple algorithms for same problem.
3.	To introduce students with recent development in area of algorithmic design.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Graph Algorithms** Topological sorting, Bellman-Ford shortest path, Floyd Warshall shortest path, Euler Path and Circuit	5
2.	**String Algorithms** Pattern Matching: Knutt-Morris-Pratt, Rabin-Karp, Suffix Trees and Suffix Arrays	5
3.	**Approximation Algorithms** Introduction to Randomized Algorithms, Approximation Algorithms, Parallel Algorithms	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Practical comparison of regular and Fibonacci heaps	3
2.	String matching with errors	2
3.	Lossless data compression with suffix trees	4
4.	Discovering shortest routes between Indian railroad stations	5

Course Outcomes:

At the end of the course, students will have:	
1.	Compare and design efficient solution for a given problem
2.	Understand selection of data structure for an algorithm
3.	Understand latest paradigms in algorithm design

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Cormen, Leiserson, Rivest, Stein, "Introduction to Algorithms", Prentice Hall of India.	2009
2.	Horowitz, Sahini, "Fundamentals of algorithms", University Press.	1996
3.	Brassard, Bratley, "Fundamentals of algorithms", Prentice Hall of India.	1996
4.	Knuth, "The Art of Computer Programming", Vol. I-III, Pearson Education.	2008
5.	Kleinberg and Tardos, "Algorithm Design", Pearson Addison-Wesley	2011

Available MOOCS:

1. https://www.coursera.org/learn/advanced-algorithms-and-complexity

2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-854j-advanced-algorithms-fall-2005/

Course Name	**:**	**Software Testing**
Course Code	**:**	**CSM5021**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the concept and importance of software testing and to
2.	To enable students to construct software that is reasonably easy to understand, modify, maintain and reliable.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Software Testing Approaches and their Applicability:** Testing techniques and their applicability-functional testing and analysis, structural testing and analysis, hybrid approaches, integration strategies, data flow analysis, stress analysis, failure analysis, performance analysis, Testing Hierarchies.	5
2.	**Test Generation:** Finite State Machines models for flow analysis, Regular expressions based testing, Test Selection, Minimizations and Prioritization, Regression Testing.	5
3.	**Object Oriented Testing:** Object Oriented Testing Issues, Object Oriented (OO) Testing Methodologies, Analysis and Design Testing-Unified Markup Language (UML)Based, Class Testing, State based Testing, Testing Web applications.	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project to Understand the Automation Test Cases generation.	3
2.	Using any Integrated Development Environment (IDE) (like Selenium), Write a test suite containing minimum 4 to 5 test cases.	3
3.	Project for the performance analysis and regression testing of any program.	4
4.	A project to illustrate the use of Object oriented testing.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	To develop testable software.
2.	To understand and deploy testing psychology
3.	generate test cases effectively from Requirements, Design Models, Code etc.
4.	To generate test cases automatically.

5.	To apply various test cases to industrial applications.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Boris Beizer, Software Testing Techniques, John Wiley &Dreamtech 2nd Edition, 2008.	2008
2.	Yogesh Singh, Software Testing, Cambridge Press, November 2012.	2012
3.	Aditya P. Mathur, Foundations of Software Testing, Pearson Education India, 2007	2007
4.	Glenford J. Myers, The Art of Software Testing, Wiley India Pvt. Ltd, 3rd edition, Nov 2011	2011
5.	John D. McGregor & David A, A practical guide to testing object-oriented software, Addison- Wesley object technology series, 2001.	2001
6.	William E. Perry, Effective Methods for Software Testing, John Wiley & Sons, 3rd edition, 2011.	2011

Available MOOCS:

1. http://nptel.ac.in/courses/106101163/

2. https://www.edx.org/course/software-testing-management-usmx-umuc-stv1-2x-1

Course Name	**:**	**Cryptography and Computer Security**
Course Code	**:**	**CSM5022**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To understand basic design principals of symmetric and asymmetric cryptography and learn how standard cryptanalytic attacks work and thereby how to avoid common design flaws.
2.	To understand hash functions and existing techniques like Advanced Encryption Standard(AES), Rivest–Shamir–Adleman (RSA) and Discrete Log.
3.	To gain knowledge of the technologies that underpin the deployment and maintenance of a secure network.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction -** Security mindset, Computer Security Concepts (CIA), Threats, Attacks and Assets.	2
2.	**Cryptographic Protocols -** Introduction to Protocols, Communications using Symmetric Cryptography, Substitution Ciphers and Transposition Cipher, Block Cipher, Steam Cipher, Modes of Operation, Symmetric and Asymmetric cryptography	3
3.	**Cryptographic Techniques** - Key Length & Management: Symmetric Key Length, Public-Key Key Length, Comparing Symmetric and Public-Key Key Length, Generating Keys, Algorithms: DIFFIE-HELLMAN, RSA, DES.	3
4.	**Practical Cryptography –** Encryption, authentication, hashing, Symmetric and Asymmetric cryptography, Digital Signatures and Certificates.	2
5.	**Network Security and Protocol Standards –** Network security issues, sniffing, IP Spoofing, Common threats, E-mail security, Secure Socket Layer (SSL), Transport Layer Security (TLS), SSH, IPSEC, Pretty Good Privacy (PGP), Intruders, Virus, Worms, Firewalls-need and features of firewall, Types of firewall, Intruder Detection Systems.	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Practical Use of Network Security Tools, Email Header Analysis, Packet sniffing, configuration of network security equipment such as firewall, routers, IDS, Wireless Access Points	14

Course Outcomes:

At the end of the course, students will be able to:	
1.	Apply the basic rules of public key and symmetric encryption for practical cryptographic problems
2.	Demonstrate the design and use of hash functions, digital signatures, and key distribution with a wide range of key types.
3.	Understand the current popular techniques of AES and RSA, digital signatures and key establishment protocols
4.	Given a problem in cryptography, be able to design an algorithm to implement the solution to that problem.
5.	To design/develop/ implement the security solution for a given application.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Introduction to Modern Cryptography by Jonathan Katz and Yehuda Lindell, CRC Press	2014
2.	Cryptography and Network Security by William Stallings, Fourth Edition, 2006 Prentice Hall. ISBN 0-13-187316-4	2006
3.	Handbook of Applied Cryptography by Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, CRC Press.	2000
4.	Applied Cryptography: Protocols, Algorithms and Source Code in C by Bruce Schneier, John Wiley and Sons	2017

Available MOOCS:

1. https://www.coursera.org/learn/crypto

2. https://online.stanford.edu/courses/xacs130-using-cryptography-correctly

PROGRAM ELECTIVE

Course Name	**:**	**Information Retrieval**
Course Code	**:**	**CSM5101**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the basic concepts in Information Retrieval and more advance techniques of multimodal based information systems.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview of the fields** Study some basic concepts of information retrieval and data mining, such as the concept of relevance, association rules, and knowledge discovery.	3
2.	**Indexing** Introduce various indexing techniques for textual information items, such as inverted indices, tokenization, stemming and stop words.	4
3.	**Retrieval Methods** Study popular retrieval models: Tokenization, vocabulary, dictionary, Indexing for zoned search, fields, word prefix match.	4
4.	**Emerging Areas in IR:** Peer-to-peer information retrieval and MapReduce, Learning to Rank;	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project to demonstrate the association rules that can be derived using data mining.	3
2.	Project to demonstrate various indexing methods that involves stemming and stop words elimination etc.	3
3.	Project to study retrieval methods that can be used for getting data from a website.	4
4.	Project to demonstrate various ranking algorithms.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understanding the basics of Information retrieval
2.	Understanding the data structures like Inverted Indices used in Information retrieval systems
3.	Understanding the different techniques for compression of an index including the

	dictionary and its posting list
4.	Understanding the different components of an Information retrieval system
5.	Developing the ability of develop a complete IR system from scratch

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Introduction to Information Retrieval, Christopher D. Manning, Prabhakar Raghavan and HinrichSchütze, Cambridge University Press. 2008.	2008
2.	Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Addison-Wesley, 2006 Gigabytes (2nd Ed.) Ian H. Witten, Alistair Moffat and Timothy C. Bell. (1999), Morgan Kaufmann, San Francisco, California.	2006
3.	Information Retrieval: Data Structures and Algorithms by Frakes, Pearson, 1st edition 1992	1992
4.	An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition Second Edition by Daniel Jurafsky and James H. Martin, 2nd edition 2009.	2009
5.	Search Engines: Information Retrieval in Practice 1st Edition by Bruce Croft (Author), Donald Metzler (Author), Trevor Strohman (Author), 2015.	2015
6.	Introduction to Information Retrieval, Christopher D. Manning, Prabhakar Raghavan and HinrichSchütze, Cambridge University Press. 2008.	2008

Available MOOCS:

1. http://web.stanford.edu/class/cs276/

2. https://www.coursera.org/courses?languages=en&query=information+retrieval

Course Name	**:**	**Mobile and Wireless Network Security**
Course Code	**:**	**CSM5102**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To analyze cutting-edge research and security solutions in wireless and mobile networks including security in next generation mobile networks.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Security in the digital age, Threats and risks to telecommunications systems, Vulnerabilities from wireline vulnerabilities to vulnerabilities in wireless communications	2
2.	Fundamental Security Mechanisms, Secure communication protocols and VPN implementation, Multimedia Content watermarking using Robust watermarking and challenge for the information society	4
3.	Wi-Fi security Dedicated architectures - Hot spot architecture, Wireless intrusion detection system(WIDS), Wireless honeypots, Wi-Fi Security - Attacks on wireless networks, security in the IEEE 802.11 standard, Authentication in wireless networks	4
4.	Security in Mobile Telecommunication Networks - security in the GSM, GPRS security, 3G security, Bluetooth Security, 4G security	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Attacks and Security Mechanisms in Wi-Fi and Mobile Networks.	2
2.	Implementing secure information exchange using watermarking of multimedia content.	3
3.	Implementation of Mobile location and navigation security and privacy.	3
4.	Development of novel secure platforms/services using mobile technologies (e.g., secure device-to-device communication in hybrid mobile systems).	3
5.	Implement technique for intrusion detection in wireless networks.	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	Architect a secure wireless network infrastructure for their organization, including strong encryption and centralized authentication.
2.	Gain insight to the hackers threats and the major techniques used against hacking wireless networks.
3.	Master hacking and vulnerability assessment tools to assess the security of wireless networks, including cracking WEP and WPA security.

4.	Identify (and fix) vulnerabilities and mis-configurations in wireless network technologies

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Wireless and Mobile Network Security, HakimaChaouchi and Maryline Laurent-Maknavicius, Wiley-ISTE.	2009
2.	Mobile and Wireless Network Security and Privacy, Springer	2007
3.	Wireless And Mobile Network Security, PallapaVenkataram and Satish Babu B., McGraw-Hill Education Ltd.	2012
4.	Mobile and Wireless Network Security and Privacy, S. Kami Makki, Peter Reiher, Kia Makki, Niki Pissinou, ShamilaMakki, Springer.	2007
5.	Security and Privacy in Mobile and Wireless Networking, Stefanos Gritzalis, Tom Karygiannis, CharalabosSkianis, Troubador Pub.	2009

Available MOOCS:

1. https://www.coursera.org/learn/wireless-communication-technologies

2. https://www.teracomtraining.com/online-courses-certification/teracom-overview-l2106.htm

Course Name	**:**	**Computer Vision**
Course Code	**:**	**CSM5103**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area.
2.	To implement different concepts and techniques covered.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview** Image acquisition, sampling and quantization, neighbors of pixels and connectivity, basic transformation	1
2.	**Image Formation Models** Monocular imaging system, Orthographic and Perspective Projection, Camera model and camera calibration, Binocular imaging systems	3
3.	**Image Processing and Feature Extraction** Image representations (continuous and discrete), Edge detection.	2
4.	**Motion Estimation** Regularization theory, Optical computation, Stereo vision, Motion Estimation, Structure from motion.	3
5.	**Shape Representation And Segmentation** Deformable curves and surfaces, snakes and active contours, level set representations, Fourier and wavelet descriptors	2
6.	**Object Recognition** Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Implement edge detection techniques	2
2.	Implement motion estimation and detection techniques	4
3.	Analysis of curves and surfaces	4
4.	Implement object recognition techniques	4

Course Outcomes:

At the end of the course, students will be able to:

1.	Understand the various edge detectors and Implement several image filtering algorithms.
2.	Understand the different ways that the shape of an object can be represented.
3.	Analyse image segmentation, representation, description, and recognition techniques

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	D. Forsyth, J. Ponce, "Computer Vision-A modern approach", Prentice Hall of India, 2nd Edition	2015
2.	R. Gonzalez and R.E. Woods, "Digital Image Processing", Pearson Education, 3rd edition	2008
3.	E. Trucco and A. Verri, "Introductory techniques for 3D computer vision", Prentice Hall	1998

Available MOOCS:

1. https://www.edx.org/course/computer-vision-and-image-analysis-0

2. https://www.edx.org/course/architecting-distributed-cloud-applications-0

Course Name	**:**	**Distributed Algorithms and Computing Systems**
Course Code	**:**	**CSM5104**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To formally model and present fundamental algorithms for concurrent distributed systems
2.	To understand message-passing and shared-memory models for various coordination issues like Clock Synchronization, Mutual exclusion, Leader election, Agreement and Consensus.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Distributed Computing Systems and Concurrency**: Relation to Parallel Multiprocessors/multicomputer Systems, Distributed and Concurrent Programs, Formal Models, Message Passing vs. Shared Memory Systems, Synchronous vs. Asynchronous Executions, Design Issues and Challenges, Distributed Computing Technologies .	2
2.	**Clocks and Synchronization:** Model Timing Assumptions, Scaler Time, Vector Time, Matrix Time, Virtual Time, Clock Synchronization: Temporal ordering of events Lamport's Logical Clock Framework, Physical Clock Synchronization, Vector Clock Implementation.	3
3.	**Coordination and Agreement:** Distributed Mutual Exclusion Algorithms (Token, Non-Token, Quorum-based): Lamport, Ricart-Agrawala, Singhal's Dynamic, Suzuki-Kasmi's Broadcast Leader Election Algorithms: Bully, Modified Bully, Chang-Robert's Ring, Consensus: Paxos and Multi-Paxos, Byzantine Agreement, Natural Language Processing (NLP) (Impossibility) Theorem.	6
4.	**Global State and Distributed Transactions:** System Model, Snapshot Algorithms for FIFO and Non-FIFO channels, Chandy-Lamport Variations	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Implementation of Deadlock through Simulation.	2
2.	S/W Simulation for Clock Synchronization in Distributed System using Lamport's Algorithm.	4

3.	Implementation of Banker's Algorithm for avoiding Deadlock.	4
4.	WAP to Implement an Election algorithm.	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	Relate concurrent and distributed systems for various real-world applications on coordination issues like Mutual Exclusion, Leader Election, and Synchronization etc.
2.	Design new concurrent algorithms based on computing technologies and verify their correctness.

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Mukesh Singhal and Ajay D. Kshemkalyani: Distributed Computing-Principles, Algorithms and Systems	2008
2.	G. Coulouris, Dollimore and Kindberg: Distributed Systems- Concepts and Design,fifth Edition	2011

Available MOOCS:

1. https://www.edx.org/course/reliable-distributed-algorithms-part-1-kthx-id2203-1x-0

2. https://www.coursera.org/courses?languages=en&query=distributed+systems

Course Name	**:**	**Ad-hoc Networks**
Course Code	**:**	**CSM5105**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To acquire the knowledge of mobile ad hoc networks, design and implementation issues and available solutions.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction, design challenges, self-organization behaviour of ad hoc networks, Cooperation in Mobile Ad-hoc Networks (MANETs)	2
2.	MAC protocols in MANETs, Routing in MANETs and Vehicular Ad-hoc Networks (VANETs)	3
3.	Multicasting in ad hoc networks, Mobility models, Transport layer protocols, Opportunistic Mobile Networks, Unmanned Aerial Vehicle (UAV) Networks, Quality of Service (QoS) Issues	6
4.	Applications: Applications of Ad-Hoc Networks and Future Directions, Ultra-wide band radio communication, Wireless fidelity systems	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Use network Simulator (NS2/NS3/NetSim etc.) for Projects: Projects related to MAC layer Protocols, routing protocols and transport layer protocols in MANET and VANET.	8
2.	Projects related to handling of QoS issues in ad-hoc Networks.	4
3.	Project to explore current research trends in ad-hoc networks.	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	Describe the unique issues and current technology trends for the implementation and deployment of wireless ad-hoc networks.
2.	Apply MAC and routing protocols to implement wireless ad-hoc networks.
3.	Analyze transport layer protocols and related QoS issues in ad-hoc networks.
4.	Design and analyze research issues related to ad-hoc networks.

Bibliography:

Sr. No.	Book Detail	Year of Publication

1.	C. Siva Ram Murthy and B. S. Manoj, “Ad Hoc Wireless Networks: Architectures and Protocols”, Prentice Hall, Pearson Education.	2012
2.	Subir Kumar Sarkar, T.G. Basavaraju, C. Puttamadappa, “Ad Hoc Mobile Wireless Networks: Principles, Protocols, and Applications”, CRC Press, Second Edition.	2016
3.	G Ram Mohana Reddy, Kiran M, “Mobile Ad Hoc Networks: Bio-Inspired Quality of Service Aware Routing Protocols”, CRC Press.	2016
4.	Salim Bitam, Abdelhamid Mellouk, “Bio-Inspired Routing Protocols for Vehicular Ad Hoc Networks”, Wiley.	2014

Available MOOCS:

1. https://ict.iitk.ac.in/courses/wireless-ad-hoc-and-sensor-networks/

Course Name	**:**	**Advanced Computer Networks**
Course Code	**:**	**CSM5106**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To develop an understanding of the underlying structure of networks and how they operate and to provide a deeper insight into the internetworking and routing issues.
2.	To learn and understand resource management issues in networks like congestion control, Quality of Service.
3.	To understand the working principles and design issues of transport layer protocols.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Internetworking and Routing** Internetworking problem – packet switching; Delivery and Forwarding of IP packets; Router Design and Implementation, scaling IP address space, Unicast routing protocols, Mobile IP, IPv6 protocol.	5
2.	**Resource Management** Data traffic – traffic descriptor, traffic profiles; Congestion – definition, network performance; Congestion control techniques. QoS: Flow characteristics; Flow classes, Techniques to improve QoS, Internet QoS models.	5
3.	**Group Communication and Transport Layer Protocol** IP Multicast addresses; Internet Group Management Protocol (IGMP) , Multicast Routing and Transport, Multicast routing protocols TCP protocol dynamics; new options in TCP; brief introduction to Stream Control Transmission Protocol (SCTP)	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Use network Simulator (NS2/NS3/NetSim/Omnet etc.) for Projects: Projects related to routing protocols and transport layer protocols in various networks.	8
2.	Projects to include QoS attributes in various types o networks	4
3.	Project to explore current research trends in computer networks.	2

Course Outcomes:

At the end of the course, students will be able to:

1.	Identify and understand the various design issues of internetworking and routing protocols
2.	Learn the performance behaviour of networks and understand the congestion control and quality of service models in networks
3.	Grasp the concepts and characteristics of various multicast routing protocol architectures
4.	Understand the working principles and design issues of transport layer protocols.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, 5th edition, Pearson.	2013
2.	William Stallings, Data and Computer Communications, Prentice Hall	2007
3.	Forouzan, Local Area Networks, Tata McGraw-Hill Education	2002
4.	Behrouz A. Forouzan, Data Communications and Networking McGraw-Hill	2013
5.	Abdul Sakib Mondal, Mobile IP: Present State and Future, Springer Science & Business Media	2012
6.	RFCs and Internet Drafts, available from Internet Engineering Task Force.	
7.	Articles in various journals and conference proceedings	

Available MOOCS:

1. http://nptel.ac.in/courses/106106091/

Course Name	**:**	**Distributed Database Management System**
Course Code	**:**	**CSM5107**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand Distributed DBMS and associated problems.
2.	To understand various algorithms and techniques for managing distributed database.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview:** Features of distributed vs Centralized databases, Principles of distributed databases, Levels of distribution transparency, Reference architecture for distributed database, Types of data fragmentation, Integrity constraints in distributed databases.	4
2.	**Query Processing:** Translation of Global query to fragment queries, Equivalence Transformation for queries, transforming global Queries to Fragment Queries, Distributed grouping and aggregation function evaluation, Parametric queries, Optimization of access strategies, A framework for query optimization, Join queries, general queries.	5
3.	**Concurrency Control:** A framework for transaction Management, Concurrency control for distributed transactions, Optimistic methods for concurrency control, Check points and cold Restart, Catalog Management in distributed databases.	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project related to any Distributed database management application.	4
2.	Configuring, installing and handling Hadoop cluster.	5
3.	Project related to analysing Big Datasets and extracting insights.	5

Course Outcomes:

At the end of the course, students will be able to:	
1.	List and explain the fundamental concepts of a distributed database system.
2.	Utilize a wide range of features available in a Distributed Database Management

	System (DDBMS) package.
3.	Develop the logical design of the database using data modelling concepts such as entity-relationship diagrams.
4.	Apply various fragmentation techniques given a problem
5.	Apply optimization techniques to Distributed Database

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Principles of Distributed Database Systems, M. Tamer Ozsu, Patrick Valduriez. Pearson Education. Third Edition	2011
2.	Distributed Databases Principles and Systems; Stefano Ceri; GuiseppePelagatti; Tata McGraw Hill;	1985
3.	Hadoop: The Definitive Guide fourth Edition; Tom White; O'reilly	2012

Available MOOCS:

1. https://www.coursera.org/learn/distributed-database

2. http://www.inf.unibz.it/dis/teaching/DDB/

Course Name	**:**	**Agile Software Development**
Course Code	**:**	**CSM5108**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To apply the principles and practices of Agile Software Development on a project of interest and relevance.
2.	To learn the fundamental principles and practices associated with each of the agile development methods.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Agile Software Development:** Basics and Fundamentals of Agile Process Methods, Values of Agile, Principles of Agile, Stakeholders, Challenges.	5
2.	**Agile and Scrum Principles:** Agile Manifesto, twelve practices of XP, Scrum Practices, Applying Scrum. Need of scrum, working of scrum, advanced Scrum Applications, Scrum and the Organization, scrum values.	3
3.	**Agile Requirements:** User Stories, Backlog Management. Agile Architecture**:** Feature-Driven Development. Agile Risk Management**:** Risk and Quality Assurance, Agile Tools.	3
4.	**Agile Testing:** Agile Testing Techniques, Test-Driven Development, User Acceptance Test.	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1	Understand the background and driving forces for taking an Agile Approach to Software Development.	4
2	Understand the business value of adopting agile approach.	3
3	Understand agile development practices	3
4	Drive Development with Unit Test using Test Driven Development.	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	Able to compare Agile and Plan Driven development from an environment, management, people, and customer perspective.
2.	Differentiate between the different agile processes.
3.	Able to execute Agile testing.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Agile Software Development, Principles, Patterns, and Practices (Alan Apt Series) Robert C. Martin (Author).	2011
2.	Succeeding with Agile : Software Development Using Scrum, Pearson	2010
3.	Wireless And Mobile Network Security, PallapaVenkataram and Satish Babu B., McGraw-Hill Education Ltd.	2012
4.	Mobile and Wireless Network Security and Privacy, S. Kami Makki, Peter Reiher, Kia Makki, Niki Pissinou, ShamilaMakki, Springer.	2007
5.	Security and Privacy in Mobile and Wireless Networking, Stefanos Gritzalis, Tom Karygiannis, CharalabosSkianis, Troubador Pub.	2009

Available MOOCS:

1. https://www.coursera.org/specializations/agile-development

2. https://www.edx.org/course/agile-software-development

Course Name	**:**	**Smartphones and Next Generation Computing**
Course Code	**:**	**CSM5109**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. Lab Hours: 14

Course Objectives:

The main objectives of this course are:	
1.	To introduce the characteristics, basic concepts and systems issues in mobile and pervasive computing.
2.	To evaluate critical design trade-offs associated with different mobile technologies, architectures, and interfaces and business models.
3.	Impact of design on the usability, security, privacy and commercial viability of mobile and pervasive computing services and applications.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Smartphones** Smart Phone and mobile computing, convergence of sensing, tablet, Personal Digital Assistant (PDA), or other digital mobile devices, Mobile Apps (eg: Google Navigation App, WhatsApp Messenger, Hike, Snapdeal, MegaApps, CUTransit), Introduction to smartphone system architecture.	4
2.	**Programming Platforms** Overview of different mobile programming environments, Difference with the classical programming practices, Introduction to mobile operating systems, OS, An- droid, Windows, Mobile application development.	3
3.	**Data Collection, Localization & Crowd Sensing** Use of Location, User location and tracking system, Cell tower localization, Spot localization, Logical location, Indoor localization, Crowdsourcing for localization, Different Sources of Location Data: Cellular Systems, Multi Reference Point Systems, GPS, Use of Barometer, Data Collection using Crowdsourcing, Harnessing the Wisdom of Crowds, Crowdsourcing, Crowdfunding, Contests and Communities	4
4.	**Context Aware Sensing** Categorizing uses of contexts, Separations and Generality, Event driven and State Driven Behaviors	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1	Compares existing and anticipated wireless technologies, focusing on 3G cellular networks and wireless LANs	4
2	Evaluates terminal-side operating systems/programming environments, including Microsoft Windows Mobile, Palm OS, Symbian, J2ME, and Linux	3
3	Considers the limitations of existing terminal designs and several pressing application design issues	3
4	Explores challenges and possible solutions relating to the next phase of smart phone development, as it relates to services, devices, and networks	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	Have knowledge of sensors in smartphone.
2.	Vulnerabilities of a smartphone with respect to security and privacy.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Sensing and Systems in Pervasive Computing: Engineering Context Aware Systems, By Dan Chalmers (2011), Springer Science & Business Media	2011
2.	Principles of Mobile Computing, Hansmann, Lothar Merk, Martin Niclous, Stober	2013
3.	Mobile Computing, Tomasz Imielinski, Springer	2014

Available MOOCS:

1. https://www.edx.org/course/computing-technology-inside-smartphone-cornellx-engri1210x-0

2. https://www.coursera.org/learn/smartphone-emerging-technologies

Course Name	**:**	**Cloud Computing and Security**
Course Code	**:**	**CSM5110**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14
Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To analyze the components of cloud computing showing how business agility in an organization can be created.
2.	To compare modern security concepts as they are applied to cloud computing and assess the security of virtual systems and Evaluate the security issues related to multi-tenancy.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Cloud Computing Fundamentals** Cloud Computing definition, private, public and hybrid cloud. Cloud types; Product as a Service (PaaS), Infrastructure as a Service (IaaS) and Software as a Service (SaaS). Benefits and challenges of cloud computing, public vs private clouds, role of virtualization in enabling the cloud; Business Agility: Benefits and challenges to Cloud architecture.	4
2.	**Information Storage Security & Design** Storage strategy and governance; security and regulations. Designing secure solutions; the considerations and implementations involved. Securing storage in virtualized and cloud environments. Monitoring and management; security auditing and Security Information and Event Management (SIEM).	4
3.	**Security Concepts in Cloud** Confidentiality, privacy, integrity, authentication, non-repudiation, availability, access control, defence in depth, least privilege, how these concepts apply in the cloud, what these concepts mean and their importance in PaaS, IaaS and SaaS.	3
4.	**Virtualization System-Specific Attacks** Guest hopping, attacks on the VM (delete the Virtual Machine (VM) , attack on the control of the VM, code or file injection into the virtualized file structure), VM migration attack, hyper-jacking.	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Installation and configuration of Hadoop/Eucalyptus etc.	2
2.	Deployment of service and its usage over cloud.	2
3.	Implementation of techniques to manage cloud resources efficiently.	3

4.	Implementation of Para-Virtualization using VM Ware‘s Workstation/ Oracle‘s Virtual Box and Guest O.S	3
5.	Implementing techniques to secure Servers in Cloud	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Identify which cloud model will best serve that current process requirements
2.	Compare between the various cloud providers based on the services and security provided to the customer.
3.	Able to propose security requirements needed for the processes that need to be run on a cloud and effectively select one of the available cloud services.

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Cloud Computing: From beginning to end by Ray J Rafaels, CreateSpace Independent Publishing Platform	2015
2.	Privacy and Security for Cloud Computing by Siani Pearson, George Yee, Springer	2015
3.	Cloud Computing: A Practical Approach for Learning and Implementation by A. Srinivasan and J. Suresh, Pearson	2014
4.	Cloud Computing: Methodology, Systems, and Applications by Lizhe Wang, Rajiv Ranjan, Jinjun Chen, BoualemBenatallah, CRC Press	2017
5.	Cloud Computing: Principles, Systems and Applications by Nick Antonopoulos and Lee Gillam, Springer	2017
6.	Cloud Computing: Principles and Paradigms by RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley	2010
7.	Cloud Computing Bible by Barrie Sosinsky, Wiley	2010
8.	Cloud Computing by Velte, Tata McGraw-Hill	2009

Available MOOCS:

1. https://www.edx.org/course/cloud-computing-security-usmx-university-maryland-university-cc617x

2. https://www.coursera.org/specializations/cloud-computing

Course Name	**:**	**Recommender Systems**
Course Code	**:**	**CSM5201**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the basic concepts and techniques of recommender systems, including collaborative and content-based filtering techniques, and techniques for computing contextual recommendations, recommendations for groups, packages recommendations and diverse recommendations.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction**,** Search and Filtering Techniques, Applications of recommendation systems, Issues with recommender system, Collaborative Filtering, Content-based Filtering.	6
2.	Evaluation designs: Accuracy, Coverage, confidence, novelty, diversity, scalability, and serendipity.	4
3.	Contextual Recommendations, Social tagging recommender systems, Explanations in Recommender Systems	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project to demonstrate various search and filtering techniques for recommender system.	3
2.	Project to demonstrate use of various evaluation metrics like used in recommender system.	3
3.	Project to use the recommender system in social media tagging.	4
4.	Project to illustrate scalability issue in recommender system.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Present the scientific underpinnings of recommender systems and design recommendation system for a particular application domain.
2.	Evaluate recommender systems on the basis of metrics such as accuracy, rank accuracy, diversity, product coverage, and serendipity

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Recommender Systems: The Textbook by Charu C. Aggarwal (Author), springer, 2016	2016
2.	Recommender Systems Handbook by Francesco Ricci (Editor), LiorRokach (Editor), Bracha Shapira, springer, 2011.	2011
3.	Statistical Methods for Recommender Systems, Deepak K. Agarwal, LinkedIn Corporation, California, Bee-Chung Chen, LinkedIn Corporation, California, 2016,	2016
4.	Collective Intelligence in Action, SatnamAlag, September 2008, Manning Publications Co.	2008

Available MOOCS:

1. https://www.coursera.org/specializations/recommender-systems

Course Name	**:**	**Web Crawlers and Search Engines**
Course Code	**:**	**CSM5202**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the theoretical and engineering aspects of search engine technology and various algorithms that are used in the major components of large scale search engines.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview and Crawlers:** Architecture of a general-purpose search engine, such as Google or AltaVista.	3
2.	**Indexing and Retrieval:** Indexing and retrieving text files by words, Database structure.	4
3.	**Link Analysis for Ranking:** Using link structure to evaluate the importance of a Web page. PageRank.	4
4.	**Evaluation:** Measuring the quality of a search engine. Precision/recall and other measures.	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project to give basic understanding of web crawler.	3
2.	Project to implement basic focused crawling strategy using various sopping criteria.	3
3.	Project to analyse the link structure between various webpages.	4
4.	Project to use various evaluation metrics to compare the implemented crawler performance with pre-existing crawlers.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Have a good understanding of techniques used for improving ranking of webpages and be able to apply these concepts into practice.
2.	Improve ranking of web pages on commonly used search engines
3.	Avoid use of black hat techniques which may result in websites being banned

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	SoumenCharkabarti, Mining the Web: Discovering Knowledge from	2002

	Hypertext Data, Morgan Kaufmann, 2002.	
2.	The Anatomy of a Large Scale Hypertextual Web Search Engine Sergey Brin and Lawrence Page, Seventh International World Wide Web Conference, 1998.	1998
3.	Searching the Web Arvind Arasu et al., ACM Transactions on Internet Technology, 2001.	2001
4.	Information Retrieval: Implementing and Evaluating Search Engines (MIT Press) February, 2016 by Stefan Büttcher, Charles L. A. Clarke.	2016
5.	Modern Information Retrieval: The Concepts and Technology behind Search (2nd Edition) (ACM Press Books), 2016	2016

Available MOOCS:

1. https://www.coursera.org/learn/text-retrieval

Course Name	**:**	**Image and Video Processing**
Course Code	**:**	**CSM5203**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the basic theory and algorithms those are widely used in digital image processing.
2.	To learn current technologies and issues those are specific to image processing systems.
3.	To develop hands-on experience to process images.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction and Fundamental to Digital Image Processing:** Origin of Digital Image Processing, Fundamental steps in Digital Image Processing, Components of Digital Image Processing System, Image sensing and acquisition, Image sampling, quantization and representation, Basic relationship between pixels.	**3**
2.	**Image Enhancement in the Spatial Domain & Frequency domain** Basic grey level transformation, Histogram processing, Basics of Spatial filtering, Smoothing and Sharpening spatial filters, Introduction to Fourier Transform and the Frequency Domain, Discrete Fourier Transform, Smoothing and Sharpening Frequency –Domain filters.	**4**
3.	**Image Compression:** Fundamentals, Image compression models, Error free compression, Lossy compression.	**3**
4.	**Video enhancement:** noise reduction, super-resolution, scratch/dust removal	**2**
5.	**Video compression:** motion-compensated hybrid DCT/Differential pulse-code modulation (DPCM) coding, H.26X and MPEG-X families of compression standards, error resilience in video coding	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Analysis of image and video files	2
2.	Implementing image enhancement techniques	4
3.	Implement smoothing and sharpening	2
4.	Implement **v**ideo enhancement techniques	4
5.	Implement image and video compression techniques	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develop image processing applications.
2.	Develop video processing applications.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Digital Image processing By Rafael C. Gonzalez and Richard E. Woods - Pearson Education, 3rd edition	2008
2.	Fundamentals of Digital Image Processing by A.K. Jain, Prentice Hall	1994
3.	Digital Image processing: An algorithmic approach By Madhuri A Joshi, Prentice Hall, 1st Edition	2006

Available MOOCS:

1. https://www.coursera.org/learn/digital

2. https://www.my-mooc.com/en/mooc/digital/

Course Name	**:**	**Mobile Computing**
Course Code	**:**	**CSM5204**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14
Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand the concept and role of mobile computing.
2.	To provide familiarity with the network protocol and modern mobile wireless communication

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Overview of wireless and mobile systems and the challenges therein. Radio channel and wireless physical layer design. Medium access, multiplexing, link adaptation.	2
2.	Multi-hop routing protocols, routing metrics. Multicast, multi-hop data forwarding, opportunistic routing. Solutions to handle mobility at various layers of the networking stack. TCP behaviour over wireless, other transport layer issues.	4
3.	Basic Mobile IP, Mobile IP Type-MIPV4 and MIPv6, Mobile IP: Concept, Four basic entities for MIPv4, Mobile IPv4 Operations, Registration, Tunnelling, MIPv4 Reverse Tunnelling, MIPv4 Triangular Routing, Problems and Limitations of Mobile IP (MIP), MIPv4 Route Optimization Energy efficiency, localization, security. Smartphone-based platform architectures and applications. Future directions: dynamic spectrum access, heterogeneous networks, internet of things.	5
4.	Evolution of Modern Mobile Wireless Communication System, First Generation Wireless Networks, Second Generation (2G) Wireless Cellular Networks, Major 2G standards, 2.5G Wireless Networks, Third Generation 3G Wireless Networks, Wireless Local Area Networks (WLANs), Cellular –WLAN Integration, All-IP Network: Vision for 4G	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Use network simulators (NS2/NS3/NetSim etc.) Enhance any routing or mac layer protocol to provide quality of service metrics to VoIP or Video traffic.	6
2.	Develop, implement and evaluate different path selection criteria for on-demand routing protocols to determine under what network conditions each one gives the best performance.	4

3.	Create a small application for smartphones using android programming	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Analyze the applications of mobile telecommunication systems and design applications for Smartphone-based architectures.
2.	Assess the performance of routing protocols and transport layer protocols for a given network.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	G. Coulouris, DollimorenadKindberg: Distributed Systems- Concepts and Design, fourth Edition.	2009
2.	Jochen Schiller: Mobile Communications, Second Edition, Pearson Education.	2003

Available MOOCS:

1. https://www.edx.org/course/mobile-computing-with-app-inventor-cs-principles-0

2. http://nptel.ac.in/courses/106106147/

Course Name	**:**	**Wireless Sensor Networks**
Course Code	**:**	**CSM5205**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To have an understanding of the fundamental concepts of wireless sensor networks along with the various protocols used at various layers
2.	They should learn to apply sensor network protocols, mechanisms, and algorithms to implement sensing systems.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction** Brief Introduction to Wireless Networks: An introduction to Global System for Mobile communications (GSM), General Packet Radio Service (GPRS)/ 3G/ Long-Term Evolution (LTE) / "4G, Bluetooth/ Bluetooth Low Energy/ Profiles, Applications of wireless sensor networks.	2
2.	**Node Architecture** The Sensing Subsystem - Analog-to-Digital Converter; The Processor Subsystem, Communication Interfaces, Prototypes.	3
3.	**Sensor Network Protocol Stack** Physical layer, Medium Access Control: Wireless Medium Access Control (MAC) Protocols, Characteristics of MAC Protocols in Sensor Networks, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols,Fundamentals on PHY, Medium Access Control Sublayer for Low-Rate Personal and Body-Area Networks ((Institute of Electrical and Electronics Engineers (IEEE) 802.15.4 / IEEE 802.15.6)	4
4.	**Localization** Localization and positioning Ranging Techniques, Range-Based Localization, Range-Free Localization, Event-Driven Localization, WSN programming, Distributed detection, Distributed estimation	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1	Sensing data using WSN motes.	3
2	Simulating WSNs made up of motes running TinyOS using the TinyOS simulation framework TOSSIM. This header file can be used to easily	3

	output binary data as a hex dump.	
3	Collecting, disseminating and processing data in WSNs and using Deluge to disseminate programs.	4
4	Introduction to the use of cryptographically secured (private key) communication in WSNs.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand communication protocols for wireless sensor networks.
2.	Design function of the node architecture and use of sensors for various applications.
3.	Use operating systems and programming languages for wireless sensor nodes.
4.	Be familiar with architectures, functions and performance of wireless sensor networks systems and platforms.
5.	Analyze the specific requirements for applications in wireless sensor networks

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	W. Dargieand C. Poellabauer, "Fundemntalsof Wireless Sensor Networks – Theoryand Practice", Wiley.	2010
2.	KazemSohraby, Daniel Minoli and TaiebZnati, "wireless sensor networks - Technology, Protocols, and Applications", Wiley Interscience.	2007
3.	Takahiro Hara,Vladimir I. Zadorozhny, and Erik Buchmann, "Wireless Sensor Network Technologies for the Information Explosion Era", Springer.	2010
4.	Edgar H. Callaway, "Wireless Sensor Networks: Architectures and Protocols", CRC press.	2003
5.	C. S. Raghavendra, Krishna M. Sivalingam and TaiebZnati, "Wireless sensor networks", kluwer academic publishers.	2004
6.	Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Elsevier.	2004
7.	Robert Faludi, "Building Wireless Sensor Networks", O'Reilly.	2010
8.	Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John wiley and sons.	2007
9.	Rajeev Shorey, A. Ananda, MunChoon Chan and Wei Tsang Ooi, "Mobile, wireless, andSensor networks - technology, applications, and future directions", IEEE press and wileyinterscience.	2006

Available MOOCS:

1. https://www.coursera.org/lecture/internet-of-things-history/sensor-networks-n-to-1-iOmzK

2. https://swayam.gov.in/course/4408-wireless-adhoc-and-sensor-networks

Course Name	**:**	**Advanced Data Warehouse and Data Mining**
Course Code	**:**	**CSM5206**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures:14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand the basic concepts of Data Warehouse and Data Mining techniques.
2.	To analyse supervised and unsupervised models, apply pre-processing methods on raw data and estimate the accuracy of the data mining algorithms.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview:** Data Warehouse Modelling: Data Cube and Online Analytical Processing (OLAP), Data Warehouse Design and Usage: A Business Analysis Framework for Data Warehouse Design	3
2.	**Classification:** Decision Tree Induction, Bayes Classification Methods, Rule-Based Classification, Techniques to Improve Classification Accuracy: Introducing Ensemble Methods, Bagging, Boosting and AdaBoost.	3
3.	**Clustering:** Overview of Basic Clustering Methods, Partitioning Methods, Hierarchical Methods: Agglomerative versus Divisive Hierarchical Clustering, Distance Measures in Algorithmic Methods	4
4.	**Mining Complex Data Types:** Mining Sequence Data: Time-Series, Symbolic Sequences and Biological Sequences, Mining Other Kinds of Data, Data Mining Applications	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Demonstration of Association rule process on any dataset using Apriori algorithm.	4
2.	Demonstration of classification rule process on any dataset.	2
3.	Demonstration of clustering rule process on any dataset using simple k-means	2
4.	Demonstration of differences in results using decision tree and cross-validation on a data set.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Process raw data to make it suitable for various data mining algorithms.
2.	Apply the techniques of clustering, classification, association finding, feature selection and visualization to real world data

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Han J &Kamber M, "Data Mining: Concepts and Techniques", Third Edition, Elsevier.	2011
2.	Pang-Ning Tan, Michael Steinback, Vipin Kumar, "Introduction to Data Mining", Pearson Education.	2008

Available MOOCS:

1. https://www.coursera.org/learn/dwdesign

2. https://www.edx.org/course/delivering-relational-data-warehouse

Course Name	**:**	**Crowd-Sensing and Pervasive Computing**
Course Code	**:**	**CSM5207**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Total No. Lectures: 21

Course Objectives:

The main objectives of this course are:	
1.	To teach the basics of ubiquitous computing (also known as pervasive computing) as well as the basics of research, including reading research papers, speaking and presentation, formulating research questions, and empirical investigation.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction:** Definitions (Mobile, Ubiquitous Computing, IoT, Android Introduction and Setup)	2
2.	**Location-Aware computing** (determining location, geocoding, Maps & Google places) Databases, Introduction to Context, Context-Aware computing, Introduction to sensors, Android sensor programming Human-centric sensing (detecting user state, step counting, activity recognition, inferring user intent	4
3.	**Wearable computing & Social Media** , Glass and Augmented Reality, Eye-Tracking, Digital Pen and Paper. Mobile social networking & crowd sensing, Event based social network	3
4.	**Mobile affective computing** Human Activity and Emotion Sensing, Health Apps, Mobile p2p computing, Smart Homes and Intelligent Buildings	3
5.	**IoT and data analytics** IOT and Data Management, Data cleaning and processing, Data storage models, Search techniques, Deep Web, Semantic sensor web, Semantic Web Data Management, Searching in IOT	3
6.	**Crowd Sensing** Real-time and Big Data Analytics for The Internet of Things/Mobile Sensors, Heterogeneous Data Processing, High-dimensional Data Processing, Parallel and Distributed Data Processing	4
7.	**Crowd sensing data using various sensors** Incentivization Models for Crowdsourced data and Privacy Issues	2

Course Outcomes:

At the end of the course, students will be able to:

1.	Have clear understanding of socio-physical systems
2.	Relate to current trends in pervasive computing and develop a sense of practicality.
3.	Be able to develop application for embedded devices including pocket PCs, PDAs and wireless phones

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Sensing and Systems in Pervasive Computing: Engineering Context Aware Systems, By Dan Chalmers (2011), Springer Science & Business Media	2011
2.	Principles of Mobile Computing, Hansmann, Lothar Merk, Martin Niclous, Stober	2013
3.	Mobile Computing, Tomasz Imielinski, Springer	2014
4.	Pervasive Computing, 2nd Ed., by Uwe Hansmann,et.al. Springer Verlag	2003

Available MOOCS:

1. http://nptel.ac.in/courses/108102045/37

Course Name	**:**	**Cryptocurrency and Blockchain Technology**
Course Code	**:**	**CSM5208**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total no. of lectures: 14
Total no. of lab hrs: 14

Course Objectives:

The main objectives of this course are:	
1.	To have a basic understanding of blockchain technology and cryptocurrency and to study the security issues and safeguards related to bitcoin trading.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Course Description and Blockchain, Disruption/News: Price Rise, Distinction between Blockchain vs Cryptocurrency vs Token, Definition diagram: Pillars of Blockchain, Industry Applications of Blockchain: Government, Healthcare, His- tory of Centralized Services, trusted third party: Shift from gold standard to flat currency to Hash cash/digital currency (look at BEM)/Bitcoin, Trustless system, Immutability, Security, Privacy, Anti-fragility, etc.	6
2.	Cryptocurrency and Markets: Cryptocurrencies - talk about Bitcoin / Ethereum, where is the value - what are people investing in, Methods to purchase Bit- coins/Ethereum Setting up a Wallet.	4
3.	Issues with Blockchain: Security and Safeguards, Protection from attackers, Hacks on exchanges, what is stopping adoption, Scalability problems, Network attacks to destroy bitcoin, Legal adoption in various countries and laws.	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Implementation of blockchain concept and related projects that will give practical experience in real world blockchain development scenarios.	14

Course Outcomes:

At the end of the course, students will be able to:	
1.	Build efficient blockchain models to carry out advanced tasks with the practical approach.
2.	Evaluate the use and risks involved with Blockchain.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Blockchain: The Complete Step-by-step Guide to Understanding Blockchain and the Technology Behind It by Jay Isaac	2012
2.	Research Papers	

Available MOOCS:

1. https://www.coursera.org/learn/cryptocurrency

2. https://www.edx.org/course/blockchain-and-fintech-basics-applications-and-limitations

ENGINEERING MATHEMATICS

Course Name	**:**	**Number Theory and Finite Fields**
Course Code	**:**	**EMM5014**
Credits	**:**	**1**
L T P	**:**	**2-1-0**
Segment	**:**	**1-2**

Total No. of Lectures– 10

Total No. of Tutorials -5

Course Objectives:

The main objectives of this course are:	
1.	To describe the fundamental properties of integers and to prove basic theorems.
2.	To solve congruences and generate random numbers.
3.	To understand the basic concepts of groups, rings and finite fields.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction, Divisibility, The Euclidean algorithm, primes, Fundamental theorem of Arithmetic, Congruences, Residue classes and reduced residue classes, Generation of random numbers using mid square method and congruence method.	04
2.	Fermat's theorem, Euler's theorem, Solution of congruences, Chinese Remainder theorem with applications, Euler's φ-function,	04
3.	Groups, Rings and Fields, Finite Fields GF(p^n)	02

Course Outcomes:

At the end of the course, students will be able to:	
1.	Describe the fundamental properties of integers
2.	Prove basic theorems and solve congruences.
3.	generate random numbers

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	"An introduction to theory of numbers", Niven I., Zuckerman S. H. and Montgomary L. H. , John Wiley and Sons.	1991
2.	"Theory of Numbers", Hardy and Wright W. H., Oxford University Press.	2008
3.	"Higher Arithmetic", Davenport H., Cambridge University Press	2008
4.	"Elementary Number Theory", David M. Burton, Wm.C.brown Publishers, Dubuque, Ivova.	2011
5.	"Cryptography and Network Security" William Stallings, Pearson	2003

Course Name	**:**	**Discrete Mathematics**
Course Code	**:**	**EMM5015**
Credits	**:**	**1**
L T P	**:**	**2 1 0**
Segment	**:**	**3-4**

Total no. of lectures: 10
Total no. of tutorials: 4

Course Objectives:

The main objectives of this course are:	
1.	To will cover theoretical as well as practical aspects of probability and graph theory.
2.	To develop the student's ability to test and evaluate the performance of an algorithm.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Probability:** Pre-requisites: Introduction, Methods of Counting: permutation and combination, Pigeonhole principle; Sample Space; Conditional Probability; Bayes theorem and its applications in building spam filters, legitimacy of an attack.	2
2.	**Graph Theory:** Graph terminology, Handshaking lemma, Connectivity, Planarity of graphs, Graph Coloring, using graphs to represent social relationships, graphs and socio-grams, levels of measurement	4
3.	**Formal Methods of Proof:** Direct Proving Techniques: by cases, induction, strong induction and structural induction; Indirect Proving Techniques: by contradiction, by contrapositive; Application in proving the correctness of algorithms	2
4.	**Growth of Functions:** Types of growth functions, masters theorem, computing asymptotic time and space complexity of algorithms	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	Have a clear understanding of various topics of graph theory and their application in computer science
2.	Test and evaluate a given algorithm Check efficiency of an algorithm

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Graph theory by Reinhard Diestel	2000
2.	Discrete Mathematics and its applications by Kenneth Rosen	2007
3.	An Introduction to Probability Theory and its Applications vol 1 by Willam Feller, Third Edition.	2008

4.	Introduction to Algorithms by Cormen, Leiserson, Riverst, and Stein, Third Edition.	2009

Course Name	**:**	**Optimization Techniques and Genetic Algorithm**
Course Code	**:**	**EMM5012**
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segment	**:**	**5-6**

Total No. of Lectures – 10

Total No. of Practical's -10

Course Objectives:

The main objectives of this course are:	
1.	To understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2.	To identify and solve various optimization problems using Genetic Algorithms.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction to optimization problem, local and global optimum, conversion of a constrained problem to unconstrained problem.	04
2.	Genetic Algorithms, Binary and Real coded Genetic Algorithms, Coding and decoding of variables, Key steps in a GA, starting population, fitness evaluation, reproduction, crossover, mutation, evaluation.	06

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Using Genetic Algorithms in various optimization Problems	10

Course Outcomes:

At the end of the course, students will be able to:	
1.	The students are able to form mathematical model of optimization problems.
2.	The students are able to distinguish between linear and nonlinear models .
3.	The students are able to solve simple problems using Mathematica/MATLAB

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	"Practical Genetic Algorithms", Haupt, R. L. and Haupt, S.E., John Wiley & Sons	1998
2.	"Genetic Algorithm in Search, Optimization and Machine Learning" , Goldberg, D.E., Addison Wesley.	1989
3.	"Engineering Optimization", Ranjan, Ganguli, University Press.	2011

SEMESTER – II

SOFT SKILLS

&

MANAGEMENT

Course Name	**:**	**Communication Skills (CS)**
Course Code	**:**	**SSM5021**
Credits	**:**	**1.5**
L T P	**:**	**0-1-4**
Segment	**:**	**1-2**

Total no. of Tutorials: 07
Total no. of lab hrs: 28

Course Objectives:

The main objectives of this course are:	
1.	To enhance competence in communication skills: verbal and nonverbal.
2.	To provide orientation in technical communication skills: spoken and written.
3.	To sensitize students to attitude formation and behavioural skills.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Communication Skills, Soft Skills and Interpersonal Communication**	1
2.	**Speech:** Structure, Elements, Content, Organization and Delivery J-a-M	1
3.	**Writing Skills:** Letters, Minutes of Meeting	1
4.	**Technical Report Writing:** Concept & Structure	1
5.	**Research Writing:** Concept & Structural Framework	1
6.	**Power Point Presentation:** Project Presentation	1
7.	**Interviews**	1

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Self- Introduction	2
2.	Negotiation Skills & Role Play	2
3.	J-a-M Session	2
4.	Building Word Power through Reading	2
5.	Group Discussion and Case Study	4
6.	Writing Skills: Letters, Minutes of Meeting	2
7.	Technical Report Writing: Concept & Structure	4
8.	Research Writing: Concept & Structural Framework	4
9.	Power Point Presentation: Project Presentation	4
10.	Interviews	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	The students will enhance their competence in communication skills and technical communication and develop awareness of attitude formation and behavioural

	appropriateness.
2.	The course will address the gap which exists between employer expectations and student proficiency.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Technical Communication, Meenakshi Raman and Sangeeta Sharma, Oxford University Press	2015
2.	English for Research Paper Writing, Adrian Wallwork, Springer, London	2011
3.	English Vocabulary In Use: Advanced+ CD, McCarthy Michael, CUP, Cambridge	2004
4.	Advanced English Grammar, Martin Hewings, CUP, Cambridge	2003
5.	Study Listening, Lynch Tony, CUP, Cambridge	2004
6.	Study Speaking , Anderson Kenneth, CUP, Cambridge	2010
7.	Study Reading , Glendenning H. Eric, CUP, Cambridge	2004
8.	Study Writing , Lyons Liz Hamp & Ben Heasley, CUP, Cambridge	2004
9.	Study skills in English, Michael J. Wallace, CUP, Cambridge	2004

Course Name	**:**	**Management and Entrepreneurship/ IPR**
Course Code	**:**	**SSM5022**
Credits	**:**	**1**
L T P	**:**	**0-3-0**
Segment	**:**	**3-4**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To make students familiar with the concepts of Management and Entrepreneurship and understand how to develop new start-up and manage it effectively.
2.	To create awareness about the concepts of Innovation, Ideation and IPR.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Principles and Functions of Management	1
2.	Planning Process - Hypothetical Planning of an Event/Activity	1
3.	Form of Organization Structure - Case Study	1
4.	Human Resource Planning and Process, Current HR Practices	2
5.	Elements of Directing and Effective Control Mechanism Activity: Role Playing/Management Game	2
6.	Concepts of Entrepreneurship and Characteristics of Entrepreneurs	1
7.	Development Phases of Entrepreneurship -Idea Generation -Project Formulation and Validation -Business plan	4
8.	Ecosystem for Entrepreneurship Development and IPR	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	The students will learn to develop and manage new project/start-up.
2.	The students will be able to use management skills for success of business venture.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	"Entrepreneurship", TrehanAlpana, Dreamtech Press/Wiley India Publication.	2018
2.	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	2017
3.	"Essentials of Management: International and Leadership Perspective", WeihrichH.and Koontz H., 9th Edition, Pubs: McGraw Hill.	2012

4.	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014
5.	"Principles & Practice of Management", Prasad L.M., 8th Edition, Pubs: Sultan Chand & Sons.	2015
6.	"Management: Text and Cases", Rao V.S.P. and Krishna V.H., Pubs: Excel Books.	2008
7.	"Management: Concept, Practice and Cases", Aswathappa K. and GhumanKarminder, Pubs: Mc Graw Hill Education.	2010
8.	"Dynamics of Entrepreneurial Development & Management", Desai V., 5th Edition, Pubs: Himalaya Publishing House.	2012
9.	"Projects: Planning, Analysis, Selection, Financing, Implementation and Review", Chandra P., 8th Edition, Pubs: McGraw-Hill Education (India).	2014
10.	"Entrepreneur's Toolkit", Harvard Business School, Pubs: Harvard University Press.	2004
11.	"Essentials of Project Management", Ramakrishna K, Pubs: PHI Learning.	2010
12.	Harvard Business Review: Entrepreneur's Handbook	2018
13.	WIPO Annual Publications	

Course Name	**:**	**Professional Ethics**
Course Code	**:**	**SSM5023**
Credits	**:**	**0.5**
L T P	**:**	**0-3-0**
Segment	**:**	**5-6**

Total No. Tutorials: 07

Course Objectives:

The main objectives of this course are:	
1.	To provide basic knowledge about ethics, values, norms and standards and their importance in professional life.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics.	2
2.	**Self-Awareness & Self Development:** Concept of Self Awareness – Need, Elements, Self-Assessment – SWOT Analysis, Self-Concepts – Self-Knowledge, Assertiveness and Self-Confidence, Self-Esteem, Concept of Self-Development, Social Intelligence, Emotional Intelligence, Managing Time and Stress, Positive Human Qualities (Self-Efficacy, Empathy, Gratitude, Compassion, Forgiveness and Motivation	2
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives. Ethical dilemmas in business ethics.	1
4.	**Professionalism in engineering and its relation to ethics:** Ethics in Practice: Professional accountability, Roles of Professionals.	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	The students will be able to distinguish between right and wrong in both personal and professional life.
2.	The students will learn about their strengths, weaknesses, opportunities & threats and work enthusiastically to transform weaknesses into strengths and threats into opportunities.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Pubs: Himalaya Publishing House.	2014
2.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Pubs: Oxford University Press.	2007
3.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Pubs:	2006

	Tata McGraw Hill	
4.	"Business Ethics and Professional Values", Rao A.B., Pubs: Excel Books	2006
5.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Pubs: Prentice Hall	2001
6.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Pubs: Brooks/Cole, Cengage Learning	2010
7.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Pubs: Hamilton Printing Company	1997

PROGRAM CORE

Course Name	**:**	**Data Science**
Course Code	**:**	**CSM5031**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28
Total No. of Lab hrs. 28

Course Objectives:

The main objectives of this course are:	
1.	To provide with the knowledge and expertise to become a proficient data scientist.
2.	To demonstrate an understanding of statistics and machine learning concepts that are vital for data science

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Data Science:** What is data science, relation to data mining, machine learning, big data and statistics, Motivating examples	2
2.	**Getting To Know Your Data:** From data to features- Interactive group discussion, Representing problems with matrices, Representing problem with relations Computing simple statistics- Means, variances, standard deviations, weighted averaging, modes, quartiles Simple visualizations-Histograms, Boxplots, Scatterplots, Time series, Spatial data	2
3.	**Overview of Tasks & Techniques: Prediction:** The prediction task-Definition, Examples, Format of input / output data Prediction algorithms- Decision trees, Rule learners, Linear/logistic regression, Nearest neighbour learning. Support vector machines Properties of prediction algorithms and practical exercises, Combining classifiers	2
4.	**Evaluation and Methodology of Data Science:** Experimental setup- Training, tuning, test data, Holdout method, cross-validation, bootstrap method Measuring performance of a model- Accuracy, ROC curves, precision-recall curves, Loss functions for regression Interpretation of results- Confidence interval for accuracy, Hypothesis tests for comparing models, algorithms	2
5.	**Data Engineering:** Attribute selection- Filter methods, Wrapper methods Data discretization- Unsupervised discretization, Supervised discretization Data transformations- PCA and variants	2
6.	**Overview of Tasks & Techniques: Probabilistic Models:**	2

	Introduction- Probabilities, Rule of Bayes and Conditional Independence Naive Bayes- Application to spam filtering Bayesian Networks- Graphical representation, Independence and correlation Temporal models- Markov Chains, Hidden Markov Models	
7.	**Overview of Tasks & Techniques: Exploratory Data Mining:** Introduction to Exploratory Data Mining Association discovery- What is association discovery?, What are the challenges?, In detail: Apriori Clustering- What is clustering?, What are the challenges?, In detail: agglomerative clustering	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Case Studies in Data Science: Eve, the Pharmaceutical Robot Scientist: Data Science for Drug Discovery	10
2.	Case Studies in Data Science: Data science for sports analytics	10
3.	Case Studies in Data Science: Data science for sensor data (Introduction to challenge)	8

Course Outcomes:

At the end of the course, students will be able to:	
1.	Create competitive advantage from both structured and unstructured data
2.	Predict outcomes with supervised machine learning techniques.
3.	Unearth patterns in customer behaviour with unsupervised techniques.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media	
2.	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning, Springer Texts in Statistics	
3.	I. Witten, E. Frank, M. Hall. Data Mining: Practical Machine Learning Tools and Techniques (3rd Edition), Morgan Kaufmann	

Available MOOCS:

1. https://www.coursera.org/browse/data-science?languages=en

2. https://www.edx.org/learn/data-science

Course Name	**:**	**Soft Computing**
Course Code	**:**	**CSM5041**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28

Total No. of Lab hrs. 28

Course Objectives:

The main objectives of this course are:	
1.	To understand and analyse various soft computing techniques for a given problem.
2.	To get familiar with latest trends for problem solving in soft computing domain.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Soft Computing and MATLAB/ SCI LAB or any other open source software** Evolution of Computing: Soft Computing Constituents Arrays and array operations, Functions and Files	4
2.	**Fuzzy Logic** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making	5
3.	**Neural Networks** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks	8
4.	**Genetic Algorithms** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition	6
5.	**Recent Trends** Recent Trends in deep learning, various classifiers, neural networks and genetic algorithm. Implementation of recently proposed soft computing techniques	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Setting up MATLAB	2
2.	Experiments with neural network toolbox	4
3.	Experiments with fuzzy logic toolbox	4
4.	Implementing fuzzy logic	6

5.	Implementing artificial neural network	6
6.	Implementing genetic algorithms	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Identify and describe soft computing techniques and their roles in building intelligent machines
2.	Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems
3.	Apply genetic algorithms to combinatorial optimization problems
4.	Evaluate and compare solutions by various soft computing approaches for a given problem

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall of India	2009
2.	S. N. Deepa, S. N. Shivanandam, "Principles of Soft Computing", Wiley India, 2nd Edition	2011
3.	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall of India	2009

Available MOOCS:

1. https://www.class-central.com/tag/soft%20computing

2. https://swayam.gov.in/course/4574-introduction-to-soft-computing

PROGRAM ELECTIVE

Course Name	**:**	**Social Network Analytics**
Course Code	**:**	**CSM5301**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To ingest and visualize social media data, render network visualizations, and understand accuracy, bias, validity, and repeatability in social media representation.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview of Social Media:** Definitions, cognitive and sociological theories for motivation to use social media, history of social media, varied uses of different platforms, Application Programming Interface (APIs).	2
2.	**Graphs and Centrality:** Terminology, basic graph theory, and network centrality measures. Students will be taught to calculate basic centrality measures by hand.	2
3.	**Social Theory and Network Topology:** Sociological theories behind the formation of relationships and group structure. The six social forces (prestige, reciprocity, homophily, propinquity, transitivity, and structural balance) will be introduced.	2
4.	**Clustering and Subgroup Analysis:** A review of common clustering algorithms for use in networks and their application. Block modelling, modularity, graph reduction, localized network measure.	2
5.	**Network and Community Measures:** Centralization, fragmentation, clustering coefficient, density, and other graph-level and community measures.	2
6.	**Data and APIs:** Data considerations to include changing APIs, differing data storage challenges for weighted/unweighted, sparse/dense networks. Collection bias for network chaining, random sampling, missing data, and other collection issues.	2
7.	**Statistical Analysis of Networks:** Introduction to exponential random graph models. Hypothesis testing and time series analysis.	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Provide a general overview of NLP application in social media analysis to include: machine translation, named entity recognition, part-of-speech tagging, stemming, co-reference resolution.	7

2.	Sentiment Analysis and Topic Classification: sentiment analysis (happy/sad) and topic classification (what are they happy/sad about).	7

Course Outcomes:

At the end of the course, students will be able to:	
1.	Characterize social media clusters and discourse using natural language processing, sentiment analysis and topic classification
2.	Conduct basic social network analysis to include centrality, subgroup analysis, social theory, and statistical analysis of networks.
3.	Conduct over-time network analysis including statistical change detection, exponential random graph modelling, and stochastic actor oriented modelling

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Marshall Sponder, "Social Media Analytics: Effective Tools for Building, Interpreting, and Using Metrics"	2013
2.	Gonçalves, Alex, "Social Media Analytics Strategy Using Data to Optimize Business Performance"	2017

Available MOOCS:

1. https://www.coursera.org/learn/python-social-network-analysis

2. https://www.edx.org/course/social-network-analysis-sna-utarlingtonx-link-la-snax

Course Name	**:**	**Image and Video Analytics**
Course Code	**:**	**CSM5302**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn object classification and categorization techniques, face detection and activity recognition in videos.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Shadow Removal, Invariant Image Representation, Local feature Extraction	4
2.	Biologically Inspired Vision, Object Classification, Categorization, face detection	4
3.	Tracking, Activity Recognition, Anomaly Detection, Intrusion detection, Handling occlusion, scale and appearance changes	6

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Applications of local feature extraction	2
2.	Implement object classification techniques	4
3.	Implement activity recognition for videos	4
4.	Building face detection application	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand and implement object classification and categorization techniques
2.	Understand and implement activity recognition approaches
3.	Understand and develop face detection application

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	BoguslawCyganek, "Object Detection and Recognition in Digital Images: Theory and Practice", Wiley India	2015

2.	AF. Bobick et al., "The representation and recognition of action using temporal templates", CVPR	1997
3.	Efros et al., "Action Recognition at a Distance", ICCV	2003
4.	X. Sun et al., "Action Recognition via Local Descriptors and Holistic Features", CVPR	2009
5.	Weinland et al., "Action Recognition using Exemplar-based Embedding", CVPR	2008

Available MOOCS:

1. https://www.coursera.org/learn/digital

2. https://www.edx.org/course/sparse-representations-in-signal-and-image-processing-fundamentals

Course Name	**:**	**Convex Optimization**
Course Code	**:**	**CSM5303**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To recognize convex optimization problems and how to solve these numerically using either an existing software library or by deriving/implementing a suitable method that exploits problem structure

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Convex Analysis** Convex sets, cones, inner and outer descriptions, Topological properties, Polyhedral sets and representations, Some main theorems (Caratheodory, Krein-Milman.), Separating and Supporting Hyperplanes, Convex functions, Jensen's inequality, Gradient inequality, Maxima and minima of convex functions, Sub-gradients	4
2.	**Linear Programming** Structural properties, theorem on alternative, LP Duality, Some applications in classification (machine learning), compressed sensing, network flows	3
3.	**Convex Programming:** Conic programs, geometric programs (GPs), semi-definite programs (SDPs), Lagrangian, Duality, Optimality conditions (KKT Conditions, saddle points)	4
4.	**Basic Algorithms:** Gradient descent, Sub-gradient, conjugate-gradient, Newton's method, quasi-Newton methods	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Design a novel optimization method for an existing problem of some importance.	5
2.	Give a novel theoretical proof that an existing optimization method works.	4
3.	Implement a known method and show that it works practically (possibly in a new setting/regime that has not been considered before).	5

Course Outcomes:

At the end of the course, students will be able to:	
1.	Recognize and characterize convex functions and sets
2.	Explain/characterize the subdifferential of a convex function

3.	Describe basic concepts of convex analysis
4.	Derive the Lagrange dual of a convex optimization problem
5.	Derive a convex relaxation of nonconvex quadratic problems
6.	Implement a first-order method for a large-scale optimization problem with structure
7.	Construct and implement a splitting method for a convex–concave saddle-point problem
8.	Evaluate the computational performance of an optimization algorithm

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	S. Boyd and L. Vandenberghe: "Convex Optimization", Cambridge University Press	2003
2.	A. Ben-Tal and A. Nemirovski: "Lectures on Modern Convex Optimization", lecture notes	2013

Available MOOCS:

1. http://nptel.ac.in/courses/111104068/

Course Name	**:**	**Performance Evaluation of Computer Systems and Networks**
Course Code	**:**	**CSM5304**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. Lab Hours: 14

Course Objectives:

The main objectives of this course are:	
1.	To provide students with a working knowledge of computer performance evaluation.
2.	To cover fundamental techniques such as measurement and mathematical modeling.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Probability theory and statistics:** Fundamental definitions and theorems on probability, Uniform probability model. Discrete and continuous random variables. Notable RV distributions (exponential, uniform, Poissonian, normal, binomial, chi-square, student-t etc.). Central limit theorem Sample and population: estimators and confidence intervals. Data analysis and summarization. Model fitting, experiment design.	7
2.	**Analytical System modelling and capacity planning:** Queueing theory: Markov Property, Poisson processes, birth/death systems. Transient and steady-state solutions. Single-queue systems, open and closed queueing networks.	7

Lab Work:

Sr. No.	Lab contents	No. of Hours
1	Introduction to OMNeT++	3
2	Hot Potato Routing and Backward Learning	3
3	Distance Vector Routing	4
4	State Machines: Transmission Control Protocol (TCP)	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Fundamentals of probability calculus, including the properties of some common distributions
2.	Fundamentals of statistics, especially the difference between a sample and a population, and the concept of confidence intervals
3.	Fundamentals of simulation theory: how to build a simulator, what the different data structures are, how to generate random numbers, how to carry out a sound simulation study, how to handle output simulation data.
4.	Fundamentals of analytical modelling through Markov-chain methods
5.	Extract the salient features from a sample and to present them in the most effective way

6.	Follow a scientific approach to understanding why the performance of a system varies with some factors

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	S.M. Ross "Introduction to Probability and Statistics for Engineers and Computer Scientists", Elsevier	2009
2.	R. Jain "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modelling"	1991
3.	L. Kleinrock, Queueing Systems, vol. 1, Wiley	1975

Available MOOCS:

1. http://nptel.ac.in/courses/106106048/

Course Name	**:**	**Business Analytics**
Course Code	**:**	**CSM5305**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To understand how managers use business analytics to formulate and solve business problems and to support managerial decision making.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview of Business Analytics:** Introduction to Analytics, Different types of data; Data summarization methods;	**4**
2.	Organization/sources of data; Importance of data quality; Dealing with missing or incomplete data; Data Classification	**5**
3.	**Introduction to Decision Modelling:** Decision Making under Uncertainty, Introduction to Operations Research (OR), linear programming (LP), formulating decision problems using linear programming, interpreting the results and sensitivity analysis.	**5**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project for Optimizing with multiple objectives / portfolio analytics (Using any open source business analytics software)	3
2.	Project for Optimizing complex decisions / salesforce analytics	3
3.	Project to study Predictions and skill versus luck / sports analytics.	4
4.	Project based on Decision-support systems -from concept to deployment- / supply chain analytics.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the role of business analytics within an organization.
2.	Analyse data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3.	Use decision-making tools/Operations Research techniques.
4.	Use advanced analytical tools to analyse complex problems under uncertainty

Bibliography:

Sr.	Book Detail	Year of

No.		Publication
1.	Business Analytics : Methods, Models, and Decisions by James R. Evans 2014, pearson	2014
2.	Business Analytics 1st Edition by Raj Publisher: Cengage Learning	2014
3.	Data Smart: Using Data Science to Transform Information into Insight 2013 by John W. Foreman, wiley	2013

Available MOOCS:

1. https://www.coursera.org/specializations/business-analytics

2. https://www.edx.org/course/business-analytics-fundamentals2.

Course Name	**:**	**Deep Learning**
Course Code	**:**	**CSM5306**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures:-14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To introduce the fundamentals of deep learning and the main research activities in this field
2.	To learn architectures and optimization methods for deep neural network training.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction:** Meaning and importance of Deep Learning Perceptrons, Perceptron Learning Algorithm, Deep L-Layer Neural Network, Forward Propagation in a Deep Network, Building blocks of deep neural networks, Parameters v/s Hyper-parameters.	4
2.	**Convolutional Neural Network:** Introduction to CNNs, Architecture, Convolution/pooling layers, CNN Applications	4
3.	**Recurrent Neural Networks:** Introduction to RNNs, Unfolded RNNs, Seq2Seq RNNs, Long short-term memory (LSTM), RNN Applications.	4
4.	**Deep Learning Applications:** Image Processing, Natural Language Processing, Speech recognition, Video Analytics	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Implementation of following deep learning algorithms in Python using TensorFlow:Convolution Neural Network	4
2.	Implementation of following deep learning algorithms in Python using TensorFlow:Recurrent Neural Network	4
3.	Project work involving application of Deep Learning	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the foundations of deep learning.
2.	Successfully implement, apply and test relevant learning algorithms in TensorFlow.

3.	Critically evaluate the method's applicability in new contexts and construct new applications.
4.	Follow research and development in the area.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning.	2016
2.	Bengio, Yoshua. " Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127	2009
3.	Kalchbrenner, Nal, Edward Grefenstette, and Phil Blunsom. "A convolutional neural network for modelling sentences." ACL (2014).	2014

Available MOOCS:

1. http://nptel.ac.in/courses/106106184/

2. https://www.edx.org/course/deep-learning-explained

Course Name	**:**	**Big Data Analytics**
Course Code	**:**	**CSM5401**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures:14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn Understand big data for business intelligence. Learn business case studies for big data analytics.
2.	To understand nosql big data management. Perform map-reduce analytics using Hadoop and related tools

Course Contents:

Sr. No.	**Course contents**	**No. of Lectures**
1.	What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data.	**5**
2.	Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-peer replication, sharding and replication	**5**
3.	Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures	**4**

Lab Work:

Sr. No.	**Lab contents**	**No. of Hours**
1.	Project to Understand the meaning of big data and its application.	3
2.	Project using NOSQL to get data from unstructured database	4
3.	Project to explore differed open source technologies available for big data	3
4.	Project involving yarn, Pig, grant etc.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Describe big data and use cases from selected business domains
2.	Explain NoSQL big data management
3.	Install, configure, and run Hadoop and HDFS
4.	Perform map-reduce analytics using Hadoop

5.	Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging, 2009	2009
2.	Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.	2013
3.	P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.	2012
4.	Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.	2012
5.	Eric Sammer, "Hadoop Operations", O'Reilley, 2012.	2012

Available MOOCS:

1. https://www.coursera.org/learn/big-data-introduction

2. https://www.coursera.org/specializations/big-data

Course Name	**:**	**Medical Image Processing**
Course Code	**:**	**CSM5402**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14
Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn different types of biomedical images, object detection in biomedical images and perform analysis on shape, texture and pattern.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction** Nature of Biomedical Images, Digital subtraction Angiography, Dual-energy and energy subtraction X-ray imaging, Multiframe averaging in confocal microscopy	**6**
2.	**Image Enhancement and Region of interest detection** Medical image enhancement methods, Region of interest detection: Edge detection, Segmentation and region growing, Breast tumour detection using fuzzy-sets, Object of known geometry, Detection of spinal canal, Detection of Breast boundary in mammograms, Detection of Pectoral muscles in mammograms, Improved segmentation of Breast masses	**5**
3.	**Image Analysis** Shape analysis, texture analysis, pattern analysis	**3**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Object detection in biomedical images of different nature	8
2.	Implementing shape analysis techniques	2
3.	Implement texture analysis techniques	2
4.	Implement pattern analysis techniques	2

Course Outcomes:

At the end of the course, students will be able to:	
1.	Object and pattern recognition in different types of biomedical images
2.	Perform analysis over shape, texture and pattern in biomedical images

Bibliography:

Sr. No.	Book Detail	Year of Publication

1.	Arnulf Oppelt, “Imaging Systems for Medical Diagnosis”, 2nd Edition, Siemens	2006
2.	Albert Macouski, “Medical Imaging systems”, Pearson	1983
3.	John Semmlow, “Biosignal& Medical Image Processing”, 3rd Edition, CRC Press	2014
4.	http://people.ucalgary.ca/~ranga	

Available MOOCS:

1. https://www.coursera.org/learn/image-processing

Course Name	**:**	**ADVANCED PROGRAMMING IN PYTHON, R, WEKA**
Course Code	**:**	**CSM5403**
Credits	**:**	**1**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To be proficient in advanced programming and scripting packages. Inculcate the abilities to implement real world problems.
2.	To build data analysis and visualization abilities in order to effectively bring out the results.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Beyond the Basics:**Loops, String Formatting, Modules, Libraries, Packages, Reading and writing from files. **Data Analysis:** Using the following packing Pandas, Numpy, Scipy **Data Visualization:** Matplotlib	2
2.	**Basics of R Programming**: Vectors, Matrices, Dataframe, Getting help and loading packages, Control Structures, Loop Functions and Debugging. **Data Analysis with R:** Summary statistics, Graphics in R, Probability and Distribution, Data entry and exporting data,	2
3.	**WEKA:** Classification, Prediction, Rule Mining on Real world Applications using WEKA	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Hands-on on python libraries like tensor flow, Keras, etc	6
2.	Data analysis with R	4
3.	Implementation of various machine learning algorithms on different datasets like: UCI machine learning and Kaggle Datasets.	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Clear Understanding about the concepts of programming and scripting packages
2.	Able to implement and automate the real world problems
3.	Abilities to interpret, analyze and visualize the results effectively.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	**“**Introduction to Programming in Python: An Interdisciplinary Approach”, 1e (English, Paperback, Sedgewick)	2015
2.	“Data Analysis with R”: Tony Fischetti	2015
3.	“Data Mining with WEKA”: University of Waikato	2011

Available MOOCS:

1. https://www.futurelearn.com/courses/advanced-data-mining-with-weka

2. https://www.analyticsvidhya.com/blog/2016/01/top-certification-courses-sas-r-python-machine-learning-big-data-spark-2015-16/

Course Name	**:**	**Bioinformatics**
Course Code	**:**	**CSM5404**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Total No. Lectures: 21

Course Objectives:

The main objectives of this course are:	
1.	To learn different types of biomedical images, object detection in biomedical images and perform analysis on shape, texture and pattern

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Basic Molecular Biology** Cell Structure and Function: Cell components. Different types of cell. Chromosome structure and organisation. Cell division. The Hereditary Material: DNA structure, replication and protein synthesis. Structure and roles of RNA. Genetic code. Mechanism of protein synthesis: transcription and translation. Mutation. Recombinant DNA Technology: Restriction enzymes. Hybridisation techniques. Gene cloning. Polymerase chain reaction. Genomics and Structural Genomics: Genes, genomes, mapping and DNA sequencing	**6**
2.	Gene Prediction: Methods for analysing genomic DNA to identify genes using neural networks and HMMs. Detecting Distant Homology: Methods for inferring remote relationships between genes and proteins using dynamic programming, Hidden Markov Model (HMMs) , hierarchical clustering.	**5**
3.	Protein Structure Prediction: Methods for predicting the secondary and tertiary structure of proteins using neural networks, SVMs, genetic algorithms and stochastic global optimization. Transcriptomics: Methods for analysing gene expression and microarray data using clustering and SVMs. Drug Discovery Informatics: Approaches to drug discovery using bioinformatics techniques	**10**

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the advantages and disadvantages of different machine learning techniques in bioinformatics
2.	Evaluate the relative merits of different approaches by correct benchmarking techniques
3.	Use theoretical approaches to model and analyse complex biological systems

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Jeremy M Berg et al., "Biochemistry", 8th Edition, WH Freeman and co.	2015
2.	Minoru Kanehesa, "Post-genome Informatics", Oxford University Press UK	2000
3.	C.A. Orengo et al., "Bioinformatics- Genes, Proteins and Computers" BIOS Scientific Publishers	2003
4.	J.D. Murray, "Mathematical Biology", Springer	1993

Available MOOCS:

1. https://www.coursera.org/specializations/bioinformatics

Course Name	**:**	**Architecture of Distributed Cloud Applications**
Course Code	**:**	**CSM5405**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the benefits of distributed cloud applications with an emphasis on maintaining high-availability and scalability in a cost-effective way while also dealing with inevitable hardware and software failures.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Distributed Cloud Applications - Distributed Cloud Application Fundamentals, Microservices, Containers, embracing failure, orchestrators, when to split a monolith into microservices, 12-factor services, and when and how to use Containers.	**3**
2.	Networking Communication - Networking Communication, Service APIs, Fault-Tolerant Network Communication	**2**
3.	Messaging Communication - messaging with queues and fault-tolerant message processing.	**2**
4.	Upgrading, and Configuration - Versioning Service Code, Shutting Down and Reconfiguring Services	**2**
5.	Leader Election – need of leader, using leader election and role of lock for leader election	**2**
6.	Storage Services - Introduction to Data Storage Services, Object Storage Services, Database Storage Services, Data Consistency, Versioning Data Schemas, Backup, Restore and Disaster recovery	**3**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Develop a cloud application capable of performing multi-threading.	3
2.	Develop a cloud application using Socket Programming.	3
3.	Develop a cloud application using Remote Method Invocation (RMI)	3
4.	Develop a cloud application capable of providing Web Services.	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	understand the basic concepts, various pros and cons of specific technologies, and the resilient patterns that are heavily used by distributed cloud applications. This knowledge will help a student to easily build cost-efficient and fault-tolerant systems.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Architecting the Cloud: Design Decisions for Cloud Computing Service Models By Michael J. Kavis, Wiley	2014
2.	Architecting for Scale: High Availability for Your Growing Applications By Lee Atchison, O,Reilly.	2016
3.	Cloud Architecture Patterns By Bill Wilder, O,Reilly	2012
4.	Web Services and SOA: Principles and Technology by M.P. Papazoglou, 2nd Edition, Prentice-Hall.	2013
5.	Distributed Systems: Concepts and Design by G. Coulouris, 5th ed., Addison- Wesley	2011

Available MOOCS:

1. https://www.edx.org/course/architecting-distributed-cloud-applications-0

Course Name	**:**	**Information Warfare**
Course Code	**:**	**CSM5406**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Total No. Lectures: 21

Course Objectives:

The main objectives of this course are:	
1.	To understand how the internet functions from a technical and governance perspective.
2.	To identify issues arising with respect to data capture in the context of online technology and recognise concepts of privacy in the online context.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview:** How internet works, ethical Hacking and Leaking, Surveillance and National Security, international legal framework for the conduct of electronic/cyber surveillance.	3
2.	**Cyber-attacks:** Cyber-attack strategy, traditional and non-traditional points of attack, 43 current cyber-attack vectors, cyber-attack process, tools and techniques supporting the attack process, modular design of cyber weapons, sources of cyber-attack code for reuse and cloaking	6
3.	**Countermeasures for cyber-attacks:** profiling and vulnerability announcement monitoring, Social profiling of targets in support of social engineering, disinformation and misdirection in cyber-attack code, counter cyber forensics in cyber-attack code	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project related to Implementation of ethical hacking techniques.	4
2.	Project related to simulation of cyber-attacks.	5
3.	Project related to simulation of cyber-attack counter measures.	5

Course Outcomes:

At the end of the course, students will be able to:	
1.	Understand the nature and context of cyber operations and cyber-attacks.
2.	Identify the actions of whistleblowers and whistleblowing platforms.
3.	Appreciate the legal and ethical context of hacking.
4.	Understand the nature and context of cyber operations and cyber-attacks.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Richard A. Clarke, Robert Knake, " Cyber War: The Next Threat to National Security and What to Do About It", Ecco	2012
2.	Peter W. Singer, Allan Friedman: "Cybersecurity and Cyberwar: What Everyone Needs to Know"	2014

Available MOOCS:

1. https://www.edx.org/course/cyberwar-surveillance-security-adelaidex-cyber101x-0

Course Name	**:**	**Game Theory**
Course Code	**:**	**CSM5407**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Total No. Lectures: 21

Course Objectives:

The main objectives of this course are:	
1.	To apply game-theoretic analysis, both formally and intuitively, to negotiation and bargaining situations.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction and Overview Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy Nash equilibrium, dominant strategies	**3**
2.	Mixed-Strategy Nash Equilibrium pure and mixed strategy Nash equilibria	**2**
3.	Alternate Solution Concepts Iterative removal of strictly dominated strategies, minimax strategies and the minimax theorem for zero-sum game, correlated equilibria	**3**
4.	Extensive-Form Games Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium, introduction to imperfect-information games, mixed versus behavioral strategies.	**4**
5.	Repeated Games Repeated prisoners dilemma, finite and infinite repeated games, limited-average versus future-discounted reward, folk theorems, stochastic games and learning.	**3**
6.	Bayesian Games General definitions, ex ante/interim Bayesian Nash equilibrium.	**3**
7.	Coalitional Games Transferable utility cooperative games, Shapley value, Core, applications.	**3**

Course Outcomes:

At the end of the course, students will be able to:	
1.	Model competitive real world phenomena using concepts from game theory.
2.	Possess a set of intermediate level game-theoretic skills which can be applied in real world contexts.
3.	Review and critically assess literature which deals with game theory and related materials.
4.	Recommend and prescribe which strategies to implement

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Gibbons, R., Game Theory for Applied Economists, Princeton University Press	1992
2.	Dixit, A. and B. Nalebuff, The Art of Strategy, WW Norton	2008
3.	Dixit, A. and B. Nalebuff, Thinking Strategically, WW Norton	1991
4.	Salim Bitam, Abdelhamid Mellouk, "Bio-Inspired Routing Protocols for Vehicular Ad Hoc Networks", Wiley.	2014

Available MOOCS:

1. http://nptel.ac.in/courses/110104063/

2. https://www.coursera.org/learn/game-theory-introduction

Course Name	**:**	**Approximation Algorithms**
Course Code	**:**	**CSM5408**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Total No. Lectures: 21

Course Objectives:

The main objectives of this course are:	
1.	To learn and design polynomial time approximation algorithms for NP-Hard problems using various techniques.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Introduction to approximation problems, NP-hard problems, need of approximation algorithms, bounding the optimum Vertex cover problem, Set cover problem, 0/1 knapsack problem	**3**
2.	Steiner Tree, Travelling Salesman Problem, Max flow-min cut problems	**4**
3.	Approximation Scheme, Fully Polynomial-Time Approximation Scheme (FPTAS), Polynomial-Time Approximation Scheme (PTAS) Knapsack, Multiprocessor Scheduling	**4**
4.	Linear Programming Techniques	**4**
5.	Rounding Techniques	**3**
6.	Primal-dual Technique	**3**

Course Outcomes:

At the end of the course, students will be able to:	
1.	Need and design of approximation algorithms using various techniques
2.	Approach and design approximation algorithm for problems not known

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Vijay V Vazirani, “Approximation Algorithms”, Springer India	2002
2.	Jon Kleinberg, Eva Tardos, “Algorithm Design”, Pearson India, 1st Edition	2014

Available MOOCS:

1. https://www.coursera.org/learn/approximation-algorithms-part-1

2. http://pages.cs.wisc.edu/~shuchi/courses/880-S07/

Course Name	**:**	**High Performance Computing**
Course Code	**:**	**CSM5409**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To understand various activities that happen during program execution, and how they are managed by the hardware (architectural features) and system software (operating systems, run-time systems)
2.	To understand organization of parallel systems.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview:** Programming languages and programming-language extensions for High Performance Computing (HPC), Compiler options	3
2.	**Optimization:** optimizations for modern single-core and multi-core processors, program profiling, Execution profiling, timing techniques, and benchmarking for modern single-core and multi-core processors, Hardware Architecture	4
3.	**Parallel System organization:** Parallelization strategies, task parallelism, data parallelism, and work sharing techniques Introduction to message passing and Message Passing Interface (MPI) programming, Problem decomposition, graph partitioning, and load balancing, Introduction to shared memory and OpenMP programming.	7

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project related to implantation of Program Profiling.	4
2.	Project related to Parallelization techniques.	5
3.	Project related to message passing using MPI programing.	5

Course Outcomes:

At the end of the course, students will be able to:	
1.	Explain the fundamental concepts of High performance computing.
2.	Understand that more advanced use of software and parallel hardware is required to further speed up processing of programs.
3.	write code that is highly optimized for modern multi-core processors and clusters using modern software development tools, performance profilers, specialized algorithms, parallelization strategies

4.	Understand to how to apply different recycling techniques to reduce waste production and pollution.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	K.R. Wadleigh and I.L. Crawford: Software Optimization for High Performance Computing: Creating Faster Applications	2000
2.	B. Wilkinson and M. Allen, Prentice Hall: "Parallel Programming: Techniques and Applications using Networked Workstations and Parallel Computers" (2nd ed.)	2004
3.	G. Karniadakis and R. Kirby II , "Parallel Scientific Computing in C++ and MPI" by, Cambridge University Press.	2003

Available MOOCS:

1. https://www.coursera.org/courses?query=high%20performance%20computing

2. http://nptel.ac.in/courses/106108055/

OPEN ELECTIVE

Course Name	**:**	**Data Science**
Course Code	**:**	**CSO5001**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28
Total No. of Lab hrs. 28

Course Objectives:

The main objectives of this course are:	
1.	To provide students with a foundation to: Apply game-theoretic analysis, both formally and intuitively, to negotiation and bargaining situations.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Data Science:** What is data science, relation to data mining, machine learning, big data and statistics, Motivating examples	2
2.	**Getting To Know Your Data:** From data to features- Interactive group discussion, Representing problems with matrices, Representing problem with relations Computing simple statistics- Means, variances, standard deviations, weighted averaging, modes, quartiles Simple visualizations-Histograms, Boxplots, Scatterplots, Time series, Spatial data	2
3.	**Overview of Tasks & Techniques: Prediction:** The prediction task-Definition, Examples, Format of input / output data Prediction algorithms- Decision trees, Rule learners, Linear/logistic regression, Nearest neighbour learning. Support vector machines Properties of prediction algorithms and practical exercises, Combining classifiers	2
4.	**Evaluation and Methodology of Data Science:** Experimental setup- Training, tuning, test data, Holdout method, cross-validation, bootstrap method Measuring performance of a model- Accuracy, ROC curves, precision-recall curves, Loss functions for regression Interpretation of results- Confidence interval for accuracy, Hypothesis tests for comparing models, algorithms	2
5.	**Data Engineering:** Attribute selection- Filter methods, Wrapper methods Data discretization- Unsupervised discretization, Supervised discretization Data transformations- PCA and variants	2
6.	**Overview of Tasks & Techniques: Probabilistic Models:** Introduction- Probabilities, Rule of Bayes and Conditional Independence Naive Bayes- Application to spam filtering	2

	Bayesian Networks- Graphical representation, Independence and correlation Temporal models- Markov Chains, Hidden Markov Models	
7.	**Overview of Tasks & Techniques: Exploratory Data Mining:** Introduction to Exploratory Data Mining Association discovery- What is association discovery?, What are the challenges?, In detail: Apriori Clustering- What is clustering?, What are the challenges?, In detail: agglomerative clustering	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Case Studies in Data Science: Eve, the Pharmaceutical Robot Scientist: Data Science for Drug Discovery	10
2.	Case Studies in Data Science: Data science for sports analytics	10
3.	Case Studies in Data Science: Data science for sensor data (Introduction to challenge)	8

Course Outcomes:

At the end of the course, students will be able to:	
1.	Create competitive advantage from both structured and unstructured data
2.	Predict outcomes with supervised machine learning techniques.
3.	Unearth patterns in customer behavior with unsupervised techniques.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Joel Grus**,** Data Science from Scratch: First Principles with Python, O'Reilly Media	
2.	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning, Springer Texts in Statistics	
3.	I. Witten, E. Frank, M. Hall. Data Mining: Practical Machine Learning Tools and Techniques (3rd Edition), Morgan Kaufmann	

Available MOOCS:

1. https://www.coursera.org/browse/data-science?languages=en

2. https://www.edx.org/learn/data-science

Course Name	**:**	**Soft Computing**
Course Code	**:**	**CSO5002**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28

Total No. of Lab hrs. 28

Course Objectives:

The main objectives of this course are:	
1.	To understand and analyse various soft computing techniques for a given problem.
2.	To get familiar with latest trends for problem solving in soft computing domain.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Soft Computing and MATLAB** Evolution of Computing: Soft Computing Constituents Introduction to MATLAB, Arrays and array operations, Functions and Files	4
2.	**Fuzzy Logic** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making	5
3.	**Neural Networks** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks	8
4.	**Genetic Algorithms** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition	6
5.	**Recent Trends** Recent Trends in deep learning, various classifiers, neural networks and genetic algorithm. Implementation of recently proposed soft computing techniques	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Setting up MATLAB	2
2.	Experiments with neural network toolbox	4
3.	Experiments with fuzzy logic toolbox	4
4.	Implementing fuzzy logic	6
5.	Implementing artificial neural network	6

6.	Implementing genetic algorithms	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Identify and describe soft computing techniques and their roles in building intelligent machines
2.	Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems
3.	Apply genetic algorithms to combinatorial optimization problems
4.	Evaluate and compare solutions by various soft computing approaches for a given problem

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall of India	2009
2.	S. N. Deepa, S. N. Shivanandam, "Principles of Soft Computing", Wiley India, 2nd Edition	2011
3.	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall of India	2009

Available MOOCS:

1. https://www.class-central.com/tag/soft%20computing

2. https://swayam.gov.in/course/4574-introduction-to-soft-computing

Course Name	**:**	**Data Structures**
Course Code	**:**	**CSO5003**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Course Objectives:

The main objectives of this course are:	
1.	To study efficient algorithms for a number of fundamental problems, learn techniques for designing algorithms using appropriate data structures, prove correctness and analyze running times of algorithms.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	Elementary Data Structures - Stacks and queues, linked list, implementing pointers and objects, Representing rooted trees	**2**
2.	Dictionaries: Sets, Dictionaries, Hash Tables, Open Hashing, Closed Hashing (Rehashing Methods), Hashing Functions (Division Method, Multiplication Method, Universal Hashing), Skip lists, Analysis of Skip lists.	**3**
3.	Amortized Analysis - Aggregate analysis, The accounting method, The potential method, Dynamic tables	**3**
4.	Introduction to Binary search trees, B-Trees, Fibonacci trees, Red-black trees, Mergeable heaps	**4**
5.	Priority Queues: Binary Heaps - Implementation of insert and delete min, creating heap; Binomial Heaps and Operations.	**2**
6.	Data Structures for Disjoint Sets - Disjoint-set operations, Linked-list representation of disjoint sets, Disjoint-set forests	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Implement an efficient algorithm for matrix multiplication and perform its complexity analysis.	2
2.	Design an application capable of implement a dictionary using Binary Search Trees.	3
3.	Design an application capable of implement a dictionary using Red Black Trees.	3
4.	Design a small project which utilizes binomial heaps.	3
5.	Design an application for text searching using a suitable data-structure.	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	To impart the basic concepts of data structures and algorithms

2.	Be able to understand and apply amortised analysis on data structures, including binary search trees, mergeable heaps, and disjoint sets.
3.	Understand the implementation and complexity analysis of fundamental algorithms.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Thomas Cormen, Charles Leiserson, Ronald Rivest and Clifford Stein, Introduction to Algorithms, MIT Press (third edition).	2009
2.	S. Dasgupta, C.H. Papadimitriou, and U.V. Vazirani, Algorithms, Mcgraw-Hill.	2006
3.	J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley, 2006.	2006
4.	Richard F. Gilberg& Behrouz A. Forouzan Data Structures A Psedocode Approach with C, second edition, CENGAGE Learning.	2004
5.	Reema Thareja, Data Structures using C, Oxford University press.	2014
6.	Jean-Paul Tremblay, P. G. Sorenson, Introduction to Data Structure and its Applications, Tata Mc-Graw Hill.	2001
7.	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, MIT Press	2009

Available MOOCS:

1. https://www.edx.org/course/introduction-data-structures-adelaidex-data101x

2. https://www.coursera.org/specializations/data-structures-algorithms

Course Name	**:**	**Digital Image Processing**
Course Code	**:**	**CSO5004**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn digital image fundamentals and exposed to simple image processing techniques.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction** – Origin, Steps in Digital Image Processing, Components, Image Sensing and Acquisition, Image Sampling and Quantization, Relationships between pixels, color models, classification of images and feature extraction.	2
2.	**Spatial Domain:**Gray level transformations, Histogram processing, Basics of Spatial Filtering, Smoothing and Sharpening Spatial Filtering, Frequency Domain: Introduction to Fourier Transform	3
3.	**Image Restoration and Segmentation:** Noise models, Mean Filters, Order Statistics, Adaptive filters, Band reject Filters, Band pass Filters, Notch Filters, Optimum Notch Filtering, Inverse Filtering, Wiener filtering, Segmentation: Detection of Discontinuities, Edge Linking and Boundary detection, Region based segmentation, Morphological processing, erosion and dilation.	4
4.	**Wavelets and Image Compression: Introduction to** Wavelets, Compression: Fundamentals, Image Compression models, Error Free Compression, Variable Length Coding, Bit-Plane Coding, Lossless Predictive Coding, Lossy Compression, Lossy Predictive Coding, Compression Standards.	3
5.	Image Representation: Boundary representation, Boundary description, Regional Descriptors	2

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Using MATLAB (or equivalent software), perform various arithmetic operations on two images.	2
2.	Using MATLAB (or equivalent software), represent image as a histogram, segment its colors and perform histogram equalization	3
3.	Using MATLAB (or equivalent software), detect the edge of an image operators.	2

4.	Using MATLAB (or equivalent software), Implement various spatial image enhancement functions on a bitmap image –Mirroring (Inversion)	2
5.	Implement a function in MATLAB for image morphology that analyze the form and shape detail of image structures	2
6.	Implement a function in MATLAB for Image Restoration and Segmentation.	3

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develop an overview of the field of image processing.
2.	Understand the fundamental algorithms and how to implement them.
3.	Represent features of images.
4.	Gain experience in applying image processing algorithms to real problems.

Bibliography:

Sr. No.	**Book Detail**	**Year of Publication**
1.	Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education.	2010
2.	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd.	2011
3.	Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd.	2011
4.	Willliam K Pratt, "Digital Image Processing", John Willey.	2007
5.	Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd.	2011

Available MOOCS:

1. https://www.coursera.org/courses?languages=en&query=digital+image+processing

2. https://online.stanford.edu/courses/ee368-digital-image-processing

Course Name	**:**	**Business Analytics**
Course Code	**:**	**CSO5006**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Overview of Business Analytics:** Introduction to Analytics, Different types of data; Data summarization methods;	**4**
2.	Organization/sources of data; Importance of data quality; Dealing with missing or incomplete data; Data Classification	**5**
3.	**Introduction to Decision Modelling:** Decision Making under Uncertainty, Introduction to Operations Research (OR), linear programming (LP), formulating decision problems using linear programming, interpreting the results and sensitivity analysis.	**5**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project for Optimizing with multiple objectives / portfolio analytics	3
2.	Project for Optimizing complex decisions / salesforce analytics	3
3.	Project to study Predictions and skill versus luck / sports analytics.	4
4.	Project based on Decision-support systems -from concept to deployment- / supply chain analytics.	4

Course Outcomes:

At the end of the course, students will be able to:	
5.	Understand the role of business analytics within an organization.
6.	Analyse data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
7.	Use decision-making tools/Operations Research techniques.
8.	Use advanced analytical tools to analyse complex problems under uncertainty

Bibliography:

Sr. No.	Book Detail	Year of Publication

1.	Business Analytics : Methods, Models, and Decisions by James R. Evans 2014, pearson	2014
2.	Business Analytics 1st Edition by Raj Publisher: Cengage Learning	2014
3.	Data Smart: Using Data Science to Transform Information into Insight 2013 by John W. Foreman, wiley	2013

Available MOOCS:

1. https://www.coursera.org/specializations/business-analytics

2. https://www.edx.org/micromasters/business-analytics

Course Name	**:**	**Cloud Computing**
Course Code	**:**	**CSO5005**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures: 14

Total No. of Lab hrs. 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the basic Cloud types and delivery models and develop an understanding of the risk and compliance responsibilities and Challenges for each Cloud type and service delivery model.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction to Cloud Computing :** Online Social Networks and Applications, Cloud introduction and overview, Different clouds, Risks, Novel applications of cloud computing	5
2.	**Cloud Computing Architecture:** Requirements, Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The Serial Peripheral Interface(SPI) Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model	5
3.	**Cloud Deployment Models :** Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise	4

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Project to Understand basic working of cloud	3
2.	Project to divide online resources of cloud virtually as different devices	3
3.	Project for the service delivery model of cloud	4
4.	A project to understand impact of cloud on resources and users	4

Course Outcomes:

At the end of the course, students will be able to:	
1.	Identify security aspects of each cloud model
2.	Develop a risk-management strategy for moving to the Cloud
3.	Implement a public cloud instance using a public cloud service provider
4.	Apply trust-based security model to different layer

5.	Identify security aspects of each cloud model

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Publication Date: November 2, 2009	2009
2.	Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice), Tim Mather, ISBN-10: 0596802765, O'Reilly Media, September 2009	2009
3.	Cloud Computing: Principles and Paradigms by RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley 2012	2012
4.	Cloud Computing Bible By Barrie Sosinsky, wiley 2011	2011

Available MOOCS:

1. https://www.coursera.org/courses?query=cloud%20computing

2. https://www.edx.org/learn/cloud-computing