Program Structure B.E. Computer Engineering

Fourth Year (Computer) (Semester VII)

(REV 2012)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut	Theory	TW/ Pract	Tut	Total
CPC701	Digital Signal Processing	4	2	-	4	1	-	5
CPC702	Cryptography and System Security	4	2	-	4	1	-	5
CPC703	Artificial Intelligence	4	2	-	4	1	-	5
CPE7042X	Elective-II	4	2	-	4	1	-	5
CPP701	Project I	-	-	-	-	3	-	3
CPL701	Network Threats and Attacks Laboratory	-	4	-	-	2	-	2
	Total	**16**	**12**	**-**	**16**	**09**	-	**25**

Course Code	Course Name	Examination Scheme							
		Internal Assesment							
		Internal Assesment			End Sem Exam	Exam Duration (in Hrs)	TW	oral	Tot
		Test 1	Test 2	Avg					
CPC701	Digital Signal Processing	20	20	20	80	03	25	-	125
CPC702	Cryptography and System Security	20	20	20	80	03	25	25 (prac	150
CPC703	Artificial Intelligence	20	20	20	80	03	25	25	150
CPE7042X	Elective-II	20	20	20	80	03	25	25	150
CPP701	Project I	-	-	-	-	-	50	50	100
CPL701	Network Threats and Attacks Laboratory	-	-	-	-	-	25	50	50
	Total	**-**	**-**	**80**	**320**	-	**200**	**175**	**775**

Program Structure for B.E. Computer Engineering

Second Year (Computer) (Semester VIII)

(REV 201)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract	Tut	Theory	TW/ Pract	Tut	Total
CPC801	Data Warehouse and Mining	4	2	-	4	1	-	5
CPC802	Human Machine Interaction	4	2	-	4	1	-	5
CPC803	Parallel and distributed Systems	4	2	-	4	1	-	5
CPE803X	Elective-III	4	2	-	4	1	-	5
CPP802	Project II	-	-	-	-	6	-	6
CPL801	Cloud Computing Laboratory	-	2	-	-	1	-	1
	Total	**16**	**10**	**-**	**16**	**11**	-	**27**

Course Code	Course Name	Examination Scheme							
		Internal Assesment							
		Internal Assesment			End Sem Exam	Exam Duration (in Hrs)	TW	oral	Tot
		Test 1	Test 2	Avg					
CPC801	Data Warehouse and Mining	20	20	20	80	03	25	25	150
CPC802	Human Machine Interaction	20	20	20	80	03	25	25	150
CPC803	Parallel and distributed Systems	20	20	20	80	03	25	25	150
CPE803X	Elective-III	20	20	20	80	03	25	25	150
CPP802	Project II	-	-	-	-	-	50	50	100
CPL801	Cloud Computing Laboratory	-	-	-	-	-	25	-	-
	Total			80	320		175	150	725

Elective I Sem 6

CPE6011 Operation Research

CPE6012 Project Management

CPE6013 Foreigh Language – German

CPE6014 Foreigh Language – French

Elective II Sem 7

System Group	**CPE7021**	Advance Algorithms
	CPE7022	Computer Simulation and Modeling
Electronics Group	**CPE7023**	Image Processing
Software Group	**CPE7024**	Software Architecture
	CPE7025	Soft Computing
DB Group	**CPE7026**	ERP and Supply Chain Management

Elective III - Sem 8

Electronics Group	**CPE8031**	Machine Learning
Digital Group	**CPE8032**	Embedded Systems
Network Group	**CPE8033**	Adhoc wireless networks
	CPE8034	Digital Forensic
DB Group	**CPE8035**	Big data Analytics

Course Code	Course/Subject Name	Credits
CPC701	**Digital Signal Processing**	5

Objectives:

1. To learn the fundamental concepts of Digital Signal Processing.
2. To explore the properties of DFT in mathematical problem solving.
3. To illustrate FFT calculations mathematically and develop FFT based DSP algorithms.
4. To introduce DSP processor for real time signal processing application

Outcomes: Learner will be able to…

1. To understand the concept of DT Signal and perform signal manipulation
2. To perform analysis of DT system in time domain
3. To develop FFT flow-graph and Fast DSP Algorithms.
4. To design DSP system for Real Time Signal Processing.

Module	Detailed Contents	Hrs.
01	**Discrete Time Signal** 1.1 Introduction to Digital Signal Processing, Discrete Time Signals, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals, Signal Manipulations(shifting, addition, subtraction, multiplication), Classification of Signals, Linear Convolution formulation(without mathematical proof), Circular Convolution formulation(without mathematical proof), Matrix Representation of Circular Convolution, Linear by Circular Convolution. Auto and Cross Correlation formula evaluation,	12
02	**Discrete Time System** 2.1 Introduction to Discrete Time System, Classification of DT Systems (Linear/Non Linear, Causal/Non Causal, Time Invariant/Time Variant Systems, Stable/ Unstable), BIBO Time Domain Stability Criteria. LTI system, Concept of Impulse Response and Step Response. 2.2 Concept of IIR System and FIR System, Output of IIR and FIR DT system using Time Domain Linear Convolution formula Method.	08
03	**Discrete Fourier Transform** 3.1 Introduction to DTFT, DFT, Relation between DFT and DTFT, Properties of DFT without mathematical proof (Scaling and Linearity, Periodicity, Time Shift and Frequency Shift, Time Reversal, Convolution Property and Parsevals' Energy Theorem). DFT computation using DFT properties. 3.2 Transfer function of DT System in frequency domain using DFT. Linear and Circular Convolution using DFT. Response of FIR system calculation in frequency domain using DFT.	08
04	**Fast Fourier Transform** 4.1 Radix-2 DIT-FFT algorithm, DIT-FFT Flowgraph for N=4, 6 & 8, Inverse	06

	FFT algorithm. Spectral Analysis using FFT, Comparison of complex and real, multiplication and additions of DFT and FFT.	
05	**DSP Algorithms** 5.1 Carls' Correlation Coefficient Algorithm, Fast Circular Convolution Algorithm, Fast Linear Convolution Algorithm, Linear FIR filtering using Fast Overlap Add Algorithm and Fast Overlap Save Algorithm,	08
06	**DSP Processors and Application of DSP** 6.1 Need for Special architecture of DSP processor, Difference between DSP processor & microprocessor, A general DSP processor TMS320C54XX series, Case study of Real Time DSP applications to Speech Signal Processing and Biomedical Signal Processing.	06

List of Experiments:

Implementation of programs must be either in C or C++ only. Application can be developed using open source simulation software such as Scilab. A List of compulsory eight experiments is given below. Additional experiments within the scope of the syllabus can be added.

1. Sampling and Reconstruction

Aim:

To study sampling and reconstruction of signal

Objective:

Develop a program to sample a continuous time signal and convert it to Discrete Time Signal.

Problem Definition:

1. Sample the input signal and display first 50 samples. Calculate data rate and bit rate.
2. Reconstruct the original signal and display the original and reconstructed signals.
3. Vary the sampling frequency and observe the change in the quality of reconstructed signal.

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2. To perform Discrete Correlation

Aim:

To study mathematical operation Correlation and measure degree of similarity between two signals

Objective:

1. Write a function to find correlation operation.
2. Calculate correlation of a DT signals and verify the results using mathematical formulation.
3. Measure the degree of similarity using Carl's Correlation Coefficient formula in time domain.

Input Specifications:

1. Length of first Signal L and signal values.
2. Length of second Signal M and signal values.

Problem Definition:

1. Find auto correlation of input signal. What is the significance of value of output signal value at n=0?.
2. Find auto correlation of delayed input signal.
3. Find cross correlation of input signal and delayed input signal,
4. Find cross correlation of input signal and scaled delayed input signal.
5. Compare the resultant signals. Give your conclusion.
6. Take two input finite length DT signals and develop a function to find Carl's Correlation Coefficient value. Determine the degree of similarity of two signals from the calculated Carl's Correlation Coefficient value.

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3. To perform Discrete Convolution

Aim:

The aim of this experiment is to study mathematical operation such as Linear convolution, Circular convolution, Linear convolution using circular convolution.

Objective:

1. Develop a function to find Linear Convolution and Circular Convolution
2. Calculate Linear Convolution, Circular Convolution, Linear Convolution using Circular Convolution and verify the results using mathematical formulation.
3. Conclude on aliasing effect in Circular convolution

Input Specifications:

1. Length of first Signal L and signal values.
2. Length of second Signal M and signal values.

Problem Definition:

1. Find Linear Convolution and Circular Convolution of L point sequence x[n] and M point sequence h[n].
2. Find Linear Convolution of L point sequence x[n] and M point sequence h[n] using Circular convolution.
3. Give your conclusion about No of values in linearly convolved signal, and Aliasing effect in Circular Convolution.

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4. To perform Discrete Fourier Transform

Aim:
The aim of this experiment is to study magnitude spectrum of the DT signal.

Objective:
1. Develop a function to perform DFT of N point signal
2. Calculate DFT of a DT signal and Plot spectrum of the signal.
3. Conclude the effect of zero padding on magnitude spectrum.
4. Calculate the number of real multiplications and real additions required to find DFT.

Input Specifications:
1. Length of Signal N
2. Signal values

Problem Definition:
1. Take any four-point sequence x[n].
- Find DFT X[k].
- Compute number of real multiplications and real additions required to find X[k].
- Plot Magnitude Spectrum of the signal.

2. Append the input sequence by four zeros. Find DFT and plot magnitude spectrum. Repeat the same by appending the sequence by eight zeros. Observe and compare the magnitude spectrum. Give your conclusion.

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5. To perform Fast Fourier Transform

Aim:
To implement computationally fast algorithms.

Objective:
1. Develop a program to perform FFT of N point signal.
2. Calculate FFT of a given DT signal and verify the results using mathematical formulation.
3. Illustrate the computational efficiency of FFT.

Input Specifications:
- Length of Signal N
- Signal values

Problem Definition:
Take any eight-point sequence x[n].

- Find FFT X[k].
- Write number of real multiplications and real additions involved in finding X[k].

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6. Filtering of long Data Sequence

Aim:

To perform filtering of Long Data Sequence using Overlap Add Method and Overlap Save Method.

Objective:

Develop a function to implement Fast Overlap Add and Fast Overlap Save Algorithm using FFT.

Input Specifications:

1. Length of long data sequence and signal values.
2. Length of impulse response M and coefficient values of h[n].

Problem Definition:

Find the output of a Discrete Time system using Fast Overlap Add Method OR Fast Overlap Save Method.

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7. Real Time Signal Processing

Aim:

To perform real time signal processing using TMS320 Processor.

Objective:

Study real time signal processing.

Input Specifications:

1. Real Time Speech Signal

Problem Definition:

1) Capture the real time audio signal.
2) Filter it by convolving input signal with the impulse response of FIR filter using Fast Overlap Add filtering Algorithm OR Fast Overlao Save Filtering Algorithm.
3) Observe the quality of output signal.

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8. Application of Digital Signal Processing

Aim:

To implement any Signal Processing operation on one dimensional signal.

Objective:
To develop application of signal processing.

Input Specifications:
One dimensional signal.

Rules:

1. Number of students in one Group : min - 2 max -3

2. Decide one DSP application of your choice. Collect the information related to the application from the published granted patents. Download the related published papers from the standard refereed journals and conferences.

3. Develop a block diagram of the proposed system and flowchart of proposed system algorithm, implement it using Scilab/C, C++ language and obtain the appropriate results.

4. Prepare the three to four pages report on the mini project in IEEE paper format. Report should include Abstract, Introduction, Related Theory, Proposed System Design/Algorithm, Experimentation & Result Analysis, Conclusion, and References.

5.

Term Work:

- Term work shall consist of minimum **<u>08</u>** assignments and course project.
- Journal must include at least 1 assignment on each module and two quiz.
- The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignment:……..…… (05) Marks.
- Attendance (Theory+ Practical)……. (05) Marks

TOTAL: ……. (25) Marks.

Text Books :

1. Ashok Ambardar, 'Digital Signal Processing', Cengage Learning, 2007, ISBN : 978-81-315-0179-5.

2. Emmanuel C. Ifeachor, Barrie W. Jervis, “Digital Signal Processing: A Practical Approach”, Pearson Education ISBN 0-201-59619- 9

3. S. Salivahanan, A. Vallavaraj, C. Gnanapriya, ‘Digital Signal Processing’ TataMcgraw Hill Publication First edition (2010). ISBN 978-0-07-066924-6.

4. Avtar Signh, S.Srinivasan,”Digital Signal Processing’, Thomson Brooks/Cole, ISBN : 981-243-254-4

Reference Books :

1. B. Venkatramani, M. Bhaskar ,”Digital Signal Processor’, TataMcGraw Hill, Second Edition, (2001). ISBN : 978-0-07-070256-1.

2. Sanjit Mitra, ‘Digital Signal Processing : A Computer Based Approach’ , TataMcGraw Hill, Third Edition

3. Dr, Shaila Apte, “Digital Signal Processing,”, Wiley India, Second Edition,2013 ISBN : 978-81-2652142-5

4. Proakis Manolakis, ‘Digital Signal Processing : Principles, Algorithms and Applications’ Fourth 2007, Pearson Education, ISBN 81-317-1000-9.

5. Monson H. Hayes, “Schaums Outline of Digital Signal Processing’ McGraw Hill International second edition. ISBN : 978-00-7163509-7

Course Code	Course/Subject Name	Credits
CPC702	**Cryptography and System Security**	5

Objectives:

1. To provide students with contemporary knowledge in Cryptography and Security.
2. To understand how crypto can be used as an effective tools in providing assurance concerning privacy and integrity of information.
3. To provide skills to design security protocols for recognize security problems.

Outcomes: Learner will be able to…

1. Understand the principles and practices of cryptographic techniques.
2. Understand a variety of generic security threats and vulnerabilities, and identify & analyze particular security problems for given application.
3. Appreciate the application of security techniques and technologies in solving real-life security problems in practical systems.
4. Apply appropriate security techniques to solve security problem
5. Design security protocols and methods to solve the specific security problems.
6. Familiar with current research issues and directions of security.

Module	Detailed Contents	Hrs
01	**Introduction** 1.1 Security Attacks, Security Goals, Computer criminals, Methods of defense, Security Services, Security Mechanisms	06
02	**Basics of Cryptography** 2.1 Symmetric Cipher Model, Substitution Techniques, Transportation Techniques, Other Cipher Properties- Confusion, Diffusion, Block and Stream Ciphers.	06
03	**Secret Key Cryptography** 3.1 Data Encryption Standard(DES), Strength of DES, Block Cipher Design Principles and Modes of Operations, Triple DES, International Data Encryption algorithm, Blowfish, CAST-128.	06
04	**Public Key Cryptography** 4.1 Principles of Public Key Cryptosystems, RSA Algorithm, Diffie-Hellman Key Exchange	04
05	**Cryptographic Hash Functions** 5.1 Applications of Cryptographic Hash Functions, Secure Hash Algorithm, Message Authentication Codes – Message Authentication Requirements and Functions, HMAC, Digital signatures, Digital Signature Schemes, Authentication Protocols, Digital Signature Standards.	06
06	**Authentication Applications** 6.1 Kerberos, Key Management and Distribution, X.509 Directory Authentication service, Public Key Infrastructure, Electronic Mail Security: Pretty Good Privacy, S/MIME.	06

07	**7.1 Program Security** Secure programs, Nonmalicious Program Errors, Malicious Software – Types, Viruses, Virus Countermeasures, Worms, Targeted Malicious Code, Controls against Program Threats. **7.2 Operating System Security** Memory and Address protection, File Protection Mechanism, User Authentication. **7.3 Database Security** Security Requirement, Reliability and Integrity, Sensitive data, Inference, Multilevel Databases **7.4 IDS and Firewalls** Intruders, Intrusion Detection, Password Management, Firewalls-Characteristics, Types of Firewalls, Placement of Firewalls, Firewall Configuration, Trusted systems.	08
08	**8.1 IP Security** Overview, Architecture, Authentication Header, Encapsulating Security Payload, Combining security Associations, Internet Key Exchange, Web Security: Web Security Considerations, Secure Sockets Layer and Transport Layer Security, Electronic Payment. **8.2 Non-cryptographic protocol Vulnerabilities** DoS, DDoS, Session Hijacking and Spoofing, Software Vulnerabilities-Phishing, Buffer Overflow, Format String Attacks, SQL Injection.	06

Term Work:

Term work should consist of at least 10experiments, 2 assignments based on above theory syllabus.

The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignment:……..…… (05) Marks.
- Attendance (Theory+ Practical)……. (05) Marks

TOTAL: ……. (25) Marks.

Practical/Oral examination:

Practical Exam will be based on above syllabus.

Syllabus for Practical

Suggested topics for experiment but not limited to:

1. RSA and MD5 algorithms.
2. Packet Analyzer.

3. IPSec
4. Spoofing
5. PGP(Pretty Good Privacy)
6. Port Scanning
7. Vulnerability scanner
8. Buffer Overflow
9. Intrusion Detection System
10. Password cracking
11. Firewall
12. SSL

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Cryptography and Network Security: Principles and Practice 5th edition, William Stallings, Pearson.
2. Network Security and Cryptography 2nd edition, Bernard Menezes, Cengage Learning.
3. Cryptography and Network, 2nd edition, Behrouz A Fourouzan, Debdeep Mukhopadhyay, TMH.

Reference Books:

1. Cryptography and Network Security by Behrouz A. Forouzan, TMH
2. Security in Computing by Charles P. Pfleeger, Pearson Education.
3. Computer Security Art and Science by Matt Bishop, Addison-Wesley.

Course Code	Course/Subject Name	Credits
CPC703	**Artificial Intelligence**	5

Objectives:

1. To conceptualize the basic ideas and techniques underlying the design of intelligent systems.
2. To make students understand and Explore the mechanism of mind that enable intelligent thought and action.
3. To make students understand advanced representation formalism and search techniques.
4. To make students understand how to deal with uncertain and incomplete information.

Outcomes: Learner will be able to

1. Ability to develop a basic understanding of AI building blocks presented in intelligent agents.
2. Ability to choose an appropriate problem solving method and knowledge representation technique.
3. Ability to analyze the strength and weaknesses of AI approaches to knowledge– intensive problem solving.
4. Ability to design models for reasoning with uncertainty as well as the use of unreliable information.
5. Ability to design and develop the AI applications in real world scenario.

Module	Detailed Contents	Hrs
01	**Introduction to Artificial Intelligence** 1.1 Introduction , History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub-areas of AI, Applications of AI, Current trends in AI.	04
02	**Intelligent Agents** 2.1 Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent.	04
03	**Problem solving** 3.1 Solving problem by Searching : Problem Solving Agent, Formulating Problems, Example Problems. 3.2 Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS) , Depth Limited Search, Depth First Iterative Deepening(DFID), Informed Search Methods: Greedy best first Search ,A* Search , Memory bounded heuristic Search. 3.3 Local Search Algorithms and Optimization Problems: Hill-climbing search Simulated annealing, Local beam search,	14

	Genetic algorithms. 3.4 Adversarial Search: Games, Optimal strategies, The minimax algorithm , Alpha-Beta Pruning.	
04	**Knowledge and Reasoning** 4.1 Knowledge based Agents, The Wumpus World, The Propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL, Forward chaining, backward Chaining. 4.2 Knowledge Engineering in First-Order Logic, Unification, Resolution, Introduction to logic programming (PROLOG). 4.3 **Uncertain Knowledge and Reasoning:** Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Inference in belief network.	12
05	**Planning and Learning** 5.1The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning. 5.2 Learning: Forms of Learning, Inductive Learning, Learning Decision Tree. 5.3 Expert System: Introduction, Phases in building Expert Systems, ES Architecture, ES vs Traditional System.	10
06	**Applications** 6.1 Natural Language Processing(NLP), Expert Systems.	04

Term Work:

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/case studies): …….. (15) Marks.
- Assignment:……..…… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

There will be at least two assignments covering the above syllabus.

Practical/Oral examination:

Practical examination based on the above syllabus will be conducted.

List of AI Practical / Experiments

All the programs should be implemented in C/C++/Java/Prolog under Windows or Linux environment. Experiments can also be conducted using available open source tools.

1. One case study on NLP/Expert system based papers published in IEEE/ACM/Springer or any prominent journal.

2. Program on uninformed and informed search methods.

3. Program on Local Search Algorithm.

4. Program on Optimization problem.

5. Program on adversarial search.

6. Program on Wumpus world.

7. Program on unification.

8. Program on Decision Tree.

Any other practical covering the syllabus topics and subtopics can be conducted.

Reference Books (Practicals):

1. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Pearson Education, Third Edition.
2. Elaine Rich and Kevin Knight "Artificial Intelligence "Third Edition
3. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.
4. Han Kamber, “Data Mining Concepts and Techniques”, Morgann Kaufmann Publishers.

Text Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach “Second Edition" Pearson Education.
2. Saroj Kaushik “Artificial Intelligence” , Cengage Learning.
3. George F Luger “Artificial Intelligence” Low Price Edition , Pearson Education., Fourth edition.

Reference Books:

1. Ivan Bratko “PROLOG Programming for Artificial Intelligence”, Pearson Education, Third Edition.
2. Elaine Rich and Kevin Knight “Artificial Intelligence” Third Edition
3. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989.
4. Hagan, Demuth, Beale, “Neural Network Design” CENGAGE Learning, India Edition.
5. Patrick Henry Winston , “Artificial Intelligence”, Addison-Wesley, Third Edition.
6. Han Kamber, “Data Mining Concepts and Techniques”, Morgann Kaufmann Publishers.
7. N.P.Padhy, “Artificial Intelligence and Intelligent Systems”, Oxford University Press.

Course Code	Course/Subject Name	Credits
CPE7021	**Advanced Algorithms**	5

Objectives:

1. To teach fundamentals of analysis of algorithm at depth
2. To provide in depth study of advanced data structures and its uses
3. To teach analysis of problems from different domains

Outcomes: Learner will be able to…

1. Identify and use suitable data structures for given problem from different domains
2. Appreciate the role of Graph algorithms in solving variety of problems
3. Appreciate the role of Optimization by using linear programing
4. Analyze the various algorithms from different domains

Module	Detailed Contents	Hrs
01	**Introduction** 1.1 Asymptotic notations Big O, Big Θ,Big Ω,o ,ω notations ,Proofs of master theorem, applying theorem to solve problems	03
02	**Advanced Data Structures** 2.1 Red-Black Trees: properties of red-black trees , Insertions , Deletions 2.2 B-Trees and its operations 2.3 Binomial Heaps: Binomial trees and binomial heaps, Operation on Binomial heaps	09
03	**Dynamic Programing** 3.1 matrix chain multiplication, cutting rod problem and its analysis	06
04	**Graph algorithms** 4.1 Bellman ford algorithm, Dijkstra algorithm, Johnson's All pair shortest path algorithm for sparse graphs	06
05	**Maximum Flow** 5.1 Flow networks , the ford Fulkerson method ,max bipartite matching , push Relabel Algorithm , The relabel to front algorithm	08
06	**Linear Programing** 6.1 Standard and slack forms, Formulating problems as linear programs, simplex algorithm, Duality, Initial basic feasible solution	08
07	**Computational Ggeometry** 7.1 Line Segment properties, Determining whether any pair of segment intersects, finding the convex hull, Finding the closest pair of points.	08

Term Work:

Term work should consist of at least 6 experiments, 2 assignments based on above theory syllabus.

The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignment:……..…… (05) Marks.
- Attendance (Theory+ Practical)……. (05) Marks

TOTAL: ……. (25) Marks.

Practical/Oral examination:

Oral examination based on above syllabus will be conducted

Syllabus for Practical

Suggested topics for experiment but not limited to:

1. Red – black trees and its various operations
2. Binomial Heaps and its various operations
3. Dynamic programing: matrix chain multiplication , cutting rod example
4. Bellman ford , Johnson's algorithm for sparse graphs
5. Ford Fulkerson algorithm , push relabel to front methods
6. Finding closest pair of points, Determining the convex hull
7. Implementation of Simplex algorithm

Text Books:

1. T.H. Coreman , C.E. Leiserson, R.L. Rivest, and C. Stein, "Introduction to algorithms",2nd edition , PHI publication 2005
2. Ellis Horowitz , Sartaj Sahni , S. Rajsekaran. "Fundamentals of computer algorithms" University press

Course Code	Course/Subject Name	Credits
CPE7023	**Image Processing**	5

Objectives:

1. To learn the fundamental concepts of Digital Image Processing and Video Processing .
2. To understand basic image enhancement and segmentation techniques.
3. To illustrate Image Transform calculations mathematically and develop fast transform algorithm
4. To learn Image Compression and Decompression Techniques

Outcomes: Learner will be able to…

1. Understand the concept of Digital Image and Video Image.
2. Explain image enhancement and Segmentation technique.
3. Develop fast image transform flowgraph
4. Solve Image compression and decompression techniques
5. Perform Binary Image Processing Operations

Module	Detailed Contents	Hrs.
01	**Digital Image and Video Fundamentals** 1.1 Introduction to Digital Image, Digital Image Processing System, Sampling and Quantization, Representation of Digital Image, Connectivity, Image File Formats : BMP, TIFF and JPEG. Colour Models (RGB, HSI, YUV) Introduction to Digital Video, Chroma Sub-sampling, CCIR standards for Digital Video	06
02	**Image Enhancement** 2.1 Gray Level Transformations, Zero Memory Point Operations, Histogram Processing, Neighbourhood Processing, Spatial Filtering, Smoothing and Sharpening Filters. Homomorphic Filtering	09
03	**Image Segmentation and Representation** 3.1 Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based Segmentation, Split and Merge Technique, Image Representation and Description, Chain Code, Polygonal Representation, Shape Number, Moments.	09
04	**Image Transform** 4.1 Introduction to Unitary Transform, Discrete Fourier Transform(DFT), Properties of DFT, Fast Fourier Transform(FFT), Discrete Hadamard Transform(DHT), Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Discrete Wavelet Transform(DWT),	09
05	**Image Compression** 5.1 Introduction, Redundancy, Fidelity Criteria, 5.2 Lossless Compression Techniques : Run Length Coding, Arithmetic Coding, Huffman Coding, Differential PCM,	09

	5.3 Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization, JPEG, MPEG-1.	
06	**Binary Image Processing** 6.1 Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling, Thinning and Thickening, Connected Component Labeling, Iterative Algorithm and Classical Algorithm	06

Term Work:

Term work should consist of at least 08 experiments.
Journal must include at least 1 assignment on each module and two quiz.
The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignment:……..…… (05) Marks.
- Attendance (Theory+ Practical)……. (05) Marks

TOTAL: ……. (25) Marks.

Practical/Oral examination:

Oral exam will be based on the above syllabus

Practicals

Implementation of programs must be either in C or C++ only. A List of experiments is given below. Input can be Monochrome OR Colour Image. Additional experiments within the scope of the syllabus can be added.

1. Image Enhancement [Any two techniques]
   (1) using Zero Memory Point Operations.
   (2) using Histogram Processing Technique
   (3) using Spatial Filtering [Smoothing Filters/ Sharpening Filters]
   (4) using Homomorphic Filtering

2. Image Segmentation [Any two techniques]
(1) Horizontal and Vertical Line Detection
(2) Edge Detection
(3) Split and Merge Technique
(4) Edge Linking using Hough Transform

3. Image Compression and De-compression [Any two techniques]
(1) Arithmetic Coding and Decoding
(2) Huffman Coding and Decoding
(3) IGS Quantization/ Vector Quantization based Compression and De-compression
(4) Transform based Image Compression and De-compression [FFT/ FHT/DCT/ DWT]

4. Binary Image Processing [Any two techniques]
   (1) Opening followed by Closing
   (2) Hit or Miss Transform
   (3) Thinning/Thickening/ Region Fillling / Boundary Extraction
   (4) Connected Component Algorithm

Text Books :

1. Rafel C. Gonzalez and Richard E. Woods, 'Digital Image Processing', Pearson Education Asia, Third Edition, 2009,

2. S. Jayaraman, E.Esakkirajan and T.Veerkumar, "Digital Image Processing" TataMcGraw Hill Education Private Ltd, 2009,

3. Anil K. Jain, "Fundamentals and Digital Image Processing", Prentice Hall of India Private Ltd, Third Edition

4. S. Sridhar, "Digital Image Processing", Oxford University Press, Second Edition, 2012.

5. Robert Haralick and Linda Shapiro, "Computer and Robot Vision", Vol I, II, Addison Wesley, 1993.

Reference Books:

1. Dwayne Phillps, "Image Processing in C", BPB Publication, 2006

2. B. Chandra and D.Dutta Majumder, "Digital Image Processing and Analysis", Prentice Hall of India Private Ltd, 2011

3. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", Prentice Hall of India Private Ltd, Third Edition

4. Fred Halshall, "Multimedia Communications: Applications, Networks Protocols and Standards,", Pearson Education 2001

5. David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", Pearson Education, Limited, 2011

Course Code	Course/Subject Name	Credits
CPE7024	**Software Architecture**	5

Outcomes:

Software architecture is foundational to the development of large, practical software-intensive applications.

After successful completion of this course learner will be able to:

- Visualize the architectural concepts in development of large, practical software-intensive applications.
- Rather than focusing on one method, notation, tool, or process, this new course widely surveys software architecture techniques, enabling us to choose the right tool for the job at hand.

Module	Detailed Contents	Hrs.
01	**Basic Concepts** 1.1 Concepts of Software Architecture 1.2 Models. 1.3 Processes. 1.4 Stakeholders	03
02	**Designing Architectures** 2.1 The Design Process. 2.2 Architectural Conception. 2.3 Refined Experience in Action: Styles and Architectural Patterns. 2.4 Architectural Conception in Absence of Experience.	02
03	**Connectors** 3.1 Connectors in Action: A Motivating Example. 3.2 Connector Foundations. 3.3 Connector Roles. 3.4 Connector Types and Their Variation Dimensions. 3.5 Example Connectors.	06
04	**Modeling** 4.1 Modeling Concepts. 4.2 Ambiguity, Accuracy, and Precision. 4.3 Complex Modeling: Mixed Content and Multiple Views. 4.4 Evaluating Modeling Techniques. 4.5 Specific Modeling Techniques.	04
05	**Analysis** 5.1 Analysis Goals. 5.2 Scope of Analysis. 5.3 Architectural Concern being Analyzed. 5.4 Level of Formality of Architectural Models.	08

	5.5 Type of Analysis. 5.6 Analysis Techniques.	
06	**Implementation and Deployment** 6.1 Concepts. 6.2 Existing Frameworks. 6.3 Software Architecture and Deployment. 6.4 Software Architecture and Mobility.	04
07	**Conventional Architectural styles** 7.1 Pipes and Filters 7.2 Event- based, Implicit Invocation 7.3 Layered systems 7.4 Repositories 7.5 Interpreters 7.6 Process control	05
08	**Applied Architectures and Styles** 8.1 Distributed and Networked Architectures. 8.2 Architectures for Network-Based Applications. 8.3 Decentralized Architectures. 8.4 Service-Oriented Architectures and Web Services.	08
09	**Designing for Non-Functional Properties** 9.1 Efficiency. 9.2 Complexity. 9.3 Scalability and Heterogeneity. 9.4 Adaptability. 9.5 Dependability.	04
10	**Domain-Specific Software Engineering** 10.1 Domain-Specific Software Engineering in a Nutshell. 10.2 Domain-Specific Software Architecture. 10.3 DSSAs, Product Lines, and Architectural Styles.	04

Term Work:

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments):…….. (20) Marks.
- Attendence:……..…… (05) Marks.

TOTAL: ……. (25) Marks.

Practical/Oral examination:

An Oral examination is to be conducted based on the above syllabus

Topics For Experiment:

1. Modeling using xADL
2. Analysis - Case study
3. Visualization using xADL 2.0
4. Integrate software components using a middleware
5. Use middleware to implement connectors
6. Wrapper to connect two applications with different architectures
7. Creating web service
8. Architecture for any specific domain

Books:

Text Books:

1. "Software Architecture: Foundations, Theory, and Practice" by Richard N. Taylor, Nenad Medvidovic, Eric Dashofy, ISBN: 978-0-470-16774-8
2. M. Shaw: Software Architecture Perspectives on an Emerging Discipline, Prentice-Hall.
3. Len Bass, Paul Clements, Rick Kazman: Software Architecture in Practice, Pearson.

References:

1. "Pattern Oriented Software Architecture" by Frank Buchnan et al, Wiley India.
2. "The Art of Software Architecture" by Stephen T. Albin.

Course Code	Course/Subject Name	Credits
CPE7025	**Soft Computing**	5

Objectives:

1. To Conceptualize the working of human brain using ANN.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.
4. To provide the mathematical background for carrying out the optimization and familiarizing genetic algorithm for seeking global optimum in self-learning situation.

Outcomes: Learner will be able to…

1. Ability to analyze and appreciate the applications which can use fuzzy logic.
2. Ability to design inference systems.
3. Ability to understand the difference between learning and programming and explore practical applications of Neural Networks (NN).
4. Ability to appreciate the importance of optimizations and its use in computer engineering fields and other domains.
5. Students would understand the efficiency of a hybrid system and how Neural Network and fuzzy logic can be hybridized to form a Neuro-fuzzy network and its various applications.

Module	Detailed Contents	Hours
01	**Introduction to Soft Computing** 1.1 Soft computing Constituents, Characteristics of Neuro Computing and Soft Computing, Difference between Hard Computing and Soft Computing, Concepts of Learning and Adaptation.	**04**
02	**Neural Networks** **2.1 Basics of Neural Networks:** Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model, **2.2 Supervised Learning algorithms:** Perceptron (Single Layer, Multi layer), Linear separability, Delta learning rule, Back Propagation algorithm, **2.3 Un-Supervised Learning algorithms:** Hebbian Learning, Winner take all, Self Organizing Maps, Learning Vector Quantization.	**14**

03	**Fuzzy Set Theory** 3.1 Classical Sets and Fuzzy Sets, Classical Relations and Fuzzy Relations, Properties of membership function, Fuzzy extension principle, Fuzzy Systems- fuzzification, defuzzification and fuzzy controllers.	**14**
04	**Hybrid system** 4.1 Introduction to Hybrid Systems, Adaptive Neuro Fuzzy Inference System(ANFIS).	**04**
05	**Introduction to Optimization Techniques** **5.1 Derivative based optimization**- Steepest Descent, Newton method. **5.2 Derivative free optimization**- Introduction to Evolutionary Concepts.	**06**
06	**Genetic Algorithms and its applications:** 6.1 Inheritance Operators, Cross over types, inversion and Deletion, Mutation Operator, Bit-wise Operators, Convergence of GA, Applications of GA.	**06**

Term Work:

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/case studies): …….. (15) Marks.
- Assignments:…….…… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Practical/Oral examination:

Oral examination will be based on the above syllabus.

PRACTICALS:

All the programs should be implemented in C/C++/Java/MATLAB under Windows or Linux environment. Experiments can also be conducted using available open source tools like OCTAVE and SCILAB

LIST OF SC PRACTICAL / EXPERIMENTS

1. One case study on Fuzzy/Neural/GA based papers published in IEEE/ACM/Springer or any prominent journal.

2. To implement Fuzzy Sets.

3. To implement Fuzzy Relations.
4. To implement Fuzzy Controllers.
5. To implement Basic Neural Network learning rules.
6. To implement any Supervised Learning algorithm.
7. To implement any Unsupervised Learning algorithm.
8. To implement a simple application using Genetic Algorithm.

Any other practical covering the syllabus topics and subtopics can be conducted.

Reference Books (for practicals) :

1. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.
2. S.Rajasekaran and G.A.Vijayalakshmi Pai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning.
3. Hagan, Demuth, Beale,"Neural Network Design" CENGAGE Learning, India Edition.
4. Satish Kumar, “Neural Networks –A classroom approach”, Second Edition,TMH Publication.

Text Books:

1. Timothy J.Ross "Fuzzy Logic With Engineering Applications" Wiley.
2. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning.
4. J.-S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
5. Jacek.M.Zurada "Introduction to Artificial Neural Sytems" Jaico Publishing House.

Reference Books:

1. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
2. Zimmermann H.S "Fuzzy Set Theory and its Applications" Kluwer Academic Publishers.
3. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.
4. Hagan, Demuth, Beale, "Neural Network Design" CENGAGE Learning, India Edition.

Course Code	Course/Subject Name	Credits
CPE7026	**Enterprise Resource Planning and Supply Chain Management (ERP & SCM)**	5

Objectives:

1. To understand the technical aspects of ERP and SCM systems.
2. To understand the steps and activities in the ERP and SCM life cycle.
3. To identify and describe typical functionality in an ERP and SCM system.
4. To understand tools and methodology used for designing ERP and SCM for an Enterprise.

Outcomes: Learner will be able to…

1. To conceptualize the basic structure of ERP and SCM
2. To identify implementation strategy used for ERP and SCM.
3. To apply design principles for various business module in ERP and SCM.
4. To apply different emerging technologies for implementation of ERP and SCM.

Module	Detailed Contents	Hours
Enterprise Resource Planning		
01	**Introduction** 1.1 What is an Enterprize, Introduction to ERP, Need for ERP, Structure of ERP, Scope and Benefits, Typical business processes.	02
02	**ERP and Technology** 2.1 ERP and related technologies, Business Intelligence, E-business and E-commerce, Business Process Reengineering,	04
03	**ERP and Implementation** 3.1 ERP implementation and strategy, Implementation Life cycle, Pre-implementation task, requirement definition , implementation methodology.	06
04	**ERP Business Modules** 4.1 Modules: Finance, manufacturing, human resources, quality management, material management, marketing. Sales distribution and service.	08
05	**Extended ERP** 5.1 Enterprise application Integration (EAI), open source ERP, cloud ERP.	04
Supply Chain Management (SCM)		
06	**Introduction and strategic decisions in SCM**	08

	6.1 Introduction to SCM, Generic Types of supply chain, Major Drivers of Supply chain, Strategic decisions in SCM, Business Strategy, CRM strategy, SRM strategy, SCOR model.	
07	**Information Technology in SCM** 7.1 Types of IT Solutions like Electronic Data Inter change (EDI), Intranet/ Extranet, Data Mining/ Data Warehousing and Data Marts, E-Commerce, E- Procurement, Bar coding, RFID, QR code.	06
08	**Mathematical modelling for SCM** 8.1 Introduction, Considerations in modelling SCM systems, Structuring the logistics chain, overview of models: models on transportation problem, assignment problem, vehicle routing problem, Model for vendor analysis, Make versus buy model.	06
09	**Agile Supply Chain** 9.1 Introduction, Characteristics of Agile Supply Chain, Achieving Agility in Supply Chain.	02
10	**Cases of Supply Chain** 10.1 Cases of Supply Chain like, News Paper Supply Chain, Book Publishing, Mumbai Dabbawala, Disaster management, Organic Food, Fast Food.	02

Term Work:

The distribution of marks for term work shall be as follows:

- Mini project:…….…… (20) Marks.
- Attendance ……...……. (05) Marks

TOTAL: ……. (25) Marks.

Practical/Oral examination:

Oral examination will be based on the above syllabus.

The lab will be conducted on mini project which may be conducted on the following:

1) Simulating business processes of an Enterprise.
2) Designing a web portal for an Enterprise using E-business Models.
3) E-procurement model.
4) Open source ERP
5) Cloud ERP
6) Business process agility
7) SCM model.
8) Implementing Business Intelligence
9) Any other relevant topics covering the syllabus.

Text Books:

1. Enterprise Resource Planning : concepts & practices, by V.K. Garg & N.K. Venkatakrishnan ; PHI.
2. Supply Chain Management Theories & Practices: R. P. Mohanty, S. G. Deshmukh, - Dreamtech Press.
3. ERP Demystified: II Edition, by Alexis Leon,McGraw Hill .
4. Enterprise wide resource planning: Theory & practice: by Rahul Altekar,PHI.

Reference Books:

1. ERP to E^2 ERP: A Case study approach, by Sandeep Desai, Abhishek Srivastava, PHI.

2. Managerial Issues of ERP system, by David Olson, McGraw Hill.

Course Code	Course/Subject Name	Credits
CPE7022	**Computer Simulation and Modeling**	5

Course Objectives:

This course presents an introduction to discrete event simulation systems. Emphasis of the course will be on modeling and the use of simulation languages/software to solve real world problems in the manufacturing as well as services sectors. The course discusses the modeling techniques of entities, queues, resources and entity transfers in discrete event environment. The course will teach the students the necessary skills to formulate and build valid models, implement the model, perform simulation analysis of the system and analyze results properly. The "theory" of simulation involves probability and statistics, thus a good background in probability and statistics is a required prerequisite

Course Outcomes:

1. Apply simulation concepts to achieve in business, science, engineering, industry and services goals
2. Demonstrate formulation and modeling skills.
3. Perform a simulation using spreadsheets as well as simulation language/package
4. Generate pseudorandom numbers using the Linear Congruential Method
5. Evaluate the quality of a pseudorandom number generator using statistical tests
6. Analyze and fit the collected data to different distributions

Module	Detailed Contents	Hours
Computer Simulation and Modeling		
01	Introduction to Simulation. Simulation Examples. General Principles	15
02	Statistical Models in simulation. Queuing Models	08
03	Random Number Generation. Testing random numbers (Refer to Third edition) Random Variate Generation: Inverse transform technique, Direct Transformation for the Normal Distribution, Convolution Method, Acceptance-Rejection Technique (only Poisson Distribution).	09

04	Analysis of simulation data : Input Modeling ,Verification, Calibration and Validation of Simulation , Models , Estimation of absolute performance.	12
05	Application : Case study on 1. Processor and Memory simulation 2. Manufacturing & Material handling	04

Text Books:

Discrete Event System Simulation; Third Edition, Jerry Banks, John Carson, Barry Nelson, and David M. Nicol, Prentice-Hall

Discrete Event System Simulation; Fifth Edition, Jerry Banks, John Carson, Barry Nelson, and David M. Nicol, Prentice-Hall

References:

4. System Modeling & Analysis; Averill M Law, 4th Edition TMH.
5. Principles of Modeling and Simulation; Banks C M , Sokolowski J A; Wiley
6. System Simulation ; Geoffrey Gordon ; EEE
7. System Simulation with Digital Computer; Narsing Deo, PHI

Term work:

Laboratory work: 10 marks

Mini Simulation Project presentation: 10 marks

Attendance : 5 marks

Suggested Practical List (If Any):

Perform simulation exercises given in the text book (third edition) using spreadsheets and/or simulation language/package

5. Queue- single server, multi-server, classic case- dump truck
6. Inventory – Lead time=0, lead time fixed, lead time probabilistic
7. Reliability problem
8. Tutorials on statistical models
9. Random number generate and test
10. Goodness of fit test
11. Output analysis – Point estimate and Confidence Interval

Simulation: Real World Examples – can be in the field of business, transportation, medical, computing, manufacturing and material handling- Presentation to be taken.

Practical/Oral examination:

Oral examination will be based on the above syllabus.

Course Code	Course/Subject Name	Credits
CPL701	**Network threats and attacks Laboratory**	02

Outcomes: After completion of this Laboratory course learner will be able To

1. Use network-based tools for network analysis
2. Use techniques for Network scaning
3. Identify network vulnerability
4. Use tools to simulate intrusion detection system
5. To understand and install a firewall

Module	Detailed Contents
01	**1.1 Title:** Study the use of network reconnaissance tools like WHOIS, dig, traceroute, nslookup to gather information about networks and domain registrars. **Objective:** Objective of this module to how to gather information about the networks by using different n/w reconnaissance tools. **Scope:** Network analysis using network based tools **Technology**: Networking
02	**2.1 Title:** Study of packet sniffer tools like wireshark, ethereal, tcpdump etc. You should be able to use the tools to do the following 1. Observer performance in promiscuous as well as non-promiscous mode. 2. Show that packets can be traced based on different filters. **Objective:** Objective of this module is to observer the performanance in promiscuous & non-promiscous mode & to find the packets based on different filters. **Scope:** Packet grapping, message and protocol analysis **Technology:** Networking
03	**3.1 Title:** Download and install nmap. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, etc. **Objective:** objective of this module to learn nmap installation & use this to scan different ports. **Scope:** used for ip spoofing and port scanning **Technology**: Networking

04	**4.1 Title:** Detect ARP spoofing using open source tool ARPWATCH. **Objective:** Objective of the module to find ARP spoofing using open source. **Scope**: Ip spoofing using arp packaging tool **Technology:** Networking
05	**5.1 Title:** Use the Nessus tool to scan the network for vulnerabilities. **Objective:** Objective of the module is scan system and network analysis. **Scope:** It used for system analysis, security and process analysis **Technology:** Networking
06	**6.1 Title:** Implement a code to simulate buffer overflow attack. **Objective:** Objective of the module Is to check buffer overflow in an NS2 environment **Scope:** It uses to analyse memory overflow attack **Technology**: Networking
07	**7.1 Title:** Set up IPSEC under LINUX **Objective:** Objective of the module for implementing security vulnerabilities **Scope:** to study different ipsec tools. **Technology**: Networking
08	**8.1 Title:** Install IDS (e.g. SNORT) and study the logs. **Objective:** Simulate intrusion detection system using tools such as snort **Scope:** It is used for intrusion detection system vulnerability scans **Technology:** Networking
09	**9.1 Title:** Use of iptables in linux to create firewalls. **Objective:** To study how to create and destroy firewall security parameters. **Scope:** system security and network security **Technology**: Networking
10	**10.1 Title:** Mini project **Objective:** To implement Networking concepts

	Scope: To understand Network & system tools **Technology:** Networking

Term Work:

The distribution of marks for term work shall be as follows:

- Lab Assignments:..... (10)
- Mini project:…….…… (10) Marks.
- Attendance ……...……. (05) Marks

TOTAL: ……. (25) Marks.

Oral examination:

Oral examination is to be conducted by pair of internal and external examiners based on above syllabus and the mini projects done.

References:

1. Network Security Assessment by Chris McNab, O'Reilly
2. Network Security Hacks, Andrew Lockhart, O'Reilly
3. The Web Application Hacker's Handbook 2nd Edition by Dafydd Stuttard & Marcus Pinto,Wiley Publication(2014).
4. Securing the Virtual Environment by Davi Ottenheimer & Matthew Wallace,Willey Publication(2012).

Course Code	Course/Subject Name	Credits
CPC801	**Data Warehousing and Mining**	5

Objectives:

1. To study the methodology of engineering legacy databases for data warehousing and data mining to derive business rules for decision support systems.
2. To analyze the data, identify the problems, and choose the relevant models and algorithms to apply.

Outcomes: Learner will be able to…

1. Enable students to understand and implement classical algorithms in data mining and data warehousing; students will be able to assess the strengths and weaknesses of the algorithms, identify the application area of algorithms, and apply them.
2. Students would learn data mining techniques as well as methods in integrating and interpreting the data sets and improving effectiveness, efficiency and quality for data analysis.

Module	Detailed Contents	Hrs.
01	**Introduction to Data Warehousing** 1.1 The Need for Data Warehousing; Increasing Demand for Strategic Information; Inability of Past Decision Support System; Operational V/s Decisional Support System; Data Warehouse Defined; Benefits of Data Warehousing ;Features of a Data Warehouse; The Information Flow Mechanism; Role of Metadata; Classification of Metadata; Data Warehouse Architecture; Different Types of Architecture; Data Warehouse and Data Marts; Data Warehousing Design Strategies.	04
02	**Dimensional Modeling** 2.1 Data Warehouse Modeling Vs Operational Database Modeling; Dimensional Model Vs ER Model; Features of a Good Dimensional Model; The Star Schema; How Does a Query Execute? The Snowflake Schema; Fact Tables and Dimension Tables; The Factless Fact Table; Updates To Dimension Tables: Slowly Changing Dimensions, Type 1 Changes, Type 2 Changes, Type 3 Changes, Large Dimension Tables, Rapidly Changing or Large Slowly Changing Dimensions, Junk Dimensions, Keys in the Data Warehouse Schema, Primary Keys, Surrogate Keys & Foreign Keys; Aggregate Tables; Fact Constellation Schema or Families of Star.	06
03	**ETL Process** 3.1 Challenges in ETL Functions; Data Extraction; Identification of Data Sources; Extracting Data: Immediate Data Extraction, Deferred Data Extraction; Data Transformation: Tasks Involved in Data Transformation, Data Loading: Techniques of Data Loading, Loading the Fact Tables and Dimension Tables Data Quality; Issues in Data Cleansing.	06
04	**Online Analytical Processing (OLAP)**	04

	4.1 Need for Online Analytical Processing; OLTP V/s OLAP; OLAP and Multidimensional Analysis; Hypercubes; OLAP Operations in Multidimensional Data Model; OLAP Models: MOLAP, ROLAP, HOLAP, DOLAP;	
05	**Introduction to data mining** 5.1 What is Data Mining; Knowledge Discovery in Database (KDD), What can be Data to be Mined, Related Concept to Data Mining, Data Mining Technique, Application and Issues in Data Mining	02
06	**Data Exploration** 6.1 Types of Attributes; Statistical Description of Data; Data Visualization; Measuring similarity and dissimilarity.	02
07	**Data Preprocessing** 7.1 Why Preprocessing? Data Cleaning; Data Integration; Data Reduction: Attribute subset selection, Histograms, Clustering and Sampling; Data Transformation & Data Discretization: Normalization, Binning, Histogram Analysis and Concept hierarchy generation.	04
08	**Classification** 8.1 Basic Concepts; **Classification methods:** 1. Decision Tree Induction: Attribute Selection Measures, Tree pruning. 2. Bayesian Classification: Naïve Bayes' Classifier. **8.2 Prediction**: Structure of regression models; Simple linear regression, Multiple linear regression. **8.3 Model Evaluation & Selection: A**ccuracy and Error measures, Holdout, Random Sampling, Cross Validation, Bootstrap; Comparing Classifier performance using ROC Curves. **8.4 Combining Classifiers**: Bagging, Boosting, Random Forests.	06
09	**Clustering** 9.1 What is clustering? Types of data, Partitioning Methods (K-Means, K-Medoids) Hierarchical Methods(Agglomerative , Divisive, BRICH), Density-Based Methods (DBSCAN, OPTICS)	06
10	**Mining Frequent Pattern and Association Rule** 10.1 Market Basket Analysis, Frequent Itemsets, Closed Itemsets, and Association Rules; Frequent Pattern Mining, Efficient and Scalable Frequent Itemset Mining Methods, The Apriori Algorithm for finding Frequent Itemsets Using Candidate Generation, Generating Association Rules from Frequent Itemsets, Improving the Efficiency of Apriori, A pattern growth approach for mining Frequent Itemsets; Mining Frequent itemsets using vertical data formats; Mining closed and maximal patterns; Introduction to Mining Multilevel Association Rules and Multidimensional Association Rules; From Association Mining to Correlation Analysis, Pattern Evaluation Measures; Introduction to Constraint-Based Association Mining.	08

Term Work:

Term work should consist of at least of the following:

1. One case study given to a group of 3 /4 students of a data mart/ data warehouse.
    a. Write Detail Statement Problem and creation of dimensional modeling (creation star and snowflake schema)
    b. Implementation of all dimension table and fact table
    c. Implementation of OLAP operations.

2. Implementation of classifier like Decision tree, Naïve Bayes, Random Forest using any languages like Java

3. Use WEKA to implement like Decision tree, Naïve Bayes, Random Forest

4. Implementation of clustering algorithm like K-means, K- Medoids, Agglomerative, Divisive using languages any like Java, C# , etc.

5. Use WEKA to implement the following Clustering Algorithms – K-means, Agglomerative, Divisive.

6. Implementation Association Mining like Apriori, FPM using languages like Java, C#, etc.

7. Use WEKA to implement Association Mining like Apriori, FPM.

8. Use R tool to implement Clustering/Association Rule/ Classification Algorithms.

9. Detailed study of any one BI tool like Oracle BI, SPSS, Clementine, and XLMiner etc. (paper Assignment)

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

An oral exam will be held based on the above syllabus

Text Books:

1) Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann 3nd Edition

2) Paulraj Ponniah, “Data Warehousing: Fundamentals for IT Professionals”, Wiley India
3) Reema Theraja “Data warehousing”, Oxford University Press.
4) M.H. Dunham, "Data Mining Introductory and Advanced Topics", Pearson Education

Reference Books:

1) Randall Matignon, "Data Mining using SAS enterprise miner ", Wiley Student edition.
2) Alex Berson , S. J. Smith, “Data Warehousing, Data Mining & OLAP” , McGraw Hill.
3) Vikram Pudi & Radha Krishna, “Data Mining”, Oxford Higher Education.
4) Daniel Larose, “Data Mining Methods and Models”, Wiley India.

Course Code	Course/Subject Name	Credits
CPC802	**Human Machine Interaction**	5

Objectives:

1. To stress the importance of a good interface design.
2. To understand the importance of human psychology in designing good interfaces.
3. To motivate students to apply HMI in their day – to – day activities.
4. To bring out the creativity in each student – build innovative applications that are user friendly.
5. To encourage students to indulge into research in Machine Interface Design.

Outcomes: Learner will be able to…

1. To design user centric interfaces.
2. To design innovative and user friendly interfaces.
3. To apply HMI in their day-to-day activities.
4. To criticise existing interface designs, and improve them.
5. To Design application for social and technical task.

Module	Detailed Contents	Hrs.
01	**Introduction** 1.1 Introduction to Human Machine Interface, Hardware, software and operating environment to use HMI in various fields. 1.2 The psychopathology of everyday things – complexity of modern devices; human-centered design; fundamental principles of interaction; Psychology of everyday actions- how people do things; the seven stages of action and three levels of processing; human error;	10
02	**Understanding goal directed design** 2.1 Goal directed design; Implementation models and mental models; Beginners, experts and intermediates – designing for different experience levels; Understanding users; Modeling users – personas and goals.	08
03	**GUI** 3.1 benefits of a good UI; popularity of graphics; concept of direct manipulation; advantages and disadvantages; characteristics of GUI; characteristics of Web UI; General design principles.	08
04	**Design guidelines** 4.1 perception, Gesalt principles, visual structure, reading is unnatural, color, vision, memory, six behavioral patterns, recognition and recall, learning, factors affecting learning, time.	08
05	**Interaction styles** 5.1 menus; windows; device based controls, screen based controls;.	06
06	**Communication** 6.1 text messages; feedback and guidance; graphics, icons and images; colours.	08

Term Work:

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/case studies): …….. (15) Marks.
- Assignment:…..…… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

Oral examination will be based on the above syllabus.

Laboratory:

Students are free to choose any tool that they feel appropriate for a given experiment. Each experiment will involve research about a certain category of people, and then developing an appropriate interface.

Students are expected to perform at least eight experiments from the given list.

LIST OF HMI PRACTICAL / EXPERIMENTS

1. Know your client –

   a. Children (4-5 years of age): An application to teach math.

   b. Teenagers: Design a digital diary for young teens to help them overcome various social pressures they deal with during their teen years. The diary should also be like a self help tool which would help them deal with incidents like bullying, peer pressure, etc.. This is an open project and you can think in any direction to make the children sail through their teen years while trying to discover life around them.

   c. Older generation: Folks from the older generation has been very wary of using their credit card on the Internet. They have various concerns when it comes to paying their bills. Also because of their old age, it will be beneficial for them to use the internet and pay their phone, electricity, gas, etc. bills

   d. Rural people: ATVM for train ticketing in rural area

2. Understand the trouble of interacting with machines - Redesign interfaces of home appliances like microwave oven, land-line phone, fully automatic washing machine.

3. Learn HCI design principles – heuristic evaluation: Identify 5 different websites catering to one specific goal (eg. Goal – on-line shopping and 5 different websites – ebay, amazon, flipkart, zovi, myntra) and perform a competitive analysis on them to understand how each one caters to the goal, the interactions and flow of the payment system and prepare a report on the same..

4. Learn the importance of menus and navigation – website redesign: News websites like CNN are always cluttered with information. It takes the user a few minutes to find his way through and maybe more minutes to look for some specific information. Redesign the news websites to make it look less cluttered, provide relevant information (a person sitting in Russia should not get US news as top news), intelligently dig information that he might be interested in based on his searches on the web.

5. Learn the importance of connecting humans – service design : How often have you found yourself waiting at the airport for a flight that is delayed or you've missed it and the next one is 4 hours from now, or waiting for a connecting flight? Design an experience for passengers to deal with the long waiting hours.

6. Learn the use of statistical graphics – expense tracker: Matt is a young engineer who just finished his summer internship at a leading Software Company in the United States. He has never been independent in handling his own finances and after this internship his father has asked him to start managing his money on his own. He is looking for a tool/app/software that would help him budget his finances, create goals and track them, categorize and track his credit card spending and also get insights on the various types of categories he's spending on. Design a tool/app/software that would help Matt manage his personal finances given the above requirement.

7. Learn the importance of graphics – way finding: Design a map for someone who is new to the city/town/village and is trying to understand how to commute from one place to another (inspired by New York Subway Maps, London Subway Maps)

8. Icon designing: Choose a unique domain, design a few icons and show how it can be accommodated on an interface.

9. Understand the need of colors and animation – web site for an artist: A celebrity in some form of art like music, dance, painting, martial arts, etc (not actors). This site will be used to display his works and should portray his character.

10. Understand the various input methods available for interaction – concept generation: Study the various technologies for typing – standard keyboards QWERTY, T9 (predictive text), multi-touch (SYWPE, etc.), gestures and brainstorm on the various ways in which you could improve one of the existing technologies. You could choose any of the different input types.

11. Any other new relevant topics covering the above syllabus.

Text Books:

1. Alan Dix, J. E. Finlay, G. D. Abowd, R. Beale “Human Computer Interaction”, Prentice Hall.
2. Wilbert O. Galitz, “The Essential Guide to User Interface Design”, Wiley publication.
3. Alan Cooper, Robert Reimann, David Cronin, “About Face3: Essentials of Interaction design”, Wiley publication.
4. Jeff Johnson, “Designing with the mind in mind”, Morgan Kaufmann Publication.
5. Donald A. Normann, “Design of everyday things”, Basic Books; Reprint edition 2002.

Reference Books:

1. Donald A. Norman, “The design of everyday things”, Basic books.
2. Rogers Sharp Preece, “Interaction Design:Beyond Human Computer Interaction”, Wiley.
3. Guy A. Boy “The Handbook of Human Machine Interaction”, Ashgate publishing Ltd.

Course Code	Course/Subject Name	Credits
CPC803	**Parallel and Distributed Systems**	5

Objectives:

1. To provide students with contemporary knowledge in parallel and distributed systems
2. To equip students with skills to analyze and design parallel and distributed applications.
3. To provide master skills to measure the performance of parallel and distributed algorithms

Outcomes: Learner will be able to…

1. Apply the principles and concept in analyzing and designing the parallel and distributed system
2. Reason about ways to parallelize problems.
3. Gain an appreciation on the challenges and opportunities faced by parallel and distributed systems.
4. Understand the middleware technologies that support distributed applications such as RPC, RMI and object based middleware.
5. Improve the performance and reliability of distributed and parallel programs.

Module	Detailed Contents	Hrs.
01	**Introduction** 1.1 Parallel Computing, Parallel Architecture, Architectural Classification Scheme, Performance of Parallel Computers, Performance Metrics for Processors, Parallel Programming Models, Parallel Algorithms.	06
02	**Pipeline Processing** 2.1 Introduction, Pipeline Performance, Arithmetic Pipelines, Pipelined Instruction Processing, Pipeline Stage Design, Hazards, Dynamic Instruction Scheduling,	06
03	**Synchronous Parallel Processing** 3.1 Introduction, Example-SIMD Architecture and Programming Principles, SIMD Parallel Algorithms, Data Mapping and memory in array processors, Case studies of SIMD parallel Processors	06
04	**Introduction to Distributed Systems** 4.1 Definition, Issues, Goals, Types of distributed systems, Distributed System Models, Hardware concepts, Software Concept, Models of Middleware, Services offered by middleware, Client Server model.	06
05	**Communication** 5.1 Layered Protocols, Remote Procedure Call, Remote Object Invocation, Message Oriented Communication, Stream Oriented Communication	04
06	**Resource and Process Management** 6.1 Desirable Features of global Scheduling algorithm, Task assignment approach, Load balancing approach, load sharing approach, Introduction to process management, process migration, Threads, Virtualization, Clients, Servers, Code Migration	06
07	**Synchronization**	08

	7.1 Clock Synchronization, Logical Clocks, Election Algorithms, Mutual Exclusion, Distributed Mutual Exclusion-Classification of mutual Exclusion Algorithm, Requirements of Mutual Exclusion Algorithms, Performance measure, Non Token based Algorithms: Lamport Algorithm, Ricart–Agrawala's Algorithm, Maekawa's Algorithm 7.2 Token Based Algorithms: Suzuki-Kasami's Broardcast Algorithms, Singhal's Heurastic Algorithm, Raymond's Tree based Algorithm, Comparative Performance Analysis.	
08	**Consistency and Replication** 8.1 Introduction, Data-Centric and Client-Centric Consistency Models, Replica Management. **Distributed File Systems** 8.2 Introduction, good features of DFS, File models, File Accessing models, File-Caching Schemes, File Replication, Network File System(NFS), Andrew File System(AFS), Hadoop Distributed File System and Map Reduce.	06

Term Work:

Term work should consist of at least 10 experiments, 2 assignments based on above theory syllabus.

The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): …….. (15) Marks.
- Assignments: …… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

Oral Examination will be based on above syllabus

Syllabus for Practical

Suggested topics for experiment but not limited to:

1. Load Balancing Algorithm.
2. Scalability in Distributed Environment
3. Client/server using RPC/RMI.
4. Inter-process communication
5. Election Algorithm.
6. Distributed Deadlock.
7. Name Resolution protocol.
8. Clock Synchronization algorithms.
9. Mutual Exclusion Algorithm.
10. Group Communication.
11. CORBA architecture.
12. Parallel Algorithms.
13. Message Passing Interface.

Text Books

1. M.R. Bhujade, “Parallel Computing”, 2nd edition, New Age International Publishers 2009.
2. Andrew S. Tanenbaum and Maarten Van Steen, “Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education, Inc., 2007, ISBN: 0-13-239227-5.

Reference Books

1. George Coulouris, Jean Dollimore, Tim Kindberg, “Distributed Systems: Concepts and Design” (4th Edition), Addison Wesley/Pearson Education.
2. Pradeep K Sinha, “Distributed Operating Systems : Concepts and design”, IEEE computer society press

Course Code	Course/Subject Name	Credits
CPE8031	**Elective-III Machine Learning**	5

Objectives:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To become familiar with regression methods, classification methods, clustering methods.
3. To become familiar with support vector machine and Dimensionality reduction Techniques.

Outcomes: Learner will be able to…

1. Ability to analyze and appreciate the applications which can use Machine Learning Techniques.
2. Ability to understand regression, classification, clustering methods.
3. Ability to understand the difference between supervised and unsupervised learning methods.
4. Ability to appreciate Dimensionality reduction techniques.
5. Students would understand the working of Reinforcement learning.

Module	Detailed Contents	Hrs.
01	**Introduction to Machine Learning** 1.1 What is Machine Learning?, Key Terminology, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, How to choose the right algorithm, Steps in developing a Machine Learning Application.	06
02	**Learning with Regression** 2.1 Linear Regression, Logistic Regression.	04
03	**Learning with trees** 3.1 Using Decision Trees, Constructing Decision Trees, Classification and Regression Trees (CART).	08
04	**Support Vector Machines(SVM)** 4.1 Maximum Margin Linear Separators, Quadratic Programming solution to finding maximum margin separators, Kernels for learning non-linear functions.	06
05	**Learning with Classification** 5.1 Rule based classification, classification by backpropoagation, Bayesian Belief networks, Hidden Markov Models.	06
06	**Dimensionality Reduction** 6.1 Dimensionality Reduction Techniques, Principal Component Analysis, Independent Component Analysis.	06
07	**Learning with Clustering** 7.1 K-means clustering, Hierarchical clustering, Expectation Maximization	06

	Algorithm, Supervised learning after clustering, Radial Basis functions.	
08	**Reinforcement Learning** 8.1 Introduction, Elements of Reinforcement Learning, Model based learning, Temporal Difference Learning, Generalization, Partially Observable States.	06

Term Work:

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignments:……..…… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

Oral examination will be based on the above syllabus.

LIST OF ML PRACTICAL / EXPERIMENTS

1. To implement Linear Regression

2. To implement Logistic Regression

3. To implement ID3.

4. To implement Support Vector Machine.

5. To implement Bayesian Classification.

6. To implement K-Nearest Neighbour.

7. To implement k-means Clustering.

8. To implement Agglomerative Clustering.

Any other practical covering the syllabus topics and subtopics can be conducted.

Text Books:

1. Peter Harrington “Machine Learning In Action”, DreamTech Press
2. Ethem Alpaydın, “Introduction to Machine Learning”, MIT Press
3. Tom M.Mitchell “Machine Learning” McGraw Hill
4. Stephen Marsland, “Machine Learning An Algorithmic Perspective” CRC Press

Reference Books:

1. William W.Hsieh, “Machine Learning Mehods in the Environmental Sciences”, Cambridge
2. Han Kamber, “Data Mining Concepts and Techniques”, Morgann Kaufmann Publishers
3. Margaret.H.Dunham, “Data Mining Introductory and Advanced Topics”, Pearson Education

Course Code	Course/Subject Name	Credits
CPE8032	**Elective-III Embedded Systems**	5

Objectives:

1. Develop, among students, an understanding of the technologies behind the embedded computing systems; and to differentiate between such technologies.
2. Make aware of the capabilities and limitations of the various hardware or software components.
3. Evaluate design tradeoffs between different technology choices.
4. Complete or partial design of such embedded systems

Outcomes: Learner will be able to…

1. Describe the special requirements that are imposed on embedded systems
2. Describe the key properties of microprocessor and digital signal processor
3. Sketch a design of an embedded system around a microprocessor or DSP
4. Explain how microprocessor, memory, peripheral components and buses interact in an embedded system
5. Evaluate how architectural and implementation decisions influence performance and power dissipation
6. Produce efficient code for embedded systems
7. Point out the role of the compiler in the embedded system design process
8. Define the properties of a real-time operating system
9. Estimate the requirement for additional hardware for optimized performance
10. Understand and distinguish between the RISC and the Advanced RISC architecture
11. Utilize embedded systems to perform operations such as signal processing in real time
12. Develop drivers for external peripheral devices as per requirement.

Module	Detailed Contents	Hrs.
01	**Introduction to computational technologies** 1.1 Review of computation technologies (ARM, RISC, CISC, PLD, SOC), architecture, event managers, hardware multipliers, pipelining. Hardware/Software co-design. Embedded systems architecture and design process.	08
02	**Program Design and Analysis** 2.1 Integrated Development Environment (IDE), assembler, linking and loading. Program-level performance analysis and optimization, energy and power analysis and program size optimization, program validation and testing. Embedded Linux, kernel architecture, GNU cross platform tool chain. Programming with Linux environment.	08
03	**Process Models and Product development life cycle management** 3.1 State machine models: finite-state machines (FSM), finite-state machines with data-path model (FSMD), hierarchical/concurrent state machine	08

	model (HCFSM), program-state machine model (PSM), concurrent process model. Unified Modeling Language (UML), applications of UML in embedded systems. IP-cores, design process model. Hardware software co-design, embedded product development life cycle management.	
04	**High Performance 32-bit RISC Architecture** 4.1 ARM processor family, ARM architecture, instruction set, addressing modes, operating modes, interrupt structure, and internal peripherals. ARM coprocessors, ARM Cortex-M3.	08
05	**Processes and Operating Systems** 5.1 Introduction to Embedded Operating System, multiple tasks and multiple processes. Multi rate systems, preemptive real-time operating systems, priority-based scheduling, inter-process communication mechanisms. Operating system performance and optimization strategies. Examples of real-time operating systems.	08
06	**Real-time Digital Signal Processing (DSP)** 6.1 Introduction to Real-time simulation, numerical solution of the mathematical model of physical system. DSP on ARM, SIMD techniques. Correlation, Convolution, DFT, FIR filter and IIR Filter implementation on ARM. Open Multimedia Applications Platform (OMAP)	08

Term Work:

Term work should consist of at least 10 practicals and one mini project. Objective type term work test shall be conducted with a weightage of 10 marks.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/projects): …….…….. (10) Marks.
- Mini project: …… (10) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

The final certification and acceptance of Term Work ensures the satisfactory performance of laboratory work and minimum passing in term work.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

Oral examination will be based on the above syllabus.

List of Experiments:

Topic-1: Troubleshooting Tools [Any One]

In-Circuit Emulator (ICE) and In-Circuit Debugger (ICD), Logic Analyzer, Spectrum Analyzer, Pattern generator and Digital Storage Oscilloscope.

Topic -2: ARM Processors & Interfaces [Any Four]

LEDs and Keyboard Interface, LCD Interface, Counting external events with on chip counters, Real Time Clock (RTC), Pulse Width Modulation (PWM), Relay and Buzzer Control for alarm events, Stepper Motor Control , On chip ADC/DAC SPI / I2C / UART Interface, Bluetooth/Zig-bee interface.

Topic-3: Real-time Signal Processing ARM-DSP [Any Two]

Real-time physical model simulation, Correlation, convolution, DFT, FIR or IIR design, Real-time DAS and GUI using PC and ARM, Design with Programmable Logic Devices (CPLD/FPGA).

Topic-4: Device Driver Development [Any One]

Drivers for CAN, Drivers for USB, Drivers for Ethernet, SVGA, Drivers for Graphics TFT LCD.

Topic-5: Real Time Operating System (RTOS) [Any Two]

RTLinux , MicroC/OS_II, VxWorks, WIN CE, QNX, Palm OS, Symbian OS, Android OS or equivalent OS.

Text Books:

1. Embedded Systems an Integrated Approach – Lyla B Das, Pearson
2. Computers as Components – Marilyn Wolf, Third Edition Elsevier
3. Embedded Systems Design: A Unified Hardware/Software Introduction – Frank Vahid and Tony Givargis, John Wiley & Sons
4. An Embedded Software Primer – David E. Simon – Pearson Education Sough Asia
5. ARM System Developer's Guide Designing and Optimizing System Software – Andrew N. Sloss, Dominic Sysmes and Chris Wright – Elsevier Inc.

Reference Books:

1. Embedded Systems, Architecture, Programming and Design – Raj Kamal – Tata McGraw Hill
2. Embedded Linux – Hollabaugh, Pearson Education

3. Embedded Realtime Systems Programming – Sriram V Iyer, Pankaj Gupta – Tata McGRaw Hill.
4. Fundamentals of Microcontrollers and Applications in Embedded Systems – Ramesh Gaonkar – Penram International Publishing (India) Pvt. Ltd.
5. Embedded / Real-Time Systems: Concepts, Design & Programming – Dr. K. V. K. K. Prasad – Dreamtech Press, India.

Course Code	Course/Subject Name	Credits
CPE8033	**Elective-III Adhoc Wireless Networks**	5

Objectives:

1. To Identify the major issues associated with ad-hoc networks
2. To identify the requirements for protocols for wireless ad-hoc networks as compared to the protocols existing for wired network.
3. To explore current ad-hoc technologies by researching key areas such as algorithms, protocols, hardware, and applications.
4. To Provide hands-on experience through real-world programming projects
5. To provide advanced in –depth networking materials to graduate students in networking research.

Outcomes: Learner will be able to…

1. Define characteristics and features of Adhoc Networks
2. Appreciate the designing of MAC protocol for Adhoc networks
3. Implement few protocols
4. Apply security principles for routing

Module	Detailed Contents	Hrs.
01	**Introduction** 1.1 Introduction to wireless Networks. Characteristics of Wireless channel, Issues in Ad hoc wireless networks, Adhoc Mobility Models:- Indoor and outdoor models. 1.2 Adhoc Networks: Introduction to adhoc networks – definition, characteristics features, applications.	04
02	**MAC Layer** 2.1 MAC Protocols for Ad hoc wireless Networks: Introduction, Issues in designing a MAC protocol for Ad hoc wireless Networks, Design goals and Classification of a MAC protocol, Contention based protocols with reservation mechanisms. 2.2 Scheduling algorithms, protocols using directional antennas. IEEE standards: 802.11a, 802.11b, 802.11g, 802.15, 802.16, HIPERLAN.	10
03	**Network Layer** 3.1 Routing protocols for Ad hoc wireless Networks: Introduction, Issues in designing a routing protocol for Ad hoc wireless Networks, Classification of routing protocols, Table driven routing protocol, On-demand routing protocol. 3.2 Proactive Vs reactive routing, Unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithm, Energy aware routing algorithm, Hierarchical Routing, QoS aware routing.	10
04	**Transport Layer** 4.1 Transport layer protocols for Ad hoc wireless Networks: Introduction, Issues in designing a transport layer protocol for Ad hoc wireless Networks, Design goals of a transport layer protocol for Ad hoc wireless	07

	Networks, Classification of transport layer solutions, TCP over Ad hoc wireless Networks, Other transport layer protocols for Ad hoc wireless Networks.	
05	**Security** 5.1 Security: Security in wireless Ad hoc wireless Networks, Network security requirements, Issues & challenges in security provisioning, Network security attacks, Key management, Secure routing in Ad hoc wireless Networks.	07
06	**QoS** 6.1 Quality of service in Ad hoc wireless Networks: Introduction, Issues and challenges in providing QoS in Ad hoc wireless Networks, Classification of QoS solutions, MAC layer solutions, network layer solutions.	07

Term Work:

- Term work should consist of at least 12 experiments.
- Journal must include at least 2 assignments.
- The final certification and acceptance of term work indicates that performance in laboratory work is satisfactory and minimum passing marks may be given in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): ……..…….. (15) Marks.
- Assignment:…….…… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project

Practical/Oral examination:

oral examination based on above syllabus will be conducted

Suggested Practicals for Adhoc Wireless

1. Installation of NS2 in Ubuntu 12.04 Linux.
2. Build and exchange data in simple infrastructure and Adhoc network by using personal computer and Android based mobile.
3. Develop sample wireless network in which

    a. implement AODV and AOMDV protocol

b. Calculate the time to receive reply from the receiver using NS2.
c. Generate graphs which show the transmission time for packet.

4. Implement wireless network. Capture data frame and identify fields using NS2.
5. Configure Wireless Access Point (WAP) and build different networks.
6. Implement Mobile device as a wireless access point.
7. Communicate between two different networks which has following specifications:
   a. One network has Class A network with "Tora protocol"
   b. Second has Class B network "AODV protocol"

Practical exam will be based on the above syllabus.

Text Books:

1. Siva Ram Murthy and B.S.Manoj, "Ad hoc Wireless Networks Architectures and protocols", 2nd edition, Pearson Education, 2007
2. Charles E. Perkins, "Adhoc Networking", Addison – Wesley, 2000
3. C. K. Toh,"Adhoc Mobile Wireless Networks", Pearson Education, 2002

Reference Books:

1. Matthew Gast, "802.11 Wireless Networks: The Definitive Guide", 2nd Edition, O'Reilly Media, April 2005.
2. Stefano Basagni, Marco Conti, Silvia Giordan and Ivan Stojmenovic, "Mobile Adhoc Networking", Wiley-IEEE Press, 2004.
3. Mohammad Ilyas, "The handbook of Adhoc Wireless Networks", CRC Press, 2002

Course Code	Course/Subject Name	Credits
CPE8034	**Elective-III Digital Forensics**	5

Objectives:

1. To focus on the procedures for identification, preservation, and extraction of electronic evidence, auditing and investigation of network and host system intrusions, analysis and documentation of information gathered, and preparation of expert testimonial evidence.
2. To provide hands on experience on various forensic tools and resources for system administrators and information system security officers.

Module	Detailed Contents	Hrs.
01	**Introduction:** 1.1 Introduction of Cybercrime: Types, The Internet spawns crime, Worms versus viruses, Computers' roles in crimes, Introduction to digital forensics, Introduction to Incident - Incident Response Methodology – Steps - Activities in Initial Response, Phase after detection of an incident.	09
02	**Initial Response and forensic duplication** 2.1 Initial Response & Volatile Data Collection from Windows system - Initial Response & Volatile Data Collection from Unix system - Forensic Duplication: Forensic duplication: Forensic Duplicates as Admissible Evidence, Forensic Duplication Tool Requirements, Creating a Forensic. 2.2 Duplicate/Qualified Forensic Duplicate of a Hard Drive.	08
03	**Preserving and Recovering Digital Evidence** 3.1 File Systems: FAT, NTFS - Forensic Analysis of File Systems - Storage Fundamentals: Storage Layer, Hard Drives Evidence Handling: Types of Evidence, Challenges in evidence handling, Overview of evidence handling procedure.	09
04	**Network Forensics** 4.1 Intrusion detection; Different Attacks in network, analysis Collecting Network Based Evidence - Investigating Routers - Network Protocols - Email Tracing- Internet Fraud.	07
05	**System investigation** 5.1 Data Analysis Techniques - Investigating Live Systems (Windows & Unix) Investigating 5.2 Hacker Tools - Ethical Issues – Cybercrime.	08
06	**Bodies of law** 6.1 Constitutional law, Criminal law, Civil law, Administrative regulations, Levels of law: Local laws, State laws, Federal laws, International laws , Levels of culpability: Intent, Knowledge, Recklessness, Negligence Level and burden of proof : Criminal versus civil cases ,Vicarious liability, Laws related to computers: CFAA, DMCA, CAN Spam, etc.	07

Term Work:

- Term work should consist of at least 12 experiments.
- Journal must include at least 2 assignments.
- The final certification and acceptance of term work indicates that performance in laboratory work is satisfactory and minimum passing marks may be given in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): …….. (15) Marks.
- Assignment: …… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project.

Practical/Oral examination:

Oral exam will be based on the above syllabus.

Text Books:

1. Kevin Mandia, Chris Prosise, “Incident Response and computer forensics”, Tata McGrawHill, 2006
2. Peter Stephenson, "Investigating Computer Crime: A Handbook for Corporate Investigations", Sept 1999
3. Eoghan Casey, "Handbook Computer Crime Investigation's Forensic Tools and Technology", Academic Press, 1st Edition, 2001

References:

1. Skoudis. E., Perlman. R. Counter Hack: A Step-by-Step Guide to Computer Attacks and Effective Defenses.Prentice Hall Professional Technical Reference. 2001
2. Norbert Zaenglein, "Disk Detective: Secret You Must Know to Recover Information From a Computer", Paladin Press, 2000
3. Bill Nelson, Amelia Philips and Christopher Steuart, “Guide to computer forensics investigation “Course technology, 4th edition

Course Code	Course/Subject Name	Credits
CPE8035	**Elective III - Big Data Analytics**	5

Objectives:

1. To provide an overview of an exciting growing field of big data analytics.
2. To introduce the tools required to manage and analyze big data like Hadoop, NoSql Map-Reduce.
3. To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
4. To enable students to have skills that will help them to solve complex real-world problems in for decision support.

Outcomes: Learner will be able to…

1. Understand the key issues in big data management and its associated applications in intelligent business and scientific computing.
2. Acquire fundamental enabling techniques and scalable algorithms like Hadoop, Map Reduce and NO SQL in big data analytics.
3. Interpret business models and scientific computing paradigms, and apply software tools for big data analytics.
4. Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc.

Module	Detailed Contents	Hrs.
01	**Introduction to Big Data** 1.1 Introduction to Big Data, Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Case Study of Big Data Solutions.	03
02	**Introduction to Hadoop** 2.1 What is Hadoop? Core Hadoop Components; Hadoop Ecosystem; Physical Architecture; Hadoop limitations.	03
03	**NoSQL** 3.1 What is NoSQL? NoSQL business drivers; NoSQL case studies; 3.2 NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns; 3.3 Using NoSQL to manage big data: What is a big data NoSQL solution? Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; Four ways that NoSQL systems handle big data problems	04
04	**MapReduce and the New Software Stack** **4.1 Distributed File Systems :** Physical Organization of Compute Nodes, Large-Scale File-System Organization. **4.2 MapReduce:** The Map Tasks, Grouping by Key, The Reduce Tasks,	06

	Combiners, Details of MapReduce Execution, Coping With Node Failures. **4.3 Algorithms Using MapReduce**: Matrix-Vector Multiplication by MapReduce , Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce, Computing Natural Join by MapReduce, Grouping and Aggregation by MapReduce, Matrix Multiplication, Matrix Multiplication with One MapReduce Step.	
05	**Finding Similar Items** 5.1 Applications of Near-Neighbor Search, Jaccard Similarity of Sets, Similarity of Documents, Collaborative Filtering as a Similar-Sets Problem . 5.2 **Distance Measures:** Definition of a Distance Measure, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance.	03
06	**Mining Data Streams** **6.1 The Stream Data Model**: A Data-Stream-Management System, Examples of Stream Sources, Stream Querie, Issues in Stream Processing. **6.2 Sampling Data in a Stream** : Obtaining a Representative Sample , The General Sampling Problem, Varying the Sample Size. **6.3 Filtering Streams**: The Bloom Filter, Analysis. **6.4 Counting Distinct Elements in a Stream** The Count-Distinct Problem, The Flajolet-Martin Algorithm, Combining Estimates, Space Requirements . **6.5 Counting Ones in a Window**: The Cost of Exact Counts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.	06
07	**Link Analysis** 7.1 PageRank Definition, Structure of the web, dead ends, Using Page rank in a search engine, Efficient computation of Page Rank: PageRank Iteration Using MapReduce, Use of Combiners to Consolidate the Result Vector. 7.2 Topic sensitive Page Rank, link Spam, Hubs and Authorities.	05
08	**Frequent Itemsets** **8.1 Handling Larger Datasets in Main Memory** Algorithm of Park, Chen, and Yu, The Multistage Algorithm, The Multihash Algorithm. **8.2 The SON Algorithm and MapReduce** **8.3 Counting Frequent Items in a Stream** Sampling Methods for Streams, Frequent Itemsets in Decaying Windows	05
09	**Clustering** 9.1 CURE Algorithm, Stream-Computing , A Stream-Clustering Algorithm, Initializing & Merging Buckets, Answering Queries	05

10	**Recommendation Systems** 10.1 A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering.	04
11	**Mining Social-Network Graphs** 11.1 Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities, SimRank, Counting triangles using Map-Reduce	04

Term Work:

Assign a case study for group of 2/3 students and each group to perform the following experiments on their case-study; Each group should perform the exercises on a large dataset created by them.

The distribution of marks for term work shall be as follows:

- Programming Exercises: ……..….. (10) Marks.
- Mini project: …… (10) Marks.
- Attendance ……. (05) Marks

TOTAL: ……. (25) Marks.

Internal Assessment:

Internal Assessment consists of two tests. Test 1, an Institution level central test, is for 20 marks and is to be based on a minimum of 40% of the syllabus. Test 2 is also for 20 marks and is to be based on the remaining syllabus. Test 2 may be either a class test or assignment on live problems or course project.

Practical/Oral examination:

An oral exam will be held based on the above syllabus.

Suggested Practical List: Students will perform at least 8 programming exercises and implement one mini-project. The students can work in groups of 2/3.

1. Study of Hadoop ecosystem
2. programming exercises on Hadoop
3. programming exercises in No SQL
4. Implementing simple algorithms in Map- Reduce (3) - Matrix multiplication, Aggregates, joins, sorting, searching etc.
5. Implementing any one Frequent Itemset algorithm using Map-Reduce
6. Implementing any one Clustering algorithm using Map-Reduce
7. Implementing any one data streaming algorithm using Map-Reduce
8. Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web)

a. Twitter data analysis
b. Fraud Detection
c. Text Mining etc.

Text Books:

1. Anand Rajaraman and Jeff Ullman "Mining of Massive Datasets", Cambridge University Press,
2. Alex Holmes "Hadoop in Practice", Manning Press, Dreamtech Press.
3. Dan McCreary and Ann Kelly "Making Sense of NoSQL" – A guide for managers and the rest of us, Manning Press.

References:

1. Bill Franks **, "**Taming The Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics", Wiley
2. Chuck Lam, "Hadoop in Action", Dreamtech Press

Course Code	Course/Subject Name	Credits
CPL801	**Cloud Computing Laboratory**	1

Outcomes: Learner will be able to…

1. Appreciate cloud architecture
2. Create and run virtual machines on open source OS
3. implement Infrastructure , storage as a Service**.**
4. Install and appreciate security features for cloud

Module	Detailed Contents	Lab Session
01	**Title:** Study of Cloud Computing & Architecture. **Concept:** Cloud Computing & Architecture. **Objective:** Objective of this module is to provide students an overview of the Cloud Computing and Architecture and different types of Cloud Computing **Scope:** Cloud Computing & Architecture Types of Cloud Computing . **Technology:** ---	**01**
02	**Title:** Virtualization in Cloud. **Concept:** Virtualization **Objective:** In this module students will learn, Virtualization Basics, Objectives of Virtualization, and Benefits of Virtualization in cloud. **Scope:** Creating and running virtual machines on open source OS. **Technology:** KVM, VMware.	**02**
03	**Title:** Study and implementation of Infrastructure as a Service . **Concept:** Infrastructure as a Service**.** **Objective:** In this module student will learn Infrastructure as a Service and implement it by using OpenStack. **Scope:** Installing OpenStack and use it as Infrastructure as a Service . **Technology:** Quanta Plus /Aptana /Kompozer	**02**
04	**Title:** Study and installation of Storage as Service.	**02**

	Concept: Storage as Service (SaaS) **Objective:** is that, students must be able to understand the concept of SaaS , and how it is implemented using ownCloud which gives universal access to files through a web interface. **Scope:** is to installation and understanding features of ownCloud as SaaS**.** **Technology:** ownCloud	
05	**Title:** Implementation of identity management. **Concept:** Identity Management in cloud **Objective:** this lab gives an introduction about identity management in cloud and simulate it by using OpenStack **Scope:** installing and using identity management feature of OpenStack **Technology:** OpenStack	**02**
06	**Title:** Write a program for web feed. **Concept:** Web feed and RSS **Objective:** this lab is to understand the concept of form and control validation **Scope:** Write a program for web feed **Technology:** PHP, HTML	**02**
07	**Title:** Study and implementation of Single-Sing-On. **Concept:** Single Sing On (SSO),openID **Objective:** is to understand the concept of access control in cloud and single sing on (SSO), Use SSO and advantages of it, and also students should able to implementation of it. **Scope:** installing and using JOSSO **Technology:** JOSSO	**02**
08	**Title:** Securing Servers in Cloud. **Concept:** Cloud Security **Objective:** is to understand how to secure web server, how to secure data directory and introduction to encryption for own cloud.	**02**

	Scope: Installing and using security feature of ownCloud **Technology:** ownCloud	
09	**Title:** User Management in Cloud. **Concept:** Administrative features of Cloud Managenet ,User Management **Objective:** is to understand how to create, manage user and group of users accounts. **Scope:** Installing and using Administrative features of ownCloud **Technology:** ownCloud	**02**
10	**Title:** Case study on Amazon EC2. **Concept:** Amazon EC2 **Objective:** in this module students will learn about Amazon EC2. Amazon Elastic Compute Cloud is a central part of Amazon.com's cloud computing platform, Amazon Web Services. EC2 allows users to rent virtual computers on which to run their own computer applications	**01**
11	**Title:** Case study on Microsoft azure. **Concept:** Microsoft Azure **Objective:** students will learn about Microsoft Azure is a cloud computing platform and infrastructure, created by Microsoft, for building, deploying and managing applications and services through a global network of Microsoft-managed datacenters. How it work, different services provided by it. **Technology:** Microsoft azure	**01**
12	**Title:** Mini project. **Concept:** using different features of cloud computing creating own cloud for institute, organization etc. **Objective:** is student must be able to create own cloud using different features which are learned in previous practices. **Scope:** creating a cloud like social site for institute. **Technology:** any open system used for cloud	**05**

Term Work:

- Term work should consist of at least 6 experiments and a mini project.
- Journal must include at least 2 assignments.
- The final certification and acceptance of term work indicates that performance in laboratory work is satisfactory and minimum passing marks may be given in term work.

The distribution of marks for term work shall be as follows:

- Laboratory work (experiments): …….. (15) Marks.
- Mini project presentation: …… (05) Marks.
- Attendance ……. (05) Marks

TOTAL: …… (25) Marks.

Text Books:

1. Enterprise Cloud Computing by Gautam Shroff, Cambridge,2010
2. Cloud Security by Ronald Krutz and Russell Dean Vines, Wiley - India, 2010 , ISBN:978-0-470-58987-8
3. Getting Started with OwnCloud by Aditya Patawar , Packt Publishing Ltd, 2013
4. www.openstack.org

Course Code	Course/Subject Name	Credits
CP701 / CP802	**Project I/ II**	**3 / 6**

Guidelines for Project

- Students should do literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem.
- Students should attempt solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Guidelines for Assessment of Project I

- Project I should be assessed based on following points
  - Quality of problem selected
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
  - Breadth and depth of literature survey
- Project I should be assessed through a presentation by the student project group to a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Project II

- Project II should be assessed based on following points
  - Quality of problem selected
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiners approved by the University of Mumbai
- Students should be motivated to publish a paper based on the work in Conferences/students competitions