SCHEME OF INSTRUCTION& EXAMINATION
B.E. VIII - SEMESTER
(COMPUTER SCIENCE AND ENGINEERING)

S. No.	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1		Professional Elective – III	3	-	-	3	30	70	3	3
2		Professional Elective – IV	3	-	-	3	30	70	3	3
3		Professional Elective – V	3	-	-	3	30	70	3	3
Practical/ Laboratory Courses										
4	**PW 961 CS**	Project Work – II	-	-	16	16	50	100	-	8
			09	**-**	**16**	**25**	**140**	**310**		**17**

Professional Elective – III		
S. No.	Course Code	Course Title
1	**PE 821 CS**	Mobile Computing
2	**PE 822 CS**	Image Processing
3	**PE 823 CS**	Software Quality and Testing
4	**PE 824 CS**	Web Services and Architecture
5	**PE 825 CS**	Computational Intelligence

Professional Elective – IV		
S. No.	Course Code	Course Title
1	**PE 831 CS**	Embedded Systems
2	**PE 832 CS**	Information Retrieval Systems
3	**PE 833 CS**	Machine Learning
4	**PE 834 CS**	Natural Language Processing
5	**PE 835 CS**	Data Science using R Programming

Professional Elective – V		
1	**PE 841 CS**	Multicore and GPU Programming
2	**PE 842 CS**	Cloud Computing
3	**PE 843 CS**	Human Computer Interaction

PC: Professional Course PE: Professional Elective
L: Lectures T: Tutorials P: Practical D: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note: 1) Each contact hour is a Clock Hour
2) The duration of the practical class is two clock hours, however it can be extended wherever necessary, to enable the student to complete the experiment

Course Code	Course Title						Core / Elective
PE 821 CS	**Mobile Computing**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce basics of wireless voice and data communication technologies
- To build working knowledge on various telephone and satellite networks
- To study the working principles of wireless LANs and standards
- To study principles of adhoc networks and routing
- To gain knowledge on integration of mobile networks into Internet
- To build skills in working with wireless application protocols to develop mobile applications.

Course Outcomes

After completing this course, the student will be able to

1. Understand and apply various techniques involved in planning and construction stages.
2. Implement Adhoc Network Routing protocols.
3. Mini based project based on tracking, localization and routing in wireless networks.
4. Implement file transfer, access and authentication based applications for mobile computing.

UNIT-I

Introduction – Wireless transmission – Frequencies for radio transmission – Signals – Antennas – Signal Propagation – Multiplexing – Modulations – Spread spectrum – MAC – SDMA – FDMA – TDMA – CDMA – Cellular Wireless Networks.

UNIT-II

Telecommunication systems – GSM – GPRS – DECT – UMTS – IMT-2000 – Satellite Networks - Basics – Parameters and Configurations – Capacity Allocation – FAMA and DAMA – Broadcast Systems – DAB - DVB.

UNIT-III

Wireless LAN – IEEE 802.11 - Architecture – services – MAC – Physical layer – IEEE 802.11a - 802.11b standards – HIPERLAN – Blue Tooth.

UNIT-IV

Mobile IP, Dynamic Host Configuration Protocol, Routing in MANETs: DSDV, DSR, AODV and ZRP. MANETS vs VANETs

UNIT-V

Traditional TCP – classical TCP improvements – WAP, and WAP 2.0.
Mobile Transaction models, File Systems and Mobility Management

Suggested Readings:

1. Jochen H. Schiller, *Mobile Communications*, Addison Wesley, Second Edition, 2003.
2. William Stallings, *Wireless Communications and Networks*, PHI/Pearson Education, 2002.
3. Kaveh Pahlavan, Prasanth Krishnamurthy, *Principles of Wireless Networks*, Prentice Hall, 2003.
4. Uwe Hansmann, LotharMerk, Martin S. Nicklons and Thomas Stober, *Principles of Mobile Computing*, Springer, 2003.
5. Krzysztof Wesolowski, *Mobile Communication Systems*, John Wiley and Sons Ltd, 2002.

Course Code	Course Title						Core / Elective
PE 822 CS	**Image Processing**						**Elective**
Prerequisites	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce basics of visual perception, sampling, quantization and representation of digital images
- To introduce spatial domain and frequency domain filtering techniques necessary for image processing operations.
- To learn advanced image analysis techniques such as image compression, image segmentation, and object recognition
- To learn techniques of colour image processing, multi resolution methods, wavelets and morphological processing

Course Outcomes

After completing this course, the student will be able to

1. Analyse images in the frequency domain using various transforms
2. Design and implement algorithms that perform image processing operations such as histogram equalization, enhancement, restoration, filtering and denoising
3. Explain colour spaces, restoration and enhancement of colour images
4. Develop simple object recognition systems

UNIT-I

Image Processing: Introduction, Examples, Fundamental steps, Components, Elements of visual perception, Light and Electromagnetic Spectrum, Image sensing and Acquisition, Image Sampling and Quantization, Basic relationships between pixels.

Intensity Transformations and Spatial Filtering: Background, some basic intensity transformation functions, Histogram processing, Fundamentals of Spatial filtering, smoothing spatial filters, sharpening spatial filters, Combining Spatial Enhancement Methods.

UNIT-II

Filtering in the Frequency Domain: Background, Preliminary concepts, Sampling and Fourier Transform of Sampled Functions, Discrete Fourier Transform (DFT) of one variable, Extension to functions of two variables, Some Properties of the 2-D Discrete Fourier Transform, Basics of Filtering in the Frequency Domain, Image Smoothing, Image Sharpening, Homomorphic Filtering.

Image Restoration: Noise Models, Restoration in the presence of noise Only-Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering.

Linear Degradation, Position-invariant Degradation, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error Filtering, Constrained Least Squares Filtering, Geometric Mean Filter.

UNIT-III

Colour Image Processing: Colour fundamentals, Colour models, Pseudocolour Image Processing, Basics of Full-colour Image Processing, Colour Transformations, Smoothing and Sharpening, Colour-based Image Segmentation, Noise in Colour Images, Colour Image Compression.

Wavelets and Multi resolution Processing: Background, Multiresolution Expansions, Wavelet Transforms in One Dimension, The Fast Wavelet Transform, Wavelet Transforms in Two Dimensions, Wavelet Packets.

UNIT-IV

Image Compression: Fundamentals, Image Compression Models, Elements of Information Theory, Error-free Compression, Lossy Compression, Image Compression Standards, Some Basic Compression Methods.

Morphological Image Processing: Preliminaries, Erosion and Dilation, Opening and Closing, The Hit-or-Miss Transformation, Some Basic Morphological Algorithms, Some Basic Gray-Scale Morphological Algorithms.

UNIT-V

Image Segmentation: Fundamentals, Point, Line and Edge Detection, Thresholding, Region-based Segmentation, Segmentation using Morphological Watersheds, The use of Motion in Segmentation.

Object Recognition: Patterns and Pattern Classes, Recognition based on Decision-theoretic Methods, Structural Methods.

Suggested Readings:

1. Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing,* PHI Learning Pvt. Limited, 3rd Edition, 2008.
2. William K. Pratt, *Digital Image Processing*, John Wiley & Sons, Inc., 3rd Edition, 2001.

Course Code	Course Title						Core / Elective
PE 823 CS	**Software Quality and Testing**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand the challenges of Software Quality and the need for integration of quality activities in project life cycle
- To introduce supporting software quality devices
- To introduce software quality metrics and Quality Assurance models
- To understand the steps in software testing process and taxonomy of testing tools

Course Outcomes

After completing this course, the student will be able to

1. Describe the role of quality assurance activities in the software process
2. Compare several process improvement models such as CMM, CMMI, PCMM, and ISO9000
3. Describe several process metrics for assessing and controlling a project
4. Describe how available static and dynamic test tools can be integrated into the software development environment

UNIT - I

The Software Quality Challenge, Introduction Software Quality Factors, The Components of the Software Quality Assurance System – Overview, Development and Quality Plans.

UNIT - II

Integrating Quality Activities in the Project Life Cycle, Assuring the Quality of Software Maintenance Components, CASE Tools and their effect on Software Quality, Procedure and Work Instructions, Supporting Quality Devices, Configuration Management, Documentation Control, Project Progress Control.

UNIT - III

Software Quality Metrics, Costs of Software Quality, Quality Management Standards - ISO 9000 and Companion ISO Standards, CMM, CMMI, PCMM, Malcom Balridge, 3 Sigma, 6 Sigma, SQA Project Process Standards – IEEE Software Engineering Standards.

UNIT - IV

Building a Software Testing Strategy, establishing a Software Testing Methodology, Determining Your Software Testing Techniques, eleven – Step Software Testing Process Overview, Assess Project Management Development Estimate and Status, Develop Test Plan, Requirements Phase Testing, Design Phase Testing, Program Phase Testing, Execute Test and Record Results, Acceptance Test, Report Test Results, Test Software Changes, Evaluate Test Effectiveness.

UNIT - V

Testing Client / Server Systems, Testing the Adequacy of System Documentation, Testing Web-based Systems, Testing Off – the – Shelf Software, testing in a Multiplatform Environment, Testing Security, testing a Data Warehouse, Creating Test Documentation, Software Testing Tools, Taxonomy of Testing Tools, Methodology to Evaluate Automated Testing Tools, Load Runner, Win Runner and Rational Testing Tools, Java Testing Tools, JMetra, JUNIT and Cactus.

Suggested Readings:

1. Daniel Galin, *Software Quality Assurance–From Theory to Implementation*, Pearson Education.2004
2. Mordechai Ben Menachem / Garry S. Marliss, *Software Quality–Producing Practical, Consistent Software*, BS Publications, 2014
3. William E. Perry, *Effective Methods for Software Testing*, 2nd Edition, Wiley.
4. Srinivasan Desikan, Gopalaswamy Ramesh, *Software Testing, Principles and Practices*, 2006. Pearson Education.
5. K.V.K.K. Prasad, *Software Testing Tool*, Wiley Publishers

Web Resources:

1. http://www.sei.cmu.edu/cmmi/
2. www.ibm.com/software/awdtools/tester/functional/index.html
3. www.ibm.com/software/awdtools/test/manager/
4. *java-source.net/open-source/testing-tools*
5. www.junit.org
6. *java-source.net/open-source/web-testing-tools*

Course Code	Course Title						Core / Elective
PE 824 CS	**Web Services and Architecture**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To make the student familiar with the concepts of

- To study the evolution of SOA and Web Services
- To understand the principles of service orientation, Service layers
- To learn about WS* Specifications, messaging with SOAP and Service composition
- To learn about service oriented analysis and service oriented design
- Gained knowledge on various open standards available for developing SOA compliant web services

Course Outcomes

After completing this course, the student will be able to

1. Understand web service framework with respect to SOA
2. Develop SOA compliant web services using open standards and various technologies
3. Model and implement businesses processes using service oriented approach

UNIT- I

SOA and Web Services Fundamentals: Introducing So, The Evolution of SOA, Web services and primitive SOA.

UNIT-II

SOA and WS-*Extensions: Web Services and Contemporary SOA (I: Activity Management and Composition), Web Services and Contemporary SOA (II: Advanced Messaging, Metadata, and Security).

UNIT-III

SOA and Service-Orientation: Principles of Service-Orientation, Service Layers.

UNIT-IV

Building SOA (Planning and Analysis): SOA Delivery Strategies, Services-Oriented Analysis (I: Introduction), Service-Oriented Analysis (II: Service Modelling).

UNIT-V

Building SOA (Technology and Design): Service-Oriented Design (I: Introduction), Service-Oriented Design (II: SOA Composition Guidelines), Service-Oriented Design (III: Service-Design), Service- oriented Design (IV: Business Process Design), Fundamentals WS-*Extensions, SOA Platforms.

Suggested Readings:

1. Thomas Eri*," Service-Oriented Architecture(SOA): Concepts, Technology, and Design*, Prentice Hall PTR, 2005
2. James McGovern and Sameer Tyagi, *Java Web Services Architecture*, Morgan Kaufmann-May 2003.

Course Code	Course Title						Core / Elective
PE 825 CS	**Computational Intelligence**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce the concepts of Biological and Artificial neural networks
- To understand different neural architectures with supervised learning and their learning mechanisms
- To study different neural architectures with unsupervised learning such as PCA Networks Kohenen's Self-Organizing Maps
- To introduce Markov decision processes, Q-Learning and TD-Learning
- To study different models of evolution and learning, neuro-fuzzy techniques, rough set theory and their applications

Course Outcomes

After completing this course, the student will be able to

1. Design single and multi-layer feed-forward neural networks
2. Implement various unsupervised learning networks
3. Design new evolutionary operators, representations and fitness functions for specific practical problems
4. Apply fuzzy logic and rough sets to handle uncertainty and vagueness in practical problems

UNIT-I

Introduction to Computational Intelligence / Soft computing: Soft versus Hard Computing, Various paradigms of computing

Foundations of Biological Neural Networks: Introduction to Neural Networks, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN (Learning, Generalization, Memory, Abstraction, Applications), McCulloch-Pitts Model, Historical Developments

Essentials of Artificial Neural Networks: Introduction, Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity (Feed forward, feedback, Single and Multi-layer), Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules (Error Correction, Hebbian, Competitive, Stochastic), Types of Application (Pattern Classification, Pattern Clustering, Pattern Association / Memory, Function Approximation, Prediction, Optimization)

UNIT-II

Neural Architectures with Supervised Learning: Single Layer Feed Forward Neural Networks(Perception), Multilayer Feed Forward Neural Networks (Back propagation learning), Radial Basis Function Networks, Support Vector Machines, Simulated Annealing, Boltzmann Machine, Feedback (Recurrent) Networks and Dynamical Systems

Associative Memories: Matrix memories, Bidirectional Associative Memory, Hopfield Neural Network,

UNIT-III

Neural Architectures with Unsupervised Learning: Competitive learning, Principal Component Analysis Networks (PCA), Kohonen's Self-Organizing Maps, Linear Vector Quantization, Adaptive Resonance Theory (ART) Networks, Independent Component Analysis Networks (ICA)

UNIT-IV

Reinforcement Learning: Markov Decision Processes, Value Functions, Bellman Optimality Criterion, Policy and Value Iterations, Q-Learning, TD Learning

UNIT-V

Fuzzy Logic: Basic concepts, fuzzy set theory, basic operations, fuzzification, defuzzification, neurofuzzy approach, applications

Evolutionary and Genetic Algorithms: Basic concepts of evolutionary computing, genetic operators, fitness function and selection, genetic programming, other models of evolution and learning, ant colony systems, swarm intelligence, applications

Rough Set Theory: Basic concepts, indiscernability relation, lower and upper approximation, decision systems based on rough approximation, applications

Suggested Readings:

1. Jacek M. Zurada. Introduction to Artificial Neural Systems, Jaico Publishers, 1992.
2. S. Haykin. Neural Networks: A Comprehensive Foundation, Prentice Hall, 1999.
3. P. S. Churchland and T. J. Sejnowski. The Computational Brain. MIT Press, 1992.
4. A. M. Ibrahim. Introduction to Applied Fuzzy Electronics. PHI, 2004
5. Z. Pawlak. Rough Sets, Kluwer Academic Publishers, 1991.

Course Code	Course Title						Core / Elective
PE 831 CS	**Embedded Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To provide basics of embedded systems design and development flow.
- To study the processor architectures that supports embedded systems.
- To gain knowledge developing platforms for embedded systems.
- To provide basics of real time operating systems that supports embedded systems.
- To study the concepts on testing and development tools.

Course Outcomes

After completing this course, the student will be able to

1. Understand the basics of embedded systems design and development flow.
2. Apply knowledge to develop the embedded systems.
3. Analyse the real time operating that supports embedded systems.

UNIT-I

Design of Embedded System: Sensors and Actuators, Embedded Processors, Memory Architectures, Input and Output.

UNIT-II

Embedded Systems Development Environment: IDE, Cross compilation, Disassembler, Simulators, Emulators and Debugging, Target hardware debugging, Boundary Scan.

Embedded Computing Platform: Programming for Embedded systems using C, Device drivers, program modelling concepts, Process of Embedded system development: embedded software development on microcontroller platform, network-based embedded applications and embedded control applications.

UNIT-III

Embedded C Programming: Review of data types - Scalar Types-Primitive Types-Enumerated Types-Subranges, Structure types-character strings -arrays- Functions. Interfacing C with Assembly. Embedded programming issues - Re-entrancy, Portability, Optimizing, and testing embedded C programs.

UNIT-IV

Concept of Embedded Operating Systems: Differences between Traditional OS and RTOS. Real-time System Concepts, RTOS Kernel & Issues in Multitasking – Task Assignment, Task Priorities, Scheduling, Intertask Communication & Synchronization – Definition of Context Switching, Foreground ISRs and Background Tasks. Critical Section – Reentrant Functions, Interprocess Communication (IPC) – IPC through Semaphores, Mutex, Mailboxes, Message Queues or Pipes and Event Flags.

UNIT-V

VxWorks – POSIX Real Time Extensions, timeout features, Task Creation, Semaphores (Binary, Counting), Mutex, Mailbox, Message Queues, Memory Management – Virtual to Physical Address Mapping.

Suggested Readings:

1. Edward Ashford Lee and Sanjit Arunkumar Seshia, *Introduction to Embedded Systems- A Cyber-Physical Systems Approach*, Second Edition, MIT Press, 2017.
2. Jones, M Tim, *GNU/Linux Application Programming*, 2nd Edition, Course Technology PTR, 2008.
3. Raj Kamal, *Embedded systems Architecture, programming & Design*, Tata McGraw Hill, 2010.

4. Real Time Systems, C.M. Krishna and G. Shin, McGraw-Hill Companies Inc., McGraw Hill International Edition, 1997.
5. Programming Embedded Systems with C and GNU Development Tools, Second Edition, 1977.

Course Code	Course Title						Core / Elective
PE 832 CS	**Information Retrieval Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand indexing and querying in information retrieval systems
- To learn the different models for information retrieval
- To expose the students to text classification and clustering
- To learn about web searching

Course Outcomes

After completing this course, the student will be able to

1. Understand the algorithms and techniques for information retrieval (document indexing and retrieval, query processing)
2. Quantitatively evaluate information retrieval systems
3. Classify and cluster documents
4. Understand the practical aspects of information retrieval such as those in web search engines.

UNIT-I

Boolean Retrieval: An example information, Building an inverted index, Processing Boolean queries, The extended Boolean model versus ranked retrieval.

The term vocabulary and postings lists: Document delineation and character sequence decoding, determining the vocabulary of terms, Faster postings list intersection via skip pointers, Positional postings, and Phrase queries.

Dictionaries and tolerant retrieval: Search structures for dictionaries, Wildcard queries, Spelling correction.

Index construction: Hardware basics, blocked sort-based indexing, Single-pass in-memory indexing, Distributed indexing, Dynamic indexing, Other types of indexes.

UNIT-II

Index compression: Statistical properties of terms in information retrieval, Dictionary compression, Postings file compression.

Scoring, term weighting and the vector space model: Parametric and zone indexes, Term frequency and weighting, the vector space model for scoring, and Variant tf-idf functions.

Computing scores in a complete search system: Efficient scoring and ranking, Components of an information retrieval system, Vector space scoring and query operator interaction.

Evaluation in information retrieval: Information retrieval system evaluation, Standard test collections, Evaluation of unranked retrieval sets, Evaluation of ranked retrieval results, Assessing relevance.

UNIT-III

Relevance feedback and query expansion: Relevance feedback and pseudo relevance feedback, Global methods for query reformulation.

XML retrieval: Basic XML concepts, Challenges in XML retrieval, A vector space model for XML retrieval, Evaluation of XML retrieval, Text-centric vs. data-centric XML retrieval.

Probabilistic information retrieval: Basic probability theory, The Probability Ranking Principle, The Binary Independence Model.

Language models for information retrieval: Language models, The query likelihood model.

UNIT-IV

Text classification and Naive Bayes: The text classification problem, Naive Bayes text classification, The Bernoulli model, Properties of Naive Bayes, and Feature selection.

Vector space classification: Document representations and measures of relatedness in vector spaces, Rocchio classification, k- nearest neighbour, Linear versus nonlinear classifiers.

Flat clustering: Clustering in information retrieval, Problem statement, Evaluation of clustering, k-means.

Hierarchical clustering: Hierarchical agglomerative clustering, Single-link and complete-link clustering, Group-average agglomerative clustering, Centroid clustering, Divisive clustering.

UNIT-V

Matrix decompositions and Latent semantic indexing: Linear algebra review, Term-document matrices and singular value decompositions, Low-rank approximations, Latent semantic indexing.

Web search basics: Background and history, Web characteristics, Advertising as the economic model, The search user experience, Index size and estimation, Near-duplicates and shingling.

Web crawling and Indexes: Overview, Crawling, Distributing indexes, Connectivity servers.

Link analysis: The Web as a graph, Page Rank, Hubs and Authorities.

Suggested Readings:

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze, *An Introduction to Information Retrieval*, Cambridge University Press, Cambridge, England, 2008
2. David A. Grossman, Ophir Frieder, *Information Retrieval–Algorithms and Heuristics*, Springer, 2nd Edition (Distributed by Universities Press), 2004.
3. Gerald J Kowalski, Mark T Maybury. *Information Storage and Retrieval Systems*, Springer, 2000
4. Soumen Chakrabarti, *Mining the Web: Discovering Knowledge from Hypertext Data*, Morgan-Kaufmann Publishers, 2002.

Course Code	Course Title						Core / Elective
PE 833 CS	**Machine Learning**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To make the student familiar with the concepts of

- To introduce the basic concepts of machine learning and range of problems that can be handled by machine learning.
- To introduce the concepts of instance based learning and decision tree induction
- To introduce the concepts of linear separability, Perceptron and SVM
- To learn the concepts of probabilistic inference, graphical models and evolutionary learning
- To learn the concepts of ensemble learning, dimensionality reduction and clustering

Course Outcomes

After completing this course, the student will be able to

1. Explain the strengths and weaknesses of many popular machine learning approaches
2. Recognize and implement various ways of selecting suitable model parameters for different machine learning techniques
3. Design and implement various machine learning algorithms in a range of real-world applications

UNIT-I

Introduction: Learning, Types of Machine Learning.
Concept learning: Introduction, Version Spaces and the Candidate Elimination Algorithm.
Learning with Trees: Constructing Decision Trees, CART, Classification Example

UNIT-II

Linear Discriminants: The Perceptron, Linear Separability, Linear Regression
Multilayer Perceptron (MLP): Going Forwards, Backwards, MLP in practices, Deriving back
Propagation SUPPORT Vector Machines: Optimal Separation, Kernels

UNIT-III

Some Basic Statistics: Averages, Variance and Covariance, The Gaussian, The Bias-Variance Trade-off Bayesian learning: Introduction, Bayes theorem. Bayes Optimal Classifier, Naive Bayes Classifier.
Graphical Models: Bayesian networks, Approximate Inference, Making Bayesian Networks, Hidden Markov Models, The Forward Algorithm.

UNIT-IV

Evolutionary Learning: Genetic Algorithms, Genetic Operators, Genetic Programming
Ensemble Learning: Boosting, Bagging
Dimensionality Reduction: Linear Discriminant Analysis, Principal Component Analysis

UNIT-V

Clustering: Introduction, Similarity and Distance Measures, Outliers, Hierarchical Methods, Partitional Algorithms, Clustering Large Databases, Clustering with Categorical Attributes, Comparison

Suggested Readings:

1. Tom M. Mitchell, *Machine Learning*, Mc Graw Hill, 1997
2. Stephen Marsland, *Machine Learning - An Algorithmic Perspective*, CRC Press, 2009
3. Margaret H Dunham, *Data Mining*, Pearson Edition., 2003.

4. Galit Shmueli, Nitin R Patel, Peter C Bruce, *Data Mining for Business Intelligence*, Wiley India Edition, 2007
5. Rajjan Shinghal, *Pattern Recognition*, Oxford University Press, 2006.

Course Code	Course Title						Core / Elective
PE 834 CS	**Natural Language Processing**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn about corpus-based work collections
- To understand the models and methods of Statistical NLP
- To introduce IR and ML based techniques for NLP tasks

Course Outcomes

1. Impalement probabilistic models and estimate parameters for such models
2. Gain understanding of linguistic phenomenon and will explore linguistic features relevant to each NLP task
3. Apply the methods to new NLP problems and also to problems outside NLP

UNIT- I

Natural Language Processing: Introduction to Natural Language Processing, the study of Language, Applications of NLP, Evaluating Language Understanding Systems, Different levels of Language Analysis, Representations and Understanding, Organization of Natural Language Understanding Systems, Linguistic Background: An outline of English syntax Spoken Language input and output Technologies. Written language Input – Mathematical Methods – statistical Modelling and classification Finite State Methods.
Grammar for Natural Language Processing – Parsing – Semantic and Logic Form –

UNIT- II

Introduction to Semantics and Knowledge Representation: some applications like Machine translation, database interface Semantic Interpretation, word senses and ambiguity, Basic logical form language, Encoding ambiguity in logical from, Thematic roles, Linking syntax and semantics, Recent trends in NLP.

UNIT- III

Grammars and Parsing: Grammars and sentence Structure, Top-Down and Bottom-Up Parsers, Transition Network Grammars, Top- Down Chart Parsing. Feature Systems and Augmented Grammars: Basic Feature system for English, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.

UNIT- IV

Semantic Interpretation: word senses and ambiguity, Basic logical form language, Encoding ambiguity in logical from, Thematic roles, Linking syntax and semantics, Recent trends in NLP.

UNIT-V

Ambiguity Resolution: Statistical Methods, Probabilistic Language Processing, Estimating Probabilities, Part-of-Speech tagging, Obtaining Lexical Probabilities, Probabilistic Context- Free Grammars, Best First Parsing. Semantics and Logical Form, Word senses and Ambiguity, Encoding Ambiguity in Logical Form.

Suggested Readings:

1. Christopher D. Manning, Hinrich Schutze, *Foundations of Statistical Natural Language Processing,* MIT Press, 1999.
2. James Allan, *Natural Language Understanding*, Pearson Education, 1994.
3. Tanveer Siddiqui, US Tiwary, *Natural Language Processing and Information Retrieval,* Oxford University Press, 2008.

4. Akshar Bharti, Vineet Chaitanya and Rajeev Sangal, “NLP: A Paninian Perspective”, Prentice Hall, New Delhi
5. D. Jurafsky, J. H. Martin, “Speech and Language Processing”, Pearson

Course Code	Course Title						Core / Elective
PE 835 CS	**Data Science using R Programming**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn basics of R Programming environment: R language, R- studio and R packages
- To learn various statistical concepts like linear and logistic regression, cluster analysis, time series forecasting
- To learn Decision tree induction, association rule mining and text mining

Course Outcomes

After completing this course, the student will be able to

1. Use various data structures and packages in R for data visualization and summarization
2. Use linear, non-linear regression models, and classification techniques for data analysis
3. Use clustering methods including K-means and CURE algorithm

UNIT-I

Introduction to R: Introduction, Downloading and Installing R, IDE and Text Editors, Handling Packages in R.

Getting Started with R: Introduction, Working with Directory, Data Types in R, Few Commands for Data Exploration.

Loading and Handling Data in R: Introduction, Challenges of Analytical Data Processing, Expression, Variables, Functions, Missing Values Treatment in R, using as 'Operator to Change the Structure of the Data, Victors, Matrices, Factors, List, Few Common Analytical Tasks, Aggregation and Group Processing of a Variable, Simple Analysis Using R, Methods for Reading Data, Comparison of R GUI's for Data Input, Using R with Databases and Business Intelligence Systems.

UNIT-II

Exploring Data in R: Introduction, Data Frames, R Functions for Understanding Data in Data Frames, Load Data Frames, Exploring Data, Data Summary, Finding the Missing Values, Invalid Values and Outliers, Descriptive Statistics, Spotting Problems in Data with Visualization.

UNIT-III

Linear Regression Using R: Introduction, Model Fitting, Linear Regression, Assumptions of Linear Regression, Validating Linear Assumption.

Logistic Regression: Introduction, What Is Regression? Introduction to Generalized Linear Model, Logistic Regression, Binary Logistic Regression, Diagnosing Logistic Regression, Multinomial Logistic Regression Model.

UNIT-IV

Decision Tree: Introduction, What Is a Decision Tree? Decision Tree Representation in R, Appropriate Problems for Decision Tree Learning, Basic Decision Tree Learning Algorithm, Measuring Features, Hypothesis Space Search in Decision Tree Learning, Inductive Bias in Decision Tree Learning, Why Prefer Short Hypotheses, Issues in Decision Tree Learning.

Time Series in R: Introduction, What Is Time Series Data, Reading Time Series Data, Decomposing Time Series Data, Forecasts Using Exponential Smoothing, ARIMA Models.

UNIT-V

Clustering: Introduction, What Is Clustering, Basic Concepts in Clustering, Hierarchical Clustering, K-Means Algorithm, CURE Algorithm, clustering in Non-Euclidean Space, Clustering for Streams and Parallelism.

Association Rules: Introduction, Frequent Itemset, Data Structure Overview, Mining Algorithm Interfaces, Auxiliary Functions, Sampling from Transaction, Generating Synthetic Transaction Data, Additional Measures of Interestingness, Distance Based Clustering Transaction and Association.

Text Mining: Introduction, Definition of Text Mining, A Few Challenges in Text Mining, Text Mining Verses Data Mining, Text Mining in R, General Architectures of Text Mining Systems, Pre-Processing of Documents in R, Core Text Mining Operations, Using Background Knowledge for Text Mining, Text Mining Query Languages.

Mining Frequent Patterns, Associations and Correlations: Basic Concepts and Methods. Frequent Itemset, Closed Itemset and Association Rules. Frequent Itemset: Mining Methods, Pattern Evaluation Methods, Sentiment Analysis

Suggested Readings:

1. Nina Zumel, Practical Data Science with R, Manning Publications, 2014.
2. Peter Bruce and Andrew Bruce, Practical Statistics for Data Scientists, O'Reilly, 2017.
3. Hadley Wickham and Garrett Grolemund, R for Data Science, O'Reilly, 2017.
4. Roger D Peng, R Programming for Data science, Lean Publishing, 2016.
5. Rafael A Irizarry, Introduction to Data Science, Lean Publishing,2016.
6. Seema Acharya, Data Analytics using R, McGraw Hill, 2018.
7. Crawley, Michael J., The R book, John Wiley & Sons, 2017.

Course Code	Course Title						Core / Elective
PE 841 CS	**Multi-core and GPU Programming**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	L			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To learn the paradigms of parallel computing, PRAM and BSP model.
- To study the heterogeneous processor architectures
- To understand the multicore programming using OpenCL
- To provide basics of OpenCL computing models

Course Outcomes

After completing this course, the student will be able to

1. Apply the knowledge of parallel computing models to solve real time applications.
2. Gain the knowledge of heterogeneous processor architectures
3. Apply the multi core programming knowledge to solve the sequential tasks.

UNIT-I

Introduction to Parallel Computing: Scope of Parallel Computing, Sieve of Eratosthenes, Control and Data Approach, PRAM model of parallel computation, Design paradigms of Parallel Computing, examples, Bulk Synchronous Parallel (BSP) model, algorithms on PRAM and BSP model.

UNIT-II

Introduction to Heterogeneous Multi-Core Processors, Many cores Programming, Cell Processor Multi-Node Computing.

Introduction to Graphics Processors, Graphics Processing Units, GPGPUs and GPU Hardware. Programming using CUDA/ OpenCL, Direct Compute CPU alternatives, Directives and libraries, Understanding Parallelism with GPUs.

UNIT-III

Heterogeneous Multi-Core Programming with OpenCL: OpenCL Programming Model, OpenCL Device Architectures, Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories

UNIT-IV

Introduction to OpenCL: Understanding OpenCL's Concurrency and Execution Model, Dissecting a CPU/GPU, OpenCL Implementation. Programs for concurrent Data Structures such as Worklists, Linked-lists. Synchronization across CPU and GPU

Functions: Device functions, Host functions, Kernels functions, Using libraries (such as Thrust), and developing libraries.

UNIT-V

Case Studies: Image Processing, Graph algorithms, Simulations, Deep Learning, Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing

Suggested Readings:

1. David Kaeli, Perhaad Mistry, Dana Schaa and Dong Ping Zhang, *Heterogeneous Computing with OpenCL 2.0*, 1st Edition, Mourgan Kaufmann, 2015.

2. Vipin Kumar, George Karypis, Anshul Gupta, Ananth Grama, Introduction to Parallel Computing, Addison Wesley, 2nd Edition, 2003.
3. Gregory V. Wilson, *Practical Parallel Programming*, PHI, 1998.

Course Code	Course Title						Core / Elective
PE 842 CS	**Cloud Computing**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce basic concepts cloud computing and enabling technologies
- To learn about Auto-Scaling, capacity planning and load balancing in cloud
- To introduce security, privacy and compliance issues in clouds
- To introduce cloud management standards and programming models

Course Outcomes

After completing this course, the student will be able to

1. Understand the architecture and concept of different cloud models: IaaS, PaaS, SaaS
2. Create virtual machine images and deploy them on cloud
3. Identify security and compliance issues in clouds.

UNIT- I

Introduction, Benefits and challenges, Cloud computing services, Resource Virtualization, Resource pooling sharing and provisioning

UNIT -II

Scaling in the Cloud, Capacity Planning, Load Balancing, File System and Storage,

UNIT-III

Multi-tenant Software, Data in Cloud, Database Technology, Content Delivery Network, Security Reference Model, Security Issues, Privacy and Compliance Issues

UNIT-IV

Portability and Interoperability Issues, Cloud Management and a Programming Model Case Study, Popular Cloud Services

UNIT-V

Enterprise architecture and SOA, Enterprise Software, Enterprise Custom Applications, Workflow and Business Processes, Enterprise Analytics and Search, Enterprise Cloud Computing Ecosystem.

Suggested Readings:

1. Cloud Computing - Sandeep Bhowmik, Cambridge University Press, 2017.
2. Enterprise Cloud Computing - Technology, Architecture, Applications by Gautam Shroff, Cambridge University Press, 2016.
3. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, *Distributed and Cloud Computing from Parallel Processing to the Internet of Things*, Elsevier, 2012.

Course Code	Course Title						Core / Elective
PE 843 CS	**Human Computer Interaction**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce interaction frameworks and styles
- To learn about interaction design process, design standards and principles
- To introduce the concept of usability and usability testing
- To familiarize interface components and technical issues of concern

Course Outcomes

Students who successfully complete this course will be able to:

1. Describe different types of interactive environments and interaction styles
2. Understand the user interface design process and the need for user-centred design
3. Describe techniques for developing prototypes of user interfaces and evaluation of user interfaces
4. Create an appropriate usability test plan
5. Understand the human and technical issues involved in the usage of text, icons and colours in user interfaces.

UNIT- I

Interaction Paradigms: Computing Environments, Analysing Interaction Paradigms, Interaction Paradigms
Interaction Frameworks and Styles: Frameworks for Understanding Interaction, Coping with Complexity, Interaction Styles.

UNIT- II

Interaction Design Process: Iterative Design, User-centred Design, Interaction Design Models, Overview of Interaction Design Models
Discovery: Discovery Phase Framework, Collection, Interpretation, Documentation
Design: Conceptual Design, Physical Design, Evaluation, Interface Design Standards, Designing the Facets of the Interface.

UNIT-III

Design Principles: Principles of Interaction Design, Comprehensibility, Learnability, Effectiveness/Usefulness, Efficiency/Usability, Grouping, Stimulus Intensity, Proportion, Screen Complexity, Resolution/Closure, Usability Goals
Interaction Design Models: Model Human Processor, Keyboard Level Model, GOMS, Modelling Structure, Modelling Dynamics, Physical Models
Usability Testing: Usability, Usability Test, Design the Test, prepare for the Test, Perform the Test, Process the Data

UNIT- IV

Interface Components: The WIMP Interface, Other Components
Icons: Human Issues Concerning Icons, Using Icons in Interaction Design, Technical Issues Concerning Icons
Colour: The Human Perceptual System, Using Colour in Interaction Design, Colour Concerns for Interaction Design, Technical Issues Concerning Colour

UNIT- V

Text: Human Issues Concerning Text, Using Text in Interaction Design, Technical Issues Concerning Text

Speech and Hearing: The Human Perceptual System, Using Sound in Interaction Design, Technical Issues Concerning Sound

Touch and Movement: The Human Perceptual System, Using Haptics in Interaction Design, Technical Issues Concerning Haptics.

Suggested Readings:

1. Steven Heim, *The Resonant Interface: HCI Foundations for Interaction Design*, Addison-Wesley, 2007
2. J. Preece, Y. Rogers, and H. Sharp, *Interaction Design: Beyond Human-Computer Interaction*, Wiley & Sons, 2nd Edition, 2007
3. Ben Shneiderman, Catherine Plaisant, *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, Addison-Wesley, 5thEdition, 2009.

Course Code	Course Title						Core / Elective
PW 961 CS	**Project Work - II**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**16**	**50**	**100**	**8**

Course Objectives

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic literature survey and documentation
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to the real-world problems.
2. Evaluate different solutions based on economic and technical feasibility
3. Effectively plan a project and confidently perform all aspects of project management
4. Demonstrate effective written and oral communication skills

The aim of Project work –II is to implement and evaluate the proposal made as part of Project Work - I. Students can also be encouraged to do full time internship as part of project work-II based on the common guidelines for all the departments. The students placed in internships need to write the new proposal in consultation with industry coordinator and project guide within two weeks from the commencement of instruction.

The department will appoint a project coordinator who will coordinate the following:

1. Re-grouping of students - deletion of internship candidates from groups made as part of project Work-I
2. Re-Allotment of internship students to project guides
3. Project monitoring at regular intervals

All re-grouping/re-allotment has to be completed by the 1st week of VIII semester so that students get sufficient time for completion of the project.

All projects (internship and departmental) will be monitored at least twice in a semester through student presentation for the award of sessional marks. Sessional marks are awarded by a monitoring committee comprising of faculty members as well as by the supervisor. The first review of projects for25 marks can be conducted after completion of five weeks. The second review for another 25 marks can be conducted after 12 weeks of instruction.

Common norms will be established for the final documentation of the project report by the respective departments. The students are required to submit draft copies of their project report within one week after completion of instruction.

Note: Three periods of contact load will be assigned to each project guide.