Haldia Institute of Technology (Autonomous)

B. Tech in Computer Science & Engineering (Cyber Security)

PROGRAM OUTCOMES (ALIGNED WITH GRADUATE ATTRIBUTES) (PO)

At the end of this program, graduates will be able to

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Curriculum Structure

Semester III (Second year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Engineering Science Course	ESC-CS-301	Digital Electronics	3	0	0	3
2		Professional Core Course	PCC-CS-301	Data Structure and Algorithms	3	1	0	4

3		Professional Core Course	PCC-CS-302	Computer Organization & Architecture	3	1	0	4
4		Basic Science Course	BSC-CS-301	Linear Algebra	3	0	0	3
5		Humanities Social Science including Management Course	HSMC-CS-301	Economics for Engineers	2	0	0	2
6	Practical	Engineering Science Course	ESC-CS-391	Digital Electronics Lab	0	0	3	1.5
7		Professional Core Course	PCC-CS-391	Data Structure and Algorithms Lab	0	0	3	1.5
8		Professional Core Course	PCC-CS-392	Computer Architecture Lab	0	0	3	1.5
9		Professional Core Course	PCC-CS-393	IT Workshop (Python)	0	0	3	1.5
Total Credits								22

Semester IV (Second year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Engineering Science Course	ESC-CS-401	Discrete Mathematics	3	1	0	4
2		Professional Core Course	PCC-CS-401	Object Oriented Programming	3	0	0	3
3		Professional Core Course	PCC-CS-402	Operating System	3	0	0	3
4		Professional Core Course	PCC-CS-403	Formal Language and Automata Theory	3	0	0	3
5		Basic Science Course	BSC-CS-401	Biology	2	0	0	2
6		Mandatory Course	MC-CS-401	Environmental Sciences	2	0	0	0
7	Practical	Professional Core Course	PCC-CS-491	Object Oriented Programming Lab	0	0	3	1.5
8		Professional Core Course	PCC-CS-492	Operating System Lab	0	0	3	1.5
Total Credits								18

Semester V (Third year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Engineering Science Course	ESC-CS-501	Probability and Statistics	3	0	0	3
2		Professional Core Course	PCC-CS-501	Database Management System	3	0	0	3
3		Professional Core Course	PCC-CS-502	Design and Analysis of Algorithm	3	1	0	4
4		Professional Core Course	PCC-CS-503	Data Communication and Networks	3	0	0	3
5		Professional Core Course	PCC-CS-504	Cryptography	3	1	0	4

6		Professional Core Course	PCC-CS-505	Malware Analysis	2	0	0	2
7	Practical	Professional Core Course	PCC-CS-591	Database Management System Lab	0	0	3	1.5
8		Professional Core Course	PCC-CS-592	Design and Analysis of Algorithm Lab	0	0	3	1.5
9		Professional Core Course	PCC-CS-593	Data Communication and Networks Lab	0	0	3	1.5
Total Credits								23.5

Semester VI (Third year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Core Course	PCC-CS-601	Network Security	3	0	0	3
2		Professional Core Course	PCC-CS-602	Ethical Hacking	2	0	0	2
3		Professional Core Course	PCC-CS-603	Artificial Intelligence	3	0	0	3
4		Humanities and Social Sciences including Management	HSMC-CS-601	Human Values and Professional Ethics	2	0	0	2
5		Professional Elective Course I	PEC-CS-601 (A/B/C/D)	Computer Graphics Internet Technology IoT Application and Design Graph Theory	3	0	0	3
6		Open Elective Course I	OEC-CS-601 (A/B/C/D)	Cyber Law and Cyber Crime Embedded System Human Resource Management Economic Policies in India	3	0	0	3
7	Practical	Professional Core Course	PCC-CS-691	Cryptography & Network Security Lab	0	0	3	1.5
8		Professional Core Course	PCC-CS-692	Artificial Intelligence Lab	0	0	4	3
Total Credits								19.5

Semester VII (Fourth year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Elective Course II	PEC-CS-701 (A/B/C/D)	Cloud Computing Software Engineering Steganography and Watermarking Digital Forensics	3	0	0	3
2		Professional Elective Course III	PEC-CS-702 (A/B/C/D)	Block chain and Cryptocurrency Social Network Analysis Advanced Computer Architecture Big Data Analytics	3	0	0	3

3		Open Elective Course II	OEC-CS-701 (A/B/C/D)	Natural Language Processing Soft skill and Interpersonal Communication Digital Signal Processing Machine Learning	3	0	0	3
4		Humanities and Social Sciences Including Management	HSMC-CS-701	Project Management and Entrepreneurship	2	0	0	2
5	Se ssi	Project	PROJ-CS-781	Project I	0	0	10	5
6		Summer Internship	SI-CS-782	Internship I				3
Total Credits								19

Semester VIII (Fourth year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Elective Course IV	PEC-CS-801 (A/B/C/D)	Quantum Computing Information Theory and Coding Cyber Security in Block chain Technology Bio Informatics	3	0	0	3
2		Professional Elective Course V	PEC-CS-802 (A/B/C/D)	Security Assessment and Risk Analysis Mobile Computing Deep Learning Digital Image Processing	3	0	0	3
3		Open Elective Course III	OEC-CS-801 (A/B/C/D)	Operations Research Remote Sensing and GIS Ecommerce and ERP Business Analytics	3	0	0	3
4		Open Elective Course IV	OEC-CS-802 (A/B/C/D)	Numerical Methods Multimedia Technology Introduction to Arts and Aesthetics Research Methodology	3	0	0	3
5	Se ssi	Project	PROJ-CS-881	Project II	0	0	10	5
6		Winter Internship	WI-CS-882	Internship II				3
Total Credits								20

Semester-III

ESC-CS-301: Digital Electronics

Contacts: 3L per week Credits: 3

Course Outcomes (COs):

At the end of this course, students will demonstrate the ability to

- Understand working of logic families and logic gates.
- Convert a number from one base system to another.
- Understand Boolean algebra and represent digital circuits from Boolean expressions.
- Design and implement many Combinational circuits.

- Design and implement various Sequential logic circuits.
- Understand the process of Analog to Digital conversion and Digital to Analog conversion.

Prerequisites:

1. Number Systems

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Binary Number System & Boolean Algebra (recapitulation); BCD, ASCII, EBDIC, Gray codes and their conversions; Signed binary number representation with 1's and 2's complement methods, Binary arithmetic, Venn diagram,	4
2	Boolean algebra (recapitulation); Representation in SOP and POS forms; Minimization of logic expressions by algebraic method. K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don't care conditions.	5
3	Combinational Circuits - Adder and Subtractor circuits (half & full adder & subtractor); Encoder, Decoder, Comparator, Multiplexer, De-multiplexer and Parity Generator. Error detecting and correcting codes. Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial adder	7
4	Sequential Circuits - Basic Flip-flop & Latch, Flip-flops -SR, JK, D, T and JK Master-slave Flip Flops, Registers (SISO, SIPO, PIPO, PISO) Ring counter, Johnson counter Basic concept of Synchronous and Asynchronous counters (detail design of circuits excluded), Design of Mod N Counter. Counters design using flip-flops	8
5	A/D and D/A conversion techniques – Basic concepts (D/A :R-2-R only [2L] A/D: successive approximation [2L]) Logic families- TTL, ECL, MOS and CMOS - basic concepts. (2L)	6

Text book and Reference books:

1. Microelectronics Engineering –Sedra & Smith-Oxford.
2. Analog Electronics, A.K. Maini, Khanna Publishing House (AICTE Recommended -2018)
3. Analog Electronics, L.K. Maheswari, Laxmi Publications (AICTE Recommended -2018)
4. Principles of Electronic Devices & circuits—B L Thereja & Sedha—S Chand
5. Digital Electronics – Kharate – Oxford
6. Digital Electronics – Logic & Systems by J.Bigmell & R.Donovan; Cambridge Learning.
7. Digital Logic and State Machine Design (3rd Edition) – D.J.Comer, OUP
8. Electronic Devices & Circuit Theory – Boyelstad & Nashelsky - PHI
9. Bell-Linear IC & OP AMP—Oxford
10. P.Raja- Digital Electronics- Scitech Publications
11. Morries Mano- Digital Logic Design- PHI
12. R.P.Jain—Modern Digital Electronics, 2/e ,McGraw Hill
13. H.Taub & D.Shilling, Digital Integrated Electronics- McGraw Hill.
14. D.RayChaudhuri- Digital Circuits-Vol-I & II, 2/e- Platinum Publishers
15. Tocci, Widmer, Moss- Digital Systems,9/e- Pearson
16. J.Bignell & R.Donovan-Digital Electronics-5/e- Cenage Learning.
17. Leach & Malvino—Digital Principles & Application, 5/e, McGraw Hill
18. Floyed & Jain- Digital Fundamentals-Pearson.

PCC-CS-301: Data Structure and Algorithms

Contacts: 3(L) + 1(T) per week **Credits: 4**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Create and Design** programs using a variety of data structures such as stacks, queues, hash tables, binary trees, heaps, graphs.
2. **Evaluate** and choose appropriate data structures to represent data items in real world.
3. **Analyze** the time and space complexities of algorithms.
4. **Implement and apply** sorting algorithms for problem solving.
5. **Understand** the concept of dynamic memory management.
6. **Identify and remember** user defined data types, linear data structures for solving real world problems.

Prerequisites:

- Programming for Problem Solving

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Introduction:** Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade off. **Searching:** Linear Search and Binary Search techniques and their complexity analysis.	9
2	**Stacks and Queue:** ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation– Corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each type of Queues:Algorithms and their analysis.	10
3	**Linked Lists**: Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, Doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.	6
4	**Trees**: Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.	6
5	**Sorting and Hashing**: Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing.	6
6	**Graph:** Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis.	3

Text book and Reference books:

1) Data Structures and Program Design in C, 2/E by Robert L. Kruse, Bruce P. Leung.
2) Data Structure & Algorithms Using C, 5th Ed., Khanna Publishing House (AICTE Recommended -2018)
3) Fundamentals of Data Structures of C by Ellis Horowitz, Sartaj Sahni, Susan Andersonfreed.
4) Data Structures in C by Aaron M. Tenenbaum.

5) Data Structures by S. Lipschutz.
6) Data Structures Using C by Reema Thareja.
7) Data Structure Using C, 2/e by A.K. Rath, A. K. Jagadev.
8) Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein.
9) Data Structures through C by Yashwant Kanetkar, BPB Publications.
10) Expert Data Structures with C++ by R.B Patel, Khanna Publishing House.

PCC-CS-302: Computer Organization & Architecture

Contacts: 3(L) + 1(T) per week **Credits: 4**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Demonstrate** the Von Neumann architecture and **relate** hardware with software.
2. **Demonstrate** sufficient knowledge and understanding of data representation, and **experiment with** basic arithmetic operations.
3. **Analyze** and **model** various functional units of CPU such as ALU, control unit and register file.
4. **Organize** the memory hierarchy and **design** a memory of any type.
5. **Explain** the instruction cycle and **tell which** units of the CPU are used for this process.
6. **Outline** various modes of I/O operations and **summarize** working principles of I/O interface circuits.

Prerequisites:

- Number systems
- Basic programming skills
- Basics of Digital Electronics

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Basic organization of the stored program computer and operation sequence for execution of a program. Role of operating systems and compiler/assembler. Fetch, decode and execute cycle, Concept of operator, operand, registers and storage. Commonly used number systems. Fixed and floating point representation of numbers. Overflow and underflow. Floating point - IEEE 754 standard.	9
2	Fixed point multiplication –Booth's algorithm. Fixed point division - Restoring and non-restoring algorithms. Design of adders – serial adder, ripple carry and carry look-ahead principles. Design of ALU.	7
3	Instruction set architecture: Instruction format. Instruction length. 0-, 1-, 2-, 3-address instructions. Instruction cycle. Instruction sets and addressing modes. Introduction to RISC architectures. RISC vs CISC architectures.	7
4	Memory organization: Performance parameters, Memory unit design with special emphasis on implementation of CPU-memory interfacing. Memory hierarchy, hard disk, static and dynamic memory, associative memory. Cache memory, Virtual memory.	9
5	Design of control unit - hardwired and microprogrammed control. Introduction to instruction pipelining.	4
6	I/O operations - Concept of handshaking, Polled I/O, interrupt and DMA.	4

Text book and Reference books:

1. Mano, M.M., "Computer System Architecture", PHI.
2. Behrooz Parhami "Computer Architecture", Oxford University Press
3. Hayes J. P., "Computer Architecture & Organisation", McGraw Hill,
4. Hamacher, "Computer Organisation", McGraw Hill,
5. T.K. Ghosh, "Computer Organization" 2nd Ed., TMH
6. Chaudhuri P. Pal, "Computer Organisation & Design", PHI,
7. P N Basu- "Computer Organization & Architecture", Vikas Pub
8. Rajaraman – "Computer Organization & Architecture", PHI
9. B.Ram – "Computer Organization & Architecture", New Age Publications

BSC-CS-301: Linear Algebra

Contacts: 3 Lectures per week Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

- **Formulate** elementary row and column operation.
- **Evaluate** matrix algebra and related matrices to linear transformation.
- **Analyze** singular value decomposition.
- **Solve** systems of linear equations.
- **Use** matrix algebra and the related matrices to linear transformations.
- **Understand** the basic ideas of linear mapping.

Prerequisites:

- Mathematics-I
- Mathematics-II

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Systems of linear equations, Matrices, Elementary row operations, Row-reduced echelon matrices. Vector spaces, Subspaces, Bases and dimension, Ordered bases and coordinates.	9
2	Linear transformations, Rank-nullity theorem, Algebra of linear transformations, Isomorphism, Matrix representation, Linear functionals, Annihilator, Double dual, Transpose of a linear transformation.	10
3	Characteristic values and characteristic vectors of linear transformations, Diagonalizability, Minimal polynomial of a linear transformation, Cayley-Hamilton theorem, Invariant subspaces, Direct-sum decompositions, Invariant direct sums, The primary decomposition theorem, Cyclic subspaces and annihilators, Cyclic decomposition, Rational, Jordan forms.	10
4	Inner product spaces, Orthonormal bases, Gram-Schmidt process.	7

Text books and Reference books:

1. E Kreyszig, Advanced Engineering Mathematics, Wiley-India
2. S. K. Mapa, Higher Algebra, Levant Books.
3. Chakravorty and Ghosh, Advanced Higher Algebra, U N Dhar Pvt. Ltd.
4. K.Hoffman and R.Kunze, Linear Algebra, 2nd Edition, Prentice- Hall of India, 2005.
5. M.Artin, Algebra, Prentice-Hall of India, 2005.
6. S.Axler, Linear Algebra Done Right, 2nd Edition, John-Wiley, 1999.
7. S. Lang, Linear Algebra, Springer UTM, 1997.
8. S.Kumaresan, Linear Algebra: A Geometric Approach, Prentice-Hall of India, 2004.
9. Jim Defranza, Daniel Gagliardi, Introduction to Linear Algebra with Application, Tata McGraw-Hill
10. Anton and Rorres, Elementary Linear Algebra, Applications version, Wiley India Edition

HSMC-CS-301: Economics for Engineers

Contacts: 2L per week **Credits: 2**

Course Outcomes (COs):

At the end of the course, the students will be able to:

- Evaluate the economic theories, cost concepts and pricing policies.
- Understand the market structures and integration concepts.
- Understand the measures of national income, the functions of banks and concepts of globalization.
- Apply the concepts of financial management for project appraisal.
- Understand accounting systems and analyze financial statements using ratio analysis.
- Understand the impact of inflation, taxation, depreciation. Financial planning, economic basis for replacement, project scheduling, and legal and regulatory issues are introduced and applied to economic investment and project-management problems

Detailed Content:

Module	***Content***	***Hours/ Module***
1	1. Economic Decisions Making – Overview, Problems, Role, Decision making process. 2. Engineering Costs & Estimation – Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types Of Estimate, Estimating Models - PerUnit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve, Benefits.	9
2	3. Cash Flow, Interest and Equivalence: Cash Flow – Diagrams, Categories & Computation, Time Value of Money, Debt repayment, Nominal& Effective Interest. 4. Cash Flow & Rate of Return Analysis – Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing an Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity and Breakeven Analysis. Economic Analysis In The Public Sector -Quantifying And Valuing Benefits & drawbacks.	9
3	5. Inflation and Price Change – Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In	9

	Engineering Economic Analysis, Cash Flows that inflate at different Rates. 6. Present Worth Analysis: End-Of-Year Convention, Viewpoint Of Economic Analysis Studies, Borrowed Money Viewpoint, Effect Of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives. 7. Uncertainty In Future Events - Estimates and Their Use in Economic Analysis, Range Of Estimates, Probability, Joint Probability Distributions, Expected Value, Economic Decision Trees, Risk, Risk vs Return, Simulation, Real Options.	
4	8. Depreciation - Basic Aspects, Deterioration & Obsolescence, Depreciation And Expenses, Types Of Property, Depreciation Calculation Fundamentals, Depreciation And Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements Of Tax Regulations For Depreciation And Capital Allowances. 9. Replacement Analysis - Replacement Analysis Decision Map, Minimum Cost Life of a New Asset, Marginal Cost, Minimum Cost Life Problems. 10. Accounting – Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation.	9

Text books and Reference books:

1. James L. Riggs, David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill
2. Donald Newnan, Ted Eschembach, Jerome Lavelle: Engineering Economics Analysis, OUP
3. John A. White, Kenneth E. Case, David B. Pratt: Principle of Engineering Economic Analysis, John Wiley
4. Sullivan and Wicks: Engineering Economy, Pearson
5. R.Paneer Seelvan: Engineering Economics, PHI
6. Michael R Lindeburg : Engineering Economics Analysis, Professional Pub
7. Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House (AICTE Recommended Textbook – 2018)

ESC-CS-391: Digital Electronics Lab

Contacts: 3P per week **Credits: 1.5**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Acquire knowledge about basics of digital electronics.
- Explain about how to solve problems related to number systems and Boolean algebra.
- Identify, analyze and design combinational circuits.
- Design BCD to Excess-3 and Binary to gray code conversion circuit.
- Compare various synchronous and asynchronous sequential circuits.
- Analyze sequential digital circuits like flip-flops, registers, counters.

Laboratory Experiments:	
1	Design a Half Adder and Full Adder using basic gates and verify outputs.
2	Design a Half Subtractor and Full Subtractor circuit using basic gates and verify outputs.
3	Construction of simple Multiplexer circuits using logic gates.
4	Construction of simple De-multiplexer circuits using logic gates.
5	Construction of simple Decoder using logic gates.
6	Construction of simple Encoder using logic gates.

7	Realization of RS / JK / D flip flops using logic gates
8	Design of Shift Register using J-K / D Flip Flop
9	Realization of Synchronous Up/Down counter
10	Design of MOD- N Counter
11	Study of DAC

PCC-CS-391: Data Structure and Algorithms Lab

Contacts: 3P per week **Credits: 1.5**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design and solve** programs using a variety of data structures such as stacks, queues, hash tables, binary trees, heaps, graphs.
2. **Evaluate** and choose appropriate data structures to represent data items in real world.
3. **Analyze** the time and space complexities of algorithms.
4. **Implement** sorting and searching algorithms for problem solving.
5. **Understand** the concept of dynamic memory management.
6. **Identify and remember** user defined data types, linear data structures for solving real world problems.

Prerequisites:

- Programming for Problem Solving
- Data Structure and Algorithms

Detailed Content:

1. Implementation of array operations
2. Stacks and Queues: adding, deleting elements Circular Queue: Adding & deleting elements
3. Application of Stack: Expression Evaluation, Expression Conversion
4. Implementation of linked lists: inserting, deleting, and inverting a linked list. Implementation of stacks & queues using linked lists
5. Polynomial addition, Polynomial multiplication
6. Recursive and Non-recursive traversal of Trees
7. Threaded binary tree traversal. AVL tree implementation
8. Implementation of different searching & sorting techniques.

Text book and Reference books:

1. Data Structures and Program Design in C, 2/E by Robert L. Kruse, Bruce P. Leung.
2. Data Structure & Algorithms Using C, 5th Ed., Khanna Publishing House (AICTE Recommended -2018)
3. Fundamentals of Data Structures of C by Ellis Horowitz, Sartaj Sahni, Susan Andersonfreed.
4. Data Structures in C by Aaron M. Tenenbaum.
5. Data Structures by S. Lipschutz.
6. Data Structures Using C by Reema Thareja.
7. Data Structure Using C, 2/e by A.K. Rath, A. K. Jagadev.
8. Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein
9. Data Structures through C by Yashwant Kanetkar, BPB Publications.
10. Expert Data Structures with C++ by R.B Patel, Khanna Publishing House

PCC-CS-392: Computer Architecture Lab

Contacts: 3P per week **Credits: 1.5**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- **Summarize** Xilinx/ Altera (VHDL) foundation tools and Hardware Description Language.
- **Demonstrate** different concepts and methods of digital system design techniques through hands-on projects.
- **Build** various combinational and sequential digital systems.
- **Identify** knowledge, techniques required to design, implement and test modern day digital systems.
- **Evaluate** and **interpret** the results of logic and timing simulations.
- **Analyze** digital systems through hands-on experiments on the Xilinx/ Altera tools.

Laboratory Experiments:

1. Write VHDL codes for various logic gates.
2. Using VHDL, design a half adder in data flow model.
3. Using VHDL, design a full adder in data flow model.
4. Using VHDL, design a half subtractor.
5. Using VHDL, design a full subtractor.
6. Using VHDL, design 1-bit comparator.
7. Using VHDL, design 4:1 Multiplexer in data flow model.
8. Using VHDL, design 2:4 Decoder in data flow model.
9. Using VHDL, design 1:4 DEMUX in data flow model.
10. Write VHDL code for basic gates: 2 i/p AND Gate (Multiple Bit Handling)
11. Using VHDL, design 4:1 Multiplexer using when-else structure.
12. Using VHDL, design 2: 4 Decoder using when-case structure.
13. Using VHDL, design 2: 4 Decoder in behavioral model.
14. Write VHDL code for 4-bit Up Counter
15. Write VHDL code for 4-bit Down Counter
16. Write VHDL code for 4-bit Up-Down Counter
17. Using VHDL, design SR-flip flop in behavioral model.
18. Write VHDL code for D Flip Flop
19. Using VHDL, design JK-flip flop in behavioral model.
20. Write VHDL code for T Flip Flop

PCC-CS-393: IT Workshop (Python)

Contacts: 3P per week **Credits: 1.5**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Develop** algorithmic solutions to simple computational problems.
2. **Identify** and repair coding errors in a program.
3. **Demonstrate** programs using simple Python statements and expressions**.**
4. **Explain** control flow and functions concept in Python for solving problems**.**
5. **Use** Python data structures – lists, tuples & dictionaries for representing compound data.
6. **Explain** files, exception, modules and packages in Python for solving problems.

Prerequisites:

- Programming for Problem Solving

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Introduction** History, Features, Setting up path, Working with Python, Basic Syntax, Variable and Data Types, Operator	3
2	**Conditional Statements** If, If- else, Nested if-else, Looping, For, While, Nested loops	3
3	**Control Statements** Break, Continue, Pass	3
4	**String Manipulation** Accessing Strings, Basic Operations, String slices, Function and Methods	3
5	**Lists** Introduction, Accessing list, Operations, Working with lists, Function and Methods	3
6	**Tuple** Introduction, Accessing tuples, Operations, Working, Functions and Methods.	3
7	**Dictionaries** Introduction, Accessing values in dictionaries, Working with dictionaries, Properties	3
8	**Functions** Defining a function, Calling a function, Types of functions, Function Arguments, Anonymous functions, Global and local variables	3
9	**Modules** Importing module, Math module, Random module, Packages, Composition, Input-Output Printing on screen, Reading data from keyboard, Opening and closing file, Reading and writing files, Functions	3
10	**Exception Handling** Exception, Exception Handling, Except clause, Try abd finally clause, User Defined Exceptions.	3

Laboratory Experiments:	
1	Practical Assignments related with implementation of PCC-CS-393

Text book and Reference books:

1. Martin C. Brown "Python: The Complete Reference", McGraw Hill Education
2. Reema Thareja., "Python Programming: Using Problem Solving Approach", Oxford University Press.
3. Ashok Namdev Kamthane and Amit Ashok Kamthane, "Programming and Problem Solving with Python", McGraw Hill,
4. Vishwajit K. Barbudhe," Introduction of Python", Notion Press
5. Taneja Sheetal and Kumar Naveen, "Python Programming - A modular approach", Pearson Education,

Semester-IV

ESC-CS-401: Discrete Mathematics

Contacts: 3(L) + 1(T) per week **Credits: 4**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Apply mathematical logic to solve problems.
2. Understand sets, relations, functions and discrete structures.
3. Use logical notations to define and reason about fundamental mathematical concepts such as sets relations and functions.
4. Identify functions and determine their properties.
5. Formulate problems and solve recurrence relations.
6. Model and solve real world problems using graphs and trees.

Prerequisites:

1. Basic Mathematics
2. Probability and Statistics

Detailed Content:

Module No	*Content*	*Hours/ Module*
1	Introduction: Objective, scope and outcome of the course.	1
2	Set Theory: Definition of sets, countable and uncountable sets, Set operations, Partition of set, Cardinality (Inclusion-Exclusion & Addition Principles) Venn Diagrams, proofs of some general identities on sets. Relation: Definition, types of relation, composition of relations, Pictorial representation of relation, Equivalence relation, Partial ordering relation, Job- Scheduling problem. Function: Definition, type of functions, one to one, into and onto function, inverse function, composition of functions, recursively defined functions, pigeonhole principle. Theorem proving Techniques: Mathematical induction, Proof by contradiction. Composition of Functions. The Pigeonhole and Generalized Pigeonhole Principles.	10
3	Propositional Logic: Proposition, First order logic, Basic logical operation, truth tables, tautologies, Contradictions, Algebra of Proposition, logical implications, logical equivalence, predicates, Normal Forms, Universal and existential quantifiers. 2-way predicate logic. Introduction to finite state machine Finite state machines as models of physical system equivalence machines, Finite state machines as language recognizers.	8
4	Posets, Hasse Diagram and Lattices: Introduction, ordered set, Hasse diagram of partially, ordered set, isomorphic ordered set, well ordered set, properties of Lattices, bounded and complemented lattices. Combinatorics: Introduction, Permutation and combination, Binomial Theorem, Multimodal Coefficients Recurrence Relation and Generating Function: Introduction to Recurrence Relation and Recursive algorithms, linear recurrence relations with constant coefficients, Homogeneous solutions, Particular solutions, Total solutions, Generating functions, Solution by method of generating functions.	7

5	Algebraic Structures: Definition, Properties, types: Semi Groups, Monoid, Groups, Abelian group, properties of groups, Subgroup, cyclic groups, Cosets, factor group, Permutation groups, Normal subgroup, Homomorphism and isomorphism of Groups, example and standard results, Rings and Fields: definition and standard results.	6
6	Graph Theory: Introduction and basic terminology of graphs, Planer graphs, Multigraphs and weighted graphs, Isomorphic graphs, Paths, Cycles and connectivity, Shortest path in weighted graph, Introduction to Eulerian paths and circuits, Hamiltonian paths and circuits, Graph colouring, chromatic number, Isomorphism and Homomorphism of graphs, matching, vertex/edge covering.	8
	Total	40

Text/Reference Books:

1. Discrete Mathematics with Applications, Koshy,Elsevier
2. Discrete Mathematical Structures ByLipshutz& Lipson, TMH
3. Discrete Mathematical Structures, Kolmanet.al,Pearson
4. Fundamentals of Discrete Mathematical Structures, K R Chowdhary, 3ed, PHI

PCC-CS-401: Object Oriented Programming

Contacts: 3 Lectures per week **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Create and explain** GUI and thread based application.
2. **Evaluate** the complexity of procedural language by using the concept of polymorphism, inheritance, abstraction, and encapsulation.
3. **Analyze** any real world problem with object oriented approach and formulate a solution for the same.
4. **Implement and apply** object oriented approach to relate to real world problem.
5. **Understand, describe** and illustrate the features of object oriented programming.
6. **Recall** the knowledge of procedural language and map it to paradigm of Object Oriented concept.

Prerequisites:

- Programming for Problem Solving

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Basics of OOP and Introduction to JAVA:** Properties of object oriented programming language, Object, Class, relationships among objects. Aggregation, Association, Generalization, meta-class. Class, object, message passing, inheritance, encapsulation, polymorphism. Basic concept of JAVA programming– advantages of java, byte-code & JVM, data types, operators, control statements & loops, array, creation of class, object, constructor, finalize and garbage collection.	8
2	**Class & Object proprieties**: Different types of access specifiers, method overloading, this keyword, use of objects as parameter & methods returning objects, call by value & call by reference, static variables, methods and block nested & inner classes, Inbuilt classes like String, Character, StringBuffer, basic string handling concepts, concept of mutable and immutable string. **Reusability properties**: Super class & subclasses including multilevel hierarchy,	10

	process of constructor calling in inheritance, use of super and final keywords with super() method, dynamic method dispatch, abstract classes & methods, interfaces. Creation of packages, importing packages, member access for packages, UTIL package.	
3	**Exception handling and I/O:** Exception handling basics, different types of exception classes, use of try & catch with throw, throws & finally, creation of user defined exception classes. Input Output stream structure, Wrapper class, command line arguments, basics of I/O operations – keyboard input using BufferedReader & Scanner classes. File copy programming using command line arguments.	6
4	**Multithreading and Applet & Swing Programming**: Basics of multithreading, main thread, thread life cycle, creation of multiple threads, thread priorities, thread synchronization, inter-thread communication, deadlocks for threads, suspending & resuming threads. Introduction to Microservices. Basics of applet programming, applet life cycle, difference between application & applet programming, parameter passing in applets. Basic of swing programming, Difference between applet and swing.	7

Text book and Reference books:

1 Object Oriented Modelling and Design, Rambaugh, James Michael, Blaha ,Prentice Hall, India.
2 Object Oriented System Development Ali Bahrami,Mc Graw Hill.
3 The complete reference-Java2, Patrick Naughton, Herbert Schildt,TMH.
4 Core Java For Beginners, R.K Das,VIKAS PUBLISHING.
5 Java How to Program, Deitel and Deitel,6th Ed. – Pearson.
6 Beginning Java 2 SDK,Ivor Horton's,Wrox.
7 Programming With Java: A Primer,E. Balagurusamy,3rd Ed.,TMH.

PCC-CS-402: Operating System

Contacts: 3L per week **Credits: 3**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the mechanisms of OS to handle processes and threads and their communication
- Develop algorithms for process scheduling for a given specification of CPU utilization, Throughput, Turnaround Time, Waiting Time, Response Time.
- Demonstrate the mechanisms involved in memory management in contemporary OS
- Understand the components and management aspects of concurrency management
- Develop the techniques for optimally allocating memory to processes by increasing memory utilization and for improving the access time.
- Design and implement file management system.

Prerequisites:

- Digital Electronics
- Computer Organization & Architecture
- Programming Concepts

Detailed Content:

Module	***Content***	***Hours/***

		Module
1	**Introduction:** Concept of Operating Systems, Generations of Operating systems, Types of Operating Systems, OS Services, System Calls, Structure of an OS - Layered, Monolithic, Microkernel Operating Systems, Concept of Virtual Machine. Case study on UNIX and WINDOWS Operating System.	3
2	**Processes:** Definition, Process Relationship, Different states of a Process, Process State transitions, Process Control Block (PCB), Context switching **Thread:** Definition, Various states, Benefits of threads, Types of threads, Concept of multithreads, **Process Scheduling**: Foundation and Scheduling objectives, Types of Schedulers, Scheduling criteria: CPU utilization, Throughput, Turnaround Time, Waiting Time, Response Time; Scheduling algorithms: Pre-emptive and Non pre-emptive, FCFS, SJF, RR; Multiprocessor scheduling: Real Time scheduling: RM and EDF.	8
3	**Inter-process Communication:** Critical Section, Race Conditions, Mutual Exclusion, Hardware Solution, Strict Alternation, Peterson's Solution, The Producer-Consumer Problem, Semaphores, Event Counters, Monitors, Message Passing, Classical IPC Problems: Reader's & Writer Problem, Dinning Philosopher Problem etc.	6
4	**Deadlocks:** Definition, Necessary and sufficient conditions for Deadlock, Deadlock Prevention, Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery.	4
5	**Memory Management:** Basic concept, Logical and Physical address map, Memory allocation: Contiguous Memory allocation – Fixed and variable partition– Internal and External fragmentation and Compaction; Paging: Principle of operation – Page allocation – Hardware support for paging, Protection and sharing, Disadvantages of paging. **Virtual Memory**: Basics of Virtual Memory – Hardware and control structures – Locality of reference, Page fault , Working Set , Dirty page/Dirty bit – Demand paging, Page Replacement algorithms: Optimal, First in First Out (FIFO), Second Chance (SC), Not recently used (NRU) and Least Recently used (LRU).	8
6	**I/O Hardware:** I/O devices, Device controllers, Direct memory access Principles of I/O Software: Goals of Interrupt handlers, Device drivers, Device independent I/O software, Secondary-Storage Structure: Disk structure, Disk scheduling algorithms **File Management**: Concept of File, Access methods, File types, File operation, Directory structure, File System structure, Allocation methods (contiguous, linked, indexed), Free-space management (bit vector, linked list, grouping), directory implementation (linear list, hash table), efficiency and performance. **Disk Management:** Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, Disk reliability, Disk formatting, Boot-block, Bad blocks	6

Text book and Reference books:

1. Operating System Concepts Essentials, 9th Edition by Avi Silberschatz, Peter Galvin, Greg Gagne, Wiley Asia Student Edition.
2. Operating Systems: Internals and Design Principles, 5th Edition, William Stallings, Prentice Hall of India.
3. Operating System: A Design-oriented Approach, 1st Edition by Charles Crowley, Irwin Publishing
4. Operating Systems: A Modern Perspective, 2nd Edition by Gary J. Nutt, Addison-Wesley
5. Design of the Unix Operating Systems, 8th Edition by Maurice Bach, Prentice-Hall of India
6. Understanding the Linux Kernel, 3rd Edition, Daniel P. Bovet, Marco Cesati, O'Reilly and Associates

PCC-CS-403: Formal Language and Automata Theory

Contacts: 3L per week **Credits: 3**

Course Outcomes (COs):

After completion of the course, students will be able to:

1. **Design** finite automata to accept a set of strings of a language.
2. For a given language **evaluate** whether the given language is regular or not.
3. **Develop** context free grammars to generate strings of context free language.
4. **Determine** equivalence of languages accepted by Push down Automata and languages generated by context free grammars.
5. **Implement** the hierarchy of formal languages, grammars and machines.
6. **Distinguish** between computability and non-computability and Decidability and undecidability.

Pre-Requisite:

NIL

Detailed Content:

Unit	*Content*	*Hrs/ Unit*
1	Introduction: Alphabet, languages and grammars, productions and derivation, Chomsky hierarchy of languages.	6
2	Regular languages and finite automata: Regular expressions and languages, deterministic finite automata (DFA) and equivalence with regular expressions, nondeterministic finite automata(NFA) and equivalence with DFA, regular grammars and equivalence with finite automata, properties of regular languages, pumping lemma for regular languages, minimization of finite automata)	7
	Context-free languages and pushdown automata: Context-free grammars (CFG) and languages (CFL),Chomsky and Greibach normal forms, nondeterministic pushdown automata (PDA) and equivalence with CFG, parse trees, ambiguity in CFG, pumping lemma for context-free languages, deterministic push down automata, closure properties of CFLs.	
	Context-sensitive languages: Context-sensitive grammars (CSG) and languages, linear bounded automata and equivalence with CSG.	
	Turing machines: The basic model for Turing machines (TM), Turing recognizable(recursively enumerable) and Turing-decidable (recursive)languages and their closure properties, variants of Turing machines, nondeterministic TMs and equivalence with deterministic TMs, unrestricted grammars and equivalence with Turing machines, TMs as enumerators	
	Undecidability: Church-Turing thesis, universal Turing machine, the universal and diagonalization languages, reduction between languages and Rice s theorem, undecidable problems about languages	

Text books and reference books:

1. John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education Asia.
2. Harry R. Lewis and Christos H. Papadimitriou, Elements of the Theory of Computation, Pearson Education Asia.
3. Dexter C. Kozen, Automata and Computability, Undergraduate Texts in Computer Science, Springer.
4. Michael Sipser, Introduction to the Theory of Computation, PWS Publishing.
5. John Martin, Introduction to Languages and The Theory of Computation, TataMcGraw Hill., PEARSON.

6. Dr. R.B.Patel, Theory of Computation, Khanna Publishing House.

BSC-CS-401: Biology

Contacts: 2L per week **Credits: 2**

Course Outcomes (COs):

After completion of the course, students will be able to:

- Demonstrate understanding of core patterns and principles of biology.
- Describe living systems, including their nature, organization and evolution.
- Apply methods of scientific inquiry in biology.
- Describe how human activities affect the living world and the physical environment.
- Describe the flow of energy and matter within and among organisms.
- Explain the historical context of biological discoveries.

Prerequisite:
NIL

Detailed Content:

Module	***Content***	***Hours/ Module***
1	To convey that Biology is as important a scientific discipline as Mathematics, Physics and Chemistry Bring out the fundamental differences between science and engineering by drawing a comparison between eye and camera, Bird flying and aircraft. Mention the most exciting aspect of biology as an independent scientific discipline. Why we need to study biology? Discuss how biological observations of 18th Century that lead to major discoveries. Examples from Brownian motion and the origin of thermodynamics by referring to the original observation of Robert Brown and Julius Mayor. These examples will highlight the fundamental importance of observations in any scientific inquiry.	2
2	The underlying criterion, such as morphological, biochemical or ecological be highlighted. Hierarchy of life forms at phenomenological level. A common thread weaves this hierarchy Classification. Discuss classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure- prokaryotes or eucaryotes. (c) energy and Carbon utilisation -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion – aminotelic, uricoteliec, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. A given organism can come under different category based on classification. Model organisms for the study of biology come from different groups. E.coli, S.cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus.	3
3	To convey that "Genetics is to biology what Newton's laws are to Physical Sciences" Mendel's laws, Concept of segregation and independent assortment. Concept of allele. Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis be taught as a part of genetics. Emphasis to be give not to the mechanics of cell division nor the phases but how genetic material passes from parent to offspring. Concepts of recessiveness and dominance. Concept of mapping of phenotype to genes. Discuss about the single gene disorders in humans. Discuss the concept of complementation using human genetics.	4
4	Biomolecules: To convey that all forms of life have the same building blocks and yet the manifestations are as diverse as one can imagine Molecules of life. In this context discuss monomeric units and polymeric structures. Discuss about sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA.Two carbon units and lipids.	4

5	Enzymes: To convey that without catalysis life would not have existed on earth Enzymology: How to monitor enzyme catalysed reactions. How does an enzyme catalyse reactions? Enzyme classification. Mechanism of enzyme action. Discuss at least two examples. Enzyme kinetics and kinetic parameters. Why should we know these parameters to understand biology? RNA catalysis.	4
6	Information Transfer:The molecular basis of coding and decoding genetic information is universal Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code. Universality and degeneracy of genetic code. Define gene in terms of complementation and recombination.	4
7	Macromolecular analysis: How to analyse biological processes at the reductionist level Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.	5
8	Metabolism: The fundamental principles of energy transactions are the same in physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergoinc reactions. Concept of Keqand its relation to standard free energy. Spontaneity. ATP as an energy currency. This should include the breakdown of glucose to CO2 + H2O (Glycolysis and Krebs cycle) and synthesis of glucose from CO2 and H2O (Photosynthesis). Energy yielding and energy consuming reactions. Concept of Energy charge.	4

Text book and Reference books:

1. Biology: A global approach: Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M, L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson Education Ltd
2. Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H. John Wiley and Sons
3. Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company
4. Molecular Genetics (Second edition), Stent, G. S.; and Calender, R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher
5. Microbiology, Prescott, L.M J.P. Harley and C.A. Klein 1995. 2nd edition Wm, C. Brown Publishers

MC-CS-401: Environmental Sciences

Contacts: 2L per week Credits: 0

Course Outcomes (COs):

At the end of this course, students will demonstrate the ability to

- Acquire fundamental knowledge of different aspects of environment and local, regional and global environmental problems.
- Get the information about ecosystem and also about its functions like Food chain, Ecological pyramids etc.
- Obtain the knowledge about the different types of resources like land, water, mineral and energy and also about the effects of environment by the usage of these resources.
- Gain the knowledge about the ecosystem diversity, its values and also about the importance of the endemic species and different techniques involved in its conservation.
- Gain the knowledge about the different types of pollutions and their control technologies, Waste water treatment, Bio medical waste management etc.,

- Acquire the complete information about EIA- Environmental Impact Assessment, Sustainable developmental activities, environmental policies and regulations, awareness among people about protection of wild life, forest and other natural resources.

Prerequisites:

- Basics of Chemistry

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Basic ideas of environment, basic concepts, man, society & environment, their interrelationship (1L) Mathematics of population growth and associated problems, Importance of population study in environmental engineering, definition of resource, types of resource, renewable, non-renewable, potentially renewable, effect of excessive use vis-à-vis population growth, Sustainable Development. (2L) Materials balance: Steady state conservation system, steady state system with non-conservative pollutants, step function. (1L) Environmental degradation: Natural environmental Hazards like Flood, earthquake, Landslide-causes, effects and control/management; Anthropogenic degradation like Acid rain-cause, effects and control. Nature and scope of Environmental Science and Engineering. (2L)	6
2	Elements of ecology: System, open system, closed system, definition of ecology, species, population, community, definition of ecosystem- components types and function. (1L) Structure and function of the following ecosystem: Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems, Mangrove ecosystem (special reference to Sundarban); Food chain [definition and one example of each food chain], Food web.(2L) Biogeochemical Cycle- definition, significance, flow chart of different cycles with only elementary reaction [Oxygen, carbon, Nitrogen, Phosphate, Sulphur]. (1L) Biodiversity- types, importance, Endemic species, Biodiversity Hot-spot, Threats to biodiversity, Conservation of biodiversity.(2L)	6
3	Atmospheric Composition: Troposphere, Stratosphere, Mesosphere, Thermosphere, Tropopause and Mesopause. (1L) Energy balance: Conductive and Convective heat transfer, radiation heat transfer, simple global temperature model [Earth as a black body, earth as albedo], Problems.(1L) Green house effects: Definition, impact of greenhouse gases on the global climate and consequently on sea water level, agriculture and marine food. Global warming and its consequence, Control of Global warming. Earth's heat budget.(1L) Lapse rate: Ambient lapse rate Adiabatic lapse rate, atmospheric stability, temperature inversion (radiation inversion).(2L) Atmospheric dispersion: Maximum mixing depth, ventilation coefficient, effective stack height, smokestack plumes and Gaussian plume model.(2L) Definition of pollutants and contaminants, Primary and secondary pollutants: emission standard, criteria pollutant. Sources and effect of different air pollutants Suspended particulate matter, oxides of carbon, oxides of nitrogen, oxides of sulphur, particulate, PAN. (2L) Smog, Photochemical smog and London smog. Depletion Ozone layer: CFC, destruction of ozone layer by CFC, impact of other green-house gases, effect of ozone modification. (1L) Standards and control measures: Industrial, commercial and residential air quality standard, control measure (ESP. cyclone separator, bag house, catalytic converter, scrubber (ventury), Statement with brief reference). (1L)	11
4	Hydrosphere, Hydrological cycle and Natural water. Pollutants of water, their origin and effects: Oxygen demanding wastes, pathogens, nutrients, Salts, thermal application, heavy metals, pesticides, volatile organic compounds. (2L) River/Lake/ground water pollution:	9

	River: DO, 5-day BOD test, Seeded BOD test, BOD reaction rate constants, Effect of oxygen demanding wastes on river [deoxygenation, reaeration], COD, Oil, Greases, pH. (2L) Lake: Eutrophication [Definition, source and effect]. (1L) Ground water: Aquifers, hydraulic gradient, ground water flow (Definition only)(1L) Standard and control: Waste water standard [BOD, COD, Oil, Grease], Water Treatment system [coagulation and flocculation, sedimentation and filtration, disinfection, hardness and alkalinity, softening] Waste water treatment system, primary and secondary treatments [Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds] tertiary treatment definition. (2L) Water pollution due to the toxic elements and their biochemical effects: Lead, Mercury, Cadmium, and Arsenic (1L)	
5	Lithosphere; Internal structure of earth, rock and soil (1L) Solid Waste: Municipal, industrial, commercial, agricultural, domestic, pathological and hazardous solid wastes; Recovery and disposal method- Open dumping, Land filling, incineration, composting, recycling. Solid waste management and control (hazardous and biomedical waste).(2L)	3
6	Definition of noise, effect of noise pollution, noise classification [Transport noise, occupational noise, neighbourhood noise] (1L) Definition of noise frequency, noise pressure, noise intensity, noise threshold limit value, equivalent noise level, L10 (18hr Index) ,n Ld.Noise pollution control. (1L)	3
7	Environmental impact assessment, Environmental Audit, Environmental laws and protection act of India, Different international environmental treaty/ agreement/ protocol. (2L)	2

Text book and Reference books:

1. M.P. Poonia & S.C. Sharma, Environmental Studies, Khanna Publishing House (AICTE Recommended Textbook – 2018)
2. Masters, G. M., "Introduction to Environmental Engineering and Science", Prentice-Hall of India Pvt. Ltd., 1991.
3. De, A. K., "Environmental Chemistry", New Age International

PCC-CS-491: Object Oriented Programming Lab

Contacts: 3P per week **Credits: 1.5**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Create** multithreaded programs.
2. **Evaluate** the complexity of procedural language by using the concept of polymorphism, inheritance, abstraction, and encapsulation.
3. **Experiment** any real world problem with object oriented approach and formulate a solution for the same.
4. **Implement and apply** object oriented approach to relate to real world problem.
5. **Understand** and develop graphical user interface using AWT.
6. **Recall** the knowledge of event handling mechanism.

Prerequisites:

- Programming for Problem Solving
- Object Oriented Programming & Java

Detailed Content:

- Implement all problems abiding by features of object oriented programming (Abstraction, Encapsulation, Reusability, Data Hiding, Generalization, and Specialization.)
- Familiarization on object oriented approach of programming: use of class, object, and reference.
- Use of constructor, static, final, array, date, access specifiers.
- Familiarization with String, StringBuffer, ArrayList and LinkedList classes.
- Familiarization on Inheritance and Dynamic Method Dispatch.
- Familiarization on Abstract Class, Interface and Package Java Exception Handling.
- Familiarization on Java IO using Scanner, BufferedReader, PrintWriter. File handling in Java.
- Exploring Java multithreading concept.
- Familiarization on Java Applet, AWT Event Handling.
- Basics of Java Swing: Different Layouts, Event Handling.

Text book and Reference books:

1. Object Oriented Modelling and Design, Rambaugh, James Michael, Blaha, Prentice Hall, India.
2. Object Oriented System Development Ali Bahrami, Mc Graw Hill.
3. The complete reference-Java2, Patrick Naughton, Herbert Schildt, TMH.
4. Core Java For Beginners, R.K Das, VIKAS PUBLISHING.
5. Java How to Program, Deitel and Deitel, 6th Ed. – Pearson.
6. Beginning Java 2 SDK, Ivor Horton's,Wrox.
7. Programming With Java: A Primer, E. Balagurusamy, 3rd Ed., TMH.

PCC-CS-492: Operating System Lab

Contacts: 3P per week Credits: 1.5

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Demonstrate shell programming which include shell scripts and explaining shell syntax (variables, conditions, control structure, and functional commands).
- Execute programs like, creating a new process, creating orphan process and zombie process, synchronizing parent and child process.
- Analyze synchronization of co-operating processes with semaphore (semctl(), semget(), semop(), set semvalue, del semvalue, semaphore p and semaphore v).
- Adapt concept of signals with sending signals, signal interface, and signal handling.
- Apply POSIX threads using pthread_create, pthread_join and pthread_exit.
- Understand Inter-Process Communication (IPC) with use of pipes, message queue etc.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Shell programming**: creating a script, making a script executable, shell syntax (variables, conditions, control structures, functions, commands).	3
2	**Process**: starting new process, replacing a process image, duplicating a process image, waiting for a process, zombie process.	2
3	**Signal**: signal handling, sending signals, signal interface, signal sets.	3
4	**Semaphore**: programming with semaphores (use functions semctl, semget, semop, set_semvalue, del_semvalue, semaphore_p, semaphore_v).	2
5	**POSIX Threads**: programming with pthread functions(viz. pthread_create, pthread_join, pthread_exit, pthread_attr_init, pthread_cancel)	3

6	**Inter-process communication**: pipes(use functions pipe, popen, pclose), named pipes(FIFOs, accessing FIFO)	3

Text and Reference Books:

1. UNIX Shell Programming by Yashavant Kanetkar, BPB Publication
2. UNIX: Concepts and Applications, 4th Edition by Sumitabha Das, McGraw Hill
3. UNIX and Shell Programming by Forouzan & Gilberg

Semester-V

ESC-CS-501: Probability and Statistics

Lecture per week (L – T): 3-0 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Students should be proficient in the application of the laws of logic to mathematical statements.
2. Students should be competent enough to analyze the data based on statistics and probability. This also enables students to make use of data through curve filling and different equations.
3. Prepare students for realization of journal papers outcomes, and expose them to the world of research. Illustrate the current research works and publications of the subjects in different fields adopted by the students as per course curriculum in various journals and literature.
4. Lighten on the latest and modern developments in the research fields. Explain how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals executing the knowledge adopted from the course.
5. An ability to function on multi-disciplinary teams and ability to analyze the local and global impact of computing on individuals, organizations, and society.
6. An understanding of professional, ethical, legal, security and social issues and responsibilities.

Prerequisites:

- Basic Mathematics.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Probability Theory: Introduction to probability concepts, Random experiments, Events, Conditional probability, Independent events, Theorem of Total Probability, Baye's theorem Sample space	5
2	Random variables (RV): Introduction to Random variables, - One dimensional Random Variables, Discrete and Continuous RV- Density and Distribution function of RV, Expectation, Variance, and its properties, Covariance, and Moments. Moment Generating function Special Distributions Binomial and Poisson distributions – Normal distribution, Exponential distributions, Weibull distribution	12
3	Correlation and regression	9

	Two dimensional random variables, Joint distribution and Joint density functions - Marginal, Conditional Distribution and Density functions. Regression and Correlation. – Partial and Multiple Correlation- Multiple Regression.	
4	Test of Significance Testing of hypothesis – Introduction - Types of errors, critical region, procedure of testing hypothesis. Large sample tests - Z test for Single Proportion, Difference of Proportion, Single mean and difference of means. Small sample tests - Student's t-test, F-test - Chi-square test - Goodness of fit - Independence of Attributes	10
5	Design of Experiments Analysis of variance – One and Two way classifications – Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD)	4

Text book and Reference books:

1. Probability and Statistics for engineers and scientists by R.E.Walpole, R.H.Mayers, S.L.Mayers and K.Ye, 9th Edition, Pearson Education (2012).
2. Probability, Statistics and Reliability for Engineers and Scientists by Bilal M. Ayub and Richard H. McCuen, 3rd edition, CRC press (2011).
3. Mathematical Statistics by M. Ray, H S Sharma, and S Chaudhary, RP & Sons Education.
4. Fundamental of Mathematical Statistics by T Veerarajan, Yes Dee Publishing Pvt Ltd.
5. Probability and Statistics for Engineers by R.A.Johnson, Miller & Freund's, 8th edition, Prentice Hall India (2010)

PCC-CS-501: Database Management System

Lecture per week (L – T): 3-0 **Credits: 3**

Course Outcomes (COs):

On completion of the course students will be able to

1. **Describe** the fundamental elements of relational database management systems
2. **Explain** the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
3. **Design** ER-models to represent simple database application scenarios
4. **Convert** the ER-model to relational tables, populate relational database and formulate SQL queries on data.
5. **Improve** the database design by normalization.
6. **Understand** the basic database storage structures and access techniques: file and page organizations, indexing methods including B tree, and hashing.

Prerequisites:

N/A

Detailed Content:

Unit	Content	Hrs/ Unit
1	**Database system architecture:** Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). **Data models:** Entity-relationship model, network model, relational	9

	and object oriented data models, integrity constraints, data manipulation operations.	
2	**Relational query languages:** Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server. **Relational database design:** Domain and data dependency, Armstrong's axioms, Normal forms, Dependency preservation, Lossless design. **Query processing and optimization:** Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms.	13
3	**Storage strategies**: Indices, B-trees, hashing.	3
4.	**Transaction processing:** Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp based schedulers, Multi version and optimistic Concurrency Control schemes, Database recovery.	5
5	**Database Security:** Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection.	3
6	**Advanced topics:** Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.	3

Text book and Reference books:

1. "Database System Concepts", 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill.
2. "Principles of Database and Knowledge – Base Systems", Vol 1 by J. D. Ullman, Computer Science Press.
3. Database Management Systems, R.P. Mahapatra, Khanna Publishing House, New Delhi (AICTE Recommended Textbook – 2018)
4. "Fundamentals of Database Systems" , 5th Edition by R. Elmasri and S. Navathe, Pearson Education
5. "Foundations of Databases", Reprint by Serge Abiteboul, Richard Hull, Victor Vianu, Addison-Wesley.

PCC-CS-502: Design and Analysis of Algorithm

Lecture per week (L – T): 3-1 **Credits: 4**

Course Outcomes (COs):

At the end of the course, the students will be able to:

- **Prove** the correctness and analyse the running time of the basic algorithms for those classic problems in various domains.
- **Apply** the algorithms and design techniques to solve problems.
- **Analyze** the complexities of various problems in different domains.
- **Apply** design and development principles in the construction of software systems of varying complexity.
- **Design** and development principles in the construction of software systems of varying complexity.
- **Adapt** current techniques, skills, and tools necessary for computing practice.

Prerequisites:

- Basics of C programming

- Data Structure and Algorithms

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Models of computation:** RAM, TM etc. time and space complexity **Asymptotic Notation Big**-O, omega, theta etc.; finding time complexity of well-known algorithms like- heapsort, search algorithm etc. **Algorithm Design techniques** Recursion- Definition, Use, Limitations, Examples: Hanoi problem. Tail Recursion	7
2	**Divide and Conquer** Basic method, use, Examples: Merge sort, Quick Sort, Binary Search, **Dynamic Programming** Basic method, use, Examples: matrix-chain multiplication, All pair shortest paths, single-source shortest path, Travelling Salesman problem	8
3	**Branch and Bound** : Basic method, use, Examples: The 15-puzzle problem **Backtracking :** Basic method, use, Examples: Eight queens problem, Graph coloring problem, Hamiltonian problem	6
4	**Greedy Method :** Basic method, use, Examples: Knapsack problem, Job sequencing with deadlines, minimum spanning tree(Prim's and Kruskal's algorithms) **Lower Bound Theory:** Bounds on sorting and sorting techniques using partial and total orders. **Disjoint Set Manipulation:** Set manipulation algorithm like UNION-FIND, union by rank, Path compression	7
5	**Properties of graphs and graph traversal algorithms :** BFS and DFS **Matrix manipulation algorithms:** Different types of algorithms and solution of simultaneous equations, DFT & FFT algorithm; integer multiplication Schemes	6
6	**Notion of NP-completeness:** P class, NP-hard class, NP-complete class, Circuit Satisfiability problem, Clique Decision Problem. **Approximation algorithms:** Necessity of approximation scheme, performance guarantee, Polynomial time approximation schemes: 0/1 knapsack Problem	6

Text book and Reference books:

1. A.Aho, J.Hopcroft and J.Ullman "The Design and Analysis of algorithms"
2. D.E.Knuth "The Art of Computer Programming", Vol. I & Vol.2
3. Horowitz Ellis, Sahani Sartaz, R. Sanguthevar "Fundamentals of Computer Algorithms".
4. Goodman: Introduction to Design and Analysis Of Algorithms TMH
5. K.Mehlhorn , "Data Structures and algorithms- Vol. I & Vol. 2"
6. S.Baase "Computer algorithms"
7. E.Horowitz and Shani "Fundamentals of Computer algorithms"

8. E.M.Reingold, J.Nievergelt and N.Deo- "Combinational algorithms- Theory and Practice", Prentice Hall, 1997
9. A. Borodin and I.Munro, "The computational complexity of Algebraic and Numeric problems"

PCC-CS-503: Data Communication and Networks

Lecture per week (L – T): 3-0 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design and investigate** why network needs flow control and error control techniques.
2. **Evaluate** the performance of the different routing protocol (RIP, OSPF) based on routing cost, convergence rate and complexity to find the shortest path.
3. **Analyze** the pieces of hardware (hub, bridge, switch, router) to make networks more efficient, faster, more secure, easier to use, able to transmit several simultaneous messages, and able to interconnect with other networks.
4. **Demonstrate** different LLC protocols, Internet Protocol, and usage of the IP address and subnet mask to setup a network.
5. **Understand** various techniques (open loop and close loop) used for congestion control and quality of service (traffic scheduling and shaping).
6. **Identify and remember** importance of existing protocols (DNS, DHCP, FTP, WWW, HTTP) running in application layer.

Prerequisites:

- Programming for Problem Solving
- Data Structure and Algorithms
- Computer Organization & Architecture

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Introduction:** Data communications, Direction of data flow - Simplex, Half-duplex, Full-duplex, Topology –Bus, Ring, Mesh. Star & Hybrid, Types of Network - LAN, MAN 7 WAN, Protocols, and Reference models – OSI & TCP/IP reference model & comparative study.	5
2	**Physical Layer:** Transmission media - Guided & Unguided, Switching – Circuit, Packet & Message, Telephone Network, Network Devices: Repeaters, Hubs, Bridges, Switches, Router and Gateway. **Data link Layer:** Types of Errors, Error Detection – Parity, CRC & Checksum, Error Correction – Hamming Code	6
3	**Data Link Layer and MAC Sublayer**: Flow Control – Stop-n-Wait & Sliding Window Protocol, ARQ Techniques – Stop-n-Wait, Go-Back- N & Selective Repeat, Framing, Bit & Byte Oriented Protocol, HDLC, Point to Point Protocol (PPP), Token Ring, FDDI and Ethernet Protocols, Reservation, Polling, Multiple access protocols - Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA.	8
4	**Network Layer**: Internet Protocol (IP), IPv4 vs IPv6, ARP & RARP, IP Addressing – Classful & Classless, Subnetting, VLSM, CIDR. Routing - Techniques, Static, Dynamic & Default Routing, Unicast Routing Protocols - RIP, OSPF, BGP.	5

5	**Transport Layer**: Process to Process delivery; UDP; TCP; Congestion Control - Open Loop, Closed Loop, Quality of service, Techniques to improve QoS - Leaky bucket & Token bucket algorithm.	4
6	**Application Layer Protocols**: DNS, SMTP, FTP & DHCP. **Modern Topic**: Introduction to wireless LAN and Bluetooth, Mobile IP, Mobile TCP.	3

Text book and Reference books:

1. Computer Networks (4th Ed.) – A. S. Tanenbaum –Pearson Education/PHI
2. Data Communications and Networking (3rd Ed.) – B. A. Forouzan –TMH
3. Data and Computer Communications (5th Ed.) – W. Stallings –PHI/ Pearson Education
4. Computer Networking -A top down approach featuring the internet– Kurose and Rose –Pearson Education
5. Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.) – Comer –Pearson Education/PHI

PCC-CS-504: Cryptography

Lecture per week (L – T): 3-1 **Credits: 4**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Formulate** cryptographic algorithms for information security.
2. **Evaluate** different encryption algorithms and modes.
3. **Analyze** security of the in-built cryptosystems.
4. **Apply** principles of public key cryptosystems, hash functions and digital signature.
5. **Remember** fundamental knowledge on finite fields and number theory.
6. **Understand** authentication schemes for identity and membership authorization.

Prerequisites:

- Linear Algebra
- Mathematics I
- Discrete Mathematics

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Introduction to Security:** Introduction to security attacks, Confidentiality, Integrity & Availability – Authentication, Authorization & Non-Repudiation – Introduction to Plain Text, Cipher Text, Encryption and Decryption Techniques, Secure Key, symmetric cipher model, substitution techniques. Caesar cipher, mono-alphabetic cipher, poly-alphabetic cipher, transposition techniques.	6
2	**Finite fields and number theory**: Groups, rings, fields, Euclid's algorithm, Finite field, polynomial arithmetic, Prime numbers, testing for primality, Chinese remainder theorem, Fermat's and Euler's theorem.	7
3	**Symmetric Encryption:** Block cipher, Stream cipher - Data Encryption Standard (DES) - Cipher Block Chaining (CBC) – Multiple Encryption DES - International Data Encryption Algorithm (IDEA) - Advanced Encryption Standard (AES).	5

4	**Asymmetric Encryption**: symmetric key generation techniques – Applications of asymmetric encryption methods – RSA, Elliptic Curve Cryptography – Homomorphic encryption.	5
5	**Digital Signature**: Digital signature standards - Secure One-time Signatures - Application of Digital Signatures – Diffie-Hellman Key Exchange - Elliptic Curve Digital Signature algorithm.	5
6	**Hashing and Message Digests**: Cryptographic Hash Functions- Applications- Simple hash functions and features for ensuring security – Hash functions based on Cipher Block Chaining- Secure Hash Algorithm (SHA) - Message Digest - MD5.	6
7	**Message Authentication**: Authentication Systems – Password and Address – Security Handshake Drawbacks - Authentication Standards – Kerberos- PKI Trust Models -Message Authentication Codes (MAC) – Security features- MAC based on Hash Functions - MAC based on Block Ciphers.	6

Text book and Reference books:

1. D. R. Stinson, Cryptography: Theory and Practice, 3rd Ed. Boca Raton, FL: Chapman & Hall/CRC, 2005.
2. W. Stallings, Cryptography and Network Security: Principles and Practice, 7th Ed. Pearson Publishers, 2017.
3. J. H. Silverman, A Friendly Introduction to Number Theory, 4th Ed. Boston: Pearson, 2012.
4. C. Kaufman, R. Perlman, and M. Speciner, Network Security: Private Communication in a Public World, 2nd Ed. United States: Prentice Hall PTR, 2002.
5. Atul Kahate, "Cryptography and Network Security", 2nd Edition, 2009, McGraw Hill Education India Pvt Ltd.

PCC-CS-505: Malware Analysis

Contacts: 2L per week **Credits: 2**

Course Outcomes (COs):

At the end of this course, students will demonstrate the ability to

- Possess the skills necessary to carry out independent analysis of modern malware samples using both static and dynamic analysis techniques.
- Identify and analyse various malware types by static, dynamic analysis and reverse engineering.
- Have an intimate understanding of executable formats, Windows internals and APIs, and malware analysis techniques.
- Extract investigative leads from host and network-based indicators associated with a malicious program.
- Apply techniques and concepts to unpack, extract, decrypt, or bypass new anti-analysis techniques in future malware samples.
- Achieve proficiency with industry standard tools including ProcMon, CFF Explorer, ProcExplore, BinText, FileAlyzer, OllyDbg etc

Prerequisite:

NIL

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Malware taxonomy - Malware threats - Malware analysis methodologies - Legal	4

	considerations - Identifying and protecting against malware - Malware hiding places - Collecting malware from live system - Identifying malware in dead system Malware Analysis Environment : Virtual machine - Real systems - Malware analysis tools ProcMon, CFF Explorer, ProcExplore, BinText, FileAlyzer, OllyDbg	
2	Static Analysis: Detailed file analysis -Database of file hashes. Identifying file compile date Identifying packing/ obfuscation methods - Strings analysis - File signature analysis - Local and online malware scanning -Identifying file dependencies.	4
3	Dynamic Analysis: System baselining - Host integrity - Monitor - Installation monitor - Process monitor - File monitor - Registry analysis/ monitoring - Network traffic monitoring/ ana lysis - Port monitor – DNS monitoring/ resolution -Simulating internet services	4
4	Code Analysis: Reverse engineering malicious code - Identifying malware passwords - Bypassing authentication - Assembly level computing Standard x86 instructions, Introduction to IDA, Olly Dbg, Advanced malware analysis Virus, Trojan. Parsing Basic analysis of an APK	4
5	Malicious Document Analysis: PDF and Microsoft Office document structures - PDF and office document vulnerabilities - Malware extraction and analysis tools - Analysis of malicious documents	4
6	Malware Challenges: Virtual environment – Live internet connection – Real, fake, and virtual services –Anti-debug and anti-forensic malware	3
7	Mobile Malware Analysis: Need for mobile application penetration testing testing methodology Android and iOS Vulnerabilities - Exploit Prevention - Handheld Exploitation- Android Root Spreading and Distribution Android Debugging	5

Text book and Reference books:

1. M. Sikorski and A. Honig, Practical Malware Analysis: The Hands-on Guide to Dissecting Malicious Software. San Francisco: No Starch Press San Francisco, CA, 2012.
2. M. H. Ligh, S. Adair, and B. Hartstein, Cookbook and DVD: Tools and Techniques for Fighting Malicious Code. Indianapolis, IN: Wiley, John Sons, 2010.
3. K. Dunham and S. Abu-Nimeh, Mobile Malware Attacks and Defense. Washington, DC, United States: Syngress Media,U.S., 2008.
4. C. H. Malin, J. M. Aquilina, and E. Casey, Malware Forensics Field Guide for Windows Systems: Digital Forensics Field Guides, R. Maxwell, Ed. Waltham, MA: Syngress Media,U.S., 2012.
5. B. Dang, A. Gazet, E. Bachaalany, and S. Josse, Practical Reverse Engineering: X86, X64, arm, Windows Kernel, Reversing Tools, and Obfuscation. United States: Wiley, 2014.
6. C. Eagle, The IDAPro Book: The Unofficial Guide to the world's most popular Disassembler, 2nd Ed. San Francisco: No Starch Press San Francisco, CA, 2011.

PCC-CS-591: Database Management System Lab

Labs per week: 3 Credits: 1.5

Course Outcomes (COs):

At the end of the course the students are able to:

1. **Apply** the basic concepts of Database Systems and Applications.
2. **Define** the basics of SQL and construct queries using SQL in database creation and interaction.
3. **Design** a commercial relational database system (Oracle, MySQL) by writing SQL using the system.
4. **Analyze** and Select storage and recovery techniques of database system.

5. **Understand** various advanced queries execution such as relational constraints, joins, set operations, aggregate functions, trigger, views and embedded SQL.
6. **Construct** various software to design and build ER Diagrams, UML, Flow chart for related database systems.

Prerequisites:

1. Oracle-SQL
2. Visual Basic 6.0

Detailed Content:

Laboratory Experiments:

Structured Query Language

1. Creating Database

- Creating a Database
- Creating a Table
- Specifying Relational Data Types
- Specifying Constraints
- Creating Indexes

2. Table and Record Handling

- INSERT statement
- Using SELECT and INSERT together
- DELETE, UPDATE, TRUNCATE statements
- DROP, ALTER statements

3. Retrieving Data from a Database

- The SELECT statement
- Using the WHERE clause
- Using Logical Operators in the WHERE clause
  Using IN, BETWEEN, LIKE , ORDER BY, GROUP BY and HAVING Clause
- Using Aggregate Functions
- Combining Tables Using JOINS
- Subqueries

4. Database Management

- Creating Views
- Creating Column Aliases
- Creating Database Users
- Using GRANT and REVOKE

5. Cursors in Oracle PL / SQL
6. Writing Oracle PL / SQL Stored Procedures

PCC-CS-592: Design and Analysis of Algorithm Lab

Labs per week:3 Credits: 1.5

Course Outcomes (COs):

On completion of this course, the students are able to:

1. **Solve** problems by applying appropriate algorithms.
2. **Analyze** the efficiency of various algorithms.
3. **Apply** techniques of stacks and queues to solve problems.
4. **Develop** a program that can be solved in many ways using different techniques.
5. **Identify** and evaluate complex problems using principles of mathematics and engineering science
6. **Design** a novel solution for real life problem

Prerequisites:

- Basics of C programming
- Data Structure and Algorithms

Lab Experiments List:

Design, develop and implement the specified algorithms for the following problems using C/C++ Language in LINUX environment.
1. Write a C/C++ program to sort the elements by using quick sort method.
2. Write a C/C++ program to sort the elements by using merge sort method.
3. Obtain the Topological ordering of vertices in a given digraph.
4. From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
5. Implement 0/1 Knapsack problem using Dynamic Programming.
6. Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.
7. Find Minimum Cost Spanning Tree of a given undirected graph using Prim's algorithm.
8. a. Compute the transitive closure of a given directed graph using Warshall's algorithm.
b. Implement All-Pairs Shortest Paths Problem using Floyd's algorithm.
9. a. Print all the nodes reachable from a given starting node in a digraph using BFS method.
b. Check whether a given graph is connected or not using DFS method.
10. Implement N Queen's problem using Back Tracking

Text Books:

1. Anany Levitin: "Introduction to the Design and Analysis of Algorithms", Pearson Education, Delhi, 2nd Edition,2007, ISBN: 9780321358288.
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran: "Fundamentals of Computer Algorithms", Universities Press, Hyderabad, 2nd Edition, 2007, ISBN-10: 8173716129.

E-Resources:

1. http://cs.gmu.edu/~pwiegand/cs483-Spring06/lecturenotes/cs483-l1pf.pdf
2. http://www.cs.cornell.edu/~kozen/papers/daa.pdf

PCC-CS-593: Data Communication and Networks Lab

Labs per week: 3 **Credits: 1.5**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design** an application to execute command remotely using socket programming.

2. **Evaluate** file transfer application using socket programming.
3. **Analyze** the hardware (hub, bridge, switch, router) to make networks more efficient, faster, more secure, easier to use, able to transmit several simultaneous messages, and able to interconnect with other networks.
4. **Implement** error-control mechanism for data transmission.
5. **Understand** the concepts of NIC installation and configuration.
6. **Remember** to gather network information using socket programming.

Prerequisites:

- Programming for Problem Solving
- Data Structure and Algorithms
- Object Oriented Programming & Java
- Data Communication and Networks

Detailed Content:

1. NIC Installation & Configuration
2. TCP/UDP Socket Programming – Introduction
3. Sockets – Operation, Socket types, Domains, Closing Sockets
4. Client/Server Models - Usage
5. Connection Based Services - Client and Server actions
6. Connectionless Services - Client and Server actions
7. Access Network Database - Host Information, Network Information, Protocol Information
8. Implement Multicasting / Broadcasting socket I/O.
9. Implement ARQ techniques.

Text book and Reference books:

1. Computer Networks (4th Ed.) – A. S. Tanenbaum –Pearson Education/PHI
2. Data Communications and Networking (3rd Ed.) – B. A. Forouzan –TMH
3. Data and Computer Communications (5th Ed.) – W. Stallings –PHI/ Pearson Education
4. Computer Networking -A top down approach featuring the internet– Kurose and Rose – Pearson Education
5. Internetworking with TCP/IP, vol. 1, 2, 3(4th Ed.) – Comer –Pearson Education/PHI

Semester-VI

PCC-CS-601: Network Security

Lecture per week (L): 3 **Credits: 3**

Course Outcomes (COs):

After studying this course, students will be able to:

1. **Identify** some of the factors driving the need for network security
2. **Analyse** and classify particular examples of attacks
3. **Assess** the terms vulnerability, threat and attack
4. **Analyse** physical points of vulnerability in simple networks
5. **Compare** and contrast symmetric and asymmetric encryption systems and their vulnerability to attack, and explain the characteristics of hybrid systems

6. **Create** new security mechanisms

Prerequisites:

1. Computer Network Fundamentals
2. Data Structure and Algorithms
3. Basics of Operating System

Detailed Content:

Unit	*Content*	*Hrs. / Unit*
1.	Attacks on Computers & Computer Security - Introduction, Need for Security, Security approaches, Principles of Security, Types of attack.	5
2.	Cryptography: Concepts & Techniques Introduction, Plaintext & Cipher text, Substitution Techniques, Transposition Techniques, Encryption & Decryption, Symmetric & Asymmetric key Cryptography, Key Range & Key Size	6
3.	Symmetric Key Algorithm - Introduction, Algorithm types & Modes, Overview of Symmetric Key Cryptography, DES(Data Encryption Standard) algorithm, IDEA(International Data Encryption Algorithm) algorithm, RC5 (Rivest Cipher 5) algorithm.	6
4.	Asymmetric Key Algorithm, Digital Signature and RSA - Introduction, Overview of Asymmetric key Cryptography, RSA algorithm, Symmetric & Asymmetric key Cryptography together, Digital Signature, Basic concepts of Message Digest and Hash Function (Algorithms on Message Digest and Hash function not required).	5
5.	Internet Security Protocols, User Authentication - Basic Concepts, SSL protocol, Authentication Basics, Password, Authentication Token, and Certificate based Authentication, Biometric Authentication.	6
6.	Electronic Mail Security - Basics of mail security, Pretty Good Privacy, S/MIME. Firewall - Introduction, Types of firewall, Firewall Configurations, DMZ Network	4

Text book and Reference books:

1. "Cryptography and Network Security", William Stallings, 2nd Edition, Pearson Education Asia
2. "Cryptography and Network Security" by V.K. Jain, Khanna Publishing House,
3. "Network Security private communication in a public world", C. Kaufman, R. Perlman and M. Speciner, Pearson
4. Cryptography & Network Security: Atul Kahate, TMH.
5. "Network Security Essentials: Applications and Standards" by William Stallings, Pearson.
6. "Designing Network Security", MerikeKaeo, 2nd Edition, Pearson Books
7. "Building Internet Firewalls", Elizabeth D. Zwicky, Simon Cooper, D. Brent Chapman, 2nd Edition, Oreilly.
8. "Practical Unix & Internet Security", Simson Garfinkel, Gene Spafford, Alan Schwartz, 3rd Edition, Oreilly

PCC-CS-602: Ethical Hacking

Lecture per week: 2 Credits: 2

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Formulate** reverse engineering process.
2. **Evaluate** how social engineering can be done by attacker to gain access of useful and sensitive information about confidential data.
3. **Analyze** various types of attacks, attackers and security threats and vulnerabilities present in computer system.
4. **Apply** tools and techniques to face the domain of ethical hacking and ethical responsibilities.
5. **Remember** cryptography and basics of web application attacks.
6. **Understand** fundamentals of ethical hacking and penetration testing.

Prerequisites:

- Operating System
- Data Communication and Networks
- Cryptography

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Ethical Hacking: Introduction, Networking & Basics, Foot Printing, Google Hacking, Scanning, Windows Hacking, Linux Hacking, Trojans & Backdoors, Virus & Worms.	4
2	Proxy & Packet Filtering, Denial of Service, Sniffer, Social Engineering System and Network Vulnerability and Threats to Security, Various types of attack and the various types of attackers in the context of the vulnerabilities associated with computer and information systems and networks Physical Security, Steganography.	6
3	Cryptography, Wireless Hacking, Firewall & Honeypots, IDS & IPS, Vulnerability, Penetration Testing, Session Hijacking, Hacking Web Servers, SQL Injection, Cross Site Scripting, Exploit Writing, Buffer Overflow.	5
4	Reverse Engineering, Email Hacking, Incident Handling & Response, Bluetooth Hacking, Mobile Phone Hacking Basic ethical hacking tools and usage of these tools in a professional environment. Legal, professional and ethical issues likely to face the domain of ethical hacking. Ethical responsibilities, professional integrity and making appropriate use of the tools and techniques associated with ethical hacking.	7

Text book and Reference books:

1. Georgia Weidman, Penetration Testing: A Hands on Introduction to Hacking, No Startch Press, First Edition 2014.
2. Rafay Baloch, Ethical Hacking and Penetration Testing Guide, CRC Press, 2015.
3. Dr. Patrick Engebretson, The Basics of Hacking and Penetration Testing, Syngress Publications Elseveir, 2013.
4. Michael T. Simpson, Kent Backman, James Corley, Hands-On Ethical Hacking and Network Defense, 2016
5. Steven DeFino, Barry Kaufman, Nick Valenteen, Official Certified Ethical Hacker Review Guide, 2015
6. Abhinav Ojha, Beginners Guide to Ethical Hacking and Cyber Security, Notion Press; 1st edition.

PCC-CS-603: Artificial Intelligence

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand the various searching techniques, constraint satisfaction problem and example problems-game playing techniques.
2. Apply these techniques in applications which involve perception, reasoning and learning.
3. Explain the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals.
4. Acquire the knowledge of real-world Knowledge representation.
5. Analyse and design a real-world problem for implementation and understand the dynamic behaviour of a system.
6. Use different machine learning techniques to design AI machine and enveloping applications for real world problems.

Prerequisites:

1. Data Structure & Algorithm
2. Probability

Detailed Content:

MODULE NO	*CONTENT*	*HOURS/ MODULE*
1	Introduction: Objective, scope and outcome of the course	1
2	Meaning and definition of artificial intelligence, Physical Symbol System Hypothesis, production systems, Characteristics of production systems; Breadth first search and depth first search techniques. Heuristic search Techniques: Hill Climbing, Iterative deepening DFS, bidirectional search. Analysis of search methods. A* algorithm, and their analysis. Introduction to Genetic Algorithms.	6
3	Knowledge Representation, Problems in representing knowledge, knowledge representation using propositional and predicate logic, logical consequences, syntax and semantics of an expression, semantic Tableau. Forward and backward reasoning. Proof methods, substitution and unification, conversion to clausal form, normal forms, resolution, refutation, deduction, theorem proving, in referencing, monotonic and non-monotonic reasoning. Introduction to prolog.	8
4	Network-based representation and reasoning, Semantic networks, Conceptual Graphs, frames. Description logic (DL), concept language, reasoning using DL. Conceptual dependencies (CD), scripts, reasoning using CD. Introduction to natural language processing.	6
5	Adversarial search and Game theory, classification of games, game playing strategies, prisoner's Dilemma. Game playing techniques, minimax procedure, alpha-beta cut-offs. Complexity of alpha-beta search. Automated planning, classical planning problem, forward planning, partial order planning, planning with proposal logic, hierarchical task planning, multiagent planning	7
6	Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets. Probabilistic reasoning, Bayes theorem, construction of Bayesian networks, belief propagation. Markov processes and Hidden Markov models	6
	Total	34

Text/ Reference Books:

1. Artificial Intelligence: Elaine Rich, Kevin Knight, Mc-Graw Hill.
2. Introduction to AI & Expert System: Dan W. Patterson, PHI.
3. Artificial Intelligence by Luger (Pearson Education)
4. Russel & Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.

HSMC-CS-601: Human Values and Professional Ethics

Contacts: 2L per week **Credits: 2**

Course Outcomes (COs):

At the end of this course, students will demonstrate the ability to

- Understand Engineering and Technology as social and professional activities.
- Demonstrate the effects of technological growth, crisis of global resources and possible way out.
- Understand knowledge development for ethics in profession.
- Dissect development of professional and human values.
- Explain development of inner core and initiation of lifelong learning and survival process in professional arena.
- Demonstrate development of Moral character and thought of development of the country.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Science, Technology and Engineering as knowledge and as Social and Professional Activities ***Effects of Technological Growth:*** Rapid Technological growth and depletion of resources, Reports of the Club of Rome. Limits of growth: sustainable development. Energy Crisis: Renewable Energy Resources. Environmental degradation and pollution. Eco-friendly Technologies. Environmental Regulations, Environmental Ethics. Appropriate Technology Movement of Schumacher; later developments. Technology and developing notions. Problems of Technology transfer, Technology assessment impact analysis. Human Operator in Engineering projects and industries. Problems of man, machine, interaction, Impact of assembly line and automation. Human centered Technology.	10
2	***Ethics of Profession:*** Engineering profession: Ethical issues in Engineering practice, Conflicts between business demands and professional ideals. Social and ethical responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.	8
3	***Profession and Human Values:*** Values Crisis in contemporary society. Nature of values: Value Spectrum of a good life. Psychological values: Integrated personality; mental health. Societal values: The modern search for a good society, justice, democracy, secularism, rule of law, values in Indian Constitution. Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity. Moral and ethical values: Nature of moral judgments; canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility.	10

Text book and Reference books:

1. Stephen H Unger, Controlling Technology: Ethics and the Responsible Engineers, John Wiley & Sons, New York 1994 (2^{nd} Ed)

2. Deborah Johnson, Ethical Issues in Engineering, Prentice Hall, Englewood Cliffs, New Jersey 1991.
3. A N Tripathi, Human values in the Engineering Profession, Monograph published by IIM, Calcutta 1996

PEC-CS-601A: Computer Graphics

Contacts: 3L per week **Credits: 3**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- **Outline** computer graphics system, display devices and various application areas of graphics.
- **Develop** scan conversion algorithms for line, circle and ellipse with examples.
- **Demonstrate** and **illustrate** 2D and 3D transformation operations such as translation, rotation, scaling, etc.
- **Analyze** and **model** any kind of 3D objects using viewing, clipping and projection techniques.
- **Apply** various curve and surface representation methods such as B-Spline, Bezier, etc.
- **Demonstrate** and **discuss** various hidden surface removal algorithms, and lighting and shading models.

Prerequisites:

- Basic Mathematics
- Design and Analysis of Algorithms

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction to computer graphics & graphics systems: Overview of computer graphics, representing pictures, preparing, presenting & interacting with pictures for presentations; Visualization & image processing; RGB color model, direct coding, lookup table; storage tube graphics display, Raster scan display, 3D viewing devices, Plotters, printers, digitizers, Light pens etc.; Active & Passive graphics devices; Computer graphics software.	6
2	Scan conversion: Points & lines, Line drawing algorithms; DDA algorithm, Bresenham's line algorithm, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, fill algorithm, boundary fill algorithm, flood fill algorithm.	8
3	2D transformation & viewing: Basic transformations: translation, rotation, scaling; Matrix representations & homogeneous coordinates, transformations between coordinate systems; reflection shear; Transformation of points, lines, parallel lines, intersecting lines. Viewing pipeline, Window to view port co-ordinate transformation, clipping operations, point clipping, line clipping, clipping circles, polygons & ellipse. Cohen and Sutherland line clipping, Sutherland-Hodgeman Polygon clipping, Cyrus-Beck clipping method.	9
4	3D transformation & viewing: 3D transformations: translation, rotation, scaling & other transformations. Rotation about an arbitrary axis in space, reflection through an arbitrary plane; general parallel projection transformation; clipping, view port clipping, 3D viewing.	5
5	Curves: Curve representation, surfaces, designs, Bezier curves, B-spline curves, end conditions for periodic B-spline curves, rational B-spline curves. Hidden surfaces: Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Painter's algorithm, scan-line algorithm; Hidden line elimination, wire frame	6

	methods , fractal - geometry.	
6	Color & shading models: Light & color model; interpolative shading model; Texture.	2

Text book and Reference books:

1. Hearn, Baker – "Computer Graphics (C version 2nd Ed.)" – Pearson education.
2. Ghosh – "Computer Graphics & Multimedia" – Penram.
3. Z. Xiang, R. Plastock – "Schaum's outlines Computer Graphics (2nd Ed.)" – TMH
4. D. F. Rogers, J. A. Adams – "Mathematical Elements for Computer Graphics (2nd Ed.)" – TMH

PEC-CS-601B: Internet Technology

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Define the concepts of networking and internet.
2. Explain the features of TCP/IP and Routing Protocol and application of VOIP Technology and Multimedia and Threats.
3. Illustrate the concepts of Web design languages like HTML, Perl, Java Script and java applet and create cookies.
4. Differentiate the concept of Java socket and Java RMI (Client Server Programming).
5. Explain the concept of Multimedia Applications, Search Engine and Web Crawler.
6. Design a dynamic web page using the concept of Languages.

Prerequisites:

- Knowledge of Programming Language
- Computer Networks

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction: Overview, Network of Networks, Intranet, Extranet and Internet. World Wide Web: Domain and Sub domain, Address Resolution, DNS, Telnet, FTP, HTTP. Review of TCP/IP : Features, Segment, Three-Way Handshaking, Flow Control, Error Control, Congestion control, IP Datagram, IPv4 and IPv6. IP Subnetting and addressing : Classful and Classless Addressing, Subnetting.NAT, IP masquerading, IP tables. Internet Routing Protocol : Routing -Intra and Inter Domain Routing, Unicast and Multicast Routing, Broadcast. Electronic Mail : POP3, SMTP.	8
2	HTML : Introduction, Editors, Elements, Attributes, Heading, Paragraph. Formatting, Link, Head, Table, List, Block, Layout, CSS.Form, Iframe, Colors, Colorname, Colorvalue. Image Maps :	10

	Map, area, attributes of image area. Extensible Markup Language (XML) : Introduction, Tree, Syntax, Elements, Attributes, Validation, Viewing. XHTML in brief. CGI Scripts : Introduction, Environment Variable, GET and POST Methods.	
3	PERL : Introduction, Variable, Condition, Loop, Array, Implementing data structure, Hash, String, Regular Expression, Filehandling, I/O handling. JavaScript : Basics, Statements, comments, variable, comparison, condition, switch, loop, break. Object – string, array, Boolean, reg-ex. Function, Errors, Validation. Cookies : Definition of cookies, Create and Store a cookie with example Java Applets: Container Class, Components, Applet Life Cycle, Update method; Parameter passing applet, Applications.	10
4	Client-Server programming In Java : Java Socket, Java RMI. Threats : Malicious code-viruses, Trojan horses, worms; eavesdropping, spoofing, modification, denial of service attacks. Network security techniques : Password and Authentication; VPN, IP Security, security in electronic transaction, Secure Socket Layer (SSL), SecureShell (SSH). Firewall : Introduction, Packet filtering, Stateful, Application layer, Proxy.	6
5	Internet Telephony : Introduction, VoIP. Multimedia Applications : Multimedia over IP: RSVP, RTP, RTCP and RTSP. Streaming media, Codec and Plugins, IPTV. Search Engine and Web Crawler : Definition, Meta data, Web Crawler, Indexing, Page rank, overview of SEO	6

Text book and Reference books:

1. Web Technology: A Developer's Perspective, N.P. Gopalan and J. Akilandeswari, PHI Learning, Delhi, 2013.
2. Internetworking Technologies, An Engineering Perspective, Rahul Banerjee, PHI Learning, Delhi, 2011.

PEC-CS-601 C: IoT Application and Design

Lecture per week: 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

- Understand the application areas of IOT.
- Analyse basic protocols in wireless sensor network.
- Understand building blocks of Internet of Things and characteristics.

- Apply IoT in Industrial and Commercial Building Automation and Real World Design Constraints.
- Design IoT applications in different domain and be able to analyse their performance.
- Create basic IoT applications on embedded platform.

Prerequisites:

- Data communication and Network

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Introduction to IoT** Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs	4
2	**IoT & M2M** Machine to Machine, Difference between IoT and M2M, Software define Network	4
3	**Network & Communication aspects** Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination	6
4	**Challenges in IoT** Design challenges, Development challenges, Security challenges, Other challenges	5
5	**Domain specific applications of IoT** Home automation, Industry applications, Surveillance applications, Other IoT applications	6
6	**Developing IoTs** Introduction to Python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python	5

Text book and Reference books:

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach"
2. Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice".
3. Matt Richardson & Shawn Wallace, Getting Started with Raspberry Pi . O'Reilly (SPD), 2014.
4. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wileypublication, 1st Edition, November 2013.
5. Jeeva Jose, Internet of Things, Khanna Publishing House, New Delhi (AICTE Recommended – 2018)
6. Michale Miller, "The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World", PearsonEducation
7. Hanes David ,Salgueiro Gonzalo, Grossetete Patrick, Barton Rob ,"IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things" , PearsonEducation
8. RMD SundaramShriram, K Vasudevan, Abhishek S Nagarajan,"Internet of Things" ,Wiley publication,

PEC-CS-601D: Graph Theory

Lecture per week : 3 Credits: 3

Course Outcomes (COs):

Upon completion of this course, the students should be able to

1. **Understand** the various types of graph Algorithms and graph theory properties.
2. **Analyse** the NP – complete problems.
3. **Distinguish** the features of the various tree and matching algorithms
4. **Appreciate** the applications of digraphs and graph flow.
5. **Understand** the linear programming principles and its conversion.
6. **Apply** suitable graph model and algorithm for solving applications.

Prerequisites:

1. Mathematical proof technique (induction, proof by contradiction)
2. Linear algebra (determinants, eigenvalues).

Detailed Content:

Unit	Content	Hrs/Unit
1	Introduction - Graph Terminologies - Types of Graphs - Sub Graph- Multi Graph - Regular Graph - Isomorphism - Isomorphic Graphs - Sub-graph - Euler graph - Hamiltonian Graph - Related Theorems.	9
2	Trees -Properties- Distance and Centres - Types - Rooted Tree-- Tree Enumeration- Labeled Tree - Unlabeled Tree - Spanning Tree - Fundamental Circuits- Cut Sets - Properties - Fundamental Circuit and Cut-set- Connectivity- Separability -Related Theorems.	9
3	Network Flows - Planar Graph - Representation - Detection - Dual Graph - Geometric and Combinatorial Dual - Related Theorems - Digraph - Properties - Euler Digraph.	9
4	Matrix Representation - Adjacency matrix- Incidence matrix- Circuit matrix - Cut-set matrix - Path Matrix- Properties - Related Theorems - Correlations. Graph Coloring - Chromatic Polynomial - Chromatic Partitioning - Matching - Covering - Related Theorems.	9
5	Graph Algorithms- Connectedness and Components- Spanning Tree- Fundamental Circuits- Cut Vertices- Directed Circuits- Shortest Path - Applications overview.	9

Text and reference books:

1. Narsingh Deo, "Graph Theory with Application to Engineering and Computer Science", Prentice-Hall of India Pvt.Ltd, 2003.
2. L.R.Foulds , "Graph Theory Applications", Springer, 2016.
3. Bondy, J. A. and Murty, U.S.R., "Graph Theory with Applications", North Holland Publication, 2008.
4. West, D. B., ―Introduction to Graph Theory, Pearson Education, 2011.
5. John Clark, Derek Allan Holton, ―A First Look at Graph Theory‖, World Scientific Publishing Company, 1991.
6. Diestel, R, "Graph Theory", Springer, 3rd Edition, 2006.
7. Kenneth H.Rosen, "Discrete Mathematics and Its Applications", Mc Graw Hill , 2007

OEC-CS-601A: Cyber Law and Cyber Crime

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

After studying this course, student will be able to:

1. **Design** learner conversant with the social and intellectual property issues emerging from cyberspace.
2. **Explore** the legal and policy developments in various countries to regulate cyberspace
3. **Develop** the understanding of relationship between commerce and cyberspace
4. **Understand** in depth knowledge of information technology act and legal frame work of right to privacy, data security and data protection.
5. **Remember** various case studies on real time crimes.
6. **Evaluate** the legal implication of cyber crime

Prerequisites:

1. Computer Network Fundamentals
2. Cyber Security and Cyber attacks

Unit	*Content*	*Hrs./ Unit*
1.	**Introduction of Cybercrime:** What is cybercrime? Forgery, Hacking, Software Piracy, Computer Network intrusion [4L]. **Category Cybercrime:** of how criminals plan attacks, passive attack, Active attacks, cyberstalking. [4L]	8
2.	**Cybercrime Mobile & Wireless devices**: Security challenges posted by mobile devices, cryptographic security for mobile devices, Attacks on mobile/cellphones, Theft, Virus, Hacking. Bluetooth; Different viruses on laptop [8L]	8
3.	**Tools and Methods used in Cybercrime**: Proxy servers, pan word checking, Random checking, Trojan Horses and Backdoors; DOS & DDOS attacks; SQL injection: buffer over flow. [8L]	8
4.	**Phishing & Identity Theft**: Phishing methods, ID Theft; Online identity method. [4L] **Cybercrime & Cybersecurity**: Legal aspects, Indian laws, IT act, Public key certificate. [4L]	8

Text book and Reference books:

1. Cyber security by Nina Gobole & Sunit Belapune; Wiley India.
2. Information Security & Cyber laws, Gupta & Gupta, Khanna Publishing House

OEC-CS-601B: Embedded System

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to

- **Acquire** a basic knowledge about fundamentals of microcontrollers
- **Define** programming and system control to perform a specific task.
- **Design** devices and buses used in embedded networking
- **Develop** programming skills in embedded systems for various applications.
- **Experiment** about basic concepts of circuit emulators.
- **Discuss** about Life cycle of embedded design and its testing.

Prerequisites:

- Basic electronics.
- Digital electronics.
- Microprocessors & Microcontrollers
- C programming.

Detailed Content:

Unit	Content	Hrs/ Unit
1	Introduction-defining Real time systems, Embedded Real Time Systems, Special Characteristics of real time systems, a brief evolutionary history. Hardware Architectures of Real Time systems.	12
2	Software architectures (concepts of interrupt driven activation, need for real time monitor, pseudo parallelism), meeting of deadlines& real time constraints	6
3	Overview of WARD & MELLOR Methodology: Ward & Mellor Life Cycle, the essential model step, the implementation model, real time extensions of DFD	10
4	Real time languages: overview of ADA/Java Extension	4
5	Real time Operating Systems	4
6	System Development Methodologies	4

Text/ Reference Books:

1. "Embedded System Design" Frank Vahid & Tony Givargis; John Wiley & sons, Inc.
2. "Real – Time Systems and software" Alan C. Shaw ; John Wiley & Sons Inc
3. "Fundamentals of embedded Software", Daniel W. Lewis, Pearson
4. "Real time Systems", J. W. S. Liu, Pearson
5. "Embedded Realtime System Programming", S. V. Iyer and P. Gupta, TMH
6. "An Embedded System Primer" David E. Simon; Addison-Wesley Pub
7. "Embedded System Design" Steve Heath; Butterworth-Heinemann Pub.
8. "Embedded System Computer Architecture" Graham Wilson, Butterworth-Heinemann

OEC-CS-601C: Human Resource Management

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Demonstrate** an understanding of key terms, theories/concepts and practices within the field of HRM
2. **Design** competence in development and problem-solving in the area of HRM
3. **Formulate** innovative solutions to problems in the fields of HRM
4. **Identify** and appreciate the significance of the ethical issues in HR
5. **Analyze** the problem and issues related to human resources in an organization.
6. **Integrate** the understanding of various HR concepts along with the domain concept in order to take correct business decisions.

Prerequisites:

1. Interpersonal and soft skill
2. English communication

Detailed Content:

Module	*Content*	*Hours/ Module*
1	HRD-Macro Perspective: HRD Concept, Origin and Need, HRD as a Total System; Approaches to HRD; Human Development and HRD; HRD at Macro and Micro Climate	5
2	HRD–Micro Perspective: Areas of HRD; HRD Interventions Performance Appraisal, Potential Appraisal, Feedback and Performance Coaching, Training, Career Planning, OD or Systems Development, Rewards, Employee Welfare and Quality of Work Life and Human Resource Information; Staffing for HRD: Roles of HR Developer; Physical and Financial Resources for HRD; HR Accounting; HRD Audit, Strategic HRD	7
3	Instructional Technology for HRD Learning and HRD; Models and Curriculum; Principles of Learning; Group and Individual Learning; Transactional Analysis; Assessment Centre; Behaviour Modeling and Self Directed Learning.	7
4	Human Resource Training and Development: Concept and Importance; Assessing Training Needs; Designing and Evaluating T&D Programmes; Role, Responsibilities and challenges to Training Managers.	5
5	Training Methods: Training with in Industry (TWI): On the Job & Off the Job Training; Management Development: Lecture Method; Role Play; In-basket Exercise; Simulation; Vestibule Training; Management Games; Case Study; Programmed Instruction; Team Development; Sensitivity Training; Globalization challenges and Strategies of Training; Program, Review on T&D Programmes in India	7

Text book and Reference books:

1. Nadler, Leonard: Corporate Human Resource Development, Van Nostrand Reinhold, ASTD, New York.
2. Rao, T.V and Pareek, Udai: Designing and Managing Human Resource Systems, Oxford IBH Pub. Pvt.Ltd., New Delhi , 2005.
3. Rao, T.V: Readings in HRD, Oxford IBH Pub. Pvt. Ltd., New Delhi, 2004.
4. Viramani, B.R and Seth, Parmila: Evaluating Management Development, Vision Books, New Delhi.
5. Rao, T.V.(et.al): HRD in the New Economic Environment, Tata McGraw-Hill Pub.Pvt, Ltd., New Delhi, 2003

OEC-CS-601D: Economic Policies in India

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

After studying this course, student will be able to:

- Understand comprehensive of Indian Economy.
- Analyse govt policies and programs
- Formulate the links between household behaviour and the economic models of demand.
- Understand govt policies and programs
- Remember how planning and infrastructure support can develop an economy.
- Apply their knowledge in policy formulation

Prerequisites:

- Fundamental of Economics

Detailed Content:

Unit	*Content*	*Hrs. / Unit*
1.	**Basic Structure of the Indian Economy** Concepts of Development, Underdevelopment – Basic Features of Indian Economy: Growth and Structural Changes in Indian Economy – Demographic Features – Population: Size, Growth, Composition and their Implications on Indian Economy – Concept of Demographic Dividend –Occupational Distribution of Population in India – Population Policy of India.	8
2.	**National Income, Poverty and Unemployment** Estimation of National Income – Trends and Composition of National Income in India – Income Inequalities in India: Magnitude, Causes, Consequences and Remedial Measures – Poverty in India: Concept, Types, Causes and Consequences – Unemployment in India: Concept, Types, Trends, Causes and Consequences – Poverty Alleviation and Employment Generation Programmes in India.	8
3.	**Planning and Public Policy** Five Year Plans: Concept and Objectives – Review of Five Year Plans – NITI Aayog – Economic Reforms: Liberalization, Privatization and Globalization – Impact of WTO on Indian Economy.	8
4.	**Agricultural and Industrial Sectors** Importance and Role of Agriculture in Indian Economy – Trends in Agricultural Production and Productivity – Land Reforms – Green Revolution – Agricultural Finance – Agricultural Marketing – Agricultural Pricing – Food Security in India. Structure, Growth, Importance and Problems of Indian Industry – Large, Medium and Small Scale Industries: Role and Problems – Industrial Policies of 1948, 1956 and 1991– FEMA and Competition Commission of India –Disinvestment Policy – Foreign Direct Investment.	8

Text book and Reference books:

1. Ahluwalia, I.J. and I.M.D Little (Eds.) (1999), India's Economic Reforms and Development (Essays in honour of Manmohan Singh), Oxford University Press, New Delhi.
2. Bardhan, P. K. (9th Edition) (1999), The Political Economy of Development in India, Oxford University Press, New Delhi.
3. Bawa, R. s. and P. S. Raikhy (Ed.) (1997), Structural Changes in Indian Economy, Guru Nanak Dev University Press, Amritsar.
4. Brahmananda, P. R. and V. R. Panchmukhi (Eds.) (2001), Development Experience in the Indian Economy: Inter-State Perspectives, Book well, Delhi.
5. Chakravarty, S. (1987), Development Planning: The Indian Experience, Oxford University Press, New Delhi.
2. Dantwala, M. L. (1996), Dilemmas of Growth: The Indian Experience, Sage Publications, New Delhi.
3. Datt, R. (Ed.) (2001), Second Generation Economic Reforms in India, Deep Publications, New Delhi.
4. Government of India, Economic Survey (Annual), Ministry of Finance, New Delhi.
5. Jain, a. K. (1986), Economic Planning in India, Ashish Publishing House, New Delhi.
6. Jalan, B. (1992), The Indian Economy – Problems and Prospects, Viking, New Delhi.

PCC-CS-691: Cryptography & Network Security Lab

Labs per week (P): 3 **Credits: 1.5**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design** various networking protocols.
2. **Evaluate** security mechanisms using rigorous approaches by key ciphers and hash functions.
3. **Analyze** the vulnerabilities in any computing system and hence be able to design a security solution.
4. **Apply** symmetric and asymmetric key algorithms for cryptography.
5. **Remember** the concept and application of public key cryptography.
6. **Understand** the application of firewall, SSH for network security.

Prerequisites:

- Programming for Problem Solving
- Object Oriented Programming
- Operating System
- Data Communication and Networks
- Cryptography
- Network Security

Detailed Content:

1) Implementation of Caesar Cipher, Substitution cipher and Hill Cipher technique
2) Implementation of the Play fair Cipher
3) Implementation of the Pure Transposition Cipher
4) Implementation of Euclid Algorithm.
5) Implementation of DES Encryption and Decryption
6) Implementation of the AES Encryption and decryption
7) Implementation of RSA Encryption Algorithm
8) Calculation of message digest of text using SHA-1, MD5 algorithms.
9) Implementation of Diffie-Hellman Key Exchange mechanism.
10) Configure SSH (Secure Shell) and send/receive a file on this connection to verify the correctness of this system using the configured parameters.
11) Configure a firewall to block the following for 5 minutes and verify the correctness of this system using the configured parameters:
    (a) Two neighborhood IP addresses on your LAN (b) All ICMP requests
12) Configure a mail agent to support Digital Certificates, send a mail and verify the correctness of this system using the configured parameters.

Text book and Reference books:

1. William Stallings, Cryptography and Network security Principles and Practices, Pearson/PHI.
2. Wade Trappe, Lawrence C Washington, Introduction to Cryptography with coding theory, Pearson.
3. W. Mao, Modern Cryptography – Theory and Practice, Pearson Education.
4. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing – Prentice Hall of India.
5. Cryptography and Network Security – by Atul Kahate – TMH.
6. Data Communications and Networking- by Behourz A Forouzan.

PCC-CS-692: Artificial Intelligence Lab

Contacts: 3P per week Credits: 1.5

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Demonstrate the applications of AI and agent-based approach to AI.
2. Obtain first-order predicate calculus, logical reasoning and problem solving using Python language.
3. Study and discuss various techniques and algorithms of AI used in general problem solving, optimization problems, constraint satisfaction problems, and game programming.
4. Familiarize students with various sub-areas of AI, such as expert systems, natural language processing and machine learning.
5. Study and discuss various techniques and algorithms of AI used in Genetic Algorithm.
6. Dissect various techniques and algorithms of AI used in Expert System.

Prerequisites:

- Data Structures
- Probability
- Python Programming Language

Detailed Content:

Sl No	*Content*
1	Anaconda: Learn how to use Anaconda to manage packages and environments for use with Python.
2	Jupyter Notebooks: Learn how to use Jupyter Notebooks to create documents combining code, text, images, and more.
3	Numpy Basics: • Learn the value of NumPy and how to use it to manipulate data for AI problems. • Mini-Project: Use NumPy to mean normalize anndarray and separate it into several smaller ndarrays.
4	Pandas Basics: • Learn to use Pandas to load and process data for machine learning problems. • Mini-Project: Use Pandas to plot and get statistics from stock data
5	Matplotlib Basics: Learn how to use Matplotlib to choose appropriate plots for one and two variables based on the types of data you have.

Text/Reference Books:

1. Machine Learning for Absolute Beginners: A Plain English Introduction Author: Oliver Theobald Publisher — Scatterplot Press
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems (First Edition) Author: AurelienGeron Publisher — O'Reilly Media
3. Machine Learning (in Python and R) For Dummies Author: John Paul Mueller and Luca Massaron
4. Machine Learning in Action Author: Peter Harrington Publisher — Manning Publications

Semester-VII

PEC-CS-701A: Cloud Computing

Lectures per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Discuss the core concepts of cloud computing paradigm.
2. Analyze services, systems, platforms, frameworks to support cloud computing.
3. Illustrate the concepts of cloud storage system services.
4. Assess virtualization technology services in open source cloud computing environment.
5. Understand data center technology from industry centric perspective.
6. Identify cloud security issues to demonstrate real time applications.

Prerequisites:

1. Basic knowledge of Programming.
2. DBMS
3. Basics of security and privacy.
4. Operating System.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Definition of Cloud Computing and Basics: Defining a Cloud, Cloud types- NIST Model, Cloud Cube model, Deployment models (Public, Private, Hybrid and Community Clouds), Service Platform as a Service, Software as a Service with examples of services/service providers, models – Infrastructure as a Service, Cloud Reference model, Characteristics of Cloud Computing – a shift in paradigm Benefits and advantages of Cloud Computing, A brief introduction on Composability, Infrastructure, Platforms, Virtual Appliances, Communication Protocols, Applications, Connecting to the Cloud by Clients, IaaS – Basic concept, Workload, partitioning of virtual private server instances, Pods, aggregations, silos PaaS – Basic concept, tools and development environment with examples SaaS - Basic concept and characteristics, Open SaaS and SOA, examples of SaaS platform Identity as a Service (IDaaS) Compliance as a Service (CaaS)	9
2	Use of Platforms in Cloud Computing: Concepts of Abstraction and Virtualization, Virtualization technologies : Types of virtualization (access, application, CPU, storage), Mobility patterns (P2V, V2V, V2P, P2P, D2C, C2C, C2D, D2D) Load Balancing and Virtualization: Basic Concepts, Network resources for load balancing, Advanced load balancing (including Application Delivery Controller and Application Delivery Network), Mention of The Google Cloud as an example of use of load balancing Hypervisors: Virtual machine technology and types, VMware vSphere Machine Imaging (including mention of Open Virtualization Format – OVF) Porting of applications in the Cloud: The simple Cloud API and AppZero Virtual Application appliance, Concepts of Platform as a Service, Definition of services, Distinction between SaaS and PaaS (knowledge of Salesforce.com and Force.com), Application development Use of PaaS Application frameworks, Discussion of Google Applications Portfolio – Indexed search, Dark Web, Aggregation and disintermediation, Productivity applications and service, Adwords, Google Analytics, Google Translate, a brief discussion on Google Toolkit (including introduction of Google APIs in brief), major features of Google App Engine service., Discussion of Google Applications Portfolio – Indexed search, Dark Web, Aggregation and disintermediation, Productivity applications and service, Adwords, Google Analytics, Google Translate, a brief discussion on Google Toolkit (including introduction of Google APIs in brief), major features of Google App Engine service, Windows Azure platform: Microsoft's approach, architecture, and main elements, overview of	12

	Windows Azure AppFabric, Content Delivery Network, SQL Azure, and Windows Live services	
3	Cloud Infrastructure: Cloud Management: An overview of the features of network management systems and a brief introduction of related products from large cloud vendors, Monitoring of an entire cloud computing deployment stack – an overview with mention of some products, Lifecycle management of cloud services (six stages of lifecycle). Concepts of Cloud Security: Cloud security concerns, Security boundary, Security service boundary Overview of security mapping Security of data: Brokered cloud storage access, Storage location and tenancy, encryption, and auditing and compliance Identity management (awareness of Identity protocol standards)	7
4	Concepts of Services and Applications: Service Oriented Architecture: Basic concepts of message-based transactions, Protocol stack for an SOA architecture, Event-driven SOA, Enterprise Service Bus, Service catalogs, Applications in the Cloud: Concepts of cloud transactions, functionality mapping, Application attributes, Cloud service attributes, System abstraction and Cloud Bursting, Applications and Cloud APIs Cloud-based Storage: Cloud storage definition – Manned and Unmanned Webmail Services: Cloud mail services including Google Gmail, Mail2Web, Windows Live Hotmail, Yahoo mail, concepts of Syndication services	8
5	Data Center Technology: Server Virtualization – Automation – Remote Operation and Management –Data Center virtualization: Computing – Storage – Network – Carrier and External Network Interconnection – Web Tier Load Balancing and Acceleration. Case Study implementation of OpenNebula - OpenStack.	4

Text book and Reference books:

1. Cloud Computing Bible by Barrie Sosinsky, Wiley India Pvt. Ltd, 2013
2. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", McGraw-Hill, 2010.
3. Kai Hwang, Fox and Dongarra, Morgan Kaufmann, "Distributed and Cloud Computing", 1st Edition, Elseiver, 2012.
4. Thomas Erl , Ricardo Puttini , Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture", Prentice –Hall, 2013.
5. Rajkumar Buyya, James Broberg, Andrzej Goscinski, "Cloud Computing Principles and Paradigms", John Wiley & Sons, Inc Publications, 2011
6. Cloud Computing – Second Edition by Dr. Kumar Saurabh, Wiley India

PEC-CS-701B: Software Engineering

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Describe the importance of software engineering lifecycle models in the development of software and apply the knowledge to the solution of complex engineering problems.
2. Analyze the requirements and develop SRS documents following the principles in modeling software based on real life applications.
3. Design and develop software which adheres to the standard software design guideline & benchmarks.

4. Create and apply appropriate techniques for software testing.
5. Demonstrate knowledge and understanding of engineering and management principles for software projects management.
6. Understand software matrices like size, effort and cost estimation, and software quality metrics.

Prerequisites:

- Basic knowledge of programming

Detailed Content:

Module	*Content*	*Hours/ Module*
1	Software Engineering -Objectives, Definitions, Software Process models - Waterfall Model, Prototype model, RAD, Evolutionary Models, Incremental, Spiral, Software Project Planning- Feasibility Analysis, Technical Feasibility, Cost- Benefit Analysis, COCOMO model.	7
2	Structured Analysis, Context diagram and DFD, Physical and Logical DFDs, Data Modelling, ER diagrams, Software Requirements Specification.	5
3	Design Aspects: Top-Down and Bottom-Up design; Decision tree, decision table and structured English, Structure chart, Transform analysis Functional vs. Object-Oriented approach.	6
4	Unified Modeling Language Class diagram, interaction diagram: collaboration diagram, sequence diagram, state chart diagram, activity diagram, implementation diagram.	4
5	Coding & Documentation - Structured Programming, Modular Programming, Module Relationship- Coupling, Cohesion, OO Programming, Information Hiding, Reuse, System Documentation.	5
6	Testing - Levels of Testing, Integration Testing, System Testing, Software Quality, Quality Assurance, Software Maintenance, Software Configuration Management, Software Architecture.	9

Text and Reference books:

1. Software Engineering: A practitioner's approach - Pressman (TMH)
2. Software Engineering- Pankaj Jalote (Wiley-India)
3. Software Engineering- Rajib Mall (PHI)
4. Software Engineering -Agarwal and Agarwal (PHI)

PEC-CS-701C: Steganography and Watermarking

Lecture per week: 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Understand** the History and importance of watermarking and steganography.
2. **Describe** Steganography and Watermarking fundamental concepts principles.
3. **Analyse** Applications and properties of watermarking and steganography.
4. **Demonstrate** Models and algorithms of watermarking.
5. **Design** and implement efficient data hiding methods.

6. **Identify** theoretic foundations of steganography and steganalysis.

Prerequisites:

- Cryptography

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Introduction** Information Hiding, Steganography and Watermarking – History of watermarking – Importance of digital watermarking – Applications – Properties – Evaluating watermarking systems. Watermarking Models & Message Coding: Notation – Communications – Communication based models – Geometric models – Mapping messages into message vectors – Error correction coding – Detecting multi-symbol watermarks.	6
2	**Watermarking With Side Information & Analyzing Errors:** Informed Embedding – Informed Coding – Structured dirty-paper codes – Message errors – False positive errors – False negative errors – ROC curves – Effect of whitening on error rates	6
3	**Perceptual Models**: Evaluating perceptual impact – General form of a perceptual model – Examples of perceptual models – Robust watermarking approaches – Redundant Embedding, Spread Spectrum Coding, Embedding in Perceptually significant coefficients	6
4	**Watermark Security & Authentication:** Security requirements – Watermark security and cryptography – Attacks – Exact authentication – Selective authentication – Localization – Restoration	6
5	**Steganography:** Steganography communication – Notation and terminology – Information theoretic foundations of steganography – Practical steganographic methods – Minimizing the embedding impact – Steganalysis	6

Text book and Reference books:

1. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Digital Watermarking and Steganography, Margan Kaufmann Publishers, New York.
2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Digital Watermarking, Margan Kaufmann Publishers, New York.
3. Michael Arnold, Martin Schmucker, Stephen D. Wolthusen, Techniques and Applications of Digital Watermarking and Contest Protection, Artech House, London.
4. Shih Frank Y, Digital Watermarking and Steganography, Taylor & Francis Inc.

PEC-CS-701D: Digital Forensics

Lecture per week: 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Formulate** and Judges a crime from a given case study.

2. **Evaluate** the importance of various digital forensic tools for analysis to achieve adequate perspectives of digital forensic investigation in various applications/devices like Windows/Unix system.
3. **Analyze** the methodology of incident response and various security issues in ICT world, and identify digital forensic tools for data collection.
4. **Apply** the method to generate legal evidence and supporting investigation reports and will also be able to use various digital forensic tools.
5. **Understand** the need of digital forensic and role of digital evidences.
6. **Define or Remember** the concept of Forensics and its associates.

Prerequisites:

- Malware Analysis
- Operating System
- Cyber Law and Cyber Crime

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Digital Forensics Science: Forensics science, computer forensics, and digital forensics. Computer Crime: Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics.	4
2	Cyber Crime Scene Analysis: Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation.	6
3	Evidence Management & Presentation: Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, explain what the normal case would look like, define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.	7
4	Computer Forensics: Prepare a case, begin an investigation, understand computer forensics workstations and software, conduct an investigation, and complete a case, Critique a case, Network Forensics: open-source security tools for network forensic analysis, requirements for preservation of network data.	7
5	Current computer forensics tools- software, hardware tools, validating and testing forensic software, addressing data-hiding techniques, performing remote acquisitions, E-Mail investigations- investigating email crime and violations, understanding E-Mail servers, specialized E-Mail forensics tool. Mobile Forensics: mobile forensics techniques, mobile forensics tools. Legal Aspects of Digital Forensics: IT Act 2000, amendment of IT Act 2008.	7

Text book and Reference books:

1. John Sammons, "The Basics of Digital Forensics", Elsevier.
2. John Vacca, "Computer Forensics: Computer Crime Scene Investigation", Laxmi Publications.
3. Warren G. Kruse II and Jay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley.
4. Nelson, B, Phillips, A, Enfinger, F, Stuart, C., "Guide to Computer Forensics and Investigations", 2nd ed., Thomson Course Technology.

PEC-CS-702A: Block chain and Cryptocurrency

Lecture per week (L): 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design, build** and deploy a distributed application.
2. **Evaluate** security, privacy and efficiency of a given block chain system.
3. **Analyze** functionality of cryptocurrency system.
4. **Apply** block chain in various domains.
5. **Remember** cryptography and consensus algorithms.
6. **Understand** the history, types and applications of block chain.

Prerequisites:

- Operating System
- Data Communication and Networks
- Cryptography
- Network Security

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Basics**: Distributed Database, Two General Problem, Byzantine General problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. **Cryptography**: Hash function, Digital Signature - ECDSA, Memory Hard Algorithm, Zero Knowledge Proof.	7
2	**Blockchain**: Introduction, Advantage over conventional distributed database, Block chain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Block chain application, Soft & Hard Fork, Private and Public block chain.	8
3	**Distributed Consensus**: Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Sybil Attack, Energy utilization and alternate.	5
4	**Cryptocurrency:** History, Distributed Ledger, Bitcoin protocols - Mining strategy and rewards, Ethereum - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin.	6
5	**Cryptocurrency Regulation**: Stakeholders, Roots of Bit coin, Legal Aspects-Crypto currency Exchange, Black Market and Global Economy. **Applications**: Internet of Things, Medical Record Management System, Domain Name Service and future of Block chain.	6

Text book and Reference books:

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Princeton University Press.
2. Imran Bashir, Mastering Blockchain: Distributed Ledger Technology, decentralization, and smart contracts explained, 2nd Edition, Packt Publishing Ltd.
3. Wattenhofer, the Science of the Block chain.

4. Andreas M. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, O'Reilly Media Inc.
5. Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System.
6. Dr. Gavin Wood, ETHEREUM: A Secure Decentralized Transaction Ledger, Yellow paper.2014.
7. Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, A survey of attacks on Ethereum smart contracts.

PEC-CS-702B: Social Network Analysis

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand the concept of semantic web and related applications.
2. Learn knowledge representation using ontology.
3. Understand human behaviour in social web and related communities.
4. Learn visualization of social networks.
5. Develop semantic web related applications.
6. Represent knowledge using ontology.

Prerequisites:

- Basic Mathematics
- Probability and Statistics

Detailed Content:

Sl No	*Content*	*Hours/ Module*
1	Introduction: Objective, scope and outcome of the course.	1
2	Introduction to Semantic Web: Limitations of current Web - Development of Semantic Web - Emergence of the Social Web - Social Network analysis: Development of Social Network Analysis - Key concepts and measures in network analysis - Electronic sources for network analysis: Electronic discussion networks, Blogs and online communities - Web-based networks - Applications of Social Network Analysis.	5
3	Ontology and their role in the Semantic Web: Ontology-based knowledge Representation - Ontology languages for the Semantic Web: Resource Description Framework - Web Ontology Language - Modelling and aggregating social network data: State-of-the-art in network data representation - Ontological representation of social individuals - Ontological representation of social relationships - Aggregating and reasoning with social network data - Advanced representations.	7
4	Extracting evolution of Web Community from a Series of Web Archive - Detecting communities in social networks - Definition of community - Evaluating communities - Methods for community detection and mining - Applications of community mining algorithms - Tools for detecting communities social network infrastructures and communities - Decentralized online social networks - Multi-Relational characterization of dynamic social network communities.	8
5	Understanding and predicting human behaviour for social communities - User data management - Inference and Distribution - Enabling new human experiences - Reality mining - Context - Awareness - Privacy in online social networks - Trust in online environment - Trust models based on subjective logic - Trust network analysis - Trust transitivity analysis - Combining trust and reputation - Trust	6

	derivation based on trust comparisons - Attack spectrum and countermeasures.	
6	Graph theory - Centrality - Clustering - Node-Edge Diagrams - Matrix representation - Visualizing online social networks, Visualizing social networks with matrix-based representations - Matrix and Node-Link Diagrams - Hybrid representations - Applications - Cover networks - Community welfare - Collaboration networks - Co-Citation networks.	6
	Total	33

Text/ References Books:

1. Peter Mika, ―Social Networks and the Semantic Web, First Edition, Springer 2007.
2. Borko Furht, ―Handbook of Social Network Technologies and Applications, 1st Edition, Springer, 2010.
3. Guandong Xu ,Yanchun Zhang and Lin Li, ―Web Mining and Social Networking – Techniques and applications, First Edition, Springer, 2011.
4. Dion Goh and Schubert Foo, ―Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively, IGI Global Snippet, 2008.
5. Max Chevalier, Christine Julien and Chantal Soule-Dupuy, ―Collaborative and Social Information Retrieval and Access: Techniques for Improved user Modelling, IGI Global Snippet, 2009.
6. John G. Breslin, Alexander Passant and Stefan Decker, ―The Social Semantic Web, Springer, 2009.

PEC-CS-702C: Advanced Computer Architecture

Contacts: 3L per week Credits: 3

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- **Explain** various parameters to measure the performance of a processor.
- **Demonstrate** the parallel computing concepts and **compare** parallel computing with sequential computing.
- **Explain** the pipelining technique and its related issues.
- **Demonstrate** the vector processing, array processors and multiprocessors.
- **Outline** and **design** various types of interconnection networks for parallel computers.
- **Dissect** different techniques required to improve the performances of cache memory and main memory.

Prerequisites:

Computer Organization & Architecture

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction: Review of basic computer architecture (Revisited), Quantitative techniques in computer design, measuring and reporting performance.	3
2	Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques; Compiler techniques for improving performance.	9
3	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors.	6
4	Multiprocessor architecture: taxonomy of parallel architectures; Centralized shared- memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers.	8

5	Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.	4
6	Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.	8

Text book and Reference books:

1. Computer Architecture and Parallel Processing by Hwang and Briggs (Mc-Graw Hill)
2. Advanced Computer Architecture by Hwang (Mc-Graw Hill)
3. Computer Architecture: A Qualitative Approach by Hennesey & Patterson (Morgan Kaufman)

PEC CS-702D: Big Data Analytics

Lecture per week: 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Understand** the concept of data management and evolution of Big Data.
2. **Understand** and implement various big data technology foundations.
3. **Apply** the fundamentals of Hadoop ecosystem and its components for data analysis.
4. **Analyse** the optimization techniques in data bases.
5. **Analyse** the storage techniques in data bases.
6. **Explore** the understanding of text, sentiment analytics.

Prerequisites:

- Database Management System
- C/C++ or Java in Linux
- Data Structures and Algorithms

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Introduction to Big Data and Hadoop** Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere BigInsights and Big Sheets	5
2	**HDFS (Hadoop Distributed File System)** The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.	7
3	**Map Reduce** Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.	7
4	**Hadoop Eco System** **Pig :** Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators.	7

	Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. **Hbase** : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS. **Big SQL** : Introduction	
5	**Data Analytics with R** Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR	6

Text book and Reference books:

1. Big Data, Black Book, DT Editorial Services, Dreamtech Press, 2015
2. Big Data and Analytics, Seema Acharya, Subhashini Chellappan, Infosys Limited, Publication: Wiley India Private Limited,1st Edition 2015
3. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analystics, John Wiley & sons, 2012.
4. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007
5. Pete Warden, Big Data Glossary, O'Reilly, 2011.
6. Big Data For Dummies, Judith Hurwitz, Alan Nugent, Fern Halper, Marcia Kaufman, Wiley 2013

OEC-CS-701A: Natural Language Processing

Contacts: 3L per week **Credits: 3**

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Justify** the various steps necessary for processing natural language
2. **Suggest** appropriate lexical and parsing techniques for a given natural language
3. **Apply** appropriate statistical models for a given natural language application
4. **Modify** existing algorithms to suit any natural language for processing
5. **Recommend** appropriate pre-processing steps essential for the various applications involving natural language processing.
6. **Design** applications involving natural language

Prerequisites:

- Linear algebra
- Probability and Statistics
- Artificial Intelligence
- Programming in any high-level language, preferably Python

Detailed Content:

Unit	Content	Hrs/ Unit
1	**Regular Expressions and Automata** (Recap) [**2L**] Introduction to NLP, Regular Expression, Finite State Automata	11

	Tokenization [**5L**] Word Tokenization, Normalization, Sentence Segmentation, Named Entity Recognition, Multi Word Extraction, Spell Checking - Bayesian Approach, Minimum Edit Distance **Morphology** [**4L**] Morphology - Inflectional and Derivational Morphology, Finite State Morphological Parsing, The Lexicon and Morphotactics, Morphological Parsing with Finite State Transducers, Orthographic Rules and Finite State Transducers, Porter Stemmer	
2	**Language Modeling** [**4L**] Introduction to N-grams, Chain Rule, Smoothing - Add-One Smoothing, Witten-Bell Discounting; Backoff, Deleted Interpolation, N-grams for Spelling and Word Prediction, Evaluation of language models. **Hidden Markov Models and POS Tagging** [**4L**] Markov Chain, Hidden Markov Models, Forward Algorithm, Viterbi Algorithm, Part of Speech Tagging - Rule based and Machine Learning based approaches, Evaluation	8
3	**Text Classification** [**4L]** Text Classification, Naïve Bayes' Text Classification, Evaluation, Sentiment Analysis - Opinion Mining and Emotion Analysis, Resources and Techniques **Context Free Grammar** [**5L**] Context Free Grammar and Constituency, Some common CFG phenomena for English, Top-Down and Bottom-up parsing, Probabilistic Context Free Grammar, Dependency Parsing	9
4	**Computational Lexical Semantics** [**4L**] Introduction to Lexical Semantics - Homonymy, Polysemy, Synonymy, Thesaurus - WordNet, Computational Lexical Semantics - Thesaurus based and Distributional Word Similarity **Information Retrieval** [**5L**] Boolean Retrieval, Term-document incidence, The Inverted Index, Query Optimization, Phrase Queries, Ranked Retrieval - Term Frequency - Inverse Document Frequency based ranking, Zone Indexing, Query term proximity, Cosine ranking, Combining different features for ranking, Search Engine Evaluation, Relevance Feedback	9

Text Books and References:

1. Speech and Language Processing, Jurafsky and Martin, Pearson Education
2. Foundation of Statistical Natural Language Processing, Manning and Schutze, MIT Press

OEC-CS-701B: Soft Skill and Interpersonal Communication

Lecture per week: 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Develop effective communication skills (spoken and written).
2. Develop effective presentation skills.
3. Develop all-round personalities with a mature outlook to function effectively in different circumstances.
4. Develop broad career plans, evaluate the employment market, identify the organizations to get good placement, match the job requirements and skill sets.
5. Improve self-confidence.

6. Become more effective individual through goal/target setting, self-motivation and practicing creative thinking.

Prerequisites:

- English Grammar

Detailed Content:

Module	*Content*	*Hours/ Module*
1	An Introduction – Definition and Significance of Soft Skills; Process, Importance and Measurement of Soft Skill Development. Inter personal relations; communication models, process and barriers; team communication; developing interpersonal relationships through effective communication; listening skills; essential formal writing skills; corporate communication styles –assertion, persuasion, negotiation	6
2	SWOT & Creative Thinking Discovering the Self; Setting Goals; Beliefs, Values, Attitude, Virtue. Developing Positive Thinking and Attitude; Driving out Negativity; Meaning and Theories of Motivation; Enhancing Motivation Levels.	6
3	Corporate Communication Public Speaking: Skills, Methods, Strategies and Essential tips for effective public speaking. Group Discussion: Importance, Planning, Elements, Skills assessed; Effectively disagreeing, Initiating, Summarizing and Attaining the Objective. Interview& Presentation Skills: Interviewer and Interviewee– in-depth perspectives. Before, During and After the Interview. Tips for Success: Types, Content, Audience Analysis, Essential Tips – Before, During and After, Overcoming Nervousness	6
4	Non-Verbal Communication & Personality Development Importance and Elements; Body Language. Concept, Essentials Meaning, Nature, Features, Stages, Models; Learning Skills; Adaptability Skills.	6
5	Business Etiquette & Team Work Concept of Teams; Building effective teams; Concept of Leadership and honing Leadership skills. Meaning, Nature, Features, Stages, Models; Learning Skills; Adaptability Skills	6

Text book and Reference books:

1. Managing Soft Skills for Personality Development – edited by B.N. Ghosh, McGraw Hill India, 2012.
2. Effective Communication and Soft Skills, Nitin Bhatnagar, Pearson Education India, 2011
3. English and Soft Skills – S.P. Dhanavel, Orient Blackswan India, 2010.
4. Effective Business Communication, Kulbhushan Kumar, Khanna Publishing House, 2021

OEC-CS-701C: Digital Signal Processing

Lecture per week (L): 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Design linear discrete-time systems and filters and analyse their behaviour.
2. Represent continuous-time signals and linear systems in discrete time, so that such signals can be recovered in continuous time when necessary.
3. Compute approximations to Fourier transforms of continuous-time signals with finite discrete time methods.
4. Understand the analytical tools such as Fourier transforms, Discrete Fourier transforms, Fast Fourier Transforms and Z-Transforms required for digital signal processing.
5. Design and realize various digital filters for digital signal processing.
6. Understand the applications of DSP in speech processing and spectrum analysis.

Prerequisites:

- Digital Electronics

Detailed Content:

Sl No	*Content*	*Hours/ Module*
1	Introduction: Objective, scope and outcome of the course.	1
2	Discrete-time signals: Concept of discrete-time signal, basic idea of sampling and reconstruction of signal, sampling theorem, sequences – periodic, energy, power, unit-sample, unit-step, unit-ramp, real & complex exponentials, arithmetic operations on sequences. LTI Systems: Definition, representation, impulse response, derivation for the output sequence, concept of convolution, graphical, analytical and overlap-add methods to compute convolution supported with examples and exercises, properties of convolution, interconnections of LTI systems with physical interpretations, stability and causality conditions, recursive and non-recursive systems.	8
3	Z-Transform: Definition, mapping between s-plane and z-plane, unit circle, convergence and ROC, properties of Z-transform, Z-transform on sequences with examples and exercises, characteristic families of signals along with ROCs, convolution, correlation and multiplication using Z-transform, initial value theorem, Perseval's relation, inverse Z-transform by contour integration, power series & partial-fraction expansions with examples and exercises. Discrete Fourier Transform: Concept and relations for DFT/IDFT, Twiddle factors and their properties, computational burden on direct DFT, DFT/IDFT as linear transformations, DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circular convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences – Overlap-Save and Overlap-Add methods with examples and exercises. Fast Fourier Transform: Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithms, signal flow graphs, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations and exercises.	11
4	Filter Design: Basic concepts of IIR and FIR filters, difference equations, design of Butterworth IIR analog filter using impulse invariant and bilinear transforms, design of linear phase FIR	5

	filters, no. of taps, rectangular, Hamming and Blackman windows.	
5	Digital Signal Processor: Elementary idea about the architecture and important instruction sets of TMS320C 5416/6713 processor, writing of small programs in Assembly Language. FPGA: Architecture, different sub-systems, design flow for DSP system design, mapping of DSP algorithms onto FPGA.	5
	TOTAL	30

Text and reference books:

1. Digital Signal Processing – Principles, Algorithms and Applications, J.G.Proakis & D.G.Manolakis, Pearson Ed.
2. Digital Signal processing – A Computer Based Approach, S.K.Mitra, TMH Publishing Co.
3. Digital Signal Processing Signals, Systems and Filters, A. Antoniou, TMH Publishing Co.
4. VLSI Digital Signal Processing Systems Design and Implementation, Wiley International Publication.
5. Digital Signal Processing with Field Programmable Gate Arrays, U.Meyer-Baese, Springer.

OEC-CS-701D: Machine Learning

Lecture per week: 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Develop** an appreciation for what is involved in learning models from data.
2. **Understand** a wide variety of learning algorithms.
3. **Understand** how to evaluate models generated from data.
4. **Apply** the algorithms to a real problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.
5. **Understand** the foundation of generative models.
6. **Understand** algorithms for learning Bayesian networks.

Prerequisites:

- Design and Analysis of Algorithm
- Probability and Statistics

Detailed Content:

Module	***Content***	***Hours/ Module***
1	**Introduction to Machine Learning** Classical machine vs Adaptive Machine, Different Learning strategies, Supervised, Unsupervised, Semi Supervised, Reinforcement learning, Transfer learning (TL). Basic of Training and Testing Phase Training and testing data, Over fitting and Under fitting	4
2	**Feature Selection Techniques** Filter Methods- Information gain, Chi-Square test, Correlation and coefficient. Wrapper methods- Recursive feature elimination, Genetic Algorithm. Embedded method- Decision trees	3

	Principal Component Analysis (PCA)	
3	**Regression Analysis** Dependent vs Independent variable. Introduction, Confusion Matrix, Curse Of Dimensionality, Managing Missing Features, Managing Categorical Data. Explain Linear regression, Logistic regression,Polynomial regression, Ridge regression, Lasso regression, Elastic Net regression	7
4	**Classification** Binary vs Multiclass Classification, K Nearest Neighbor (kNN), Conditional Probability, Bayes Theorem. Naive Bayes Classifier. Naive Bayes Variants: Bernoulli Naive Bayes, Multinomial Naive Bayes, Gaussian Naive Bayes. Support Vector Machine (SVM), Non-Linear Support Vector Machine (SVM) And Kernel Function. Decision Tree Algorithm, Random Forest (RF), ROC Curve.	8
5	**Clustering** K-means Clustering, DBSCAN, Hierarchical Clustering : Agglomerative Clustering and Divisive Clustering	4
6	**Ensemble Learning** Ensemble Method: Bagging (Bootstrap Aggregation), Boosting, Voting Classifier: Hard Voting and Soft Voting.	3
7	Gradient Descent Algorithm, Introduction of Back Propagation Algorithm. Artificial Neural Network, Recurrent Neural Network (RNN)	3

Text book and Reference books:

1. Tom M. Mitchell, Machine Learning, McGraw Hill Education.
2. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing.
3. Saikat Dutt, Subramanian Chandramouli, Machine Learning, Pearson Education.
4. Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning: From Theory To Algorithms, Cambridge University Press.
5. S. Rogers and M. Girolami, A first course in Machine Learning, CRC Press, 2011.

HSMC-CS-701: Project Management and Entrepreneurship

Contacts: 2L per week **Credits: 2**

Course Outcomes (COs):

Upon completion of this course, the students will be able to:

- **Examine** role of entrepreneur in economic development.
- **Describe** the steps to establish an enterprise.
- **Compare** and classify types of entrepreneurs.
- **Explain** project Identification and formulation.
- **Define** project evaluation.
- **Evaluate** the entrepreneurial support in India

Prerequisites:

- Software Engineering

Detailed Content:

Unit	*Contents*	*Hrs/ Unit*
1	1. **Entrepreneurship Introduction:** Meaning and Concept of Entrepreneurship, Innovation and entrepreneurship, Contributions of entrepreneurs to the society, risk-opportunities perspective, and mitigation of risks 2. **Entrepreneurship – An Innovation:** Challenges of Innovation, Steps of Innovation Management, Idea Management System, Divergent v/s Convergent Thinking, Qualities of a prospective Entrepreneur 3. **Idea Incubation:** Factors determining competitive advantage, Market segment, blue ocean strategy, Industry and Competitor Analysis (market structure, market size, growth potential), Demand-supply analysis 4. **Entrepreneurial Motivation:** Design Thinking - Driven Innovation, TRIZ (Theory of Inventive Problem Solving), Achievement motivation theory of entrepreneurship – Theory of McClelland, Harvesting Strategies 5**. Information:** Government incentives for entrepreneurship, Incubation, acceleration. Funding new ventures – bootstrapping, crowd sourcing, angel investors, Government of India's efforts at promoting entrepreneurship and innovation – SISI, KVIC, DGFT, SIDBI, Defense and Railways 6. **Closing the Window:** Sustaining Competitiveness, Maintaining Competitive Advantage, the Changing Role of the Entrepreneur. 7. Applications and Project Reports Preparation	12
2	1. **Project Management:** Definitions of Project and Project Management, Issues and Problems in Project Management, Project Life Cycle - Initiation / Conceptualization Phase, Planning Phase, Implementation / Execution Phase, Closure / Termination Phase 2. **Project Feasibility Studies** – Pre-Feasibility and Feasibility Studies, Preparation of Detailed Project Report, Technical Appraisal, Economic/Commercial/Financial Appraisal including Capital Budgeting Process, Social Cost Benefit Analysis 3. **Project Planning** – Importance of Project Planning, Steps of Project Planning, Project Scope, Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS), Phased Project Planning 4. **Project Scheduling and Costing** – Gantt chart, CPM and PERT Analysis, Identification of the Critical Path and its Significance, Calculation of Floats and Slacks, Crashing, Time Cost Trade-off Analysis, Project Cost Reduction Methods. 5**. Project Monitoring and Control** – Role of Project Manager, MIS in Project Monitoring, Project Audit 6. Case Studies with Hands-on Training on MS-Project	12

Text Books and Reference Books:

1. Business, Entrepreneurship and Management: Rao, V.S.P.; Vikas
2. Entrepreneurship: Roy Rajeev; OUP.
3. Text Book of Project Management: Gopalkrishnan, P. and Ramamoorthy, V.E.; McMillan
4. Project Management for Engineering, Business and Technology: Nicholas, J.M., and Steyn, H.; PHI
5. Project Management: The Managerial Process: Gray, C.F., Larson, E.W. and Desai, G.V.; MGH

Semester-VIII

PEC-CS-801A: Quantum Computing

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Explain the working of a Quantum Computing program, its architecture and program model.
2. Develop quantum logic gate circuits.
3. Design different mathematical foundation for quantum computing.
4. Develop quantum computing algorithm.
5. Program quantum algorithm on major toolkits.
6. Find different quantum computational complexity.

Prerequisites:

- Data Structure and Algorithm
- Programming in Python/C#

Detailed Content:

Module	*Content*	*Hours/ Module*
1	Introduction to Quantum Computing: Motivation for studying Quantum Computing Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.), Origin of Quantum Computing Overview of major concepts in Quantum Computing: Qubits and multi-qubits states, Bracket notation. Bloch Sphere representation, Quantum Superposition, Quantum Entanglement	3
2	Math Foundation for Quantum Computing: Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors	8
3	Building Blocks for Quantum Program: Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere, Multi-qubits States, Quantum superposition of qubits (valid and invalid superposition), Quantum Entanglement, Useful states from quantum algorithmic perceptive e.g. Bell State, Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc. Programming model for a Quantum Computing Program: Steps performed on classical computer, Steps performed on Quantum Computer, Moving data between bits and qubits.	8
4	Quantum Algorithms: Basic techniques exploited by quantum algorithms: Amplitude amplification, Quantum Fourier Transform, Phase Kick-back, Quantum Phase estimation, Quantum Walks. Major Algorithms: Shor's Algorithm, Grover's Algorithm, Deutsch's Algorithm, Deutsch -Jozsa Algorithm. OSS Toolkits for implementing Quantum program: IBM quantum experience Microsoft Q: Rigetti PyQuil (QPU/QVM)	10
5	Quantum Computational Complexity and Error Correction: Computational complexity, Black-box model, Lower bounds for searching general, Black-box lower bounds, Polynomial method, Block sensitivity, Adversary methods, Classical	7

	error correction, Classical three-bit code, Fault tolerance, Quantum error correction Three- and nine-qubit quantum codes, Fault-tolerant quantum computation.	

Text book and Reference books:

1. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
2. David McMahon, "Quantum Computing Explained", Wiley.
3. IBM Experience: https://quantumexperience,ng,bluemix.net
4. Microsoft Quantum Development Kit: https://www.microsoft.com/en-us/quantum/development-kit
5. Forest SDK PyQuil: https://pyquil.readthedocs.io/en/stable/
6. P. Kaye, R. Laflamme, and M. Mosca, "An introduction to Quantum Computing", Oxford University Press, 1999.
7. V. Sahni, "Quantum Computing", Tata McGraw-Hill Publishing Company, 2007.

PEC-CS-801B: Information Theory and Coding

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Apply various source coding techniques.
2. Design the channel performance using information theory.
3. Comprehend various error control code properties
4. Apply linear block codes for error detection and correction
5. Apply convolution codes for performance analysis & cyclic codes for error detection and correction.
6. Design BCH & RS codes for channel performance improvement against burst errors.

Prerequisites:

1. Basic Mathematics
2. Probability and Statistics

Detailed Content:

Sl No	*Content*	*Hours/ Module*
1	Introduction: Objective, scope and outcome of the course.	1
2	Source Coding Uncertainty and information, average mutual information and entropy, information measures for continuous random variables, source coding theorem, Huffman codes.	5
3	Channel Capacity And Coding Channel models, channel capacity, channel coding, information capacity theorem, The Shannon limit.	5
4	Linear And Block Codes For Error Correction Matrix description of linear block codes, equivalent codes, parity check matrix, decoding of a linear block code, perfect codes, Hamming codes.	5
5	Cyclic Codes	5

	Polynomials, division algorithm for polynomials, a method for generating cyclic codes, matrix description of cyclic codes, Golay codes.	
6	BCH Codes Primitive elements, minimal polynomials, generator polynomials in terms of minimal polynomials, examples of BCH codes.	5
7	Convolutional Codes Tree codes, trellis codes, polynomial description of convolutional codes, distance notions for convolutional codes, the generating function, matrix representation of convolutional codes, decoding of convolutional codes, distance and performance bounds for convolutional codes, examples of convolutional codes, Turbo codes, Turbo decoding.	5
	Total	31

Text and Reference Books:

1. Andre Neabauer, "Coding Theory: Algorithms, Architectures & Applications", Wiley Publications, 2010.
2. Kennedy, "Electronic Communication systems", McGraw Hill, 4th Ed., 1999.
3. John Proakis, "Digital Communications", TMH, 5th Ed., 2008.
4. Simon Haykin, "Communication System", Wiley, 2008.
5. Jorge Castineira, Moreira, "Essentials of Error Control Coding", Wiley, 2006.

PEC-CS-801C: Cyber Security in Block chain Technology

Lecture per week (L): 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand how blockchain systems (mainly Bitcoin and Ethereum) work
2. Design, build, and deploy smart contracts and distributed applications
3. Integrate ideas from blockchain technology into their own projects
4. Design, develop, test and evaluate secure software.
5. Develop policies and procedures to manage enterprise security risks.
6. Learn and analyse various private-key and public-key cryptography algorithms

Prerequisites:

1. Computer Networks
2. Network Security & Cryptography.
3. Block Chain and Crypto currency.
4. Design and analysis of Algorithm

Detailed Content:

Sl No	Content	Hours/ Module
1	CONVENTIONAL AND MODERN ENCRYPTION Model of network security – Security attacks, services and attacks – OSI security architecture – Classical encryption techniques – SDES – Block cipher Principles DES – Strength of DES – Block cipher design principles – Block cipher mode of operation – Evaluation criteria for AES – RC4 -	5

	Differential and linear cryptanalysis – Placement of encryption function – traffic confidentiality.	
2	PUBLIC KEY ENCRYPTION Number Theory – Prime number – Modular arithmetic – Euclid's algorithm – Fermet's and Euler's theorem – Primality – Chinese remainder theorem – Discrete logarithm – Public key cryptography and RSA – Key distribution – Key management – Diffie Hellman key exchange – Elliptic curve cryptography.	5
3	AUTHENTICATION: Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC – SHA - HMAC – CMAC - Digital signature and authentication protocols – DSS.	5
4	INTRODUCTION Basic of Blockchain Architecture – Challenges – Applications – Block chain Design Principles -The Blockchain Ecosystem - The consensus problem - Asynchronous Byzantine Agreement - AAP protocol and its analysis - Nakamoto Consensus on permission-less, nameless, peer-to-peer network - Abstract Models for BLOCKCHAIN - GARAY model - RLA Model - Proof of Work (PoW) as random oracle - formal treatment of consistency, liveness and fairness - Proof of Stake (PoS) based Chains - Hybrid models (PoW + PoS).	5
5	CRYPTOGRAPHIC FUNDAMENTALS Cryptographic basics for crypto currency - a short overview of Hashing, cryptographic algorithm – SHA 256 signature schemes, encryption schemes and elliptic curve cryptography- Introduction to Hyperledger- Hyperledger framework - Public and Private Ledgers.	5
6	BIT COIN Bit coin - Wallet - Blocks - Merkley Tree - hardness of mining - transaction verifiability - anonymity - forks - double spending - mathematical analysis of properties of Bit coin. Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their uses.	5
7	ETHEREUM Ethereum - Ethereum Virtual Machine (EVM) - Wallets for Ethereum - Solidity - Smart Contracts - some attacks on smart contracts. Ethereum and Smart Contracts- The Turing Completeness of Smart Contract Languages and verification challenges- comparing Bitcoin scripting vs. Ethereum Smart Contracts	5
	TOTAL	35

Text/Reference Books:

1. Melanie Swan, "Block Chain: Blueprint for a New Economy", O'Reilly, first edition – 2015.
2. Daniel Drescher, "Block Chain Basics", Apress; 1stedition, 2017
3. Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, Delhi.
4. Imran Bashir, "Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing, first edition – 2012.

PEC-CS-801D: Bio informatics

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Design** basic algorithms used in Pairwise and Multiple alignments.
2. **Understand** the methodologies used for database searching, and determining the accuracies of database search.
3. **Application** of probabilistic model to determine important patterns.
4. **Prediction** of structure from sequence and subsequently testing the accuracy of predicted structures.
5. **Determine** the protein function from sequence through analyzing data.
6. **Analysis** and development of models for better interpretation of biological data to extract knowledge.

Prerequisites:

- Biological Science
- Basics of Data Structure and Programming

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction to Bioinformatics A word on Bioinformatics, Introduction, Branches of Bioinformatics, Aims of Bioinformatics, Scope/research areas of bioinformatics	5
2	Sequence and molecular file form and ats, Introduction, Sequence file formats, Sequence conversion tools, Molecular file formats, Molecular file format conversion Databases in bioinformatics & introduction: - Introduction, Biological databases, Classification schema of biological databases, Biological database retrieval system Biological sequence databases, National Centre for biotechnology information (NCBI), Introduction, Tools and databases of NCBI, Database retrieval tool, Sequence submission to NCBI, BLAST, PSI-BLAST, RPS-BLAST, Specialized tools, Nucleotide database, Literature database, Protein database, Gene expression database, GEO, Structural database, Chemical database, Other databases, EMBL Nucleotide Sequence Database, Introduction, Sequence retrieval, Sequence submission at EMBL, Resources of EMBL, Biological annotation and data curation, Sequence.	8
3	Introduction, Concept of alignment, Scoring Matrices, PAM, BLOSUM, Alignment of pairs of sequences, Alignment algorithms, Heuristic methods, Multiple sequence Alignment (MSA) Gene prediction methods: principles and challenges, Introduction, Biological overview, What is gene prediction? Computational methods of gene prediction, Combination of two methods, Why is gene prediction difficult.	7
4	Molecular Phylogeny Introduction, Phenotypic phylogeny and molecular phylogeny, Molecular clocks, Methods of phylogeny, Statistical Evaluation of the obtained phylogenetic trees or validation methods, Software for phylogenetic analysis, Reliability of molecular phylogenetic prediction Molecular Viewers, Introduction, A few molecular viewers, RasMol, Deep view- The Swiss-PDB viewer (SPDBV), Cn3D.	5
5	Protein and secondary structure prediction: Introduction, Levels of protein structure, Conformational parameter's Secondary structure of a protein, Secondary structure types, Secondary structure prediction, Software for secondary structure prediction, Limitations of secondary structure prediction. Protein modelling: Introduction, Methods of protein modelling, Homology or comparative modelling, Model refinement, Evaluation of the model.	7

Text book and Reference books:

1. Bioinformatics: A Textbook, Wiley Online Library
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
4. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

5. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
6. Oprea, T. (2005). Chemo informatics in Drug Discovery, Volume 23. Wiley Online Library.

PEC-CS-802A: Security Assessment and Risk Analysis

Lecture per week (L – T): 3-0 **Credits**: 3

Course Outcomes (COs):

Upon completion of this course, the students will be able to:

1. **Develop** risk management models for implementing a deeper risk management program in their organization
2. **Demonstrate** proper risk management and risk analysis technique and methodology.
3. **Plan** vulnerability assessment, threat assessment and risk analysis projects as it relates to physical security.
4. **Prepare** and present business-based recommendations for expenditure of security funds.
5. **Construct** plans that address facility access and the protection of structures and components that contain the automated information system and network equipment.
6. **Illustrate** risk analysis and protection of telecommunication

Prerequisites:

- Cyber security fundamentals

Detailed Content:

Unit	Content	Hrs/ Unit
1	Security Basics: Information Security (INFOSEC) Overview: critical information characteristics – availability information states – processing security countermeasures education, training and awareness, critical information characteristics – confidentiality critical information characteristics – integrity, information states – storage, information states – transmission, security counter measures policy, procedures and practices, threats, vulnerabilities.	7
2	Threats to and Vulnerabilities of Systems: definition of terms (e.g., threats, vulnerabilities, risk), major categories of threats (e.g., fraud, Hostile Intelligence Service (HOIS), malicious logic, hackers, environmental and technological hazards, disgruntled employees, careless employees, HUMINT, and monitoring), threat impact areas, Countermeasures: assessments (e.g., surveys, inspections), Concepts of Risk Management: consequences (e.g., corrective action, risk assessment), cost/benefit analysis of controls, implementation of cost effective controls, monitoring the efficiency and effectiveness of controls (e.g., unauthorized or inadvertent disclosure of information), threat and vulnerability assessment)	9
3	Security Planning: directives and procedures for policy mechanism, Risk Management: acceptance of risk (accreditation), corrective actions information identification, risk analysis and/or vulnerability assessment components, risk analysis results evaluation, roles and responsibilities of all the players in the risk analysis process, Contingency Planning/Disaster Recovery: agency response procedures and continuity of operations, contingency plan components, determination of backup requirements, development of plans for recovery actions after a disruptive event, development of procedures for offsite processing, emergency destruction procedures, guidelines for determining critical and essential workload, team member responsibilities in responding to an emergency situation.	8

4	Policies and Procedures: Physical Security Measures: alarms, building construction, cabling, communications centre, environmental controls (humidity and air conditioning), filtered power, physical access control systems (key cards, locks and alarms), Personnel Security Practices and Procedures: access authorization/verification (need to know), contractors, employee clearances, position sensitivity, security training and awareness, systems maintenance personnel, Administrative Security Procedural Controls: attribution, copyright protection and licensing , Auditing and Monitoring: conducting security reviews, effectiveness of security programs, investigation of security breaches, privacy review of accountability controls, review of audit trails and logs	8
5	Operations Security (OPSEC): OPSEC surveys/OPSEC planning INFOSEC: computer security – audit, cryptography encryption (e.g., point to point, network, link), cryptography key management (to include electronic key), cryptography strength (e.g., complexity, secrecy, characteristics of the key) Case study of threat and vulnerability assessment.	10

Text Book and Reference Books:

1. Whitman & Mattord, Principles of Incident Response and Disaster Recovery, Course Technology ISBN:141883663X
2. Cyber-Risk Management by Atle Refsdal, Bj¢rnar Solhaug and Ketil St¢len - Springer
3. Auditing IT Infrastructures for Compliance by Marty M. Weiss and Michael G. Solomon – Jones & Bartlett Learning
4. Quantitative Risk Assessment: The Scientific Platform by TerjeAven – Cambridge University Press
5. Information Security Risk Assessment Toolkit by Mark Talabis and Jason Martin – Elsevier
6. IT Security Risk Control Management – An Audit Preparation Plan by Raymond Pompon – Apress

PEC-CS-802B: Mobile Computing

Lecture per week: 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand the necessary knowledge of cellular communication, infrastructure-less networks
2. Analyze TCP, MAC protocols and their technical feasibility
3. Analyze device independent applications
4. Acquire knowledge about the basic concepts and principles in mobile computing
5. Understand techniques involved, in networks
6. Analyze systems issues for the design and implementation of mobile computing systems.

Prerequisites:

- Computer Networks

Detailed Content:

Module	*Content*	*Hours/ Module*
1	Introduction to Personal Communications Services (PCS): PCS Architecture, Mobility management, Networks signaling. Global System for Mobile Communication (GSM) system overview: GSM Architecture, Mobility management, Network signaling.	4

2	General Packet Radio Services (GPRS): GPRS Architecture, GPRS Network Nodes. Mobile Data Communication: WLANs (Wireless LANs) IEEE 802.11 standard, Mobile IP	4
3	Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless markup Languages (WML). Wireless Local Loop(WLL): Introduction to WLL Architecture, wireless Local Loop Technologies.	6
4	Third Generation (3G) Mobile Services: Introduction to International Mobile Telecommunications 2000 (IMT 2000) vision, Wideband Code Division Multiple Access (W-CDMA), and CDMA 2000, Quality of services in 3G.	6
5	Global Mobile Satellite Systems; case studies of the IRIDIUM and GLOBALSTAR systems. Wireless Enterprise Networks: Introduction to Virtual Networks, Blue tooth technology, Blue tooth Protocols.	6
6	Server-side programming in Java, Pervasive web application architecture, Device independent example application	4

Text book and Reference books:

1. Mobile Communications, Jochen Schiller, PHI/Pearson Education, Second Edition, 2003.
2. Fundamentals of Mobile Computing, Rajib Mall, PHI, Second Edition, 2015.
3. Wireless Communications and Networks, William Stallings, PHI/Pearson Education, 2002.
4. Principles of Wireless Networks, Kaveh Pahlavan, Prasanth Krishnamoorthy, PHI/Pearson Education, 2003.
5. Principles of Mobile Computing, Uwe Hansmann, Lothar Merk, Martin S. Nicklons and Thomas Stober, Springer, New York, 2003.
6. Mobile Communication Systems, Hazysztof Wesolowshi, John Wiley and Sons Ltd, 2002.

PEC-CS-802C: Deep Learning

Lectures per week: 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Recognize** the characteristics of deep learning models that are useful to solve real-world problems.
2. **Understand** different methodologies to create application using deep nets.
3. **Identify** and apply appropriate deep learning algorithms for analyzing the data for variety of problems.
4. **Implement** different deep learning algorithms.
5. **Design** the test procedures to assess the efficacy of the developed model.
6. **Combine** several models in to gain better results.

Prerequisites:

- Machine Learning Foundations

Detailed Content:

Module	***Content***	***Hours/ Module***

1	**Introduction:** Various paradigms of learning problems, Perspectives and Issues in deep learning framework, review of fundamental learning techniques	2
2	**Feed forward neural network:** Artificial Neural Network, activation function, multi-layer neural network. cardinality, operations, and properties of fuzzy relations	5
3	**Training Neural Network:** Risk minimization, loss function, back propagation, regularization, model selection, and optimization.	5
4	**Conditional Random Fields:** Linear chain, partition function, Markov network, Belief propagation, Training CRFs, Hidden Markov Model, Entropy.	4
5	**Transfer Learning** Transfer learning Techniques, Variants of CNN: DenseNet, PixelNet.	3
6	**Deep Learning:** Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Deep Belief Network	7
7	**Auto Encoders** Under complete Auto encoder, Regularized Auto encoder, stochastic Encoders and Decoders, Contractive Encoders	4

Text book and Reference books:

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Bishop, C. M., Pattern Recognition and Machine Learning, Springer, 2006.
3. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
4. Golub, G. H., and Van Loan, C. F., Matrix Computations, JHU Press,2013.
5. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.
6. Rajiv Chopra, Deep Learning, Khanna Publishing House, 2018.

PEC-CS-802D: Digital Image Processing

Contacts: 3L per week **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

- Review the fundamental concepts of a digital image processing system.
- Analyze images in the frequency domain using various transforms.
- Evaluate the techniques for image enhancement and image restoration.
- Categorize various compression techniques.
- Interpret Image compression standards.
- Interpret image segmentation and representation techniques.

Prerequisites:

- Digital Signal Processing
- Linear Algebra
- Discrete Mathematics

Detailed Content:

Module	***Content***	***Hours/ Module***

1	**Introduction:** Overview of Image Processing, Application area of image processing, Digital Image Representation, Sampling & quantization. Spatial and Intensity resolution, interpolation, Relationship between pixels – Neighbors, Adjacency, connectivity, Regions, Boundaries and Distance.	5
2	**Image Enhancement in Spatial Domain:** Image Quality and Need for image enhancement, Intensity transformation – negative, log, power-law and contrast stretching (linear and non-linear) Histogram based techniques, Spatial Filtering concepts, Spatial Convolution and Correlation, Image smoothing and Sharpening spatial filters. **Image Enhancement in Frequency Domain:** Properties of 1-D and 2-D Discrete Fourier Transform (DFT), Basic of filtering in the frequency domain. Image smoothing and sharpening in frequency domain.	9
3	**Image Restoration:** Introduction to degradation, Types of Image degradations, image degradation models, noise modeling, Estimation of degradation functions, Image restoration in presence of noise only – spatial filtering, Periodic noise and band – pass and band reject filtering.	5
4	**Image Compression:** coding redundancy, Image compression model, Compression Methods – Huffman coding, Arithmetic coding, LZW coding, Run-length coding, and Predicative coding and Vector quantization.	6
5	**Image Segmentation:** Introduction, Detection of Discontinuities, Point Detection, Line Detection and Edge Detection, Thresholding – Local, Global, Optimum, Multiple and Variable, Hough Transforms, Principle of region – growing, splitting and merging.	6

Text book and Reference books:

1. Rafael C. Gonzalez, Richard E woods, Digital Image Processing, Pearson.
2. S. Jayaraman, S. Esakkirajan, T. Veerakumar, Digital Image Processing, McGraw Hill
3. Anil K Jain "Fundamentals of Digital Image Processing", Pearson.
4. S. Sridhar, "Digital Image Processing", OXFORD University Press, Second Edition.
5. Bhabatosh Chanda, Dwijesh Dutta Majumder, Digital Image Processing and Analysis, Prentice Hall of India

OEC-CS-801A: Operations Research

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Design linear programming tools for optimal utilization of resources in various types of industries.
2. Evaluate transportation problems to minimize cost and understand the principles of assignment of jobs and recruitment polices.
3. Analyze decision making under certainty, uncertainty and conflicting situations.
4. Apply forecasting methods for predicting demands.
5. Understand the basic elements of a Queuing model.
6. Remember and Define PERT/CPM technique for project scheduling and resource allocation in an optimal way.

Prerequisites:

1. Probability and Statistics
2. Discrete Mathematics

Detailed Content:

Module	*Content*	*Hours/ Module*
1	Introduction to Operations Research: Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools.	3
2	Linear Programming: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Graphical Methods to Solve Linear Programming Problems, Applications, Advantages, Limitations. Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Some Basic Definitions, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP. Simplex Method: Introduction, Standard Form of LPP, Fundamental theorem of LPP, Solution of LPP - Simplex Method, The Simplex Algorithm, Penalty Cost Method or Big M-method, Two Phase Method, Solved Problems on Minimization. Duality in Linear Programming Problem: Introduction, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis.	7
3	Transportation Problem: Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality. Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem.	5
4	Project Management Using CPM-PERT: Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT, Float calculation and its importance. Cost reduction by Crashing of activity	4
5	Queuing Theory: Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Queue discipline, Service Mechanism, Classification of Queuing models, [M/M/1]:{//FCFS} Queue System, numerical. Inventory Management: Inventory classification, Different costs associated to Inventory, Inventory models with deterministic demands (EOQ, EPQ and price discount models), inventory classification systems.	6
6	Job Sequencing: Introduction to sequencing and scheduling models: n job two machines problem, n job 3 machines problem. Decision Theory: Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree.	4
7	Replacement Theory: Introduction, Replacement of capital equipment which depreciated with time, replacement by alternative equipment, Group and individual replacement policy.	3

Text book and Reference books:

1. F.S. Hillier, G.J. Lieberman, B. Nag and P. Basu, Introduction to Operation Research, 10th Edition, McGraw Hill, 2017.

2. C. Mohan and K. Deep, Optimization Techniques, New Age, 2009.
3. N.D. Vohra, Quantitative Techniques in Management, 5th Edition, McGraw-Hill.
4. K.V. Mittal and C. Mohan, Optimization Methods in Operations Research and Systems Analysis, New Age, 2003.
5. H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002.
6. Ravindran, D.T. Phillips and J.J. Solberg, Operations Research: Principles and Practice, 2nd Edition, John Willey and Sons, 2009.
7. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
8. S.J. Chandra and A. Mehra, Numerical Optimization with Applications, Narosa, 2009.
9. J.K. Sharma, Operation Research: Theory and Applications, 5th Edition, Macmillan Pub., 2013.
10. L.W. Wayne, Operations Research Applications and Algorithms, 4th Edition, Brooks/Cole, USA.

OEC-CS-801B: Remote Sensing and GIS

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

After studying this course, student will be able to:

1. **Analyse** the principles and components of photogrammetry and remote sensing.
2. **Describe** the process of data acquisition of satellite images and their characteristics
3. **Compute** an image visually and digitally with digital image processing techniques.
4. **Explain** the concepts and fundamentals of GIS.
5. **Design** of different civil engineering applications by computation knowledge of remote sensing and GIS.
6. **Apply** remote sensing in different thematic studies.

Prerequisites:

1. Internet Fundamental
2. Data Base Management System
3. Basics of Sensor Technology

Detailed Content:

Unit	Content	Hrs./ Unit
1.	**Introduction and Overview of Geographic Information Systems** Definition of a GIS, features and functions; why GIS is important; how GIS is applied; GIS as an Information System; GIS and cartography; contributing and allied disciplines; GIS data feeds; historical development of GIS. **GIS and Maps, Map Projections and Coordinate Systems** Maps and their characteristics (selection, abstraction, scale, etc.); automated cartography versus GIS; map projections; coordinate systems; precision and error	7
2.	**Data Sources, Data Input , Data Quality and Database Concepts** Major data feeds to GIS and their characteristics: maps, GPS, images, databases, commercial data; locating and evaluating data; data formats; data quality; metadata. Database concepts and components; flat files; relational database systems; data modeling; views of the database; normalization; databases and GIS. **Spatial Analysis** Questions a GIS can answer; GIS analytical functions; vector analysis including topological	11

	overlay; raster analysis; statistics; integrated spatial analysis. **Making Maps** Parts of a map; map functions in GIS; map design and map elements; choosing a map type; producing a map formats, plotters and media; online and CD-ROM distribution; interactive maps and the Web.	
3.	**Implementing a GIS** Planning a GIS; requirements; pilot projects; case studies; data management; personnel and skill sets; costs and benefits; selecting a GIS package; professional GIS packages; desktop GIS; embedded GIS; public domain and low cost packages. **Technology & Instruments involved in GIS & Remote Sensing** GIS applications; GIS application areas and user segments; creating custom GIS software applications; user interfaces; case studies. Future data; future hardware; future software; Object-oriented concepts and GIS; future issues – data ownership, privacy, education; GIS career options and how to pursue them.	10
4.	**Remote Sensing** Remote sensing of environment, E.M. Principle, Thermal infrared remote sensing, Remote sensing of Vegetation, Remote sensing of water, urban landscape	7

Text book and Reference books:

1. "Principles of geographical information systems", P. A. Burrough and R. A. Mcdonnel, Oxford.
2. "Remote sensing of the environment" ,J. R. Jensen, Pearson
3. "Exploring Geographic Information Systems", Nicholas Chrismas, John Wiley & Sons.
4. "Getting Started with Geographic Information Systems", Keith Clarke, PHI.
5. "An Introduction to Geographical Information Systems", Ian Heywood, Sarah Cornelius, and Steve Carver. Addison-Wesley Longman
6. "Fundamental of Remote Sensing and GIS", S.K. Sinha, Ayushman Publication House.

OEC-CS-801C: Ecommerce and ERP

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand fundamental concepts and technologies related to ERP.
2. Explain the different phases of ERP implementation life cycle.
3. Examine the modules, benefits and various tools of ERP.
4. Analyze the impact of e-commerce on business model and strategies.
5. Assess the electronic payment systems and software.
6. Identify and solve the security issues related to communication.

Prerequisites:

- Basic Mathematics

Detailed Content:

Sl No	*Content*	*Hours/ Module*
1	Introduction to E-Commerce Introduction What is E-Commerce, Forces behind E-Commerce Industry Framework, Brief history of E-Commerce, Inter Organizational E-Commerce Intra	6

	Organizational Commerce, and Consumer to Business Electronic Commerce, Architectural framework Network Infrastructure for E-Commerce Network Infrastructure for E-Commerce, Market forces behind I Way, Component of I way Access Equipment, Global Information Distribution Network, Broad band Telecommunication.	
2	Mobile Commerce and ERP Introduction to Mobile Commerce, Mobile Computing Application, Wireless Application Protocols, WAP Technology, Mobile Information Devices, Web Security Introduction to Web security, Firewalls & Transaction Security, Client Server Network, Emerging Client Server Security Threats, firewalls & Network Security.	6
3	E-Commerce Payment and Gateways Electronic Payments Overview of Electronics payments, Digital Token based Electronics payment System, Smart Cards, Credit Card I Debit Card based EPS, Emerging financial Instruments, Home Banking, Online Banking.	6
4	E-Commerce and EDA Net Commerce EDA, EDI Application in Business, Legal requirement in E - Commerce, Introduction to supply Chain Management, CRM, issues in Customer Relationship Management.	6
5	Internet and E-Commerce Internet and Electronic commerce, internet, extranet and enterprise solutions, information system for business operations, information system for managerial decision support, information system for strategic advantage.	6
	Total	30

Books Recommended:

1. Enterprise Resource Planning – A Managerial Perspective by D P Goyal, Tata McGraw Hill Education, 2011
2. Enterprise Resource Planning by Ashim Raj Singla, Cengage Learning, 2008
3. Enterprise Resource Planning, Alexis Leon, 2nd edition, Tata McGraw Hill
4. Enterprise Resource Planning, Ravi Shankar & S. Jaiswal, Galgotia

OEC-CS-801D: Business Analytics

Contacts: 3L per week **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

- **Understand** and critically apply the concepts and methods of business analytics.
- **Identify**, model and solve decision problems in different settings.
- **Interpret** results/solutions and identify appropriate courses of action for a given managerial situation whether a problem or an opportunity.
- **Create** viable solutions to decision making problems.
- **Apply** appropriate analytical methods to find solutions to business problems that achieve stated objectives.
- **Remember** and describe complex business problems in terms of analytical models.

Prerequisites:

- Probability and Statistics

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Foundations of Business Analytics** Introduction to Business Analytics, Analytics on Spreadsheets	3
2	**Product-Market Fit: Gap Analysis** Gap Analysis, Carrying Out Gap Analysis, Steps in Gap Analysis, Conducting a Representative Survey for Gap Analysis, Predicting, Consumer Behavior and Gap Analysis in Smartphone Market.	6
3	**Analytical Modeling by Factor and Cluster Analysis** Factor Analysis Concepts, Application of Factor Analysis Concepts of Cluster Analysis, Similarity Measures, Application of Cluster Analysis.	6
4	**Analytical Modeling by Logistics Regression and Discriminant Analysis** Linear Discriminant Analysis Model, Predictive Modeling using Discriminant Analysis, Application of Linear Discriminant Analysis for Credit Scoring of Loan Applicants. Theoretical Formulation of Logistics Regression, Mathematical Interpretation of Logistics Regression, Indicator for Model Fit, Applying Logistics Regression, Application of Logistics Regression in Predicting Risk in Portfolio Management Testing the Reliability/Consistency of the Different Factors Measured.	7
5	**Segmentation of primary target market by Heuristic Modeling** Introduction to RFM Analysis Enhancing Response Rates with RFM Analysis.	4
6	**Segmentation of target market based on large databases using Decision Tree approach.** Introduction to Chi-square Automatic Interaction Detection (CHAID) Predictive Modelling by CHAID	5

Text book and Reference books:

1. "Business Analytics: An Application Focus", Purba Halady Rao, Prentice Hall.
2. "Business Analytics" James R. Evans, Pearson.
3. "Modeling Techniques in Predictive Analytics", Thomas W. Miller, Pearson
4. "Enterprise Analytics: Optimize Performance, Process, and Decisions Through Big Data", Thomas H. Davenport, Pearson.
5. "Fundamentals of Business Analytics", Seema Acharya, Wiley India.
6. "Business Intelligence: A Managerial Perspective on Analytics", Ramesh Sharda, Dursun Delen, Efraim Turban, David King, Prentice Hall

OEC-CS-802A: Numerical methods

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Understand the limitation of analytical approach to solve real life complicated problems and how numerical methods are effective to approximate the result with minimum error.
2. Familiar with source and effect of error on numerical computations and also analyze the efficiency of different numerical methods.
3. Familiar with numerical interpolation and approximation of functions.
4. Obtain numerical solution of algebraic and transcendental equation, system of linear equations and how to solve definite integrals and initial value problems.

5. Learn various numerical techniques to solve multi-disciplinary problems in real life.
6. Solve some problems numerically and getting hands on experience.

Prerequisites:

- Basic Mathematics on Probability, Integration, Differentiation.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality, Bayes' rule.	8
2	Basic Statistics, Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation. Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, Tests for single mean, difference of means, and difference of standard deviations. Test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.	10
3	Approximation in numerical computation: Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors. Interpolation: Newton forward/backward interpolation, Lagrange's and Newton's divided difference Interpolation. Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Expression for corresponding error terms.	10
4	Numerical solution of a system of linear equations: Gauss elimination method, Matrix inversion, LU Factorization method, Gauss-Seidel iterative method. Numerical solution of Algebraic equation: Bisection method, Regula-Falsi method, Newton-Raphson method.	8
5	Numerical solution of ordinary differential equation: Euler's method, Runge-Kutta methods, Predictor Corrector methods and Finite Difference method.	4

Text book and Reference books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Chandrika Prasad & Reena Garg, Advanced Engineering Mathematics, Khanna Publishing House, 2019.
3. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
4. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003
5. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
6. Ramana, Higher Engineering Mathematics, TMH
7. Sashtry, Advanced Engineering Mathematics, PHI
8. C. Xavier: C Language and Numerical Methods.
9. R.S. Salaria, Computer Oriented Numerical Methods, Khanna Publishing House.
10. Dutta & Jana: Introductory Numerical Analysis.
11. J.B. Scarborough: Numerical Mathematical Analysis.

OEC-CS-802B: Multimedia Technology

Lecture per week (L): 3 **Credits: 3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. Create a well-designed, interactive Web site with respect to current standards and practices
2. Demonstrate in-depth knowledge in an industry-standard multimedia development tool and its associated scripting language
3. Determine the appropriate use of interactive verses standalone Web applications
4. Create time-based and interactive multimedia components
5. Identify issues and obstacles encountered by Web authors in deploying Web-based applications
6. To apply the basic understanding of concepts in real-world applications.

Prerequisites:

1. Basic Mathematics
2. Computer Organization
3. Computer Graphics

Detailed Content:

Sl No	Content	Hours/ Module
1	Multimedia: Introduction to multimedia, Components, Uses of multimedia.	1
2	Making Multimedia: Stages of a multimedia project, Requirements to make good multimedia, Multimedia Hardware - Macintosh and Windows production Platforms, Hardware peripherals - Connections, Memory and storage devices, Multimedia software and Authoring tools.	4
3	Text: Fonts & Faces, Using Text in Multimedia, Font Editing & Design Tools, Hypermedia & Hypertext.	5
4	Still Images – Bitmaps, Vector Drawing, 3D Drawing & rendering, Natural Light & Colours, Computerized Colours, Color Pallets, Image File Formats.	5
5	Sound: Digital Audio, MIDI Audio, MIDI vs Digital Audio, Audio File Formats.	5
6	Video: How Video Works, Analog Video, Digital Video, Video File Formats, Video Shooting and Editing. Animation: Principle of Animations. Animation Techniques, Animation File Formats.	5
7	Multimedia System: An overview of multimedia system and media streams, Source representation and compression techniques text, speech and audio, still image and video, Graphics and animation. Multi-modal Communication: Video conferencing, networking support, Trans-coding	5
	TOTAL	30

Text/ Reference Books:

1. Multimedia: Making it work by Tay Vaughan, TMH.
2. Multimedia: Computing, Communications Applications by R Steinmetz and K Naharstedt, Pearson.
3. Multimedia Handbook by Keyes, TMH.
4. Multimedia System Design by K. Andleigh and K. Thakkar, PHI.
5. Principles of Multimedia by Parekh, Mc Graw Hill

OEC-CS-802C: Introduction to Arts and Aesthetics

Contacts: 3L per week **Credits: 3**

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Analyze and implement the concept of Aesthetics.
- Describe a historical understanding on Western and Indian Aesthetics.
- Understand the aesthetic concepts from various Western and Indian philosophers.
- Analyze the contextual relevance of aesthetic theories.
- Develop a culture of critical and analytical thinking.
- Implement the aesthetical and philosophical concepts.

Prerequisite:

NIL

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Literary Art Kavya, Fine Arts: Painting (Chitra), Music (Sangita), Sculpture (Bhaskarya). Kavya-Laksana (Definition of Poetry), Kavya-hetu: Pratibha, Vyutpatti and Abhyasa, Their distinctive roles in Poetic Creation, Kavya Prayojana. Varieties of Kavya: Drsya and Sravya, Structural Varieties of Drsyakavya.	6
2	Different Schools of Literary Criticism (Kavyavicara): Rasa School (Bharata), Vakrokti School or the School of Alankara (Bhamaha and Kuntaka), Riti School or the School of 6 Gunas (Dandin and Vamana), Dhvani School (Anandavardhana) and Rasadvani School (Abhinavagupta).	7
3	Aesthetics and Philosophical Aesthetics: Second order Aesthetics, The World of Human Experience and Art and Experience. Art and its Definition: Art as Representation, Art as Expression and Art as Significant Form. Kantian Aesthetics (Critique of Judgment)	7
4	Art and Emotion: The Concept of Emotion, The Concept of Fiction and Fiction and Emotion. Literary Aesthetics: The Concept of Literature, Metaphor, Truth, Meaning and Interpretation.	6
5	Art, Society and Morality: Views of Tolstoy and Post-modernism.	3

Text book and Reference books:

1. K. C. Pandey. Comparative Aesthetics Vol. 1. Chowkhamba: Chowkhamba Sanskrit Series Office, 1950. English.
2. R. Gnoli. The Aesthetic Experience According to Abhinavagupta. Chowkhamba: Chowkhamba Sanskrit Series Office, 1968. English.
3. Panchapagesha Sastri. The Philosophy of Aesthetic Pleasure. Annamalai, 1940. English.

4. S. Kunjunni Raja. Indian Theories of Meaning. Madras: Adyar Library and Research Centre, 1963. English.
5. K. Krishna Murthy. Dhvanyaloka and its Critics. Mysore: Kavyalaya Publishers, 1963. English.
6. S. P Bhattacharyya. Studies in Indian Poetics. Calcutta, 1964. English.
7. Anne Sheppard. Aesthetics: An Introduction to the Philosophy of Art. UK: Oxford University Press, 1987. English.
8. Peter Lamarque. Philosophy and Fiction: Essays in Literary Aesthetics.Aberdeen University Press, 1983. English.
9. Bernard Bosque. History of Western Aesthetics.

OEC-CS-802D: Research Methodology

Lecture per week (L): 3 Credits: 3

Course Outcomes (COs):

At the end of the course, the students will be able to:

1. **Discuss** different methodologies and techniques used in research work.
2. **Explain** basic computer skills necessary for the conduct of research.
3. **Explain** key research concepts and issues.
4. **Select** and define appropriate research problem and parameters.
5. **Develop** the required numerical skills necessary to carry out research.
6. **Develop** an appropriate framework for research studies.

Prerequisites:

- Probability and Statistics

Detailed Content:

Module	***Content***	***Hours/ Module***
1	RESEARCH FORMULATION AND DESIGN Motivation and objectives – Research methods vs. Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical, concept of applied and basic research process, criteria of good research. Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review-primary and secondary sources, reviews, monograph, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature and research database, development of working hypothesis	8
2	DATA COLLECTION AND ANALYSIS Accepts of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statically package (Sigma STAT,SPSS for student t-test, ANOVA, etc.), hypothesis testing	8
3	RESEARCH ETHICS, IPR AND SCHOLARY PUBLISHING Ethics-ethical issues, ethical committees (human & animal); IPR- intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); scholarly publishing- IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.	8

4	INTERPRETATION AND REPORT WRITING Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Project Report, Layout of the Project/Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Project/Research Report, Precautions for Writing Research Reports, Conclusions.	8

Text book and Reference books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing.
5. Wadehra, B.L. 2000. Law relating to patents, trade-marks, copyright designs and geographical indications. Universal Law Publishing.
6. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
7. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
8. Coley, S.M. and Scheinberg, C. A., 1990, Proposal Writing, Sage Publications.
9. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
10. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
11. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
12. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Ess Publications.