Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

Course Contents (Syllabus) for

First Year M. Tech.
(Computer Science and Engineering)
Sem – I to II

AY 2020-21

ODD Semester

Professional Core (Theory) Courses

Title of the Course: Research Methodology for Computer Science (4IC501)	L	T	P	Cr
	2	0	0	2

Pre-Requisite Courses: Nil

Textbooks:

1. Kothari C. R., "Research Methodology", New Age international, 2006.
2. Chopra Dipak and Sondhi Neena, "Research Methodology : Concepts and cases", Vikas Publishing House, New Delhi, 2008.
3. Kumar Ranjit, "Research Methodology: A Step by Step Guide for Beginners", Sage Publisher, Second Edition,2011.
4. Sokolowski John A, Banks C.M," Modeling and Simulation Fundamentals" , A John Wiley Publication,2010.

References:

1. Philip E. and Pugh Derek , "How to get a Ph. D. – A handbook for students and their supervisors", Open University Press, 2005.
2. Melville Stuart and Wayne Goddard, "Research Methodology: An Introduction for Science & Engineering Students", Juta Publisher, Second Edition ,2001.
3. G. Ramamurthy, "Research Methodology", , Oxford University Press, Second Editon , 2005.
4. Roig .M, "Avoiding plagiarism, self-plagiarism, and other questionable writingpractices: A guide to ethical writing", 2006.
5. Vaughan , "Statistical methods for the information professional: A practical, painless approach to understanding, using and interpreting statistics", Information Today, Medord, Second edition,2004.

Course Objectives :

1. To describe concepts of research and its methodologies and construct research problems.
2. To make students familiar with research in a more appropriate manner for its publication.
3. To acquaint students with implementation of the concepts of modeling and Simulation.

Course Learning Outcomes:

CO	After completion of the course student should be able to	Bloom's Cognitive level	Descriptor
CO1	illustrate the research problem	3	Applying,
CO2	assess research procedures/simulation techniques to improve research	5	Evaluating
CO3	produce research reports in standard formats	6	Creating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	3			2		
CO2			3	2	2	2
CO3		**3**		1		3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Research	**Hrs.**
Types of research, Stages of research, Approaches, Qualities desirable, Design thinking, Research Mind, Research Attitude, openness for discussion and criticism. Creations of Mind and Intellectual Property. Creativity, Innovation and problem solving. Good habits and Best practices for a good research output	**4**
Module 2: Research Procedures	**Hrs.**
Planning the research, Study of existing literature, survey of top journals, top conferences, top experts, top websites, top tools and techniques, top problems, top applications and top x. Problem statement and scope of work. Carrying out research, experimental plans, test data, parameters, measurements to be done, programs to be written, literature to be seen - focused, literature analysis and critiques.	**4**
Module 3: Research Methods	**Hrs.**
Research Ideas and implementation methodology, experimental setup, standard and non-standard data sets, performance metrics, comparison of performance, evaluation of results. Benchmark Data sets, Performance Metrics: Precision, Recall, F-measure, etc. Data Processing: Facility with UNIX commands, awk, sed, Shell Scripting, GNUPLOT, MATLAB/ SCILAB / R.	**5**
Module 4: Analysis Techniques	**Hrs.**
Quantitative Techniques Sampling fundamentals, Testing of hypothesis using various tests like Multivariate analysis, Use of standard statistical software, Data processing, Preliminary data analysis and interpretation, Uni-variate and bi-variate analysis of data. **Statistical Analysis:** Testing for statistical significance using P-value. Statistical	**5**

hypothesis tests like T-test, testing of hypotheses, techniques such as ANOVA, Chi square test etc., Nonparametric tests. Correlation and regression analysis. Statistical software such as R/ Scilab/ Scala and languages with powerful data handling capabilities such as Python/Java.	
Module 5: Modeling and Simulation	**Hrs.**
Simulation Basics, Handling Stepped and Event-based Time in Simulations, Discrete versus Continuous Modeling, Numerical Techniques, Sources and Propagation of Error, Probability and Statistics for Simulations and Analysis, Introduction to Queues and Random Noise, Random Variants Generation, Sensitivity Analysis	**4**
Module 6: : Research Communications	**Hrs.**
To publish or not publish. Types of Publications - conference paper and presentations, Journal Paper, High impact and reputed journals, and Patents. Publishing your work, how to read a paper, how to write a paper. Research without any reference, where to publish your work, whether to patent or to publish, criteria for patent filing. Impact of Research, contributions, prototypes, tools; plug ins, and Writing a thesis. Research Ethics: Plagiarism issues, Social implications LINUX software for Document Preparation and presentation: Drawing packages, LATEX and BEAMER.	**4**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: illustrate the process of research.

Module 2: formulation of a research problem in respective study domains.

Module 3: describe the important steps in conducting research.

Module 4: implement data analytics techniques for research validation.

Module 5: summarize the concepts of modeling and Simulation.

Module 6: produce research paper in standard format.

Title of the Course: Mathematical foundations of Computer Science (4CO501)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Discrete Mathematics

Textbooks:

1. Trivedi K., Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.

References:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. Mitzenmacher M. and Upfal E., Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press.
3. Tucker Alan, Applied Combinatorics, Wiley

Course Objectives :

1. To introduce the mathematical fundamentals for computer science and engineering.
2. To study various sampling and classification problems.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	explain the basic notions of discrete and continuous probability.	3	Applying
CO2	analyze the methods of statistical inference, and the role that sampling distributions play in those methods.	4	Analyzing
CO3	perform correct and meaningful statistical analysis of simple to moderate complexity.	6	Creating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1			3			
CO2	1			2		
CO3	2		3	2	1	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Probability	**Hrs.**
Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains	**6**
Module 2: Sampling	**Hrs.**
Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood	**6**
Module 3: Statistical inference	**Hrs.**
Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment.	**7**
Module 4: Graph Theory	**Hrs.**
Graph Theory: Isomorphism, Planar graphs, graph coloring, Hamiltonian circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems	**8**
Module 5: Computer science and engineering applications	**Hrs.**
Computer science and engineering applications: Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, Operating systems, Distributed systems, Bioinformatics, Machine learning.	**8**
Module 6: Recent Trends	**Hrs.**
Recent Trends in various distribution functions in mathematical field of computer science for varying fields like bioinformatics, soft computing, and computer vision.	**6**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Explain various concepts in probability.

Module 2:

- Explain different techniques of sampling.
- Perform statistical analysis on data.

Module 3: Study different statistical inference concept in solving problems like PCA, problem of overfitting etc.

Module 4: Understand and solve problems in Graph Theory.

Module 5: Perform statistical analysis on different computer science and engineering applications.

Module 6: Study recent trends in mathematical foundations of Computer Science.

Title of the Course: Advanced Data Structures (4CO502)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: UG level course in Data Structures

Textbooks:

1. Cormen Thomas H., Leiserson Charles E., Rivest Ronald L., Stein Clifford, "Introduction to Algorithms," PHI, Third Edition, 2009
2. Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars , "Computational Geometry - Algorithms and Applications", Springer, Third Edition, 2008
3. Erik Demaine, Lecture Notes on MIT Courseware

References:

1. O'Rourke Joseph, "Computational Geometry in C", Cambridge University Press
2. Diestel Reinhard, "Graph Theory", Springer-Verlag, 2000
3. Brass Peter, "Advanced Data Structures", Cambridge University Press.

Course Objectives :

1. To impart knowledge of advanced data structures such as temporal data structures and geometric data structures.
2. To make students familiar with advanced concepts related to trees, graphs, hashing and string matching.
3. To contribute in choosing appropriate data structures and using them for solving real world problems.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	interpret and summarize the purpose and operation of advanced data structures	2	Understanding
CO2	apply and demonstrate knowledge of advanced data structures for solving real world problems.	3	Applying
CO3	analyze algorithms, compare data structures and evaluate the performance of the advanced data structures	4, 5	Analyzing, Evaluating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1				2		
CO2	2			3	1	2
CO3	3		1			

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Temporal and Geometric data structures	**Hrs.**
Temporal data structures - Persistent data structures - Model and definitions, Partial persistence, Full persistence, Retroactive data structures – Retroactivity, Full retroactivity, Non-oblivious Retroactivity **Geometric data structures** - One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees.	**8**
Module 2: Advanced Trees	**Hrs.**
Binary Search Trees, AVL trees, Red-black trees, Splay Trees, Tango Trees	**6**
Module 3: Selected Graph Problems	**Hrs.**
Vertex coloring, edge coloring, Network flows: Max flow – Mincut theorem, Ford-fulkerson Method, Push-relabel method, Random Graph based analysis.	**6**
Module 4: Hashing	**Hrs.**
Hash Function, Basic Chaining, FKS Perfect Hashing, Linear Probing, Cuckoo Hashing **Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists	**8**
Module 5: String matching	**Hrs.**
String Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Predecessor Problem, Tries, Trie node structure and its applications, Suffix trees and suffix arrays.	**6**
Module 6: Miscellaneous	**Hrs.**
Dynamic trees - Link-cut Trees, Operations on link-cut trees, Dynamic Connectivity, Euler-Tour Trees, Other Dynamic Graph Problems	**6**

Module wise Measurable Students Learning Outcomes :

Students will be able to

Module 1: describe, explain and use temporal data structures such as persistent data structures and retroactive data structures, geometric data structures

Module 2: apply knowledge of advanced trees for various applications including efficient searching.

Module 3: explain and implement various advanced graph algorithms.

Module 4: explain and apply static as well as dynamic hashing techniques.

Module 5: demonstrate, apply and analyze various text processing techniques.

Module 6: demonstrate and use dynamic trees and graphs for addressing dynamic problems

ODD Semester

Professional Core (Lab) Courses

Title of the Course: Computing Lab 1 (4CO552)	L	T	P	Cr
	0	0	4	2

Pre-Requisite Courses: Discrete Mathematics, UG level course in Data Structures Lab

Textbooks:

1. Trivedi K., Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
2. Cormen Thomas H., Leiserson Charles E., Rivest Ronald L., Stein Clifford, "Introduction to Algorithms," PHI, Third Edition, 2009
3. Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars , "Computational Geometry - Algorithms and Applications", Springer, Third Edition, 2008
4. Erik Demaine, Lecture Notes on MIT Courseware

References:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. Mitzenmacher M. and Upfal E., Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press.
3. Tucker Alan, Applied Combinatorics, Wiley
4. O'Rourke Joseph, "Computational Geometry in C", Cambridge University Press
5. Diestel Reinhard, "Graph Theory", Springer-Verlag, 2000
6. Brass Peter, " Advanced Data Structures", Cambridge University Press
7. Jain Hemant, "Problem Solving in Data Structures & Algorithms Using Python: Programming Interview Guide", Create Space Independent Publishing Platform

Course Objectives :

1. To demonstrate fundamentals of Mathematical foundations of Computer Science.
2. To have hands-on of Probability, Random variables in computer Mathematics.
3. To acquaint students with variety of advanced data structures
4. To make students practice using advanced methods of designing and analysing algorithms using advanced data structures.
5. To emphasize applying knowledge of advanced data structures while performing hands-on for solving real world problems in an appropriate manner.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	Study various algorithms and implementation options to solve a problem using advanced data structures	3	Applying
CO2	Solve and compare solution to complex problems using appropriate data structures and evaluate the performance of the advanced data structures or demonstrate the mathematical and logical basis applied to it.	4, 5	Analyzing, Evaluating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	2		1			2
CO2		1	2	3		

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents:

Laboratory Assignments :

It would consist of representative practical / simulation assignments related to all core subjects studied in the current semester. The partial list of assignments might include:

- assignments on implementation of Probability concept and Markov chains
- assignments on implementation of Sampling and various techniques
- assignments on implementation of Statistical inference and multivariate statistical models
- assignments on implementation of Graph Theory
- assignments on evaluation of recent trends in mathematics and Computer science and engineering applications.
- Implement different operations on tree based data structures
- Implement different operations on graph structures
- Implement different operations on tries.
- Implement different operations on dynamic data structures
- Implement different operations on persistent data structures
- Implement different operations on interval based data structures
- Implement different operations on tree based data structures

ODD Semester

Professional Elective (Theory) Courses

Title of the Course: Professional Elective 1 - Image Processing (4CO511)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Mathematics – Linear algebra , Probability Theory

Textbooks:

1. Gonzalez R. C., Woods R. E., "Digital Image Processing", PHI, Second Edition. 2002
2. Jain A. K., "Fundamentals of Digital Image Processing", PHI

References:

1. Sonka Milan, Vaclav Hlavac, Boyle, "Digital Image Processing and Computer Vision", Cengage Learning, Third edition, 2013
2. S. Jayaraman, S. Esakkirajan, T. Veerkumar, "Digital Image Processing", Tata McGrawHill, Third edition, 2010

Course Objectives :

1. To provide knowledge about fundamentals of digital image processing.
2. To illustrate concepts of image transforms, image enhancement, image segmentation, morphological operations, color image processing, compression.
3. To apply the image processing algorithms to real world problems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	explain fundamental concepts of digital image processing, mathematical transforms, image enhancement, segmentation, morphology, compression	2	Understanding
CO2	apply image processing algorithms to solve real life problems and compare the results	3,4	Applying , Analyzing
CO3	design and compare different image processing algorithms	6	Creating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	1			3		
CO2	2			1	2	
CO3			1		3	

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End

Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Digital Image Fundamentals	**Hrs.**
Introduction: Concept, Fundamental Steps and Components of Image Processing System **Digital Image Fundamentals:** Image Acquisition, A simple image model, Sampling and Quantization, Imaging Geometry, Different types of digital images	**6**
Module 2: Image Transforms	**Hrs.**
2D systems and Necessary Mathematical preliminaries, 2D Orthogonal and Unitary Transforms, 1-D DFT, KL-Transforms, Cosine, Hadamard Transforms, Introduction to Wavelet transforms	**8**
Module 3: Image Enhancement	**Hrs.**
Point Processing, Basic Gray Level Transformations, Histogram Processing, Spatial domain Filtering, Frequency domain filtering	**6**
Module 4: Image Segmentation and Analysis	**Hrs.**
Edge Detection – using first and second order derivatives, LoG, Canny edge detector, Boundary Extraction – Connectivity, Heuristic Graph Search, Hough Transform, Active Contour, Watershed Transform, Region-based Segmentation – region growing, region splitting and merging, Feature Extraction	**8**
Module 5: Image Compression	**Hrs.**
Fundamentals, Compression model, Lossless Vs Lossy Compression, Fundamentals of Information Theory, Run-length coding, Huffman coding, Dictionary-based compression, Predictive coding, Transform-based coding, Image Compression Standards	**6**
Module 6: Morphological Image Processing	**Hrs.**
Introduction, Dilation and Erosion, Opening and Closing, The Hit-or-miss transformation, Basic Morphological Algorithms, Boundary Extraction, Region Filling, Extraction of connected components, Thinning, Thickening	**6**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: explain the fundamental concepts of Image Processing and its applications.

Module 2: illustrate image processing transforms for image enhancement and filtering.

Module 3: explain and demonstrate various techniques to improve the quality of an image.

Module 4:

- implement various methods to divide an image into parts or groups of pixels
- describe and use segmentation for image analysis.

Module 5: demonstrate the need of image compression techniques.

Module 6: illustrate morphological operations for image processing.

Title of the Course: Professional Elective 1 - Internet of Things (4CO512)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses:

Textbooks:

1. Mandler B., Barja J., Campista Mitre, M.E., Cagá_ová, D. Chaouchi, H. Zeadally, S. Badra, M. Giordano, S. Fazio, M. Somov, A. Vieriu, R.-L., "Internet of Things. IoT Infrastructures" , Springer International Publishing, Second International Summit, IoT 360° 2015, Rome, Italy, October 27-29, 2015. Revised Selected Papers, Part I
2. Kyung, C.-M., Yasuura, H. Liu, Y. Lin, Y.-L., "Smart Sensors and Systems", Springer International Publishing,2017.

References:

1. Hersent Olivier, Boswarthick David , Elloumi Omar , "The Internet of Things: Key Applications and Protocols", Wiley-Blackwell, Second Edition ,2012

Course Objectives :

1. To discuss various topics related to wireless sensor networks significant towards emerging internet-of-things (IoT).
2. To impart knowledge of hardware, operating systems, distributed systems, networking, security and databases required for IoT technology.
3. To illustrate wireless sensor network (WSN) /Internet of Things (IoT) specific issues such as localization, time synchronization, and topology control.

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	describe requirements from emerging Smart applications, communication systems, protocols and middleware.	2	Understanding
CO2	compare and analyze communication and network protocols used in IoT	4	Analyzing
CO3	assess and evaluate mechanisms and algorithms for time synchronization, security and localization in WSNs and IoT	5	Evaluating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	1		1		3	
CO2				3	1	2
CO3	1			2		2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction and Applications:	**Hrs.**
smart transportation, smart cities, smart Living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security.	**6**
Module 2: IoT Reference Architecture	**Hrs.**
Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. **Real-World Design Constraints-** Introduction, Technical Design constraints hardware, Data representation and visualization, Interaction and remote control.	**7**
Module 3: Industrial Automation	**Hrs.**
Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things. **Commercial Building Automation-** Introduction, Case study: phase one-commercial building automation today, Case study: phase two- commercial building automation in the future.	**7**
Module 4:hardware Platform for IoT	**Hrs.**
Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases.	**8**
Module 5: IOT Physical Devices & Endpoints	**Hrs.**
What is an IOT Device, Exemplary Device Board, Linux on Raspberry , Interface and Programming & IOT Device.	**7**
Module 6: Recent trends in IoT with case studies:	**Hrs.**
Recent trends in sensor network and IOT architecture, Automation in Industrial aspect of IOT.	**5**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: explain the basic concepts related to smart applications.

Module 2: identify different IoT architectures and specify real design constraints.

Module 3: applying various case studies to understand industrial automation.

Module 4: describe different synchronization techniques, protocols middleware etc..

Module 5: demonstrate applications of data science using different techniques in visualization.

Module 6: outline recent trends in sensor network and IoT architecture

Title of the Course: Professional Elective 2 - Data Science (4CO515)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Database Concepts

Textbooks:

1. Adhikari Ani and DeNero John. Computational and Inferential Thinking, The Foundations of Data Science, UC Berkeley.
2. Jiawei Han, Micheline Kamber and Jian Pei. Data Mining Concepts and Techniques. Morgan Kaufmann, Third Edition.

References:

1. O'Neil Cathy and Schutt Rachel. Doing Data Science, Straight Talk From The Frontline. O'Reilly.
2. Leskovek Jure, Rajaraman Anand and Ullman Jeffrey. Mining of Massive Datasets. v2.1, Cambridge University Press.

Course Objectives :

1. To provide the knowledge and expertise to become a proficient data scientist.
2. To critically evaluate data visualizations based on their design and use for communicating.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Implement data collection and management using different technologies.	3	Applying
CO2	Explain how data is collected, managed and stored for data science.	4	Analyzing
CO3	Study the key concepts in data science, including their real-world applications and toolkits used by data scientists.	4	Analyzing

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	3	1	1			3
CO2			2	2		
CO3	1		2		1	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End

Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to core concepts and technologies	**Hrs.**
Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications	**6**
Module 2: Data collection and management	**Hrs.**
Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources.	**6**
Module 3: Data Preprocessing	**Hrs.**
Data Cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization.	**8**
Module 4: Data analysis	**Hrs.**
Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Correlation, Linear Regression, Least Squares, Residuals, Regression Inference.	**8**
Module 5: Data visualization	**Hrs.**
Introduction, Types of data visualization, Data for visualization: Data types, Data encodings, Retinal variables, Mapping variables to encodings, visual encodings.	**6**
Module 6: Recent trends	**Hrs.**
Recent trends in various data collection and analysis techniques, various visualization techniques, Case Study, application development methods used in data science.	**6**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Study the fundamentals of Data Science.

Module 2: Illustrate different sources of data and storage management techniques of data.

Module 3: Illustrate data preprocessing techniques

Module 4: Analyze data by using different statistical techniques.

Module 5: Implement data visualization techniques on different data sets.

Module 6: Explain recent trends in data science and identify methods used in data science.

Title of the Course: Professional Elective 2 - Advanced Network Technologies (4CO516)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Computer Networks

Textbooks:

1. Sunilkumar S., Mahabaleshwar Manvi, Kakkasageri S., "Wireless and Mobile Networks: Concepts and Protocols", Wiley Second edition, 2016.
2. Schiller J, "Mobile Communications", Addison Wesley, 2000.
3. Stallings W, "Wireless Communications and Networks", Pearson Education, Schiller, 2005.
4. Nadeau Thomas D., "SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies", Ken Gray Publisher: O'Reilly Media, August 2013.
5. Goransson Paul and Black Chuck, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, June 2014.

References:

1. Stojmenic Ivan, "Handbook of Wireless Networks and Mobile Computing", John Wiley and Sons Inc 2002.
2. Yi Bing Lin and Imrich Chlamtac, "Wireless and Mobile Network Architectures", John Wiley and Sons Inc 2000.
3. Pandya Raj, "Mobile and Personal Communications Systems and Services", PHI 2008.
4. Dargie W. and Poellabauer C., "Fundamentals of Wireless Sensor Networks –Theory and Practice", Wiley 2010.
5. Kazem Sohraby, Minoli Daniel and Znati Taieb, "wireless sensor networks -Technology, Protocols, and Applications", Wiley Interscience, 2007.
6. Hara Takahiro, Zadorozhny Vladimir I, and Buchmann Erik , "Wireless Sensor Network Technologies for the Information Explosion Era", Springer, 2010.

Course Objectives :

1. To explain key concepts of wireless networks, standards, technologies and their basic operations.
2. To appraise architectures, functions and performance of wireless sensor network systems.
3. To examine SDN/NFV motivation and its benefits in data center.

Course Learning Outcomes:

CO	After completion of the course student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	explain ,compare characteristics of wireless networks, and describe wireless sensor network and SDN/NFV technologies.	**2**	Understanding
CO2	apply acquired knowledge to recognize the performance of wireless sensor and SDN/NFV networks .	**3**	Applying
CO3	analyze wireless sensor network with case study and SDN/NFV techniques in Data center.	**4**	Analyzing

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1			2	3		
CO2			2	1		2
CO3	2				3	2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Wireless Networks	**Hrs.**
Network Architecture, Network Components, Design Issues, Network Protocols, Technologies and Applications of BAN, PAN, LAN, MAN. Wireless Wide Area Networks: Introduction to Cellular and Satellite Networks, Interworking of WLAN and WWAN, WWAN Applications	**7**
Module 2: Introduction to Mobile Ad hoc, Wireless Sensor, Wireless Mesh and Vehicular Networks	**Hrs.**
Introduction to Network, It's Motivations, Applications, Performance metrics, History and Design factors, **Network Architecture:** Traditional layered stack, Cross-layer designs, Different used Network Architectures.	**7**
Module 3: Research Issues in Wireless Networks	**Hrs.**
Sensor Motes, and Hardware parameters configuration, Channel Allocation, Error Control and Coding, Congestion Control, Routing, Addressing, Network Access Control, Mobility Control, Flow Control, Security and Privacy, QoS Management, Power Management, Cross-Layer Control, Network Modeling, Traffic Modeling, Network Measurements. **Simulation** - Introduction to one Network Simulator for wireless sensor network (NS2/NS3/Cooja /OMNET++/ Exata Cyber etc.)	**6**

Module 4: Evolution of Software Defined Networking (SDN)	Hrs.
Separation of Control Plane and Data Plane: Concepts, Advantages and Disadvantages, OpenFlow protocol. **Control Plane:** Introduction of **existing** SDN Controllers including Floodlight and Open Daylight projects. **Data Plane:** Software-based and Hardware-based; Programmable Network Hardware. Programming SDNs: Northbound Application Programming Interface, (Assignments related to languages and tools)	**8**
Module 5: Network Virtualization	**Hrs.**
Concepts, Applications, Existing Network Virtualization Framework (VMWare and others),(assignments related to Mininet based examples) **Network Functions Virtualization (NFV) and SDN:** Network architecture, NFV Infrastructure, NFV Management and Orchestration (MANO), NFV and SDN	**6**
Module 6: : Data Center Networks	**Hrs.**
Data Center Networks: Packet, Optical and Wireless Architectures, Network Topologies. Use Cases of SDNs: Data Centers, Backbone Networks, Home Networks, Traffic Engineering.	6

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: describe wireless technologies.

Module 2: distinguish between Adhoc N/W,WSN and Vehicular N/W

Module 3: categorize various research Issues in Wireless Networks

Module 4: **i**nterpret the concepts of Software Defined Networking

Module 5: explain Network Virtualization technique

Module 6: analyze the use of Data Center Networks

ODD Semester

Professional Elective (Lab) Courses

Title of the Course: Computing Lab 2 (4CO553)	L	T	P	Cr
	0	0	4	2

Pre-Requisite Courses:

Textbook:

Text Books mentioned in the corresponding theory courses.

References:

Reference Books mentioned in the corresponding theory courses.

Course Objectives :

1. To share in-depth knowledge of the course
2. To deliver hand-on experience in the field
3. To inculcate interest in different domain areas

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	To apply the knowledge gained for solving different problems	3	Applying
CO2	To analyse and evaluate the solutions and compare them	5	Evaluating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2		1			2
CO2		1	2	3		2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

Laboratory Assignments :

Lab sessions are to be utilized for problem solving/designing/implementation, to ensure that students have properly learnt the topics covered in the theory course. The partial list is as follows (the list may be updated during actual implementation) :

For course: Image Processing

- Implement and apply different types of image transforms
- Work around with different types of digital images
- Implement and / or apply different image enhancement techniques
- Implement and / or apply different image segmentation techniques and analyse them
- Implement different morphological image operations
- Apply different image compression techniques

OR

For course: Internet of Things

- Development of Smart Applications.
- Implementation of monitoring applications
- Design of Web of things.
- Use of cloud in IoT.
- Design Automation for real time application.
- Applying different case studies.

AND

For course: Data Science

- assignments on implementation of data science toolkit
- assignments on implementation of data collection & management 2-3 assignments on implementation of structural design patterns
- assignments on implementation of basic statistic methods and basic machine learning algorithms like Linear regression, SVM, Naïve Bayes
- assignments on implementation of types of data visualization including mapping variables to encodings, visual encodings using Bokeh (Python)
- assignments on evaluation of application development methods used in data science

OR

For course: Advanced Networking Technologies

- Analyzing wireless communication protocols.
- Design of AD-hoc,MANET and Sensor netwok.
- Design of routing and congestion algorithm.
- Use of SND and NFV.
- Design Network virtualization.
- Understanding SDN in data center as a case study.

ODD Semester

Open Electives Courses

ODD Semester

Mandatory Life Skill Courses

ODD Semester

Value Added
Professional Courses

EVEN Semester

EVEN Semester

Professional Core (Theory) Courses

Title of the Course: Advanced Algorithms (4CO521)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: UG level course in Algorithm Design and Analysis

Textbooks:

1. Cormen Thomas H., Leiserson Charles E., Rivest Ronald L., Stein Clifford, "Introduction to Algorithms," PHI, Third Edition, 2009
2. Aho, Hopcroft, Ullman, "The Design and Analysis of Computer Algorithms", Addison-Wesley Pub. Co., 1974.

References:

1. Kleinberg and Tardos, "Algorithm Design", Pearson Education Limited.
2. Robert Sedgewick, "Algorithms in C++", Addison-Wesley Professional, Third Edition

Course Objectives :

1. To introduce students to the advanced methods of designing and analysing algorithms.
2. To allow students choose appropriate algorithm and use it for a specific problem.
3. To impart knowledge of different classes of problems along with recent developments in the area of algorithmic design.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	apply algorithms for task at hand using different strategies	3	Applying
CO2	analyze algorithm for given problem at hand	4	Analyzing
CO3	evaluate the complexity of the algorithm	5	Evaluating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1				2		
CO2	2			3	1	
CO3	3		1			2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Elementary Algorithms	**Hrs.**
Sorting: Review of various sorting algorithms, topological sorting **Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis.	**6**
Module 2: Graph Algorithms	**Hrs.**
Matroids: Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to Minimum Spanning Tree. **Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming. **Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.	**7**
Module 3: Matrix Computations	**Hrs.**
Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition.	**7**
Module 4: Modulo Representation and DFT	**Hrs.**
Modulo Representation of integers/polynomials: Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem. **Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm.	**6**
Module 5: Linear Programming and NP-completeness	**Hrs.**

Linear Programming: Geometry of the feasibility region and Simplex algorithm **NP-completeness:** Examples, proof of NP-hardness and NP-completeness. **One or more of the following topics based on interest-** Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm	**8**
Module 6: Recent Trends	**Hrs.**
Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures.	**5**

Module wise Measurable Students Learning Outcomes : Students will be able to

Module 1:

- interpret distance based algorithms for graphs and analyse their complexity
- perform amortized analysis of different tasks

Module 2:

- learn greedy approach and dynamic programming paradigm for graphs
- compute maximum matching for graph structure

Module 3:

- learn divide and conquer paradigm and apply it for matrix computations problem

Module 4:

- use Modulo Representation of integers/polynomials learnt for interpolation problem
- learn DFT application in complex field

Module 5:

- learn the ways for solving linear programming problems
- understand proof of NP-hardness and NP-completeness with examples

Module 6:

- identify recent trends in problem solving paradigms using recent searching and sorting techniques.

Title of the Course: Soft Computing (4CO522)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Basic knowledge of mathematics

Textbooks:

1. Rajasekaran S., Vijayalakshmi Pai G.A., "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2003
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press e-book

References:

1. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2003
2. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", PHI, 1995

Course Objectives :

1. To foster student's abilities to implement soft computing based solutions for real-world problems
2. To impart knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms
3. To discuss hybrid applications of ANN, Fuzzy and GA

Course Learning Outcomes:

CO	**After completion of the course student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	analyze soft computing techniques and their roles in building intelligent machines	4	Analyzing
CO2	evaluate fuzzy logic and neural networks techniques to solve various engineering problems	5	Evaluating
CO3	build prototyping applications using genetic algorithms and hybrid approaches	6	Creating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2			3		
CO2			2	2		2
CO3	2		2	2		2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction	**Hrs.**
Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence, Characteristics of Neuro Computing and Soft Computing, Difference between Hard Computing and Soft Computing, Concepts of Learning and Adaptation	**6**
Module 2: Fuzzy Logic	**Hrs.**
Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making	**7**
Module 3: Neural Networks	**Hrs.**
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	**7**
Module 4: Genetic Algorithms	**Hrs.**
Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition	**7**
Module 5: Hybrid Systems	**Hrs.**
Introduction to Hybrid Systems, Adaptive Neuro Fuzzy Inference System(ANFIS)	**6**
Module 6: Deep Learning	**Hrs.**
Spark auto encoder, Convolutional neural networks, Recurrent neural networks, Deep belief networks	**7**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Identify and comprehend various constituents of soft computing **Module 2:** Apply fuzzy logic to control and decision making applications **Module 3:** Formulate a research problem in respective study domains **Module 4:** Apply Genetic algorithms for optimization problem **Module 5**: Design a Neuro fuzzy inference system with the learning of Neural and fuzzy **Module 6**: Acquaint with research in soft computing

EVEN Semester

Professional Core (Lab) Courses

Title of the Course: Computing Lab 3 (4CO571)	L	T	P	Cr
	0	0	4	2

Pre-Requisite Courses: Knowledge of Algorithm Design and Programming knowledge on Python, Matlab

Textbooks:

1. Cormen Thomas H., Leiserson Charles E., Rivest Ronald L., Stein Clifford, "Introduction to Algorithms," PHI, Third Edition, 2009
2. Aho, Hopcroft, Ullman, "The Design and Analysis of Computer Algorithms", Addison-Wesley Pub. Co., 1974.
3. Rajasekaran S., Vijayalakshmi Pai G.A., "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2003
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press e-book

References:

1. Kleinberg and Tardos, "Algorithm Design", Pearson Education Limited.
2. Robert Sedgewick, "Algorithms in C++", Addison-Wesley Professional, Third Edition
3. Jain Hemant, "Problem Solving in Data Structures & Algorithms Using Python: Programming Interview Guide", Create Space Independent Publishing Platform
4. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2003
5. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", PHI, 1995

Course Objectives :

1. To introduce students to the advanced methods of designing and analysing algorithms.
2. To make students choose appropriate algorithm for the problem at hand
3. To acquaint students with different paradigms of problem solving by having hands-on and use it for solving real world problem.
4. To demonstrate knowledge of implementation of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms and hybrid systems
5. To evaluate soft computing based solutions of real-world problems

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	implement the algorithm for the real world problem at hand by considering the use different strategies that can be used for solving it	3	Applying
CO2	analyze the algorithms and evaluate the complexity of the algorithm	4, 5	Analyzing, Evaluating
CO3	apply appropriate soft computing technique for creating prototyping applications	3	Applying

CO4	evaluate soft computing techniques in building intelligent machines	5	Evaluating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	2			3		
CO2	3		1			2
CO3	1		2	3		2
CO4	1		2	1		2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

Laboratory Assignments :

It should consist of representative practical / simulation assignments related to core subjects- Advanced Algorithms and Soft Computing in the current semester. The partial list is as follows (the list may be updated during actual implementation) :

- Implement various sorting based algorithms
- Implement search algorithms for graphs
- Implement minimum spanning tree for a set of nodes
- Implement graph matching techniques
- Study and implement different matrix computation methods

- Study and implement different ways of modulo representation of integers/ polynomials
- Assignments based on ANN and its applications e.g Perceptron implementation, ADALINE network implementation
- Assignments based on Fuzzy logic and its applications e.g. Operations on fuzzy sets, generate fuzzy member functions and use
- Assignments based on GA and its applications e.g. Solve optimization problems using GA, Travelling Salesman Problem using GA
- Assignments based on hybrid systems and its application e,g implementation of ANFIS
- Assignments on deep learning techniques e.g. Convolution model for fixing broken images, Tensorflow tutorial.

Title of the Course: Industrial Project (4CO573)	L	T	P	Cr
	0	0	4	2

Pre-Requisite Courses: --

Textbooks: NA

References:

1. College Digital Library
2. Journals and transactions from IEEE, ACM, Elsevier, Springer, Science Direct etc.

Course Objectives :

1. To be able to understand recent advancements in computer science and engineering by interactions with experts from industry and Institutes.
2. To be able to develop self-learning ability through rigorous literature survey and prototype development in selected area of interest.
3. To be able to communicate through delivery of a seminar, present the idea in effective way, prepare report and publish a paper.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	apply an independent learning in the identified area of computer science and engineering.	2	applying
CO2	communicate effectively, deliver a talk, convince the audience with respect to the topic under consideration, write technical report	3	analyzing
CO3	Work on Industry based Projects by applying standard software design principles.	6	Creating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2		2	1		
CO2		3				
CO3		3		3	1	2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

This course will allow students to gain knowledge of the area of research. They would gain hands-on experience in that field under the guidance of domain experts from Industry/Academia. The work done should be in the area of the dissertation work that is about to be proposed in the second year of this programme.

Students are required to refer to the reputed journals, transactions in computer science focusing on novel problems in identified area of interest. It is necessary that the student should carry out extensive literature review towards the proposed work and present the same. Also it is highly desirable to have a publication based on the study carried out in the identified area.

EVEN Semester

Professional Elective (Theory) Courses

Title of the Course: Professional Elective 3 - Computer Vision (4CO531)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Fundamentals of Digital Image Processing

Textbooks:

1. Gonzalez R. C., Woods R. E., "Digital Image Processing", PHI, Second Edition. 2002
2. Sonka Milan, Vaclav Hlavac, Boyle, "Digital Image Processing and Computer Vision", Cengage Learning, Third edition, 2013

References:

1. S. Jayaraman, S. Esakkirajan, T. Veerkumar, "Digital Image Processing", Tata McGraw Hill, Third edition, 2010
2. D. A. Forsyth, J. Ponce, "Computer Vision – A Modern approach", Pearson Education, Prentice Hall, 2005
3. Linda Shapiro, George C. Stockman, "Computer Vision", Prentice Hall, 2000

Course Objectives :

1. To impart knowledge of advanced techniques in computer vision.
2. To acquaint students with the concepts of color image processing, texture analysis, object recognition, video processing, 3D imaging etc. by applying the algorithms to build applications.
3. To allow students to compare various algorithms and select the one most appropriate for a particular application.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	apply the concepts of color image processing, fundamentals of texture analysis, object recognition methods, video processing concepts, 3D imaging	3	Applying
CO2	analyze problems and algorithms to build solutions to the real world computer vision problems.	4	Analyzing
CO3	design algorithms and evaluate results with justification	5	Evaluating

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1			3		
CO2	2		2	1	2	
CO3			1		3	

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Color Image Processing	**Hrs.**
Color Fundamentals, Color models, Gray level to color transformations, Basics of Color Image Processing, Color Transformations, Smoothing and Sharpening, Color Segmentation	**7**
Module 2: Texture Analysis	**Hrs.**
Definition, Types of texture, Texels, Texture analysis – concept and categories, Approaches to texture analysis, Statistics, Texture descriptors - statistical - Auto-correlation, co-occurrence matrices and features, edge density and direction, local binary partition, Law's texture energy measures, Wavelets and texture analysis.	**7**
Module 3: Representation & Description	**Hrs.**
Representation, Boundary Descriptors, Regional Descriptors, Use of Principal components for description, Relational Descriptors.	**6**
Module 4: Object Recognition & Restoration	**Hrs.**
Object Recognition: Object Detection Vs recognition, Patterns and Pattern Classes, Knowledge Representation, Statistical Pattern Recognition, Neural Nets, Syntactic Pattern Recognition, Optimization Techniques in Recognition. **Restoration:** Image Restoration Model, Noise Models, Restoration using spatial filtering, Reduction using frequency domain filtering.	**7**
Module 5: Moving Object Detection and Tracking	**Hrs.**
Introduction, Background Modeling, Connected Component Labeling, Shadow Detection, Single Object Tracking, Discrete Kalman Filtering, Particle-filter based tracking, Mean-shift tracking, Segmentation tracking via graph cuts	**7**
Module 6: 3D Vision	**Hrs.**

Introduction to 3D imaging and its applications. Study of any Research Paper(s) based on the current trends in 3D imaging or any case study.	**6**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: explain and use various color models, transformations and techniques of Color Image Processing.

Module 2:

- describe fundamentals of texture and its importance in analyzing images.
- compute various texture descriptors and use it further for texture classification / retrieval.

Module 3: describe different ways in which the image can be represented

Module 4:

- demonstrate and apply patterns recognition techniques to recognize objects in images for further understanding the scene.
- describe and apply image restoration in different ways.

Module 5: explain concepts of video processing and practically work with detecting moving objects and techniques for single object tracking.

Module 6:

- explain fundamentals of 3D imaging.
- carry out case study and/or study any research paper based on current trends in 3D imaging.

Title of the Course: Professional Elective 3 - Theory and Applications of Remote Sensing & GIS (4CO532)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Fundamentals of Image processing

Textbooks:

1. Chandra, A.M. and Gosh, S.K., "Remote Sensing and GIS", Narosa Publishing House. 2008
2. Lo, C.P. and Young, A.K.W., "Concepts and Techniques of Geographical Information System", Prentice Hall India. 20012

References:

1. Lillesand, T.M. and Kieffer, "Remote Sensing and Image Interpretation", John Wiley and Sons, 6th Edition. 2012
2. Chang, K, "Introduction to Geographical Systems", Tata McGraw-Hill, 4th Edition. 2010

Course Objectives :

1. To impart knowledge of the fundamentals of Remote Sensing (RS) and geographical information systems (GIS)
2. To make students familiar with Data and Data Products in RS and GIS.
3. To acquaint students Advantages and Applications of RS and GIS

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	illustrate theories and concepts of RS and GIS	3	Applying
CO2	Examine Data and Data Products of RS and GIS	4	Analyzing
CO3	Design solutions for various problems using RS and GIS tools and techniques.	6	Creating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	**3**					1
CO2	**1**			2		
CO3	**3**		3	2	2	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Concepts and Foundation of Remote Sensing	**Hrs.**
Introduction, Remote Sensing System, Electromagnetic Energy, Electromagnetic Spectrum and its Characteristics, Energy Interaction in the Atmosphere and with the Earth's Surface, Resolution in Remote Sensing, Broad Classifications of Sensors and Platform, Earth Observation Satellite and Sensors, Data Reception, Transmission and Processing, Remote Sensing Data and Data Products.	**9**
Module 2: Satellite Image Interpretation and Processing	**Hrs.**
Interpretation Procedure and Elements, Interpretation strategies and keys, Digital Image processing and Image Analysis steps, Image Rectification and Restoration, Image Enhancement, Spatial Filtering, Image Transformation, Image Classification and Analysis.	**7**
Module 3: Applications of Remote Sensing	**Hrs.**
Land use Land Cover Mapping, Crop Inventory, Ground Water Mapping, Urban Growth, Flood Plain Mapping, Wasteland Mapping, Disaster Management.	**4**
Module 4: **GIS – An Overview**	**Hrs.**
Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Various GIS packages and their salient features, Essentials components of GIS, Utility of GIS.	**4**
Module 5: GIS Data	**Hrs.**
GIS Data types and Data Representation, Data Acquisition, Georeferencing of GIS Data, Raster and Vector data, Raster to Vector conversion, Remote Sensing Data in GIS, GIS Database and Database Management System	**6**
Module 6: GIS Spatial Data Analysis and Applications	**Hrs.**
Measurements in GIS-Lengths, Perimeters, and Areas, Queries, Reclassification, Buffering and Neighborhood Functions, Map Overlay, Spatial Interpolation, Analysis of Surfaces, Network Analysis, GIS Applications- Problem Identification, Design A Data Model, Project Management, Implementation and Evaluation, Case Studies.	**9**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Practice theories and concepts of Remote Sensing.

Module 2: Analyze satellite images through Digital Image Processing

Module 3: Design solutions to various socioeconomic problems using RS data.

Module 4: Practice theories and concepts of Geographic Information System.

Module 5: Analyze GIS data and Examine processing of GIS data.

Module 6: Design solutions to various socioeconomic problems using GIS data.

Title of the Course: Professional Elective 4 - Machine Learning (4CO535)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses:

Textbooks:

1. Jason Bell, "Machine Learning Hands-On for Developers and Technical Professionals" Wiley 2015
2. Tom M. Mitchell "Machine Learning" MGH
3. Stephen Marsland, Taylor & Francis "Machine Learning: An Algorithmic Perspective" (CRC)
4. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman "The Elements of Statistical Learning".

References:

1. William Whsieh "Machine Learning Methods in the Environmental Sciences, Neural Networks" Cambridge Univ Press.
2. Richard O Duda, Peter E. Hart and David G. Stork, John "Pattern classification" Wiley &Sons Inc., 2001
3. Chris Bishop "Neural Networks for Pattern Recognition" Oxford University Press, 1995

Course Objectives :

1. To formulate machine learning problems corresponding to different applications.
2. To illustrate a range of machine learning algorithms along with their strengths and weaknesses.
3. To apply machine learning algorithms to solve problems of moderate complexity.

Course Learning Outcomes:

After the completion of the course the student should be able to		Bloom's Cognitive	
		Level	Descriptor
CO1	illustrate a range of machine learning algorithms along with their strengths and weaknesses.	2	Understanding
CO2	apply machine learning algorithms to solve typical problems in Machine Learning.	3	Applying
CO3	analyze various machine learning tools	4	Analyzing

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	2		2	1		
CO2		1	1	2		
CO3			2	3	2	2

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Statistical Decision Theory	**Hrs.**
Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares	**6**
Module 2: Classification Algorithms	**Hrs.**
Linear Classification, Logistic Regression, Support Vector Machines, Naïve Bayes Classification	**6**
Module 3: Neural Networks and Decision Trees	**Hrs.**
Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures	**8**
Module 4: Evaluation Methods	**Hrs.**
Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting, Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks	**6**
Module 5: Clustering	**Hrs.**
Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering	**8**
Module 6: Other Learning Methods	**Hrs.**
Gaussian Mixture Models, Expectation Maximization, Learning Theory, Introduction to Reinforcement Learning	**8**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Illustrate statistical decision theory

Module 2: Demonstrate classification technique for different algorithm

Module 3: Demonstrate the working of Decision Trees

Module 4: Illustrate different evaluation measures

Module 5: Explain different graphical models and clustering techniques

Module 6: Explain gaussian mixture model and learning theory

Title of the Course: Professional Elective 4 - Network Security (4CO536)	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Programming and Data Structures, Computer Networks

Textbooks:

1. Stallings W., "Cryptography and Network Security: Principles and Practice", Pearson Education, Sixth edition, 2014

References:

1. M. Speciner, R. Perlman, C. Kaufman, "Network Security: Private Communications in a Public World", Prentice Hall, Second edition, 2017
2. Gregor N. Purdy, "Linux iptables Pocket Reference", O'Reilly, First edition, 200
3. Michael Rash, "Linux Firewalls", No Starch Press, 2007

Course Objectives :

1. To impart knowledge of construction of symmetric and asymmetric key ciphers and cryptanalysis
2. To elaborate network security attacks and measures
3. To summarize network stack related security aspects

Course Learning Outcomes:

CO	**After completion of the course student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	apply various types of cryptographic algorithms and key exchange techniques	3	Applying
CO2	apply network security concepts to individual computer, network as well as to any web application	3	Applying
CO3	analyze network stack related security issues	4	Analyzing

CO-PO Mapping :

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1					
CO2	1		2	2	1	3
CO3	1		2	3	1	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction	**Hrs.**
Basic of cryptography, including conventional and public-key cryptography, hash functions, authentication, and digital signatures.	**8**
Module 2: Key Management and Distribution and User Authentication	**Hrs.**
Symmetric Key Distribution, Distribution of Public Keys, X.509 Certificates, Public-Key Infrastructure Remote User-Authentication Principles, Remote User-Authentication Using Symmetric Encryption, Kerberos Systems, Remote User Authentication Using Asymmetric Encryption	**7**
Module 3: Malicious Software and Network Access Control	**Hrs.**
Malicious Software: Viruses, Worms, System Corruption, Attack Agents, Information Theft , Keyloggers, Phishing, Spyware Payload Stealthing, Backdoors, Rootkits, Distributed Denial of Service Attacks Network Access Control, Extensible Authentication Protocol, IEEE 802.1X Port-Based Network Access Control	**5**
Module 4: IP, Transport-Level and E-Mail Security	**Hrs.**
IP Security: IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange (IKE). Transport-Level Security: Web Security Considerations, Secure Sockets Layer, Transport Layer Security, HTTPS standard, Secure Shell (SSH) application Electronic Mail Security: Pretty Good Privacy, S/MIME, Domain Keys Identified Mail	**8**
Module 5: Firewalls and Intrusion Detection Systems	**Hrs.**
Intrusion Detection, Password Management, Firewall Characteristics, Types of Firewalls, Firewall Basing, Firewall Location and Configurations	**5**
Module 6: Wireless Network Security	**Hrs.**
Mobile Device Security, IEEE 802.11i, Wireless LAN Security	**7**

Advanced Topics : Blockchains, Cloud Security and IoT security	

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student should be able to:

Module 1: Explain basics of cryptographic techniques

Module 2: Summarize key management and user authentication systems

Module 3: Identify malicious software and implement network access control

Module 4: Illustrate techniques for IP, transport layer and e-mail security

Module 5: Use firewalls and intrusion detection systems

Module 6: Apply wireless network security techniques

EVEN Semester

Professional Elective (Lab) Courses

Title of the Course: Computing Lab 4 (4CO572)	L	T	P	Cr
	0	0	4	2

Pre-Requisite Courses: NIL

Textbook:

Text Books mentioned in the corresponding theory courses.

References:

Reference Books mentioned in the corresponding theory courses.

Course Objectives :

1. To share in-depth knowledge of the course
2. To deliver hand-on experience in the field
3. To inculcate interest in different domain areas

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	To apply the knowledge gained for solving different problems	3	Applying
CO2	To analyse and evaluate the solutions and compare them	5	Evaluating

CO-PO Mapping :

PO	1	2	3	4	5	6
CO1	2			2		
CO2			2	3	1	2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

Laboratory Assignments :

Lab sessions are to be utilized for problem solving/designing/implementation, to ensure that students have properly learnt the topics covered in the theory course. The partial list is as follows (the list may be updated during actual implementation) :

For course: Computer Vision

- Implement and apply different texture analysis techniques
- Work around with different different color models and perform color transformations
- Implement and / or apply different ways of representing images
- Implement and / or apply different object recognition techniques
- Implement different ways of detecting moving objects

OR

For course: Theory and Applications of Remote Sensing & GIS

- Study of Earth Observation Satellites and Sensors
- Hands on learning of RS and GIS Tool/Software
- Visual interpretation of satellite image
- Land Use Land Cover classification/mapping of satellite image.
- Object-based satellite image classification using
- Satellite image classification using Advanced algorithms (Machine learning, Fuzzy techniques)
- Satellite image rectification and enhancement
- Georegistration of images and maps

AND

For course: Machine Learning

- Assignments on implementation of data processing.
- Assignments on implementation of decision trees and bayesian networks.
- Assignments on implementation of Artificial Neural Networks.
- Assignments on implementation of Association Rules Learning.
- Assignments on evaluation of Support Vector Machines.
- Completion of a team project work on solving a real world problem.

OR

For course: Network Security

- Classical encryption techniques
- Symmetric and asymmetric key cryptography algorithms
- Kerberos user authentication
- SSL/TLS
- SQL injection attack
- IPsec
- Virtual private network
- Linux firewall
- Cloud security

EVEN Semester

Open Electives Courses

EVEN Semester

Mandatory Life Skill Courses

EVEN Semester

Value Added Professional Courses

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