Annexure-B

Study Scheme PG Programme: M.Tech in Computer Science and Engineering

Semester-I							
Sr. No.	**Subject Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCS-811	Artificial Intelligence	3	0	0	3	3
2	PCCS-812	Advance Operating System	3	0	0	3	3
3	PECS-811	Core Elective-I	3	0	0	3	3
4	PECS-812	Core Elective-II	3	0	0	3	3
5	RMAL-811	Research Methodology and IPR	2	0	0	2	2
6	ACMH-811	English research paper writing & Professional Communication	2	0	0	2	0
7	PCCS-813	Artificial Intelligence Lab	0	0	4	4	2
8	PECS-813	Core Elective-I Lab	0	0	4	4	2
		Total	**16**	**0**	**8**	**24**	**18**
Semester-II (A)							
Sr. No.	**Subject Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCS-821	Machine Learning	3	1	0	4	4
2	PCCS-822	Advance Computer Networks	3	0	0	3	3
3	PECS-821	Core Elective-III	3	0	0	3	3
4	PECS-822	Core Elective-IV	3	0	0	3	3
5	ACMH-821	Constitution Of India	2	0	0	2	0
6	PCCS-823	Advance Computer Networks Lab	0	0	2	2	1
7	PECS-823	Core Elective-IV Lab	0	0	2	2	1
8	PCCS-824	Seminar	0	0	2	2	1
9	PCCS-825	Project Lab	0	0	4	4	2
		Total	**14**	**1**	**10**	**25**	**18**
Students are to be encouraged to go to industrial training/ Internship during summer break							
Semester-III							
Sr. No.	**Subject Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PECS-911	Core Elective-V	3	0	0	3	3
2	OECS-911	Open Elective	3	0	0	3	3
3	PCCS-911	Dissertation (Part-1)	0	0	20	20	10
		Total	**6**	**0**	**20**	**26**	**16**
Semester-IV							
Sr. No.	**Subject Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCS-921	Dissertation (Part-2)	0	0	32	32	16
		Total	**0**	**0**	**32**	**32**	**16**

List of Core Electives

CORE ELECTIVE-I (PECS-811)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-811A	Parallel Computing
2	PECS-811B	Data Preparation and Analysis
3	PECS-811C	Advance Database Systems
CORE ELECTIVE-I LAB(PECS-813)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-813A	Parallel Computing Lab
2	PECS-813B	Data Preparation and Analysis Lab
3	PECS-813C	Advance Database Systems Lab
CORE ELECTIVE-II (PECS-812)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-812A	Distributed Systems
2	PECS-812B	Advance Algorithms
3	PECS-812C	Big Data Analytics
CORE ELECTIVE-III (PECS-821)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-821A	Deep Learning
2	PECS-821B	Software Project Management
3	PECS-821C	Computer Vision
CORE ELECTIVE-IV (PECS-822)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-822A	Cloud Computing
2	PECS-822B	Internet of Things
3	PECS-822C	Bioinformatics
CORE ELECTIVE-IV LAB (PECS-823)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-823A	Cloud Computing Lab
2	PECS-823B	Internet of Things Lab
3	PECS-823C	Bioinformatics Lab
CORE ELECTIVE-V (PECS-911)		
Sr. No.	**Subject Code**	**Subject Name**
1	PECS-911A	Optimization Techniques
2	PECS-911B	Pattern Recognition
3	PECS-911C	Data Sciences

List of Open Electives

OPEN ELECTIVE		
Sr. No.	**Subject Code**	**Subject Name**
1	OECS-911A	Big Data Analytics
2	OECS-911B	Internet of Things
3	OECS-911C	Deep Learning
4	OECS-911D	Cloud Computing

SEMESTER-I

Title of the course : Artificial Intelligence

Subject Code : PCCS-811

Weekly load : 3Hrs L T P 3 0 0

Credit : 3

Course Outcome: After completion of this course students will be able to

CO1	Understanding the basics of AI and various applications of AI.
CO2	Problem Solving using Search and Control strategies.
CO3	Understanding the kowledge representation and reasoning
CO4	Understanding the architecture of Expert System and its application and neural network
CO5	Understanding the basics of Genetic Algorithm and its operators.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Definitions, Goals of AI, AI Approaches, AI Techniques, AI application Areas	08
	2. Problem solving	General problem solving, Search and control strategies, Exhaustive searches, Heuristic search techniques, Constraint satisfaction problems (CSPs), models. Heuristic Search of Game trees, Problem Reduction (AND/OR Search).	08
	3. Knowledge representation and reasoning	Knowledge representation, KR using predicate logic, Representing instance and Isa relationship,computable functions and predicates, Resolution , Natural Deduction , Representing knowledge using rules	08
Unit-2	4. Advanced Reasoning and learning	Non-monotonic reasoning, Logics for non-monotic reasoning, Augmenting a problem solver, Bayes Theorem, Bayesian networks, reasoning with Baye's network,Decision Tree	10
	5. Expert Systems and Neural Network	Introduction, Need and justification for expert systems, Basic Components & architecture of Expert systems, ES-Shells, Representing& Using Domain Knowledge, Knowledge acquisition in expert Systems. Case studies: MYCIN, RI etc, Introduction to Neural Network and its working	09
	6. Fundamentals of Genetic Algorithms	Introduction, Encoding, Operators of genetic algorithm, Basic genetic algorithms.	05

Total=48

Recommended Books:

1. Rich E, K. Knight, "Artificial Intelligence", Tata McGraw Hill.
2. George F. Luger, "Artificial Intelligence – Structures and Strategies for Complex Problem Solving", Pearson Education.
3. Russell, Norvig, "Artificial Intelligence 'a Modern Approach", Pearson Education.
4. Dan W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI.
5. E. Charnaik, D. McDermott, "Introduction to Artificial Intelligence", Addison-Wesley Publishing Company.
6. Christopher Thronton, Benedict du Bouldy,"Artificial Intelligence", New Age International Publishers.
7. Nils J. Nilsson, "Principles of Artificial Intelligence", Narosa Publishing Co.

Title of the course : **Advance Operating Systems**

Subject Code : **PCCS-812**

Weekly load : **3 Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to

CO1	Acquire the basic understanding of OS functionality.
CO2	Understand the role of OS in data storage and management.
CO3	Comprehensive knowledge of security and threat levels in OS
CO4	Implement file management strategies
CO5	In depth knowledge of different types of OS environments.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	OS Structure, Services and components, Multitasking, Multiprogramming, Time sharing, Real Time Systems, Multithreading.	08
	2. Scheduling and Deadlock	Process Management, CPU scheduling, Deadlocks, Inter-process Communication, Concurrent Processing and concurrency control.	08
	3. Memory and Input Output Management	Memory management, Virtual memory, Demand Paging and Page Replacement Algorithms, I/O and Device management, buffering and spooling.	08
Unit-2	4. File Management	File management, Filestorage, Access methods and free space management.	08
	5. Operating System Security	Introduction, External & Operational security, Threat monitoring auditing, Access control, H/W security.	08
	6. Distributed and Multiprocessor Systems	Introduction to Distributed Operating system, Multiprocessor operating system organization, Recovery and Fault Tolerance.	08

Total=48

Recommended Books:

1. Abraham Silberschatz, Peter Baer Galvin, "Operating System Concepts", Addison-Wesley.
2. Andrew S. Tanenbaum, "Modern Operating Systems", Pearson Education.
3. H.M. Deitel, "An Introduction to Operating System", Pearson Education.
4. William Stallings, "Operating Systems", Pearson Education.

Title of the course : **Parallel Computing**

Subject Code : **PECS-811A**

Weekly load : **3 Hrs** **LTP 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concepts related to parallel computing
CO2	Learn how to measure the performance of parallel computers
CO3	Understand the advanced processor technology and memory hierarchy
CO4	Acquire knowledge of memory organization
CO5	Learn the concepts behind multithreaded architecture and multicore programming

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Parallel Computer Models	The State of Computing, Multiprocessors and Multicomputers, Multivector and SIMD Computers, Architectural Development Tracks.	06
	2. Program and Network Properties	Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architecture.	06
	3. Metrics and Scalability	Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches.	06
	4. Processor Hierarchy	Advanced Processor Technology, Superscalar and Vector Processors.	06
Unit-2	5. Memory Hierarchy	Memory Hierarchy Technology, Virtual Memory Technology.	06
	6. Bus, Cache, and Shared Memory	Bus Systems, Cache Memory Organizations, Shared-Memory Organizations, Sequential and Weak Consistency Models, Cache Coherence and Synchronization Mechanisms, Message-Passing Mechanisms.	06
	7. Pipelining and Superscalar Techniques and Multivector Computers	Linear Pipeline Processors, Nonlinear Pipeline Processors, Instruction Pipeline Design, Arithmetic Pipeline Design, Superscalar Pipeline Design, Vector Processing Principles, Compound Vector Processing, Latency-Hiding Techniques.	06
	8. Principles of Multithreading	Threads Versus Processes, Types of Thread-Level Parallelism: Chip-Level Multiprocessing, Interleaved Multithreading, Simultaneous Multithreading, Hyperthreading.	06

Total=48

Recommended Books:

1. Kai Hwang, Advanced Computer Architecture, McGraw-Hill.
2. Kai Hwang, F Briggs, Computer Architecture and Parallel Processing, McGraw Hill.
3. M Flynn, Computer Architecture: Pipelined and Parallel Processor Design, 1/E, Jones and Bartlett.
4. Harry F Jordan, Fundamentals of Parallel Processing, Prentice Hall.
5. Hesham El-Rewini, Mostafa Abd-El-Barr, Advanced Computer Architecture and Parallel Processing, Wiley-Interscience.
6. Shameem Akhter, Jason Roberts, Multi-Core Programming, Intel Press.

Title of the course : **Data Preparation and Analysis**

Subject Code : **PECS-811B**

Weekly load : **3Hrs** **LTP 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course the student will be able to:

CO1	Acquire knowledge of data gathering strategies
CO2	Prepare and Present the Data
CO3	Extract the data for performing the Analysis
CO4	Understand Data Clustering and association
CO5	Design visualization and time series

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Data Gathering and Preparation	Data formats, parsing and transformation, Scalability and real-time issues.	09
	2. Data Cleaning	Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation.	11
Unit-2	3. Exploratory Analysis	Descriptive and comparative statistics, Clustering and association, Hypothesis generation.	13
	4. Visualization	Designing visualizations, Time series, Gelocated data, Correlations and connections, Hierarchies and network interactivity.	15

Total = 48

Reference Books:

1. Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt

Title of the course : **Advance Database Systems**

Subject Code : **PECS-811C**

Weekly load : **3 Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course the student will be able to:

CO1	Design distributed database for application development.
CO2	Apply query optimization principles for optimizing query performance in centralized and distributed database systems
CO3	Design distributed database schema using principles of fragmentation and allocation.
CO4	Apply distributed transaction principles for handling transactions in distributed database applications.
CO5	Apply distributed database administration principles for managing distributed database.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Database System Concepts and Architecture, Data Independence, Data Models, SQL: DDL, DML, DCL, Database Integrity, Normalization: 1NF, 2NF, 3NF, BCNF, 4NF, 5NF.	06
	2. Advanced Transaction Processing and Concurrency Control	Transaction Concepts, Concurrency Control: Locking Methods, Time-stamping Methods, Optimistic Methods for Concurrency Control, Concurrency Control in Distributed Systems	06
	3. Object Oriented and Object Relational Databases	Object Oriented Concepts with respect to Database Systems, OODBMS, OORDBMS, ORDBMS Design, Mapping of classes to relations, OORDBMS Query Language	04
	4. Parallel Databases	Parallel Databases, Distributed Databases, Difference between them, Architecture of Distributed Databases, Architecture of Parallel Databases	04
	5. Distributed Databases	Fragmentation, Replication and Allocation for distributed databases, Intra-query parallelism, Inter-query parallelism, Intra-operation parallelism, Inter-operation parallelism.	04
Unit-2	6. Database Security and Integrity	Data security risks, Data user, Access control and encrypton.	02
	7. Backup and Recovery Techniques	Backup and Recovery Concepts, Types of Database Failures, Types of Database Recovery, Recovery Techniques: Deferred Update, Immediate Update, Shadow Paging, Checkpoints, Buffer Management, Recovery	08

		Control in Distributed Systems.	
	8. Introduction to Pl/SQL	procedure, trigger and cursor	02
	9. XML and Internet Databases	Structured, Semi Structured, and Unstructured Data, XML Hierarchical Data Model, XML Documents, DTD, XML Schema, XML Querying: XPath, XQuery	04
	10. Emerging Database Technologies	Introduction to Mobile Databases, Main Memory Databases, Deductive Database Systems and brief overview of Datalog, Temporal Databases and brief introduction to TSQL, Multimedia Databases brief overview of respective query language and Spatial and Multidimensional Databases,Brief Introduction to Data Warehouse, Data Mining and OLAP	08

Total=48

Recommended Books:

1. Raghu Ramakrishnan, Johannes Gehrke, "Database Management System", McGraw Hill.
2. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database System", Pearson Education.
3. G.W. Hansen, J.V. Hansen, "Database Management and Design", PHI.
4. C.J. Date, A. Kannan, S. Swamynathan, "An Introduction to Database Systems", Pearson Education.

Title of the course : **Distributed Systems**

Subject Code : **PECS-812A**

Weekly load : **3Hrs.** **L T P: 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Students can implement programming projects that display knowledge of a variety of distributed system architectural styles. Some of these assignments represent significant programming projects with wide leeway in design and implementation choices.
CO2	Students will analyze problems, determine solutions within an assigned architectural style, and successfully implement those solutions.
CO3	Students will use cloud-based systems to run and implement assignments
CO4	Students will design and implement projects both individually and as part of a team.
CO5	Students will manage a cloud-based Web server and properly configure it.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction to Distributed Systems	Definition of distributed systems, their objectives, types, hardware and software concepts, architecture.	06
	2. Web Services Concepts	Introduction to XML, SOAP, Web and Grid services concepts.	06
	3. Communication	Inter process communication, Remote Procedure Call (RPC), Remote Method Invocation (RMI), Remote Object Invocation, and Message Oriented Communication.	08
	4. Processes	Introduction to threads, Threads in distributed and nondistributed systems, Client side software, Design issues for Servers, Software agents.	06
Unit-2	5. Naming	General issues with respect to naming, Name resolution, implementation of a name space, Domain name Systems, X.500 name space.	06
	6. Security	Introduction to security in distributed systems, General issues in authentication and access control, Security management: Key management, secure group management, authorization management; examples: Kerberos, x.509 certificates.	08
	7. Distributed Object-based Systems	Introduction to distributed object based systems, Overview of CORBA and DCOM and their comparison.	04
	8. Distributed File System and Document Based Systems	Introduction to distributed file system, distributed document-based systems, their examples.	04

Total=48

Recommended Books:

1. Andrew S Tanenbaum, Principles and Paradigms of Distributed Sytsems, Pearson Education.
2. George Coulouris, Distributed Systems, Addison Wesley.

Title of the course : **Advance Algorithms**

Subject Code : **PECS-812B**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze worst-case running times of algorithms using asymptotic analysis.
CO2	Prove the correctness of algorithms using inductive proofs and invariants.
CO3	Analyze randomized algorithms with respect to expected running time
CO4	Classify problems into different complexity classes corresponding to both deterministic and randomized algorithms
CO5	Analyze approximation algorithms

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Analysis of Algorithm	Algorithms, Analysing Algorithms, Growth of Functions-order Arithmetic, Models of computation, Performance analysis.	08
	2. Elementary data Structures	Stacks and Queues, Lists, Trees, Dictionaries, sets and Graphs.	08
	3. Basic Design Methodologies	Divide and Conquer, Dynamic Programming, Backtracking, Greedy Algorithms, Branch and bound.	08
Unit-2	4. Particular Algorithms	Disjoint set manipulation, Matrix multiplication, Pattern matching, sorting and searching algorithms, combinatorial algorithms, string processing algorithms, Algebraic Algorithms, Graph Algorithms, Comparative study of sorting techniques with their complexities.	12
	5. NP Completeness	Problem classes, NP-Completeness, Deterministic and non-Deterministic polynomial time algorithms, Theory of lower bounds Approximation Algorithms.	12

Total=48

Recommended Books:

1. Thomas H. Cormen, Charles E. Leiserson, "Introduction to Algorithms", PHI.
2. Alfred V. Aho, John E. Hopcroft, "Design & Analysis of Computer Algorithms", Pearson Education.
3. Ellis Horowitz, Sartaj Sahni, S. Rajasekaran, "Fundamentals of Computer Algorithms", Galgotia Publishers.
4. Donald E. Knuth, "The Art of Programming", Pearson Education.

Title of the course **: Data Sciences**

Subject Code **: PECS-812 C**

Weekly load **: 3Hrs** **LTP 3 0 0**

Credit **: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Explain how data is collected, managed and stored for data science
CO2	Understand the key concepts in data science
CO3	Acquire knowledge of real-world applications and the toolkit used by data scientists
CO4	Get in depth knowledge of data science applications
CO5	Implement data collection and management scripts using MongoDB

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction to Core Concepts and Technologies	Introduction, Terminology, Data Science Process, Data Science Toolkit, Types of Data, Example Applications.	06
	2. Data Collection and Management	Introduction, Sources of Data, Data Collection and APIs, Exploring and Fixing Data, Data Storage and Management, Using Multiple Data Sources.	07
	3. Data Analysis	Introduction, Terminology and Concepts, Introduction to Statistics, Central Tendencies and Distributions, Variance, Distribution Properties and Arithmetic, Samples/CLT, Basic Machine Learning Algorithms, Linear Regression, SVM, Naive Bayes.	10
Unit-2	4. Data Visualisation	Introduction, Types of Data Visualisation, Data for Visualisation: Data Types, Data Encodings, Retinal Variables, Mapping Variables to Encodings, Visual Encodings.	11
	5. Applications	Applications of Data Science,Technologies for Visualisation, Bokeh (Python)	07
	6. Recent Trends	Recent Trends in Various Data Collection and Analysis Techniques, Various Visualization Techniques, Application Development Methods of Use in Data Science.	07

Total=48

Recommended Books:

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

Title of the course : **Artificial Intelligence Lab**

Subject Code : **PCCS-813**

Weekly load : **4 Hrs** **L T P 0 0 4**

Credit : **2**

Course Outcome: After completion of this course students will be able to

CO1	Understanding the basics of AI and Prolog programming.
CO2	Implement DFS, BFS and TSP
CO3	Develop intelligentalgorithms forconstraintsatisfaction problemsand also design intelligent systemsfor Game Playing
CO4	Solve complex puzzles
CO5	Understanding the implementation and architecture of Expert System.

Introduction to prolog programming, Implementing DFS, BFS, TSP, simulated annealing, hill climbing, Hanoi problem, 8-puzzle problem and A* algorithm using Prolog,Implementation of Expert System with forward chaining using JESS/ CLIPS. Implementation Expert System with backward chaining using RVD/PROLOG

Title of the course : **Parallel Computing Lab**

Subject Code : **PECS-813A**

Weekly load : **4 Hrs** LTP: 0 0 4

Credits : **2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Gain practical skills in development ofparallel programs
CO2	Use OpenMP and MPI technologies for development of parallel programs for computing systems with shared and distributed memory
CO3	Run simulation experiments on high-performance computing systems
CO4	Perform parallel calculations efficiency assessment

LIST OF PRACTICALS

Introduction to OpenMP.Parallelizing a Simple Loop using OpenMP.Creating threads in OpenMP.Demonstrate thread synchronization in OpenMP.Demonstration of the clause used in the data environment.Create a program that computes a simple matrix vectormultiplication b=Ax, in C/C++. Use OpenMPdirectives to make it run in parallel.Create a program that computes the sum of all the elements inan array A (in C/C++). Use OpenMP directives to make it run in parallel.Create a program that finds thelargest number in an array A (in C/C++). Use OpenMPdirectives to make it run in parallel.

Title of the course : **Data Preparation and Analysis Lab**

Subject Code : **PECS-813B**

Weekly load : **4 Hrs** LTP 0 0 4

Credit : **2**

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand various data formats and their transformation
CO2	Association and clustering of data
CO3	Find meaning full visualization of data

In this lab students are required to implement and understand the various Data Formats and Various Software Tools to Transform these data formats, consistency checking, missing data, comparative statistics, Clustering and association of data, hypothesis generation on data and meaning full visualization of data.

Title of the course	: **Advance Database System Lab**	
Subject Code	: **PECS-813 C**	
Weekly load	: **4Hrs**	LTP 0 0 4
Credit	: **2**	

Course Outcomes: At the end of the course, the student will be able to

CO1	Introduction to advance database system.
CO2	To learn different software used for advance database system.
CO3	In depth knowledge of different techniques and tools used in advance database system.

In this lab the students are required to implement the applications based on

1. Fuzzy databases
2. Expert databases
3. Object-oriented Databases
4. Distributed databases

SEMESTER-II

Title of the course : **Machine Learning**

Subject Code : **PCCS-821**

Weekly load : **4 Hrs** **L T P 3 1 0**

Credit : **4**

Course Outcome: After completion of this course students will be able to

CO1	Understanding of the basics of Machine Learning.
CO2	Understanding Regression and Learning approaches.
CO3	Understanding different type of supervised learning approaches
CO4	Understanding vc dimension and ensemble methods of machine learning
CO5	Understanding types of clustering and relationship of machine learning with IOT

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Introduction to machine learning, Human Learning, types of machine learning	04
	2. Regression and Learning	Linear Regression, Introduction to Decision Tree, Learning Decision tree, overfitting, k-nearest neighbor, feature selection, feature extraction,collaborative filtering, Bayesian Learning, Naive Bayes, Bayesian Network, Logistic regression.	12
	3. Supervised Learning	Multilayer Neural Network, Backpropagation algorithm, SVM , SVM dual formation , SVM maximum margin with noise, SVM nonlinear function and kernel function, Introduction toIntroduction to Deep neural networks	12
Unit-2	4. Ensemble Methods	Introduction to computaional learning theory, sample complexity: finite hypothesis space, vc dimension, Introduction to Ensembles, Bagging and Boosting	12
	5. Clustering	Introduction to clustering, k-means clustering, agglomerative hierarchical clustering, Introduction to IOT with machine learning	08

Total=48

Recommended Books:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Sakat Dutt, S Chandramouli,Amit Kumar Das :Machine Learning, Pearson , 2018

Title of the course : **Advance Computer Networks**

Subject Code : **PCCS-822**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course the student will be able to:

CO1	Basic understanding of the layered protocol models.
CO2	A comprehensive practical knowledge of peer to peer and end to end communication.
CO3	Acquire in depth knowledge of Internetwork routing of data.
CO4	Learn working of various network protocols
CO5	Analyze the concept of process to process delivery.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Uses of Computer Networks, Network Hardware, Network Software, Reference Models.	04
	2. Physical Layer	Theoretical Basis of Data Communication, The Maximum Data Rate of a Channel. Introduction to Transmission Media. Basics of Wireless Transmission, Communication Satellites, The Public Switched Telephone Network, Structure of Telephone Network, The Local Loop, Modems, ADSL, Wireless, Trunks and Multiplexing Switching. Optical Network :links, WDM system, Optical LANs, Optical paths and networks	08
	3. Data Link Layer and Data Link Layer Switching	Data Link Layer Design Issues, Error Detection and Correction, Elementary data link protocols, one bit sliding window protocol, example data link protocol: HDLC- High Level Data Link Control. Bridges from 802.X to 802.Y, Local internetworking, Spanning tree bridges, Remote bridges, Repeaters, Hubs, Bridges, Switches, Routers, Gateway, Virtual LANs.	06
	4. Media Access Protocols and Ethernet	ALOHA, carriers sense multiple access protocols, collision free protocols, Ethernet Cabling, Manchester encoding, the Ethernet MAC sub layer protocol, the binary exponential back off algorithm, Performance.	06
Unit-2	5. Network Layer and Network Layer in internet	Routing architecture, Routing Algorithms, Congestion Control Algorithms, Internetworking, IP protocol, IP addresses, internet control protocols, internet multicasting, mobile IP,IPv6.	08
	6. Transport Layer and Internet Transport Protocols	Elements of transport Protocols, UDP,TCP--- Introduction, TCP service model, TCP protocol, TCP segment header, TCP connection establishment, TCP connection release, TCP congestion control, TCP timer Management	08
	7. The Application Layer	Introduction to DNS, Electronic mail, WWW, Multimedia.	08

Total=48

Recommended Books:

1. Andrew S. Tanenbaum, “Computer Networks”, PHI.
2. A. Behrouz Forouzan, “Data Communication and Networking”, TMH.
3. William Stalling, “Data and Computer Communication”, Pearson Education.

Title of the course : **Deep learning**

Subject Code : **PECS-821A**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcome: After completion of this course students will be able to

CO1	This course is an introduction to deep learning, a branch of machine learning concerned with the development and application of modern neural networks.
CO2	Be able to build, train and apply fully connected deep neural networks
CO3	Know how to implement efficient (vectorized) neural networks
CO4	Understand the key parameters in a neural network's architecture
CO5	Understand how to build a convolutional neural network, including recent variations such as residual networks.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	What is a neural network?Supervised Learning with Neural Networks,Why is Deep Learning taking off? Neural network Basics: Binary Classification,Logistic Regression,Logistic Regression Cost Function,Gradient Descent,Derivatives,Computation graph,Derivatives with a Computation Graph,Logistic Regression Gradient Descent,Gradient Descent on m Examples Shallow Neural Networks: Neural Networks Overview, Neural Network Representation, Computing a Neural Network's Output,Vectorizing across multiple examples,Explanation for Vectorized Implementation,Activation functions,Why do you need non-linear activation functions?,Derivatives of activation functions,Gradient descent for Neural Networks,Backpropagation algorithm,	08
	2. Deep neural networks	Deep L-layer neural network, Forward Propagation in a Deep Network, Getting your matrix dimensions right,Why deep representations?,Building blocks of deep neural networks, Forward and Backward Propagation, Parameters vsHyperparameters. Practical aspects of deep learning: Train/Dev/Test sets, Bias/ Variance, Regularization,Why regularization reduces over fitting?,Dropout Regularization,Understanding Dropout,Other regularization methods, Normalizing inputs, Vanishing / Exploding gradients, Weight Initialization for Deep Networks, Numerical approximation of gradients, Gradient checking	08
	3. Optimization algorithms	Mini-batch gradient descent, Understanding mini-batch gradient descent, Exponentially weighted averages, Understanding exponentially weighted averages, Bias correction in exponentially weighted averages, Gradient descent with momentum, RMSprop, Adam optimization algorithm, Learning rate decay, The problem of local optima	08

Unit-2	4. Hyper parameter tuning, Batch Normalization and Programming Frameworks	Tuning process, Using an appropriate scale to pick hyper parameters, Hyper parameters tuning in practice: Pandas vs. Caviar, Normalizing activations in a network, Fitting Batch Norm into a neural network, Why does Batch Norm work?, Batch Norm at test time, Softmax Regression, Training a softmax classifier, Deep learning frameworks, TensorFlow.	08
	5. Convolutional Neural Networks	Foundations of Convolutional Neural Networks: Computer Vision, Edge Detection Example, More Edge Detection, Padding, Strided Convolutions, Convolutions Over Volume, One Layer of a Convolutional Network, Simple Convolutional Network Example, Pooling Layers, CNN Example, Why Convolutions? Deep convolutional models: case studies, Why look at case studies?, Classic Networks,ResNets,Why ResNets Work, Networks in Networks and 1x1 Convolutions, Inception Network Motivation, Inception Network, Transfer Learning,Data Augmentation	08
	6. Sequence Models	Recurrent Neural Networks :Why sequence models,Notation,Recurrent Neural Network Model, Backpropagation through time, Different types of RNNs, Language model and sequence generation, Sampling novel sequences, Vanishing gradients with RNNs,Gated Recurrent Unit (GRU),Long Short Term Memory (LSTM),Bidirectional RNN,Deep RNNs.	08

Total=48

Recommended Books:

The required textbook for the course is

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning.

Other recommended supplemental textbooks on general machine learning:

2. Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification . Wiley-Interscience. 2nd Edition. 2001.
3. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4 . Academic Press, 2008.
4. Russell, S. and Norvig, N. Arti□ cial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence. 2003.
5. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.
6. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning, Springer. 2001.
7. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press. 2009.

Title of the course : **Software Project Management**

Subject Code : **PECS-821B**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Comprehend software project management activities
CO2	Understand various steps required for project planning
CO3	Create an estimation and effective cost benefit evaluation techniques
CO4	Design framework for risk management
CO5	Comprehend resource management

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Introduction to software project management, types of project, project attributes, project constraints, importance of management, problems with software projects, management control, role of project manager, steps in project planning, Programmemanagement, managing resources within Programme,	12
	2. Software Cost and Time Estimation	A system view of project management, stakeholder managementAssessment of projects, Cost-benefit Analysis, Cash flow forecasting, Cost-benefit evaluation techniques, Selection of an appropriate project technology, Choice of process model, developing the project schedule, Estimation Techniques, Problem with over and under estimates, COCOMO Model	12
Unit-2	3. Planning	Objective of Planning, Project Schedule, Activities – Sequencing and Scheduling, Development of Project Network, Time Estimation, Forward and backward Pass, Critical Path and Activities. Introduction to project risk management, Risk categories, identification, assessment, planning, management, Software Configuration Management Process: Version Control, Change Control management, PERT and CPM Models, project implementation	12
	4. Software Project Management	Resources, Nature of Resources, developing the project budget, monitoring and controlling the project, project metrics, Project targets, Management Spectrum, Associating human resource with job, Motivation, Oldham- job Characteristics Model, Decision Making, Leadership, Stress Management, Health and Safety	12

Total=48

Recommended Books:

1. Bob Hughes, Mike Cotterell, “Software Project Management”, Tata McGraw Hill.
2. Prasanna Chandra, “Projects: Panning, Analysis, Selection, Financing, Implementation and Review”, Tata McGraw Hill Publication.
3. Jeffrey K. Pinto, “Project Management”, Pearson Publications.

Title of the course : **Computer Vision**

Subject Code : **PECS-821C**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	To learn the basics of sensor and imaging.
CO2	To study about the signal representation and non linear image processing
CO3	Analyze the feature estimation in image processing techniques.
CO4	To study the image and video compression standards.
CO5	Understand analysis and classification of objects

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Sensor and Imaging: Imaging Optics, Radiometry of Imaging, Illumination sources and techniques, Camera Principles, Color Imaging, Single Sensor Color Imaging and Color Demosaicing, Range Images, 3D Imaging.	6
	2. Signal Representation	Vector Space and Unitary Trasnsforms, Multi-Resolutional Signal Representation, Wavelet Decomposition, Scale space and diffusion, Representation of color, Retinex Processing, Markov Random Field Modellings of Images.	8
	3. Non-linear Image Processing	Median and Order Statistics Filters, Rank-Ordered-Mean Filters and Signal Dependent Rank-Ordered-Mean Filters, Two Dimensional Teager Filters, Applications of nonlinear filters in image enhancement, edge detections, noise removal etc.	8
Unit-2	4. Feature Estimation	Morphological Operations, Edge Detection, Edges in multichannel images, Texture Analysis, Optical flow based motion estimation, Reflectance based shape recovery, Depth from focus, Stereo matching and depth estimation.	6
	5. Image and Video Compression Standards	Lossy and lossless compression schemes: Transform Based, Sub-band Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG-1, MPEG-4, and MPEG-7.	8
	6. Object Analysis, Classification	Bayesian Classification, Fuzzy Classification, Neural Network Classifiers, Shape Reconstruction from volumetric data, Knowledge-based interpretation of images.	5

Recommended Books:

1. Computer Vision: Algorithms and Applications by Richard Szeliski.
2. Deep Learning, by Goodfellow, Bengio, and Courville.
3. Dictionary of Computer Vision and Image Processing, by Fisher et al.

Title of the course : **Cloud Computing**

Subject Code **: PECS-822A**

Weekly load : **3Hrs** LTP 3 0 0

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	To create a brief understanding of cloud computing and other related technologies (Grid/cluster etc.).
CO2	To understand cloud service models, deployment models and service inception through virtualization in cloud.
CO3	To understand various security issues in cloud as well as an overview of the basic architectures of cloud computing.
CO4	To understand the architecture of cloud computing up to an advance stage
CO5	To understand the considerations of cloud delivery models this includes an introduction to data center and working with IaaS, PaaS and SaaS.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Understanding Cloud Computing	Origins and Influences: A Brief History, Clustering, Grid Computing, Virtualization, Technology Innovations vs. Enabling Technologies. Basic Concepts and Terminology : Cloud, IT Resource, On-Premise, Cloud Consumers and Cloud Providers, Scaling (Horizontal/Vertical), Cloud Service, Service ConsumerGoals and Benefits, Risks and Challenges, Cloud Provider, Cloud Consumer, Cloud Service Owner, Cloud Resource Administrator, Organizational Boundary, Trust Boundary.	06
	2. Service deployment Models and Virtualization	Cloud Characteristics, Cloud Service Delivery Models: IaaS, PaaS, SaaS, Deployment Models: Public Clouds, Community Clouds, Private Clouds, Hybrid Clouds. Virtualization Technology: Hardware Independence, Server Consolidation, Operating System-Based Virtualization, Hardware-Based Virtualization, Virtualization Management.	06
	3. Cloud Security	Basic Terms and Concepts- Confidentiality, Integrity, Authenticity, Availability, Threat, Vulnerability, Risk, Security Controls, Security Mechanisms, Security Policies, Threat Agents- Anonymous Attacker, Malicious Service Agent, Trusted Attacker, Malicious Insider, Cloud Security Threats- Traffic Eavesdropping, Malicious Intermediary, Denial of Service, Insufficient Authorization, Virtualization Attack.	06
	4. Cloud Computing Architecture	Fundamental Cloud Architectures- Architecture of Workload Distribution, Resource Pooling, Dynamic Scalability, Elastic Resource Capacity, Service Load Balancing, Cloud Bursting, Elastic Disk Provisioning, Redundant Storage	06
Unit-2	5. Advance cloud computing architecture	Hypervisor Clustering, Load Balanced Virtual Server Instances, Non-Disruptive Service Relocation, Zero Downtime, Cloud Balancing, Resource Reservation, Dynamic Failure Detection and Recovery, Bare-Metal Provisioning, Rapid Provisioning Architecture, Storage	06

		Workload Management	
	6. Cloud Delivery Model Considerations	Building IaaS Environments, Data Centers, Equipping PaaS Environments, Optimizing SaaS Environments, Cloud Delivery Models: The Cloud ConsumerPerspective, Working with IaaS Environments, Working with PaaS Environments , Working with SaaS Services	06
	7. Case study	Case study of a Cloud Management and Virtualization software for example Eucalyptus, VMware etc.	12

Total=48

Recommended Books:

1. Thomas Erl, Zaigham Mahmood, Ricardo Puttini, "Cloud Computing: Concepts, Technology and Architecture", Prentice Hall.
2. John W. Rittinghouse, James F. Ransome, "Cloud Computing Implementation, Management and Security", CRC Press.
3. Alfredo Mendoza, "Utility Computing Technologies, Standards, and Strategies", Artech House INC.
4. Bunker, Darren Thomson, "Delivering Utility Computing",John Wiley and Sons Ltd.
5. George Reese, "Cloud Application Architectures", O'reilly Publications.

Title of the course : **Internet of Things**

Subject Code : **PECS-822B**

Weekly load : **3Hrs** **L T P: 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the application areas of IOT
CO2	Realize the revolution of Internet in Mobile Devices, Cloud & SensorNetworks
CO3	Acquire knowledge of characteristics of different types of sensors used in IoT
CO3	Analyze randomized algorithms with respect to expected running time
CO4	Understand building blocks of Internet of Things and characteristics

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT. Introduction and Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security	08
	2. Sensors	Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc	08
	3. Characteristics of Sensors	Important Characteristics of Sensors: Determination of the Characteristics: Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modeling of Sensors, Importance and Adoption of Smart Sensors.	08
Unit-2	4. Architecture and Design constraints	IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.Real-World Design Constraints- Introduction, Technical Design constraints hardware, Data representation and visualization, Interaction and remote controlArchitecture of Smart Sensors**:** Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical. Vapor, Anodization, Sol-gel	8
	5. Hardware Platforms and Physical Devices	Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and	8

	for IOT	Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases IOT Physical Devices & Endpoints: What is an IOT Device, Exemplary Device Board, Linux on Raspberry , Interface and Programming & IOT Device	
	6. Recent Trends	Recent trends in smart sensor for day to day life, evolving sensors, their architecture and IOT architecture, Automation in Industrial aspect of IOT	8

Total=48

Recommended Books:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications.
3. Wiley. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, WileyDonald E. Knuth, "The Art of Programming", Pearson Education
5. Mandler, B., Barja, J., Mitre Campista, M.E., Cagáová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing.

Title of the course : **Bioinformatics**

Subject Code : **PECS-822C**

Weekly load : **3 Hrs** L T P 3 0 0

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to

CO1	Acquire the basic understanding of bioinformatics.
CO2	Understand the role of bioinformatics in real life.
CO3	Comprehensive knowledge of various datasets of bioinformatics.
CO4	Understand the concept of Phylogeny
CO5	In depth knowledge of techniques and tools used in bioinformatics.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction and Bioinformatics Resources	Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases: • Nucleic acid sequence databases-GenBank, EMBL, DDBJ. • Protein sequence databases- SWISS-PROT, TrEMBL, PIR, PDB. • Genome Databases - NCBI, EBI, TIGR, SANGER. • Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources).	10
	2. Sequence analysis	Various file formats for bio-molecular sequences-genbank, fasta, gcg, msf, nbrf-pir etc. • Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues. • Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series. • Sequence-based Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA.	10
	3. Pairwise and Multiple sequence alignments	Basic concepts of sequence alignment, Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA. Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.	10
Unit-2	4. Phylogeny	Phylogenetic analysis, Definition and description of phylogenetic trees and various types of trees, Method of construction of Phylogenetic trees: distance based method	10

		(UPGMA, NJ), Maximum Parsimony and Maximum Likelihood method.	
	5. Current Advancements in Bioinformatics	Introduction to System Biology, Structural Biology, Structural bioinformatics, Chemoinformatics, Immunoinformatics etc.	08

Total=48

Recommended Books:

1. Introduction to Bioinformatics by Aurther M lesk
2. Developing Bioinformatics Computer Skills By: Cynthia Gibas, Per Jambeck.
3. David W. Mount; Bioinformatics: Sequence and Genome Analysis; CSHL Press; 1st edition, 2001.
4. Andreas D. Baxevanis, Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins. Wiley-Interscience, 3rd edition 2004

Title of the course : **Advance Computer Networks Lab**

Subject Code : **PCCS-823**

Weekly load : **4Hrs** **L T P 0 0 2**

Credit : **1**

Course Outcomes: At the end of the course the student will be able to:

CO1	Gets an insight to create adhoc network scenarios using simulation softwares.
CO2	Get hands on practice on various network simulation tools: Qualnet, ns2
CO3	Implement various networking protocols
CO4	Understand the role of various latest technologies in wireless communication
CO5	Design and compare the performance of different routing protocols and simulation softwares.

This lab will cover practical work based on different protocols in the field of Computer Network, Wireless N/W and setting as well as simulation of Networked Environment.

Title of the course : **Cloud Computing Lab**

Subject Code **: PECS-823A**

Weekly load : **2 Hrs** **L T P 0 0 2**

Credit : **1**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Create and run virtual machines
CO2	Implement Infrastructure-as-a-Service and Software-as-a-Service
CO3	Understanding Amazon EC2 and Microsoft Azure services
CO4	Gain in depth knowledge of various cloud services
CO5	Create own cloud

The practical lab of Cloud Computing will cover practical use of cloud environment. The aim is to give a general understanding of cloud computing and to give the students a practical understanding of how to create virtual machines on open sources operating systems, use and implementation of Infrastructure-as-a-service and software-as-a-service. Case study of various services such as Amazon EC2, Microsoft Azure etc. Mini project such as creating a cloud like social media for the institute.

Title of the course **: Internet of things Lab**

Subject Code **: PECS-823B**

Weekly load **: 2 Hrs** **L T P: 0 0 2**

Credit **: 1**

Course Outcomes: At the end of the course, the student will be able to

CO1	Able to understand building blocks of Internet of Things and characteristics
CO2	Analyze randomized algorithms with respect to expected running time
CO3	Implement own IoT models in lab
CO4	To gain real working knowledge in the field of IoT.
CO5	Acquire knowledge of using various types of sensors for proper working of IoT

The internet of things lab will help the students to acquire skills in using cutting-edge technologies and their working including:

IoT Architecture, IETF IoT Stack/ protocols, IoT hardware platforms and sensor technology, IoT system design and applications for the students to work on real mote platform. A mini project which includes system design (design choices and monitoring & actuation requirements of application) and implementation of real IoT application system (coding/troubleshooting).

Title of the course **: Bioinformatics Lab**

Subject Code **: PECS-823C**

Weekly load **: 2 Hrs** **L T P 0 0 2**

Credit **: 1**

Course Outcomes: At the end of the course, the student will be able to

CO1	Introduction to variousbioinformatics techniques.
CO2	Study and usage of various bioinformatics datasets.
CO3	Use various searching techniques for data collection
CO4	Depth knowledge of techniques and tools used in bioinformatics.
CO5	Implement various queries on biological databases

In this lab the students are required to implement and understand the biological databases available on world wide web, queries based on biological databases, sequence similarity searching techniques using BLAST (Basic local alignment search tool) and pair-wise sequence alignment of (DNA, RNA, or protein) to identify regions of similarity that may be a consequence of functional, structural, or evolutionary relationships between the sequences.

Title of the course : **Seminar**

Subject Code : **PCCS-824**

Weekly load : **2 Hrs** **L T P 0 0 2**

Credit : **1**

Course Outcomes: At the end of the course the student will be able to:

CO1	Get opportunities to develop skills in presentation and discussion of research topics in a public forum.
CO2	Geta variety of research projects and activities in order to enrich their academic experience.
CO3	Acquire in depth knowledge of various topics
CO4	To set the stage for future recruitment by potential employers.
CO5	Acquire skills in preparing presentations and report writings

Title of the course **: Project Lab**

Subject code **: PCCS-825**

Weekly load **: 4 Hrs** **LTP 0-0-4**

Credits **: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Demonstrate a sound technical knowledge of their selected project topic.
CO2	Undertake problem identification, formulation and solution.
CO3	Design engineering solutions to complex problems utilizing a system approach.
CO4	Communicate with engineers and the community at large in written and oral forms.
CO5	Demonstrate the knowledge, skills and attitudes of a professional engineer.

Project Lab: In this, the student must select an area from emerging technologies and specify the objectives to be achieved. Evaluation criteria will be based on objectives stated and achieved.

SEMESTER-III

Title of the course : **Optimization Techniques**

Subject Code : **PECS-911A**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Describe clearly a problem, identify its parts and analyze the individual functions. Feasibility study for solving an optimization problem.
CO2	Becoming a mathematical translation of the verbal formulation of an optimizationproblem.
CO3	To design algorithms, the repetitive use of which will lead reliably to finding an approximate solution.
CO4	Evaluate and measure the performance of an algorithm. Discovery, study and solve optimization problems.
CO5	Understand optimization techniques using algorithms. Investigate, study, develop, organize and promote innovative solutions for various applications.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction and Basic Concepts	Historical Development; Engineering applications of Optimization; Art of ModelingObjective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems Classification of optimization problems. Optimization techniques – classical and advanced techniques	08
	2. Optimization using Calculus	Stationary points; Functions of single and two variables; Global OptimumConvexity and concavity of functions of one and two variablesOptimization of function of one variable and multiple variables; Gradient vectors; Examples Optimization of function of multiple variables subject to equality constraints; Lagrangian functionOptimization of function of 1 multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values Kuhn-Tucker Conditions; Examples	08
	3.Linear Programming	Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operationsGraphical method for two variable optimization problem; Examples Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems	08
	4. Linear Programming Applications	Use of software for solving linear optimization problems using graphical and simplex methodsExamples for transportation, assignment, water resources, structural and other optimization problems	

Unit-2	5. Dynamic Programming	Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality Recursive equations – Forward and backward recursions; 2 Computational procedure in dynamic programming (DP) D	12
	6. Dynamic Programming Applications	Problem formulation and application in Design of continuous beam and Optimal geometric layout of a truss Water allocation as a sequential process.	06
	7. Integer Programming	Integer linear programming; Concept of cutting plane methodMixed integer programming; Solution algorithms; Examples	06

Total=48

Recommended Books:

1. Kapoor, V.K.: Operation Research, Sultan Chand & Co., New Delhi.
2. Manmohan Gupta, P.K.: Operation Research, Sultan Chand & Co., New Delhi.
3. Pronsen, Richard: Theory and Problems of Operation Research, McGraw Hill, 1983.
4. Hiller, F.S. & Liberman, G.J., 1974: Introduction to Operations Research, 2nd Edn. Holden
5. Rao, S. S., 1978: Introduction to Optimization: Theory & Applications, Wiley Eastern.
6. Srinath, L.S.: Linear Programming, East-West, New Delhi.

Title of the course : **Pattern Recognition**

Subject Code : **PECS-911B**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Study the fundamental algorithms for pattern recognition
CO2	Instigate the various classification techniques
CO3	Originate the various structural pattern recognition and feature extraction techniques
CO4	Acquire knowledge of parameter estimation
CO5	Study the clustering concepts and algorithms

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Introduction to Pattern Recognition System, The sub-problems of pattern recognition, The basic structure of a pattern recognition system, Comparing classifiers.	04
	2. Bayes Decision Theory	Bays Decision Theory: continuous and discrete features, Classifiers, Discriminant functions and decision surfaces, Error bounds, Missing and Noisy features,Bayesian Belief networks.	04
	3. Maximum Likelihood And Bayesian Parameter Estimation	Maximum Likelyhood estimation, Bayseian Estimation and Parameter Estimation, Component Analysis and Discriminants, Expectation-Maximization, Hidden Markov Models.	08
	4. Nonparametric Techniques	Introduction, Density Estimation, Parzen Windows, K-nearest neighbour estimation, The nearest neighbour rule, Metrics and Nearest Neighbor classification, fuzzy classification	06
Unit-2	5. Linear Discrimant Functions	Introduction, Linear Discriminant functions and Decision Surfaces, Generalized Linear Discrimant functions, Two - category Linearly separable case, Relaxation procedures, Minimum Squared Error procedures, Linear Programming Algorithms, Support Vector Machines, Multicategory Generalizations.	06
	6. Multilayer Neural Networks ,Stochastic Methods, Non Metric Methods	Feedforward operation and classification, Backpropagation Algorithm,Additional network and training methods. Simulated Annealing and Boltzman machine. Tree Methods, Recognition with strings, Rule based methods, Grammatical Methods	06
	7. Unsupervised	Mixture Densities and Identifiability , Maximum	08

	Learning and Clustering	Likelyhood Estimates, application to normal mixtures, Unsupervised Bayesian Learning, Similarity measures, Criterion functions for clustering, Hierarchical clustering, On-line clustering, Graph-Theoretic Methods, Component Analysis, Low-Dimensional Representations and Multidimensional Scaling (MDS)	
	8. Applications of PR	Speech and speaker recognition, Character recognition, Scene analysis.	06

Total=48

Recommended Books:

1. Richard O.Duda, "Pattern Classification", Wiley Publication.
2. Theodoridis, Koutroumbas, "Pattern Recognition",Academic Press.
3. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer

Title of the course : **Big Data Analytics**

Subject Code : **PECS-911 C**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcome: After completion of this course students will be able to

CO1	Describe big data and use cases from selected business domains
CO2	Explain NoSQL big data management
CO3	Install, configure, and run Hadoop and HDFS
CO4	Perform map-reduce analytics using Hadoop
CO5	Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	What is big data, why big data, convergence of key trends, unstructured data,industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics	08
	2. NoSQL	Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peerpeer replication, sharding and replication, consistency, relaxing consistency ,version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.	08
	3. Hadoop	Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures	08
Unit-2	4. MapReduce	MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats	08
	5. Hbase and Cassandra	Hbase, data model and implementations,Hbase clients, Hbase examples, praxis Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration	08
	6. High Level utilities(Pig, Grunt, Hive)	Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts.Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.	08

Total=48

Recommended Books:

1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging
2. Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
4. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
5. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
8. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
9. Alan Gates, "Programming Pig", O'Reilley, 2011.

Title of the course **: Internet of Things**

Subject Code **: OECS-911B**

Weekly load **: 3Hrs** **L T P: 3 0 0**

Credit **: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the application areas of IOT
CO2	Realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks
CO3	Acquire knowledge of various types of sensors used in IoT
CO4	Analyze randomized algorithms with respect to expected running time
CO5	Understand building blocks of Internet of Things and characteristics

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	2. Introduction	Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT. Introduction and Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security	08
	2. Sensors	Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc	08
	3. Characteristics of Sensors	Important Characteristics of Sensors: Determination of the Characteristics: Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modeling of Sensors, Importance and Adoption of Smart Sensors.	08
Unit-2	4. Architecture and Design constraints	IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.Real-World Design Constraints- Introduction, Technical Design constraints hardware, Data representation and visualization, Interaction and remote controlArchitecture of Smart Sensors**:** Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical. Vapor, Anodization, Sol-gel	8
	5. Hardware Platforms and	Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and	8

	Physical Devices for IOT	Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases IOT Physical Devices & Endpoints: What is an IOT Device, Exemplary Device Board, Linux on Raspberry , Interface and Programming & IOT Device	
	6. Recent Trends	Recent trends in smart sensor for day to day life, evolving sensors, their architecture and IOT architecture, Automation in Industrial aspect of IOT	8

Total=48

Recommended Books:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi.Probability and Statistics with Reliability, Queuing, and Computer Science Applications.
3. Wiley. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, WileyDonald E. Knuth, "The Art of Programming", Pearson Education
5. Mandler, B., Barja, J., Mitre Campista, M.E., Cagáová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing.

Title of the course : Deep learning

Subject Code : OECS-911C

Weekly load : 3Hrs L T P 3 0 0

Credit : 3

Course Outcome: After completion of this course students will be able to

CO1	This course is an introduction to deep learning, a branch of machine learning concerned with the development and application of modern neural networks.
CO2	Be able to build, train and apply fully connected deep neural networks
CO3	Know how to implement efficient (vectorized) neural networks
CO4	Understand the key parameters in a neural network's architecture
CO5	Understand how to build a convolutional neural network, including recent variations such as residual networks.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	What is a neural network?Supervised Learning with Neural Networks,Why is Deep Learning taking off? Neural network Basics: Binary Classification,Logistic Regression,Logistic Regression Cost Function,Gradient Descent,Derivatives,Computation graph,Derivatives with a Computation Graph,Logistic Regression Gradient Descent,Gradient Descent on m Examples Shallow Neural Networks: Neural Networks Overview, Neural Network Representation, Computing a Neural Network's Output,Vectorizing across multiple examples,Explanation for Vectorized Implementation,Activation functions,Why do you need non-linear activation functions?,Derivatives of activation functions,Gradient descent for Neural Networks,Backpropagation algorithm,	08
	2. Deep neural networks	Deep L-layer neural network, Forward Propagation in a Deep Network, Getting your matrix dimensions right,Why deep representations?,Building blocks of deep neural networks, Forward and Backward Propagation, Parameters vsHyperparameters. Practical aspects of deep learning: Train/Dev/Test sets, Bias/ Variance, Regularization,Why regularization reduces over fitting?,Dropout Regularization,Understanding Dropout,Other regularization methods, Normalizing inputs, Vanishing / Exploding gradients, Weight Initialization for Deep Networks, Numerical approximation of gradients, Gradient checking	08
	3. Optimization algorithms	Mini-batch gradient descent, Understanding mini-batch gradient descent, Exponentially weighted averages, Understanding exponentially weighted averages, Bias correction in exponentially weighted averages, Gradient descent with momentum, RMSprop, Adam optimization algorithm, Learning rate decay, The problem of local optima	08

Unit-2	4. Hyper parameter tuning, Batch Normalization and Programming Frameworks	Tuning process, Using an appropriate scale to pick hyper parameters, Hyper parameters tuning in practice: Pandas vs. Caviar, Normalizing activations in a network, Fitting Batch Norm into a neural network, Why does Batch Norm work?, Batch Norm at test time, Softmax Regression, Training a softmax classifier, Deep learning frameworks, TensorFlow.	08
	5. Convolutional Neural Networks	Foundations of Convolutional Neural Networks: Computer Vision, Edge Detection Example, More Edge Detection, Padding, Strided Convolutions, Convolutions Over Volume, One Layer of a Convolutional Network, Simple Convolutional Network Example, Pooling Layers, CNN Example, Why Convolutions? Deep convolutional models: case studies, Why look at case studies?, Classic Networks,ResNets,Why ResNets Work, Networks in Networks and 1x1 Convolutions, Inception Network Motivation, Inception Network, Transfer Learning,Data Augmentation	08
	6. Sequence Models	Recurrent Neural Networks :Why sequence models,Notation,Recurrent Neural Network Model, Backpropagation through time, Different types of RNNs, Language model and sequence generation, Sampling novel sequences, Vanishing gradients with RNNs,Gated Recurrent Unit (GRU),Long Short Term Memory (LSTM),Bidirectional RNN,Deep RNNs.	08

Total=48

Recommended Books:

The required textbook for the course is

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning.

Other recommended supplemental textbooks on general machine learning:

2. Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification . Wiley-Interscience. 2nd Edition. 2001.
3. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4 . Academic Press, 2008.
4. Russell, S. and Norvig, N. Arti□ cial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence. 2003.
5. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.
6. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning, Springer. 2001.
7. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press. 2009.

Title of the course : **Cloud Computing**

Subject Code : **OECS-911D**

Weekly load : **3Hrs** **L T P 3 0 0**

Credit : **3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	To create a brief understanding of cloud computing and other related technologies (Grid/cluster etc.).
CO2	To understand cloud service models, deployment models and service inception through virtualization in cloud.
CO3	To understand various security issues in cloud as well as an overview of the basic architectures of cloud computing.
CO4	To understand the architecture of cloud computing up to an advance stage
CO5	To understand the considerations of cloud delivery models which includes an introduction to data center and working with IaaS, PaaS and SaaS.

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Understanding Cloud Computing	Origins and Influences: A Brief History, Clustering, Grid Computing, Virtualization, Technology Innovations vs. Enabling Technologies. Basic Concepts and Terminology: Cloud, IT Resource, On-Premise, Cloud Consumers and Cloud Providers, Scaling (Horizontal/Vertical), Cloud Service, Service ConsumerGoals and Benefits, Risks and Challenges, Cloud Provider, Cloud Consumer, Cloud Service Owner, Cloud Resource Administrator, Organizational Boundary, Trust Boundary.	06
	2. Service deployment Models and Virtualization	Cloud Characteristics, Cloud Service Delivery Models: IaaS, PaaS, SaaS, Deployment Models: Public Clouds, Community Clouds, Private Clouds, Hybrid Clouds. Virtualization Technology: Hardware Independence, Server Consolidation, Operating System-Based Virtualization, Hardware-Based Virtualization, Virtualization Management.	06
	3. Cloud Security	Basic Terms and Concepts- Confidentiality, Integrity, Authenticity, Availability, Threat, Vulnerability, Risk, Security Controls, Security Mechanisms, Security Policies, Threat Agents- Anonymous Attacker, Malicious Service Agent, Trusted Attacker, Malicious Insider, Cloud Security Threats- Traffic Eavesdropping, Malicious Intermediary, Denial of Service, Insufficient Authorization, Virtualization Attack.	06
	4. Cloud Computing Architecture	Fundamental Cloud Architectures- Architecture of Workload Distribution, Resource Pooling, Dynamic Scalability, Elastic Resource Capacity, Service Load Balancing, Cloud Bursting, Elastic Disk Provisioning, Redundant Storage	06
Unit-2	5. Advance cloud computing architecture	Hypervisor Clustering, Load Balanced Virtual Server Instances, Non-Disruptive Service Relocation, Zero Downtime, Cloud Balancing, Resource Reservation, Dynamic Failure Detection and Recovery, Bare-Metal Provisioning, Rapid Provisioning Architecture, Storage	06

		Workload Management	
	6. Cloud Delivery Model Considerations	Building IaaS Environments, Data Centers, Equipping PaaS Environments, Optimizing SaaS Environments, Cloud Delivery Models: The Cloud ConsumerPerspective, Working with IaaS Environments, Working with PaaS Environments , Working with SaaS Services	06
	7. Case study	Case study of a Cloud Management and Virtualization software for example Eucalyptus, VMware etc.	12

Total=48

Recommended Books:

1. Thomas Erl, Zaigham Mahmood, Ricardo Puttini, "Cloud Computing: Concepts, Technology and Architecture", Prentice Hall.
2. John W. Rittinghouse, James F. Ransome, "Cloud Computing Implementation, Management and Security", CRC Press.
3. Alfredo Mendoza, "Utility Computing Technologies, Standards, and Strategies", Artech House INC.
4. Bunker, Darren Thomson, "Delivering Utility Computing",John Wiley and Sons Ltd.
5. George Reese, "Cloud Application Architectures", O'reilly Publications.

SEMESTER-IV

Title of the course **: Dissertation (Part-2)**

Subject Code **: PCCS-921**

Weekly load **: 32 Hrs** **L T P 0 0 32**

Credit **: 16**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Synthesize and apply prior knowledge to designing and implementing solutions to open-ended computational problems while considering multiple realistic constraints
CO2	Design and Develop the software with software engineering practices and standards
CO3	Learn effectively presentation and writing skills
CO4	Analyze Database, Network and Application Design methods
CO5	Evaluate the various validation and verification methods