OP JINDAL UNIVERSITY

Raigarh-Chhattisgarh

Scheme and Syllabus

of

PhD. (01PhD02) Course work

Department of

Computer Science and Engineering

School of Engineering

SESSION: 2017-18

PROGRAM OUTCOMES FOR ENGINEERING DOCTORAL PROGRAM

1. **Disciplinary knowledge and problem solving**: Accomplish in-depth knowledge of a specific domain and apply it to identify, analyze and address the related research problems.
2. **Scientific Reasoning and analytical approach**: Apply theories, methodologies, knowledge, critical thinking and; inductive and deductive reasoning to design and drive research projects with appropriate hypothesis**,** experimental design, simulation, survey, case studies etc.
3. **Communication and digital skills**: Instill oral, written communication skills and life-long digital learning to prepare grant proposals; and publish and present their work.
4. **Moral and Ethics**: Imbibe moral/ ethical values for research, publications, and patents etc.
5. **Project management and finance**: Develop and apply knowledge of engineering, finance, and management principles throughout the R&D projects.
6. **Leadership Readiness**: Interact with people from diverse backgrounds as both leaders/mentors and team members with integrity and professionalism.

PROGRAM-SPECIFIC OUTCOMES FOR ENGINEERING DOCTORAL PROGRAM

PSO-1: Understand the design of the existing concepts and application of the concepts for efficiency.

PSO-2: Attempts to develop expertise in a certain professional field.

PSO-3: Individual cognitive activities aimed at acquiring new knowledge, solving theoretical and practical problems, self-education, and self-realization aid in shaping the future of specialists.

Scheme and Syllabus of Course Work for Doctor of Philosophy (Ph.D.) in Computer Science and Engineering

The PhD course work shall involve three papers and a seminar project. The three papers are:

1. Research Methodology
2. Elective I
3. Elective II

Apart from these courses, there will be a seminar project.

Examination Scheme for Ph. D. Course Work in Computer Science and Engineering

Sl. No	Subject Code	Name of Subject	Credit	Examination Scheme				
				Theory		Seminars		TOTAL MARKS
				PRE	ESE	PRE	ESE	
1	**PCW 101**	Research Methodology	5	50	50	-----	----	100
2	**SOE-P-CSE101**	Seminar Presentation	5	-----	-----	50	50	100
3	**SOE-P-CSE102 (1-5)**	Elective I	5	50	50	-----	----	100
4	**SOE-P-CSE103 (1-4)**	Elective II	5	50	50	-----	----	100
		TOTAL	**20**	**150**	**150**	**50**	**50**	**400**

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

Computer Science and Engineering

Ph.D. (Computer Science and Engineering)

(DETAILED COURSEWORK SYLLABUS)

SCHEME OF EXAMINATION:

The examination shall be conducted at the end of coursework. The Theory paper shall carry 100 Marks. The evaluation of the performance of the students in theory papers shall be based on the End Semester Examination of 100 Marks. Question Paper will be set in the view of the following syllabus and preferably covering each unit of syllabi in the unit pattern.

STANDARD OF PASSING:

As prescribed under Rules & Regulation for each degree/ programme

Sl No.	Subject code	Name of Subject
1	PCW 101	Research Methodology
2	SOE-P-CSE101	Seminar Presentation
	Elective - I	
3	SOE-P-CSE102(1)	Wireless Ad Hoc and Sensor Network
4	SOE-P-CSE102(2)	Design and Analysis of Algorithms
5	SOE-P-CSE102(3)	Internet of Things
6	SOE-P-CSE102(4)	Machine Learning
7	SOE-P-CSE102(5)	Data Structures
	Elective - II	
8	SOE-P-CSE103(1)	Data Analytics
9	SOE-P-CSE103(2)	Block Chain
10	SOE-P-CSE103(3)	Cryptography and Network Security
11	SOE-P-CSE103(4)	Cloud Computing and Application

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Research Methodology**	**Course Code:**	**PCW 101**
Credits :	**5**	**No of Hours**	**5 Hrs. / Week**
Max Marks:	**100**		

Course Description:

The Research Methodology provides theoretical and practical knowledge and also the applied skills for research design and related methods and mixed-method research domains.

Course Outcome:

Course Outcome	Doctoral candidates will be able to:
CO1	Identify a research topic in an appropriate scholarly manner.
CO2	Place a working hypothesis into a real context.
CO3	Use appropriate tools for data collection and analysis.
CO4	Match the research method to the research question.
CO5	Write up research projects using scholarly norms.
CO6	Communicate efficiently and consistently the outcomes of the research before an audience.
CO7	Critically review a research paper.
CO8	Manage deadlines in the crafting of a research paper.

Syllabus:

UNIT – I : Meaning and significance of the research

Meaning and significance of the research; Importance of scientific research in decision making; Types of research and research process; Identification of research problem and formulation of hypothesis.

UNIT – II : Research Design

Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

UNIT – III : Qualitative and Quantitative Research, Measurement
Concept of measurement, Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal.

UNIT – IV : Factor analysis
Multiple Regressions Analysis. Discriminant Analysis, Use of SPS Package, IPR issues. Factor analysis, Multiple Regressions Analysis. Discriminant Analysis, Use of SPS Package, IPR issues.

UNIT – V : Research Report
Report, Types and significance, Structure of research report, Ethical issues in research, Presentation of report. Interpretation of Data and Paper Writing, Journal selection, Impact factor of Journals. Plagiarism and Self-Plagiarism, Software for detection of Plagiarism.

Text Books:

1. Business Research Methods– Donald Cooper & Pamela Schindler, TMGH, 9th ed.
2. Business Research Methods– Alan Bryman & Emma Bell, Oxford University Press.
3. Research Methodology – C.R. Kothari.

Reference Books:

1. Research Methodology, Chawla and Sondhi, Vikas Publication
2. Research Methodology, Paneersevam, PHI

CO-PO & PSO Correlation:

	Course Name: Research Methodology								
	Program Outcomes						PSOs		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	1	2					1		
CO2:			1					1	
CO3:		2						2	
CO4:		3	1						
CO5:									2
CO6:		1							2
CO7:			2						1
CO8:					1	1			1

Note: 1: Low 2.: Moderate 3.: High

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Seminar Presentation**	**Course Code:**	**SOE-P-CSE101**
Credits :	**5**	**No of Hours**	**5 Hrs. / Week**
Max Marks:	**100**		

Course Description:

This subject has related to the techniques of scientific study and understanding of related research mobility and how to express in a scientific framework. The seminar has its importance in a career of a student to improve the logical communicative skills and confidence.

Course Outcomes:

Course Outcome	Doctoral candidates will be able to:
CO1	Understand the research methods, interpretation approach and problem-solving skills.

The scholars will present seminar papers using these tools/concepts.

1. Review of Literature and its Analysis 25 Marks;
2. Research Methodology with reference to the concerned subject, 25 Marks;
3. Report writing 25 marks;
4. References and citation 25 marks.

CO-PO & PSO Correlation:

	Course Name: Seminar Presentation								
Course Outcomes	Program Outcomes						PSOs		
	1	2	3	4	5	6	1	2	3
CO1:	2	2	2		2		2	1	1

Note: 1: Low 2.: Moderate 3.: High

Elective I

SCHOOL OF ENGINEERING

Department of Computer Science & Engineering

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Wireless Ad Hoc and Sensor Network**	**Course Code:**	**SOE-P-CSE102(1)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

MANET (Introduction, Self-organizing behaviour, Co-operation), MANET (MAC, Routing), MANET (Multicast routing, Mobility model, Transport layer, Opportunistic Mobile Networks, Opportunistic Mobile Networks, UAV networks, Wireless Sensor, Networks (Introduction), WSN (Coverage, Topology management), Mobile Sensor Networks, WSN (MAC, Congestion control,Routing), WSN (Routing). Underwater WSN, Security, Structure of sensor nodes,

Course Outcome:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Explain the basic concepts of WIRELESS networks and challenges of adhoc and sensor networks
CO2	Classify the design issues and different categories of MAC protocols
CO3	Explain the various adhoc routing protocols and transport layer mechanisms
CO4	Discuss the sensor characteristics and wsn layer protocols
CO5	Illustrate the issues of routing in wsn and QoS related performance measurements

Syllabus:

UNIT – I : Mac & Routing in AD HOC Networks

Introduction – Issues and challenges in ad hoc networks – MAC Layer Protocols for wireless ad hoc networks – Contention-Based MAC protocols – MAC Protocols Using Directional Antennas – Multiple-Channel MAC Protocols – Power-Aware MAC Protocols – Routing in Ad hoc Networks – Design Issues – Proactive, Reactive and Hybrid Routing Protocols

UNIT – II : Transport & QOS in AD HOC Networks

TCP‟s challenges and Design Issues in Ad Hoc Networks – Transport protocols for ad hoc networks – Issues and Challenges in providing QoS – MAC Layer QoS solutions – Network Layer QoS solutions – QoS Model

UNIT – III : Mac & Routing in Wireless Sensor Networks

Introduction – Applications – Challenges – Sensor network architecture – MAC Protocols for wireless sensor networks – Low duty cycle protocols and wakeup concepts – Contention-Based protocols – Schedule-Based protocols – IEEE 802.15.4 Zigbee – Topology Control – Routing Protocols

UNIT – IV : Transport & QOS in Wireless Sensor Networks

Data-Centric and Contention-Based Networking – Transport Layer and QoS in Wireless Sensor Networks – Congestion Control in network processing – Operating systems for wireless sensor networks – Examples

UNIT – V : Security in AD HOC and Sensor Networks

Security Attacks – Key Distribution and Management – Intrusion Detection – Software based Anti-tamper techniques – Water marking techniques – Defense against routing attacks – Secure Ad hoc routing protocols – Broadcast authentication WSN protocols – TESLA – Biba – Sensor Network Security Protocols – SPINS

Text Books:

1. C.Siva Ram Murthy and B.S.Manoj, —Ad Hoc Wireless Networks – Architectures and Protocols, Pearson Education, 2006.
2. Holger Karl, Andreas Willing, —Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, Inc., 2005.

Reference Books:

1. Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, —Ad Hoc Mobile Wireless Networks, Auerbach Publications, 2008.
2. Carlos De Morais Cordeiro, Dharma Prakash Agrawal, —Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition), World Scientific Publishing, 2011.
3. Waltenegus Dargie, Christian Poellabauer, —Fundamentals of Wireless Sensor Networks Theory and Practice, John Wiley and Sons, 2010
4. Xiang-Yang Li, “Wireless Ad Hoc and Sensor Networks: Theory and Applications, 1227 th edition, Cambridge university Press,2008.

CO-PO&PSO Correlation

Course Name: Wireless Ad Hoc and Sensor Network									
	PO's						PSO's		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2	1				1	2		1
CO2:	2	1				1	1		1
CO3:	2	1	1			1	1		1
CO4:	2	1	1			1	2		1
CO5:	2	1	2			1	2		1

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Design and Analysis of Algorithms**	**Course Code:**	**SOE-P-CSE102(2)**
Credits :	**5**	**No of Hours**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

Frame work of Algorithms Analysis, Algorithm Analysis Frame work-II, Asymptotic Notations, Algorithm Design Technique Basis-I, Divide and Conquer-I, Divide and Conquer-II (Closest Pair), Greedy Algorithm-I, Greedy Algorithm-II, Greedy Algorithm-III, Greedy Algorithm-IV, Pattern Matching-I, Pattern Matching-II, Combinational Search and Optimization-I, Combinational Search and Optimization-II, Longest Common Subsequence, Matrix Chain Multiplication, Scheduling with start-up and hold cost, Average case analysis for quick sort, lower bonds for sorting, Dynamic Programming, NP Completeness, Algorithm Approximation.

Course Outcome:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Understand the notion of an algorithm, asymptotic notations
CO2	Understand the algorithm design techniques using greedy method.
CO3	Understand the algorithm design techniques using dynamic programming.
CO4	Explain the algorithm design techniques using backtracking, branch and bound and NP-complete and NP-hard problems.

SYLLABUS

UNIT – I : Introduction

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types – Fundamentals of the Analysis of Algorithmic Efficiency –Asymptotic Notations and their properties. Analysis Framework –

Empirical analysis – Mathematical analysis for Recursive and Non-recursive algorithms – Visualization

UNIT – II : Brute Force and Divide and Conquer Techniques

Brute Force – Computing an– String Matching – Closest-Pair and Convex-Hull Problems -Exhaustive Search – Travelling Salesman Problem – Knapsack Problem – Assignment problem.Divide and Conquer Methodology – Binary Search – Merge sort – Quick sort – Heap Sort -Multiplication of Large Integers – Closest-Pair and Convex – Hull Problems.

UNIT – III : Dynamic Programming and Greedy Techniques

Dynamic programming – Principle of optimality – Coin changing problem, Computing a Binomial Coefficient – Floyd's algorithm – Multi stage graph – Optimal Binary Search Trees – Knapsack Problem and Memory functions.

UNIT – IV : Greedy Method and Iterative Improvement

Greedy Technique – Container loading problem – Prim's algorithm and Kruskal's Algorithm – 0/1 Knapsack problem, Optimal Merge pattern – Huffman Trees.
The Simplex Method – The Maximum-Flow Problem – Maximum Matching in Bipartite Graphs,Stable marriage Problem.

UNIT – V : Coping with the Limitations of Algorithm Power

Lower – Bound Arguments – P, NP NP- Complete and NP Hard Problems. Backtracking – n-Queen problem – Hamiltonian Circuit Problem – Subset Sum Problem. Branch and Bound – LIFO Search and FIFO search – Assignment problem – Knapsack Problem – Travelling Salesman Problem – Approximation Algorithms for NP-Hard Problems – Travelling Salesman problem – Knapsack problem.

Text Books:

1. Fundamentals of Computer Algorithms, 2nd Edition, Ellis Horowitz, Sartaj Sahni and S. Rajasekharan, Universities Press.
2. Design and Analysis of Algorithms, P. H. Dave, H. B. Dave, 2nd edition, Pearson Education.

Reference Books:

1. Algorithm Design: Foundations, Analysis and Internet examples, M. T. Goodrich and R. Tomassia, John Wiley and sons.
2. Design and Analysis of Algorithms, S. Sridhar, Oxford Univ. Press
3. Design and Analysis of algorithms, Aho, Ullman and Hopcroft, Pearson Education.
4. Foundations of Algorithms,, R. Neapolitan and K. Naimipour, 4th edition, Jones and Bartlett Student edition.
5. Introduction to Algorithms, 3rd Edition, T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, PHI

CO-PO&PSO Correlation

Course Name: Design and Analysis of Algorithms									
	PO's						PSO's		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2	1				1	2		1
CO2:	2	1				1	1	1	1
CO3:	2	1				1	1	1	1
CO4:	2	1				1	2	1	1
CO5:	2	2				1	2		1

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D**	**Semester :**	**Course Work**
Name of the Course:	**Internet of Things**	**Course Code:**	**SOE-P-CSE102(3)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

This course introduces Internet of Things (IoT) and basic networking concepts, Internet and Web Layering, Architectures, Business Aspects of the Internet of Things, Representational State Transfer (REST) and Activity Streams, Data Analytics in IOT, IoT Communication Protocols, Interoperability in IoT, IOT Security concepts, Big Data and Semantic Technologies.

Course Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Illustrate the smart objects and the technologies to connect them to network.
CO2	Compare different Application protocols for IoT.
CO3	Infer the role of Data Analytics and Security in IoT.
CO4	Identify sensor technologies for sensing real world entities and understand the role of IoT in various domains of Industry.

Syllabus:

UNIT – I : Introduction to Internet of Things

Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs IoT enabaled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs –

Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle.

UNIT – II: IoT and M2M
Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER

UNIT – III : Introduction to Python
Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling Python packages - JSON, XML, HTTPLib, URLLib, SMTPLib

UNIT – IV : IoT Physical Devices and Endpoints
Introduction to Raspberry PI-Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, reading input from pins.

UNIT – V : IoT Physical Servers and Cloud Offerings
Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework Designing a RESTful web API.

Text Books:

1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759

CO-PO&PSO Correlation

Course Name: Internet of Things									
	PO's						PSO's		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2	1				1	2		1
CO2:	2	1				1	1	1	1
CO3:	2	1				1	1	1	1
CO4:	2	1				1	2	1	1

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Machine Learning**	**Course Code:**	**SOE-P-CSE102(4)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

This course is about concepts of learning, Decision Tree learning, Neural Networks and Genetic Algorithm, Bayesian and Computational learning, Instance based learning, Advanced learning,

Course Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Apply decision tree learning and artificial neural networks.
CO2	Apply Bayesian learning using bayes theorem, naive bayes classifier and EM Algorithm.
CO3	Apply Instance based learning and reinforcement learning.

SYLLABUS

UNIT – I : Introduction

Well-posed learning problems, designing a learning system, Perspectives and issues in machine learning Concept learning and the general to specific ordering – introduction, a concept learning task, concept learning as search, find-S: finding a maximally specific hypothesis, version spaces and the candidate elimination algorithm, remarks on version spaces and candidate elimination, inductive bias. Decision Tree Learning – Introduction, decision tree representation, appropriate problems for decision tree learning, the basic decision tree learning algorithm,

hypothesis space search in decision tree learning, inductive bias in decision tree learning, issues in decision tree learning.

UNIT – II : Artificial Neural Networks-1

Introduction, neural network representation, appropriate problems for neural network learning, perceptions, multilayer networks and the back-propagation algorithm. Artificial Neural Networks-2- Remarks on the Back-Propagation algorithm, An illustrative example: face recognition, advanced topics in artificial neural networks. Evaluation Hypotheses – Motivation, estimation hypothesis accuracy, basics of sampling theory, a general approach for deriving confidence intervals, difference in error of two hypotheses, comparing learning algorithms.

UNIT – III : Bayesian learning

Introduction, Bayes theorem, Bayes theorem and concept learning, Maximum Likelihood and least squared error hypotheses, maximum likelihood hypotheses for predicting probabilities, minimum description length principle, Bayes optimal classifier, Gibs algorithm, Naïve Bayes classifier, an example: learning to classify text, Bayesian belief networks, the EM algorithm. Computational learning theory – Introduction, probably learning an approximately correct hypothesis, sample complexity for finite hypothesis space, sample complexity for infinite hypothesis spaces, the mistake bound model of learning. Instance-Based Learning- Introduction, k-nearest neighbour algorithm, locally weighted regression, radial basis functions, case-based reasoning, remarks on lazy and eager learning.

UNIT – IV : Genetic Algorithms

Motivation, Genetic algorithms, an illustrative example, hypothesis space search, genetic programming, models of evolution and learning, parallelizing genetic algorithms. Learning Sets of Rules – Introduction, sequential covering algorithms, learning rule sets: summary, learning First-Order rules, learning sets of First-Order rules: FOIL, Induction as inverted deduction, inverting resolution. Reinforcement Learning – Introduction, the learning task, Q–learning, non-deterministic, rewards and actions, temporal difference learning, generalizing from examples, relationship to dynamic programming.

UNIT – V : Analytical Learning-1

Introduction, learning with perfect domain theories: PROLOG-EBG, remarks on explanation-based learning, explanation-based learning of search control knowledge. Analytical Learning-2-Using prior knowledge to alter the search objective, using prior knowledge to augment search operators. Combining Inductive and Analytical

Learning – Motivation, inductive-analytical approaches to learning, using prior knowledge to initialize the hypothesis.

Text Books:

1. Machine Learning – Tom M. Mitchell, - MGH

Reference Books:

1. Machine Learning: An Algorithmic Perspective, Stephen Marshland, Taylor & Francis

CO-PO&PSO Correlation

Course Name: Machine Learning									
	PO's						PSO's		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2	1				1	2		1
CO2:	2	1				1	1	1	1
CO3:	2	1				1	1	1	1

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Data Structures**	**Course Code:**	**SOE-P-CSE102(5)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:
This course emphasizes on logical structure of data, it's physical representation and techniques for program development and debugging. In this course, students will also learn how to select best suited data structure to solve a particular problem. This course is also about the computational complexities of different data structures.

Course Outcomes:
After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Identify the correctness of the algorithms.
CO2	Analyze the times complexity of the algorithms using asymptotic analysis.
CO3	Compare between different data structures. Pick an appropriate data structure for a design situation.
CO4	Analyze/ summarize searching and sorting techniques.
CO5	Employ and map suitable algorithms to solve engineering problems.

Syllabus:

UNIT – I : Introduction

Introduction: Basic Terminology, Data types and its classification, Abstract Data Types. Time and Space Analysis of Algorithms, Asymptotic Notations - Average, best and worst case analysis, Simple recurrence relations and use in algorithms, Sorting and Searching algorithms.

UNIT – II : Linear Data Structure

Arrays, Stacks, Queues, Linked Lists Arrays, Sparse Matrices, Stacks, Recursion, Queues, Types of queues, linked list, Generalized linked list, Application: Garbage collection and compaction, Conversion of Infix to Postfix Expressions, Polynomial Arithmetic etc.

UNIT – III : Non-linear Data Structure

Trees, Binary Trees, Tree Traversal, Threaded Binary trees, Binary Search Tree (BST), balanced trees - AVL Trees, B-trees, B+ tree. Application: Huffman coding Algorithm etc.

UNIT – IV : Nonlinear Data Structure: Graphs

Graphs, Directed graph, Undirected graph, Traversal, Application of Graphs: Shortest path - Minimal spanning tree etc.

UNIT – V : Hashing

Introduction, types, Collision Resolution Strategies, NP-completeness.

Text books:

1. Alfred. V. Aho, John. E. Hopcroft, Jeffrey. D. Ullman, "Data Structures and Algorithms", Addison-Wesley Publications.,1985
2. Horowitz and Sahani, “Fundamentals of data Structures”, Galgotia Publication Pvt. Ltd., N Delhi.

Reference books:

1. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Second Edition, Pearson Education, Asia.1994.
2. Jean-Paul Tremblay, Paul. G. Sorenson, "An Introduction to Data Structures with Applications", Tata McGraw Hill second edition, 1991.
3. Thomas. H. Cormen, Charles. E. Leiserson, Ronald. L. Rivest, "Introduction to Algorithms", PHI 1998.
4. Lipschutz; Data structure (Schaum); TMH
5. R. Kruse et al, “Data Structures and Program Design in C”, Pearson Education Asia, Delhi-2002.

CO-PO & PSO Correlation

Course Name: Data Structures									
	PO’s						PSO’s		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2	1				1	2		1
CO2:	2	1				1	1	1	1
CO3:	2	1				1	1	1	1
CO4:		2	3				1	2	2
CO5:	1	2	3				2	1	2

Note: 1: Low 2.: Moderate 3: High

Elective II

Programme :	**Ph.D**	**Semester :**	**Course Work**
Name of the Course:	**Data Analytics**	**Course Code:**	**SOE-P-CSE103(1)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:
This course is about Descriptive statistics, Probability distribution and inferential statistics, Machine Learning, Association rule mining and Big data, Clustering analysis and Prescriptive analytics.

Course Outcomes:
After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Apply Statistics probability and distribution models to real life problems
CO2	Apply core big data techniques for data analytics.
CO3	Apply various clustering and prescriptive analytics to real life problem.

Syllabus:

UNIT – I : Data Management
Design Data Architecture and manage the data for analysis, understand various sources of Data like Sensors/Signals/GPS etc. Data Management, Data Quality(noise, outliers, missing values, duplicate data) and Data Processing & Processing.

UNIT – II : Data Analytics
Introduction to Analytics, Introduction to Tools and Environment, Application of Modeling in Business, Databases & Types of Data and variables, Data Modeling Techniques, Missing Imputations etc. Need for Business Modeling.

UNIT – III : Regression

Concepts, Blue property assumptions, Least Square Estimation, Variable Rationalization, and Model Building etc. Logistic Regression: Model Theory, Model fit Statistics, Model Construction, Analytics applications to various Business Domains etc.

UNIT – IV : Object Segmentation

Regression Vs Segmentation – Supervised and Unsupervised Learning, Tree Building – Regression, Classification, Overfitting, Pruning and Complexity, Multiple Decision Trees etc. Time Series Methods: Arima, Measures of Forecast Accuracy, STL approach, Extract features from generated model as Height, Average Energy etc and Analyze for prediction.

UNIT – V : Data Visualization

Pixel-Oriented Visualization Techniques, Geometric Projection Visualization Techniques, Icon-Based Visualization Techniques, Hierarchical Visualization Techniques, Visualizing Complex Data and Relations.

Text books:

1. Student's Handbook for Associate Analytics – II, III.
2. Data Mining Concepts and Techniques, Han, Kamber, 3rd Edition, Morgan Kaufmann Publishers.

Reference books:

1. Introduction to Data Mining, Tan, Steinbach and Kumar, Addision Wisley, 2006.
2. Data Mining Analysis and Concepts, M. Zaki and W. Meira
3. Mining of Massive Datasets, Jure Leskovec Stanford Univ. Anand Rajaraman Milliway Labs Jeffrey D Ullman Stanford Univ.

CO-PO&PSO Correlation

Course Name: Data Analytics									
	PO's						**PSO's**		
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
CO1:	**2**	**1**				**1**	**2**		1
CO2:	**2**	**1**				**1**	**1**	1	1
CO3:	**2**	**1**				**1**	**1**	1	1

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D**	**Course Work**	
Name of the Course:	**Block Chain**	**Course Code:**	**SOE-P-CSE103(2)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:
Introduction to Distributed Ledger Technologies and Blockchain, Blockchain Use-Cases, Cryptography in Blockchain, Blockchain Consensus protocols, Smart Contracts, Enterprise Blockchain, Quantum Computing and Post Quantum Cryptography, Blockchain Security Issues, Advancements in Blockchain.

Course Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Obtain knowledge about technologies of Blockchain
CO2	Learn the models of Hyper-ledger.
CO3	Incorporate the models of Blockchain- Ethereum.

Syllabus:

UNIT – I : Introduction
Block chain or distributed trust, Protocol, Currency, Cryptocurrency, How a Cryptocurrency works, Crowdfunding.

UNIT – II : Concepts & Environment
Extensibility of Blockchain concepts, Digital Identity verification, Block chain Neutrality, Digital art, Blockchain Environment.

UNIT – III : Blockchain Science:

Gridcoin, Folding coin, Blockchain Genomics, Bitcoin MOOCs

UNIT – IV : Currency & Tokens
Currency, Token, Tokenizing, Campuscoin, Coindrop as a strategy for Public adoption, Currency Multiplicity, Demurrage currency

UNIT – V : Challenges
Technical challenges, Business model challenges, Scandals and Public perception, Government Regulations

Text books:

1. Blockchain Blue print for Economy by Melanie Swan

Reference books:

1. Blockchain Basics: A Non-Technical Introduction in 25 Steps 1st Edition, by Daniel Drescher

CO-PO&PSO Correlation

Course Name: Block Chain									
	PO's						PSO's		
Course Outcomes	1	2	3	4	5	6	1	2	3
CO1:	2					1	2		1
CO2:	2	2				1	1	1	1
CO3:	2	2				1	1	1	1

- **Note:** 1: Low 2.: Moderate 3: High

Programme	**Ph.D**	**Course Work**	
Name of the Course:	**Cryptography and Network Security**	**Course Code:**	**SOE-P-CSE103(3)**
Credits :	**5**	**No of Hours :**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

Introduction to Cryptography, Encryption and Decryption process, Sympatric and Asymmetric Key Algorithms, Hashing Algorithms, Digital Identity, Signing and Tamper-proofing, Introduction to Post-Quantum Cryptography.

Course Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Different Cryptographic (symmetric and Asymetric) Methods
CO2	Learn about Hashing and Digital Identity
CO3	Learn about post quantum cryptography

SYLLABUS

UNIT – I : Introduction

Security Attacks (Interruption, Interception, Modification and Fabrication), Security Services (Confidentiality, Authentication, Integrity, Non-repudiation, access Control and Availability) and Mechanisms, A model for Internetwork security. Classical Encryption Techniques, DES, Strength of DES, Differential and Linear Cryptanalysis, Block Cipher Design Principles and Modes of operation, Blowfish, Placement of Encryption Function, Traffic Confidentiality, key Distribution, Random Number Generation.

UNIT – II : Public Key Cryptography and Hash Function

Public key Cryptography Principles, RSA algorithm, Key Management, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, NTRU Cryptosystem, Message authentication and Hash Functions, Authentication Requirements and Functions, Message Authentication, Hash Functions and MACs Hash and MAC Algorithms SHA-512, HMAC.

UNIT – III : Digital Signature and Authentication Service
Digital Signatures, Authentication Protocols, Digital signature Standard, Authentication Applications, Kerberos, X.509 Directory Authentication Service. Email Security: Pretty Good Privacy (PGP) and S/MIME.

UNIT – IV : IP Security
Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management. Web Security: Web Security Requirements, Secure Socket Layer (SSL) and Transport Layer Security (TLS), Secure Electronic Transaction (SET).

UNIT – IV : Threats and Firewall
Intruders, Viruses and Worms Intruders, Viruses and related threats Firewalls: Firewall Design Principles, Trusted Systems, Intrusion Detection Systems, Introduction to Post-Quantum Cryptography.

Text books:

1. Cryptography and Network Security (principles and approaches) by William Stallings Pearson Education, 4th Edition.

Reference books:

1. Network Security Essentials (Applications and Standards) by William Stallings Pearson Education.
2. Principles of Information Security, Whitman, Thomson.

CO-PO&PSO Correlation

Course Name: Cryptography and Network Security									
	PO's						**PSO's**		
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
CO1:	**1**					**1**	**2**		**1**
CO2:	**2**	**2**			**2**	**1**	**1**	**1**	**1**
CO3:	**2**	**2**			**2**	**1**	**1**	**1**	**1**

- **Note:** 1: Low 2.: Moderate 3: High

Programme :	**Ph.D.**	**Course Work**	
Name of the Course:	**Cloud Computing and Applications**	**Course Code:**	**SOE-P-CSE103(4)**
Credits :	**5**	**No of Hours:**	**5 Hrs / Week**
Max Marks:	**100**		

Course Description:

The course will introduce cloud domain and cover the topics of cloud deployment, and delivery models, infrastructures, virtualization, software defined networks and storage, cloud storage, and case study. As an introduction, we will discuss about the history, the motivating factors, benefits and challenges of the cloud, as well as service models, cloud service providers and use cases. Next, we will focus on different cloud deployment and delivery models, when to opt and different decision factors which affect the users to opt the cloud models. We will also discuss the virtualization, types of virtualization and how virtualization is used in cloud computing. We will discuss the case study with real time example to understand that how cloud computing is helping us to reduce the capital and operational costs, with no maintenance of services from user's end.

COURSE Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Significance and requirement of Cloud Computing
CO2	Analyze use of Hypervisor and Its Types
CO3	Cloud Workload Management
CO4	Create Virtualization for Cloud
CO5	Analyzing different cloud senarios

Syllabus:

UNIT – I : Introduction to Cloud Computing

History, Importance of Virtualization in Cloud, Anatomy of Cloud, Cloud deployment models, Cloud delivery models, Stepping stones for the development of cloud, Grid Computing, Cloud Computing.

UNIT – II : Cloud Deployment Models and Delivery Models

Decision Factors for Cloud Implementations, Public, Private and Hybrid Cloud, Overview, Infrastructure as a Service (IaaS) Cloud Delivery Model, Platform as a Service (PaaS) Cloud Delivery Model, Software as a Service (SaaS) Cloud Delivery Model.

UNIT – III : Introduction to Virtualization

Traditional IT Infrastructure, Benefits of Virtualization, Types of Virtualization, History of Virtualization

UNIT – IV : Server, Storage, Network and Application Virtualization

Types of Server Virtualization, Hypervisors, Anatomy of Server Virtualization, Benefits of Storage Virtualization, Types of Storage Virtualization, VPN, VLAN, Benefits of Application Virtualization.

UNIT – V : Case Study

Customer IT Landscape, Triggers of Virtualization, Preparation for Virtualization, Transition Tools for Virtualization, Cost savings, Cloud workload Overview, Workloads most suitable for Cloud, Workloads not suitable for Cloud

Text books:

1. Mastering Cloud Computing, by Rajkumar Buyya.
2. Cloud Computing Principles and Paradigms: Rajkumar Buyya Wiley.
3. Distributed and Cloud Computing: Kai Hwang, Mk Publication.

Reference Book:

1. Cloud Computing: Fundamentals, Industry Approach and Trends, by Rishab Sharma, Wiley Publication.
2. Cloud Application Architectures by George Reese, O'Reillly Publications, 2009

CO-PO&PSO Correlation

Course Name: Cloud Computing and Applications

	PO's						PSO's		
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
CO1:	**1**					**1**	**2**		1
CO2:	**2**	**2**			**2**	**1**	**1**	1	1
CO3:	**2**	**2**			**2**	**1**	**1**	1	1

- **Note:** 1: Low 2.: Moderate 3: High